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Managing Groundwater in the Ogallala Aquifer for Irrigation

by

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ARTICLES

MANAGING GROUNDWATER IN THE OGALLALA AQUIFER FOR IRRIGATION

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I. INTRODUCTION

Much of the High Plains area extending over parts of six states — Colorado, Kansas, Nebraska, New Mexico, Oklahoma and Texas — is underlain by the Ogallala Formation, a major aquifer supplying most of the water needs of the area's large agricultural economy (figure 1).[1] Small portions of the Ogallala Aquifer also underlie areas of South Dakota and Wyoming. Irrigated agriculture, largely supplied by water from the aquifer, expanded rapidly after World War II. Total irrigated acreage in the six states overlying the major portion of the aquifer increased from about 3.5 million acres (mostly

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1. *Six-State High Plains — Ogallala Aquifer Regional Resources Study: Summary*, High Plains Associates, Inc., Austin, Texas 1 (1982) [hereinafter cited as *Six-State High Plains Study*].

in Texas and Nebraska) in 1950 to more than 15 million acres in 1980, using more than 170,000 irrigation wells.[2]

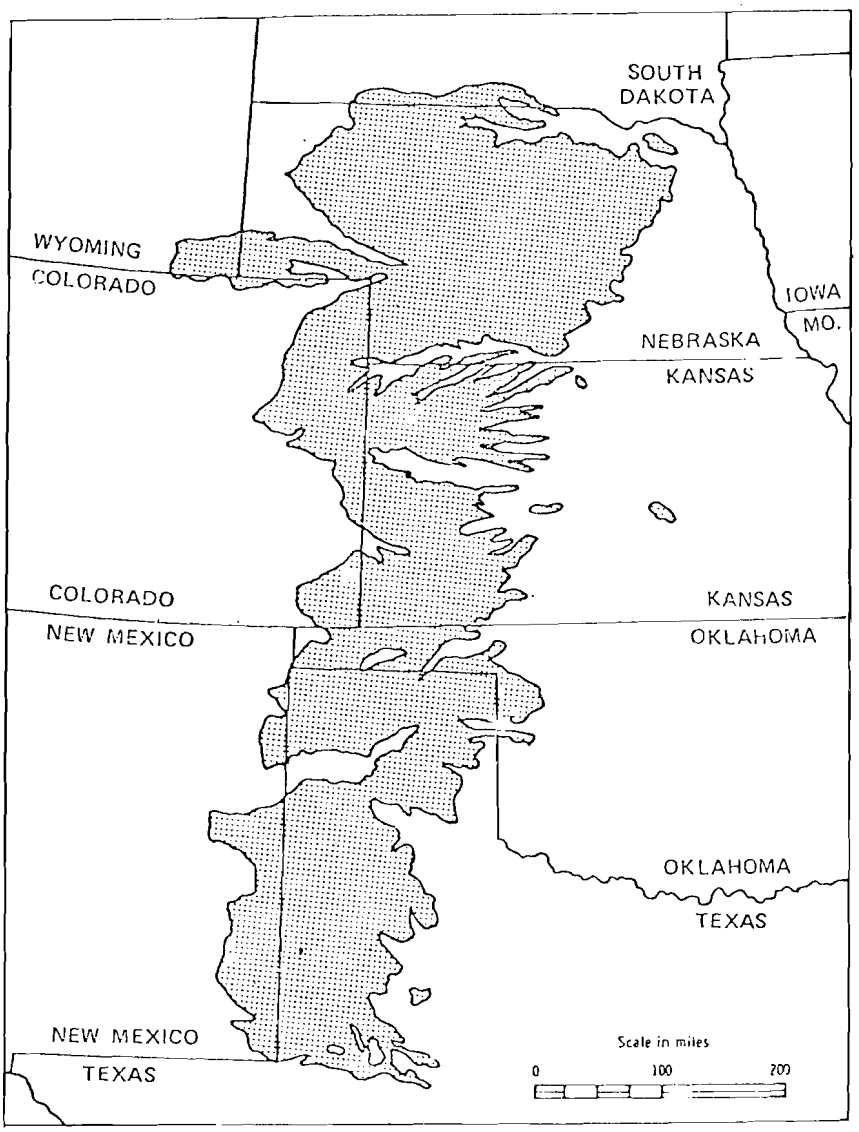

Figure 1. Generalized distribution of the Ogallala Formation (based on all available published maps).

2. *Id.* at 3; *A Summary of Results of the Ogallala Aquifer Regional Study, with Recommendations to the Secretary of Commerce and Congress*, U.S. Department of Commerce 1, 3 (1982) [hereinafter cited as *Ogallala Aquifer Regional Study*].

Water use increased as irrigated acreage expanded. Less than 7 million acre-feet of water were withdrawn each year before 1950 from the Ogallala. By 1980, more than 21 million acre-feet were pumped annually, even though over the same period improved irrigation efficiencies had reduced per acre application of water by about 30 percent, from 2 acre-feet per acre to about 1.4 acre-feet per acre.[3] Irrigators are now withdrawing from 1 to 3 acre-feet per year and are the primary cause of declining groundwater levels in the Ogallala Aquifer. The recharge rate by percolation from rainfall rarely exceeds one acre-inch per acre per year. This groundwater mining situation will eventually cause a decline in irrigation activities in the area and may result in severe economic consequences at the local, regional and national levels.[4]

This article examines existing institutional structures and laws in the six states overlying the major portion of the Ogallala Aquifer, and describes their efforts to control, regulate and conserve the declining supplies of groundwater. First, the article discusses the groundwater resources available and the impact of irrigation on agriculture in the area. The article next describes state and local agency structures for managing groundwater uses. Last, the article analyzes various management practices available to state and local agencies controlling, regulating and conserving groundwater resources.

II. Groundwater Resources Available in Area

The Ogallala Formation varies both in depth and in water reserves per unit of surface area. In 1977, of the total 3.04 billion acre-feet available, 2.3 billion acre-feet (77 percent) were located in Nebraska, where the saturated depth ranged from less than 100 feet to 1200 feet. Approximately 8 percent was located in Kansas, where saturated depth varied from less than 100 feet to 600 feet. Colorado claimed about 3 percent of the total in 1977, with a saturated depth from less than 100

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3. *Six-State High Plains Study, supra* note 1, at 3; *Ogallala Aquifer Regional Study, supra* note 2, at 3.

4. *Ogallala Aquifer Regional Study, supra* note 2, at 4; G. Sloggett, *Mining the Ogallala Aquifer: State and Local Efforts in Groundwater Management* 1 (1977) (Agricultural Experiment Station Research Report 761, Okla. State U., Stillwater, Okla.) [hereinafter cited as *Mining*].

feet to 400 feet. New Mexico contained just under 1 percent of the total, with a saturated depth of 10 to 200 feet. Texas had 9 percent of the total and a saturated depth ranging from 10 to 600 feet, while Oklahoma had 2 percent of the 3.04 billion acre-feet of water in the Ogallala, with a saturated depth ranging from less than 100 feet to 600 feet.[5]

During 1977, the six states overlying the major portion of the Ogallala contained a total of 19.9 million acres irrigated with groundwater. Declining groundwater levels, with an average annual decline of 6 or more inches in the water table, were occurring beneath about 11.9 million of these acres (table 1). The amount of irrigated land dependent upon declining groundwater varies significantly from state to state, ranging from a high of 82 percent in Texas to a low of 32 percent in Nebraska. The annual rate of decline in groundwater is an indication of its severity and it ranges from 6 inches in parts of Nebraska to 4 feet in parts of Kansas and Texas (table 2).[6]

Table 1—Area Irrigated with Declining Groundwater Supplies in Six Ogallala Area States, 1977

State	Total groundwater irrigation[1]	Decline area irrigated[1]	Percentage of total areas irrigated by declining groundwater areas
	------1,000 acres------		Percent
Colorado	1,650	570	35
Kansas	3,083	1,995	65
Nebraska	5,855	1,842	32
New Mexico	760	560	75
Oklahoma	730	507	70
Texas	7,846	6,425	82
Total	19,924	11,899	60

5. *Ogallala Aquifer Regional Study, supra* note 2 at 3.

6. Presentation by G. R. Sloggett, American Water Resources Association Annual Conference, Ground Water Irrigated Costs — On the Way Up, 2-4 (Oct. 10-15, 1982) [hereinafter cited as Costs].

Table 2—Rate of Decline for Areas of Groundwater Loss in Six Ogallala Area States, 1978

State	Average annual rate of decline
	Feet
Colorado	2
Kansas	1 to 4
Nebraska	0.5 to 2
New Mexico	1 to 2.5
Oklahoma	1 to 2.5
Texas	1 to 4

Costs are increasing for all groundwater irrigators due in part to the increasing costs of equipment and energy used in pumping water. Because of increasing pumping lifts and decreasing well yields, these costs are increasing at an even more rapid rate where the groundwater level is declining.[7] To overcome increased costs in groundwater depletion areas, farmers will have to consider the following options: reducing irrigated acreage and leaving pumping time and application rates the same; maintaining the same acreage and pumping time, but reducing the application rates; or maintaining the same acreage and application rates, but reducing pumping time.[8]

With favorable technological and economic conditions, the amount of land under irrigation in the six primary states overlying the Ogallala is expected to increase from 14.3 million acres in 1977 to 18 million acres in 2020.[9] During these years, it is estimated that 23 percent of the estimated 3.04 billion acre-feet of water stored in the aquifer in 1977 will have been used. However, in the three southern states, New Mexico, Oklahoma and Texas, more than 50 percent of the quantity of water in storage in 1977 will have been used by 2020, while nearly two-thirds of the Texas supply will be used during the period. Large withdrawals for irrigation purposes, especially in areas of low transmissivity, may lower the head sufficiently to induce upward migration of water high in chloride from lower aquifers, reducing the quality of water availa-

7. *Id.* at 5.
8. *Id.* at 13.
9. *Ogallala Aquifer Regional Study, supra* note 2, at 13.

ble for irrigation.[10] Annual volume of irrigation water supplies, however, is expected to decline slightly between 1977 and 2020. This decline would not be uniform over all six states: calculations for water use in Nebraska show figures almost doubling while projections for the remaining states show substantial declines.[11]

III. Impact of Irrigation on Agriculture in Area

Precipitation in the area overlying the Ogallala is inadequate both in quantity and seasonal reliability to yield the potential productive capacity of the area's land resources. The development of irrigation has changed the area from an extensive farming economy dependent on rangeland, dryland wheat, feed grains and cotton in the 1940s to an intensive farming economy based on irrigated feed grains, wheat, cotton, sugar beets and cattle feeding operations.[12] Irrigated cropland grew from 3 percent of harvested cropland in 1940 to 41 percent in 1978 (table 3), thereby making agriculture highly dependent on water for irrigation.[13] With supplemental water, yields of cotton, grain sorghum and wheat can be increased from 3 to 4 times that of dryland production, and other crops, including corn, sugar beets, vegetables and Irish potatoes, can be grown.[14] Currently, the Ogallala area produces more than 38 percent of the nation's total value of livestock.[15]

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10. *Id.* at 16.

11. *Id.* at 13.

12. *Mining, supra* note 4, at 1.

13. *Id.*; G. Sloggett, *Ground Water Irrigation Development in the Plains* 2 (1983) (Agricultural Economics Department Report AE No. 8359, Okla. State U., Stillwater, Okla.) [hereinafter cited as *Development*].

14. *Ogallala Aquifer Regional Study, supra* note 2 at 3.

15. *Id.* at 1.

Table 3—Total Cropland, Harvested Cropland, and Irrigated Cropland in the United States and Ogallala Areas by Selected Years

Year	Total cropland		Harvested cropland		Irrigated cropland	
	U.S.	Ogallala	U.S.	Ogallala	U.S.	Ogallala
	-1,000,000 acres-					
1940	530	36	321	30	18	1
1950	478	50	345	38	26	3
1959	448	59	311	35	33	7
1969	417	51	273	29	38	10
1978	461	52	321	34	51	14

With the growth of irrigation in the Ogallala area came a significant increase in the production of feed grains, from 150 million bushels in 1950 to 1.25 billion bushels in 1980.[16] Abundant feed grains led to a significant increase in the number of cattle fed. Feed cattle in the six primary states overlying the Ogallala Aquifer nearly quadrupled from 1960 to 1980 (table 4).[17] In 1960, 23 states reported statistics for feed cattle and calves; the Ogallala area claimed 24 percent of all the cattle and calves on feed in 1960, and 55 percent in 1980. There were 5.5 million cattle and calves on feed in the 17 states outside the Ogallala area in 1960, and only 5.3 million in 1980. Thus, all growth in cattle feeding in the country from 1960 to 1980 occurred in the six Ogallala states.[18]

16. *Six-State High Plains Study, supra* note 1, at 3; *Development, supra* note 13, at 7.

17. *Development, supra* note 13, at 7, 9.

18. *Id.* at 7, 10.

Table 4—Cattle and Calves on Feed on January 1st for 23 States and Ogallala Area

Year	23 States	Ogallala Area	
	----- 1,000 ------		Percent
1960	7,173	1,715	24
1965	9,292	2,670	29
1970	12,644	5,013	40
1975	9,619	4,529	47
1980	11,713	6,449	55

Production of the six major crops grown in the Ogallala area — wheat, corn, grain sorghum, soybeans, alfalfa and cotton — is expected to increase between 1977 and 2020. Wheat production is projected to increase by almost 45 percent, grain sorghum by more than 60 percent, corn and cotton by slightly more than 100 percent, and soybeans by more than 1,060 percent.[19] The total value of production from both irrigated and dryland crops for the area is projected to rise from approximately $4.6 billion in 1977 to $11.5 billion (in real terms) in 2020. Estimated returns to land, water and management are expected to increase from just over $1 billion in 1977 to almost $5 billion in 2020. Irrigated production accounts for 46 percent of returns in 1977 and 60 percent in 2020.[20]

IV. Organizational Structures for Groundwater Management

All six states overlying the major portion of the Ogallala Aquifer have passed groundwater management legislation. Some states give complete authority for groundwater management to state organizations, while other states empower local groundwater management districts with that authority; state and local organizations share that responsibility in still other states. All states except Texas provide for at least some management at the state level.

New Mexico and Oklahoma do not have local groundwater management agencies with regulatory powers; therefore,

19. *Ogallala Aquifer Regional Study, supra* note 2, at 5.
20. *Id.* at 13.

state agencies control all groundwater in these two states.[21] The state regulates and controls groundwater in Colorado and Kansas,[22] with some lesser regulatory authority delegated to local organizations.[23] Primary control of Nebraska groundwater lies with local agencies,[24] with lesser regulatory powers vested in state agencies.[25] Local organizations manage groundwater in Texas.[26]

A. State Agency Management of Groundwater

1. New Mexico

The State Engineer in New Mexico is appointed by the governor[27] and has primary administrative authority over the appropriation of groundwater.[28] Such authority, however, extends only to groundwater in underground water basins so declared by the State Engineer.[29] The primary regulatory mechanism in declared underground water basins is the permit system. Groundwater from these basins may be appropriated only for a beneficial use[30] and only if the State Engineer issues a permit for the withdrawal.[31]

Three underground water basins have been declared in the Ogallala area, with their boundaries defined by the State Engineer.[32] They include the Lea County Underground Water Basin in 1932, the Portales Valley Underground Water Basin in 1950, and the Capitan Underground Water Basin, south of

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21. N.M. STAT. ANN. §§ 72-12-1 to -28 (1978 & Supp. 1983); OKLA. STAT. ANN., tit. 82 §§ 1020.1 to .22 (West Supp. 1983-1984).

22. COLO. REV. STAT. §§ 37-90-101 to -141 (1973 & Supp. 1983); KAN. STAT. ANN. §§ 82a-701 to -730 (1977 & Supp. 1983).

23. COLO. REV. STAT. §§ 37-90-118 to -135 (1973 & Supp. 1983); KAN. STAT. ANN., §§ 82a -1020 to -1040 (1977 & Supp. 1983).

24. NEB. REV. STAT. §§ 46-614 to -634.01 (1978 & Supp. 1982), §§ 46-656 to -674.01 (Supp. 1982 & Supp. 1983).

25. *Id.* at §§ 46-601 to -613.01, 46-635 to -655 (1978, Supp. 1982, Supp. 1983).

26. TEX. WATER CODE ANN. §§ 52.001 to .401 (Vernon 1972 & Supp. 1984).

27. N.M. STAT. ANN. § 72-2-1 (1978).

28. *Id.* at §§ 72-12-1 to -3, -20 (1978 & Supp. 1983).

29. *Id.* at §§ 72-12-1, to -20 (Supp. 1983); McBee v. Reynolds, 74 N.M. 783, 399 P.2d 110 (1965). *See* N.M. STAT. ANN. § 72-2-8(B)(4) (1978).

30. N.M. STAT. ANN., §§ 72-12-2 to -18 (1978).

31. *Id.* at §§ 72-12-1, -3, -20 (1978 & Supp. 1983).

32. DuMars, *New Mexico Water Law: An Overview and Discussion of Current Issues*, 72 NAT. RESOURCES J. 1045, 1049 (1982).

Lea County, in 1968.[33] The State Engineer promulgates the rules and regulations applicable to each basin, and they are essentially the same in all three basins.[34] The State Engineer has determined the amount of groundwater available in each basin and has calculated the permissible withdrawals to insure adequate groundwater supplies for a 40-year period from the time the basins were declared.[35]

2. Oklahoma

Administration of groundwater in Oklahoma rests at the state level with the Oklahoma Water Resources Board.[36] The Oklahoma Ground Water Law of 1972 requires the board to conduct a hydrologic survey [37] to determine the maximum annual yield of freshwater to be produced from each fresh groundwater basin or subbasin.[38] Maximum yield represents the board's limit on the quantity of water that may be withdrawn from a basin's or subbasin's fresh groundwater reserves in one year. This limitation is to insure adequate fresh groundwater supplies in each basin or subbasin for 20 years after the enactment of the Ground Water Law, or until July 1, 1993.[39] At the present time, the Board is determining the amount of fresh groundwater available in each county.[40]

Under the Ground Water Law, groundwater is allocated according to a correlative rights system. This system apportions water within a groundwater basin or subbasin according to each landowner's acreage relative to the entire acreage of the basin or subbasin. Maximum annual yield then becomes the basis for allocating water under the correlative rights

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33. Telephone interview with Louis O'Dell, Water Rights Division of the New Mexico State Engineer Office (Dec. 7, 1983) [hereinafter cited as O'Dell Interview].

34. N.M. STAT. ANN. § 72-2-8(A) (1978).

35. *Mining, supra* note 4, at 10; O'Dell Interview, *supra* note 33; *see* Mathers v. Texaco, Inc., 77 N.M. 239, 421 P.2d 771 (1966).

36. OKLA. STAT. ANN. tit. 82 §§ 1020.1 to .22 (West Supp. 1983-1984); Mining, *supra* note 4, at 10; Jensen, *The Allocation of Percolating Water Under the Oklahoma Ground Water Law of 1972*, 14 TULSA L. J. 437 (1979).

37. OKLA. STAT. ANN., tit. 82, § 1020.4 (West Supp. 1983-1984).

38. *Id.* at § 1020.5.

39. *Id.*, Jensen, *supra* note 36, at 459-67.

40. Telephone interview with John Roles, Oklahoma Water Resources Board Oklahoma City, (Dec. 13, 1983) [hereinafter cited as Roles Interview].

system.[41]

B. State and Local Agency Shared Management of Groundwater

In Colorado, Kansas and Nebraska, state and local agencies share groundwater management. State agencies in Colorado and Kansas exercise more control over groundwater management than do local agencies, while in Nebraska local agencies have more management control than do state agencies.

1. Colorado

Groundwater not tributary to natural streams located within designated groundwater basins is managed by the state Ground Water Commission,[42] and all other groundwater, whether tributary or nontributary to natural streams, is managed by the State Engineer.[43] The commission, under the Ground Water Management Act, has authority to designate groundwater basins and define their boundaries,[44] and to administer water rights and groundwater withdrawal within such basins.[45] In addition, the commission may approve the formation of local groundwater management districts within designated groundwater basins upon petition of a required number of taxpaying electors and approval of the electorate;[46] the commission also approves regulations for such districts.[47] Groundwater withdrawal and distribution outside designated basins is administered by the State Engineer through a permit system.[48] The State Engineer is a member of the Ground Water Commission and has a secondary role in managing groundwater in designated basins.[49]

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41. OKLA. STAT. ANN. tit. 82, §§ 1020.9, .11 (West Supp. 1983).

42. COLO. REV. STAT. §§ 37-90-104 to -109, -111 to -116, -118 to -135 (1973 & Supp. 1983).

43. *Id.* at § 37-90-137; Massey, Hong, & Szilagyi, *Interstate Transfer of Colorado Water for San Marco Coal Slurry Pipeline*, 36 OKLA. L. REV. 1, 16-29 (1983).

44. COLO. REV. STAT. § 37-90-106 (1973).

45. *Id.* at §§ 37-90-107 to -109, -111 (1973 & Supp. 1983).

46. *Id.* at §§ 37-90-118 to -125 (1973).

47. *Id.* at §§ 37-90-130, -131 (1973 & Supp. 1983).

48. *Id.* at §§ 37-90-137, 37-92-501 to -504.

49. *Id.* at § 37-90-110 (1973).

The Colorado Ground Water Commission has designated seven groundwater basins in the state.[50] Two of these basins, Northern High Plains Groundwater Basin and Southern High Plains Groundwater Basin, are located in eastern Colorado. Most of the northern basin overlies the Ogallala, but only a small portion of the southern basin lies above the aquifer. In administering groundwater in these basins, the commission employs several state regulations to conserve the designated groundwater resources.[51] Eight groundwater management districts have been created by the commission within the Northern High Plains Groundwater Basin.[52] After a public hearing a district may adopt and enforce regulations governing groundwater withdrawal that are more restrictive than those of the Ground Water Commission.[53] Such regulations, however, must be approved by the commission before they are effective.[54]

2. Kansas

The primary authority for regulating groundwater use in Kansas is the Chief Engineer, who is the director of the Division of Water Resources within the State Board of Agriculture.[55] The Chief Engineer administers a statewide permit system, even within groundwater management districts, for withdrawing groundwater for a beneficial use.[56]

Kansas adopted legislation in 1972 authorizing the organization of local groundwater management districts.[57] Eligible voters may petition the Chief Engineer to organize a district, and the creation of that district is approved if certain criteria are met: for example, the land proposed for inclusion in the district must substantially comprise a hydrologic community

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50. Laitos, *The Effects of Water Law on the Development of Oil Shale*, 58 DEN. L. J. 716, 767 n.112 (1981).

51. COLO. REV. STAT. § 37-90-111 (1973 & Supp. 1983).

52. Telephone Interview with Jeris A. Danielson, State Engineer, Division of Water Resources, Colorado Department of Natural Resources, (Dec. 13, 1983) [hereinafter cited as Danielson Interview]; Sloggett, *supra* note 4, at 6.

53. COLO. REV. STAT. §§ 37-90-130, -131 (1973 & Supp. 1983).

54. *Id.* at § 37-90-131(2) (1973).

55. KAN. STAT. ANN. § 82a-706 (1977).

56. *Id.* at §§ 82a-708a to -715 (1977 & Supp. 1983).

57. *Id.* at §§ 82a-1020 to -1040; Peck, *Kansas Groundwater Management Districts*, 29 KAN. L. REV. 51 (1980).

of interest, and the formation must be approved by the electorate at a special election.[58] Five groundwater management districts have been formed in Kansas, each with a designating number. Three of those districts, Western Kansas Groundwater Management District No. 1, Southwest Kansas Groundwater Management District No. 3, and Northwest Kansas Groundwater District No. 4, include land overlying portions of the Ogallala Aquifer.[59]

Once a groundwater management district is formed, the board of directors prepares and submits to the Chief Engineer a management program outlining the nature and methods proposed for dealing with groundwater supply problems in the district. The Chief Engineer approves the management program, a public hearing is held, and the district board of directors adopts the program.[60] District boards of directors may adopt and enforce by suitable action reasonable standards and policies relating to conservation and management of groundwater within the respective districts.[61] To implement and enforce those standards and policies applicable in a specific district, the board of directors may recommend certain rules and regulations for adoption by the Chief Engineer. Such rules and recommendations are effective after adoption, and within the given district they have the same force and effect as statewide rules.[62] All three districts in the Ogallala have such specific rules and regulations.[63]

Intensive groundwater use control areas may be designated within management districts to restrict groundwater withdrawal in areas of severe groundwater mining.[64] Either the district board of directors or a requisite number of eligible voters may initiate proceedings with the Chief Engineer to designate a use control area.[65] If after a public hearing the

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58. KAN STAT. ANN., §§ 82a-1022 to -1025 (1977); Peck, *supra* note 57, at 52-54.

59. Peck, *supra* note 57, at 54-55; Telephone interview with Guy Ellis, Division of Water Resources, Kansas State Board of Agriculture (Dec. 8, 1983).

60. KAN. STAT. ANN. § 82a-1029 (1977); Peck, *supra* note 57, at 67-68.

61. KAN. STAT. ANN. § 82a-1028(n) (Supp. 1983); Peck, *supra* note 57, at 68-70.

62. KAN. STAT. ANN. § 82a-1028(o) (Supp. 1983); Peck, *supra* note 57, at 66-67.

63. Peck, *supra* note 57, at 54, 71-77; Ellis interview, *supra* note 59.

64. KAN. STAT. ANN. §§ 82a-1036 to -1038 (Supp. 1983); Peck, *supra* note 57, at 57.

65. KAN. STAT. ANN., § 82a-1036 (Supp. 1983).

Chief Engineer finds declining groundwater levels in the area, an intensive groundwater use control area is formed.[66] The Chief Engineer may close the area to further groundwater appropriation, or may reduce the permissible withdrawal, reapportioning that reduced amount according to the prior appropriation system.[67]

3. Nebraska

The two-level governmental administration of groundwater in Nebraska differs from that in Colorado and Kansas: in Nebraska, primary administrative responsibility rests with local agencies, while in Colorado and Kansas, state agencies are primarily responsible. The Nebraska state agency with primary responsibility for administering groundwater withdrawal for irrigation is the Department of Water Resources.[68] Statewide controls administered by this agency, however, only indirectly affect the volume of groundwater withdrawal and use for irrigation.[69]

Natural resources districts are Nebraska's operative enforcement agencies. Nebraska is divided into 24 districts organized primarily along drainage basin lines.[70] The districts manage natural resources within their boundaries,[71] are governed by elected boards of directors,[72] and are financed by property taxes.[73] Land in portions of 15 natural resources districts overlies the Ogallala Aquifer.[74]

Nebraska had previously enacted legislation permitting the formation of groundwater conservation districts,[75] all of which were to be established by a 1972 deadline.[76] Six dis-

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66. *Id.* at §§ 82a-1036, -1037.

67. *Id.* at § 82a-1038(a).

68. NEB. REV. STAT. §§ 46-601 to -613.01 (1978, Supp. 1982 & Supp. 1983).

69. *Id.* at §§ 46-602, -609, -651, -664.

70. *Id.* at § 2-3203 (Reissue 1977).

71. *Id.* at §§ 2-3228, -3229 (Supp. 1982 & Supp. 1983).

72. *Id.* at §§ 2-3213, -3214 (Supp. 1982).

73. *Id.* at § 2-3225.

74. Telephone interview with James R. Cook, Nebraska Natural Resources Commission (Dec. 8, 1983) [hereinafter cited as Cook Interview].

75. NEB. REV. STAT §§ 46-614 to 634.01 (Reissue 1978 & Cum. Supp. 1982).

76. *Id.* at § 46-614.01 (1978).

tricts were formed by the deadline date[77] and are scheduled to phase out by 1987.[78] After a public hearing and concurrence of the natural resources district encompassing the conservation district, each of these districts adopts rules and regulations to ensure proper groundwater conservation and to compel compliance with such rules and regulations.[79] Natural resources districts now have virtually the same groundwater management authority as groundwater conservation districts.[80]

The Nebraska Ground Water Management Act of 1972 provides for establishment of groundwater control areas to protect groundwater reserves, [81] and a later amendment authorizes the creation of groundwater management areas.[82] If an area experiences extreme groundwater problems, the directors of the natural resources district encompassing that area may request the Department of Water Resources to hold a public hearing concerning the problem. The department may designate the area a control area if it concludes that uncontrolled development and use of groundwater either has caused or is likely to cause an inadequate groundwater supply.[83] The natural resources district administers the area and assumes responsibility for adopting controls; however, any controls adopted by the district must be approved by the Department of Water Resources.[84] The control area designation creates a permit system for new wells proposed within the area, and the appropriate natural resources district issues the permits.[85] Districts may also adopt more restrictive controls than the statewide statutory controls of the Department of Water Resources, with the approval of that department.[86] Three control areas have been designated, and all three encompass land

77. Cook Interview, *supra* note 74.

78. NEB. REV. STAT. § 46-634.01 (Supp. 1982).

79. *Id.* at § 46-630 (Supp. 1982).

80. *Id.* at § 46-663.

81. *Id.* at §§ 46-656 to -674 (1978, Supp. 1982, & Supp. 1983); Aiken, *Nebraska Ground Water Law and Administration*, 59 NEB. L. REV. 917, 960-67 (1980) [hereinafter cited as Aiken].

82. NEB. REV. STAT. §§ 46-672, -673, -673.01 to -673.13, -674.01 (Supp. 1982 & Supp. 1983).

83. *Id.* at § 46-658 (Supp. 1982); Aiken, *supra* note 81, at 960-61.

84. NEB. REV. STAT. § 46-666 (Supp. 1983).

85. *Id.* at § 46-659.

86. *Id.* at § 46-666.

overlying the Ogallala Aquifer.[87]

A natural resources district may create a groundwater management area after a public hearing and after a groundwater management plan has been prepared by the district and approved by the Department of Water Resources.[88] Well drilling permits must be issued in management areas,[89] and districts may adopt other regulations with approval of the department.[90] A natural resources district in which a management area has been designated determines the total amount of water that may be withdrawn from the groundwater reservoir consistent with the groundwater reservoir's life goal, and adopts controls to allow the beneficial use of that amount of water.[91] So far, a groundwater management area has not been designated.[92]

C. Local Agency Management of Groundwater

State agencies in Texas do not directly manage or control the pumping and use of groundwater for irrigation. Groundwater management is the responsibility of local underground water conservation districts formed under the Groundwater Conservation Act of 1949.[93] Formation of a conservation district may be initiated by the Texas Water Commission or by landowners within the proposed district petitioning the commission.[94] The commission must formally designate the groundwater beneath the proposed district as an underground water reservoir before the district may be formed.[95] After the commission determines that the formation of a district is "feasible and practicable" and that it would benefit the land and public,[96] a majority of the counties in the proposed district must approve such a formation.[97] The boundaries of the

87. Aiken, *supra* note 81, at 962-66; Cook Interview, *supra* note 74.
88. NEB. REV. STAT. §§ 46-673.01 to -673.07 (Supp. 1982 & Supp. 1983).
89. *Id.* at § 46-659 (Supp. 1983).
90. *Id.* at § 46-673.09 (Supp. 1982).
91. *Id.* at § 46-673.08.
92. Cook Interview, *supra* note 74.
93. TEX. WATER CODE ANN. §§ 52.001 to .401 (Vernon 1972 & Supp. 1984).
94. *Id.* at § 52.024(a) (Vernon 1972).
95. *Id.* at § 53.023(a) (Vernon Supp. 1984).
96. *Id.* at § 52.025(a).
97. *Id.* at § 51.034(a) (Vernon 1972).

proposed district are the same as those of the underground water reservoir or subdivision of the reservoir previously designated by the commission.[98] General powers delegated to underground water conservation districts include making rules for conserving, preserving, protecting, recharging, controlling subsidence, and preventing waste of the reservoir's underground water.[99] The district may develop comprehensive plans to promote efficient use of the underground water and to control or prevent waste or subsidence.[100] Three underground water conservation districts overlie the Ogallala Aquifer: High Plains Underground Water Conservation District No. 1, North Plains Ground Water Conservation District No. 2, and Panhandle Ground Water Conservation District No. 3.[101]

V. Regulations for Managing Groundwater Use

Control over groundwater is basic to managing it; such control in the Ogallala area states may rest with either public or private landowners, or the issue of control may be unresolved. The potential degree of state or local groundwater management would appear to be less in states where private landowners own and control groundwater than in states where groundwater ownership is public and controlled by the state. Groundwater in Colorado,[102] Kansas[103] and New Mexico[104] belongs to the public. Oklahoma[105] and Texas[106] groundwater belongs to and is controlled by individual private landowners. The issue of groundwater ownership and control in Nebraska remains unresolved, but many irrigators believe groundwater

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98. *Id.* at § 52.023(a) (Vernon Supp. 1984).

99. *Id.* at § 52.101.

100. *Id.* at § 52.108(a).

101. Comment, *Ground Water Management: A Proposal for Texas*, 51 Tex. L. Rev., 289, 296-97 n.45 (1973) [hereinafter cited as *Texas Proposal*]; Telephone interview with Patrick Sullivan, Legal Counsel, Texas Department of Water Resources, (Dec. 8, 1983).

102. Colo. Rev. Stat. § 37-92-102(1) (1973).

103. Kan. Stat. Ann. § 82a-7.02 (1977).

104. N.M. Const. art. XVI, § 3; N.M. Stat. Ann. §§ 72-1-1, 72-12-1 (1978); State *ex rel.* Erickson v. McLean, 62 N.M. 264, 271, 308 P.2d 893, 987 (1957); State *ex rel.* State Game Comm'n v. Red River Valley Co., 51 N.M. 207, 217, 182 P.2d 421, 427 (1947).

105. Okla. Stat. Ann. tit. 60, § 60 (West 1971); Jensen, *supra* note 36, at 440-41.

106. Tex. Water Code Ann. § 52.002 (Vernon 1972).

belongs to them and not to the public.[107]

The stated purpose of nearly all state and local groundwater management agencies is to promote conservation of groundwater and to prevent its waste. Groundwater management agencies engage in various regulatory activities to restrict the appropriation and use of groundwater. The most common regulatory activities available to state and local agencies in the Ogallala include:

> (1) Permits issued by a governmental agency giving permission to drill wells or use groundwater;
> (2) Well spacing requirements specifying distances among wells to prevent interference among them;
> (3) Quantity restrictions limiting the amount pumped from a well; and
> (4) Controls preventing the waste of groundwater during use.[108]

All these controls have not been adopted by each of the management agencies in the Ogallala area. Some agencies have adopted only one, while others have adopted several of the available controls.

A. Permit System for Regulating Well Drilling

A permit system can limit the development of new wells and the rate of groundwater depletion. Colorado,[109] Kansas[110] and Oklahoma[111] require a state agency to issue permits before irrigation wells can be drilled anywhere in the state. State agency permits for drilling irrigation wells are required in New Mexico only in declared underground water basins.[112] Only local agency permits are required in Nebraska and Texas, and only in groundwater control areas or groundwater management areas in Nebraska[113] and in underground water conservation districts in Texas.[114] Restrictions on issuing per-

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107. Aiken, *supra* note 81, at 919, 973, 975.
108. *Mining, supra* note 4, at 5.
109. COLO. REV. STAT. §§ 37-90-107 to -109, -111(1)(c) (1973 & Supp. 1983).
110. KAN. STAT. ANN., § 82a-709 (1977).
111. OKLA. STAT ANN. tit. 82, § 1020.7 (West Supp. 1983-84).
112. N.M. STAT. ANN. §§ 72-12-3, -20, (1978).
113. NEB. REV. STAT. § 46-659 (Supp. 1983).
114. TEX. WATER CODE ANN. §§ 42.114, .118 (Vernon 1972).

mits for drilling wells vary among the states.

In Colorado, the Ground Water commission issues permits for drilling wells in designated groundwater basins,[115] and the State Engineer issues permits for drilling elsewhere.[116] In either case, permits for new wells are issued only if the groundwater will be put to a beneficial use and only if the proposed appropriation will not materially injure either the vested rights of others or any existing wells.[117] The Ground Water Commission promulgates regulations for its various basins to conserve designated groundwater resources.[118] Under this authority, the commission has promulgated the three-mile, 40 percent formula regulation for new permits in the Northern High Plains Groundwater Basin. A permit for a new well is denied if existing wells are pumping at a rate which would result in more than a 40 percent depletion of the available groundwater in an area within a three-mile radius of the proposed new well over a 25-year period (1.6 feet per year per 100 feet of average saturated depth).[119]

A permit from the Chief Engineer is required in Kansas to acquire appropriation rights to use water, including groundwater, for any purpose other than for domestic uses after January 1, 1978.[120] The Chief Engineer, in evaluating an application for a permit to drill a well, approves the application if it is in good faith and for a beneficial use, unless the withdrawal would impair a use under an existing water right or would unreasonably and prejudicially affect the public interest. In determining the impact on the public interest, the Chief Engineer may consider factors such as safe yield, recharge rates to the aquifer, and the priority and amount of existing claims to the aquifer.[121]

The Kansas Chief Engineer has adopted rules and regulations relating to issuance of well drilling permits applicable to each of the three groundwater management districts overlying

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115. COLO. REV. STAT. §§ 37-90-107 to -109, -111(1)(c) (1973 & Supp. 1983).

116. *Id.* at § 37-90-137.

117. *Id.* at §§ 37-90-107 to -109, -111(1)(c), -137(1), (2), 37-92-603(3) (b)(I).

118. *Id.* at § 37-90-111(1)(a) (1973).

119. Fundingsland v. Colorado Ground Water Comm'n, 171 Colo. 487, 491, 468 P.2d 835, 838 (1970).

120. KAN. STAT. ANN. § 82a-709 (1977).

121. *Id.* at § 82a-711 (Supp. 1983).

portions of the Ogallala Aquifer. Permit issuance under these regulations is based on a safe yield criterion or on a depletion formula.[122] For example, a permit is not issued in one groundwater management district if the proposed appropriation, when added to prior appropriations, would exceed a calculated rate of depletion of more than 40 percent of the saturated depth within a 2-mile radius of the proposed well in a 25-year period.[123] A permit in another district is denied if the proposed appropriation, along with prior appropriations, would deplete the aquifer more than 2 percent per year within a 2-mile radius of the proposed well.[124] The Chief engineer may halt further appropriations in an area designated as an intensive groundwater use control area and may deny new well drilling permits in these areas.[125]

The Oklahoma Water Resources Board issues permits for drilling new wells anywhere in the state;[126] such permits are issued for a beneficial use and if the board determines that waste will not occur.[127] The board normally issues one of the two types of permits — temporary or regular. Temporary permits, which must be renewed annually and are subject to adjacent landowners' protest, are issued until the board completes a hydrologic survey and determines the maximum annual yield of the basin or subbasin.[128] Such permits generally allocate to the applicant 2 acre-feet per year for each acre of land (owned or leased) overlying the aquifer, but allocations can be reduced if the groundwater in the aquifer could not meet needs sufficiently for a 20-year period.[129]

Regular permits are issued either initially or as replacements for temporary permits when the board completes the hydrologic survey and determines the maximum yield of the appropriate basin or subbasin, providing a final estimate of

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122. Peck, *supra* note 57, at 75-77.

123. KAN. ADMIN. REGS. § 5-23-4 (1982); Peck, *supra* note 57, at 76.

124. KAN. ADMIN. REGS. § 5-24-2 (1983).

125. KAN. STAT. ANN. § 82a-1038(2) (Supp. 1983).

126. OKLA. STAT. ANN., tit 82, § 1020.7 (West Supp. 1983-1984).

127. *Id.* at § 1020.9.

128. *Id.* at §§ 1020.10, .11(B); OKLA. WATER RESOURCES BOARD, Rules & Regulations, Rules 820.2, .4 (1982) [hereinafter cited as Okla. Regs.].

129. OKLA. STAT. ANN., tit. 82, § 1020.11(B) (West Supp. 1983-1984); Okla. Regulations, *supra* note 128, Rule 840.3.

the groundwater available.[130] A regular permit allocates to the applicant a proportion of the maximum annual yield of the basin or subbasin, an amount equal to the percentage of the applicant's land (owned or leased) overlying the fresh groundwater basin or subbasin.[131] The maximum annual yield for each basin or subbasin is based upon a maximum basin or subbasin life of 20 years.[132] Only temporary permits are being issued at present because the Water Resources Board has not completed the hydrologic survey.[133]

In Nebraska, New Mexico and Texas, permits are required only for drilling wells in certain areas. Such permits are issued by a state agency in New Mexico, and by local agencies in Nebraska and Texas. The New Mexico State Engineer issues permits to drill new irrigation wells only in declared underground water basins.[134] All appropriations must be for a beneficial use,[135] and all existing prior rights for beneficial uses are recognized.[136] In deciding whether to issue a permit, the State Engineer must determine whether unappropriated water exists after considering all prior appropriations.[137] The State Engineer must also determine that existing rights will not be impaired by the issuance of the permit.[138] Rules promulgated by the State Engineer in the three declared underground water basins provide for calculation of the permissible groundwater withdrawals to insure adequate groundwater supplies for a 40-year period. A permit is granted only if the new withdrawal will not harm existing water rights in the area within that period.[139]

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130. OKLA. STAT. ANN. tit. 82, §§ 1020.5, .9, .11(A) (West Supp. 1983-84); Okla. Regs., *supra* note 128, Rule 840.1.

131. OKLA. STAT. ANN. tit. 82, § 1020.9 (West Supp. 1983-84); Okla. Regs., *supra* note 128, Rule 840.1.

132. OKLA. STAT. ANN. tit. 82, § 1020.5 (West Supp. 1983-84).

133. Roles Interview, *supra* note 40.

134. N.M. STAT. ANN. §§ 72-12-3, -20 (1978).

135. *Id.* at § 72-12-2.

136. *Id.* at § 72-12-18.

137. Templeton v. Pecos Valley Artesian Conservancy Dist., 65 N.M. 59, 69, 352 P.2d 465, 471 (1958).

138. N.M. STAT. ANN. § 72-12-3(E) (1978); City of Roswell v. Berry, 80 N.M. 110, 112, 452 P.2d 179, 181 (1969).

139. Grant, *Reasonable Groundwater Pumping Levels Under the Appropriation Doctrine: The Law and Underlying Economic Goals*, 21 NAT. RESOURCES J. 1, 5-6

Natural resources districts in Nebraska are only required to issue permits for drilling new wells within groundwater control or management areas so designated by the Department of Water Resources.[140] Permits are denied only if the location or operation of the proposed well conflicts with any regulations or controls adopted by the natural resources district, or if the proposed use would not be beneficial.[141] If the district determines that depletion of the groundwater supply in the control area is excessive, and that the public interest cannot be protected by the district's control measures, the district, with the department's approval, may close the control area to further issuance of permits for a one-year period.[142]

Well drilling permits are required in Texas only in underground water conservation districts,[143] and only if the well is capable of producing more than 100,000 gallons of water per day.[144] Districts that issue the permits,[145] may promulgate regulations to conserve underground water and may subject the issuance of permits to such regulations.[146] None of the districts have restricted irrigation well permits.[147]

B. Well Spacing Requirements

A well spacing requirement, specifying a minimum distance between irrigations wells to reduce interference in yield, effectively regulates the number of wells that may be drilled in an area. All six states overlying the Ogallala have some authority to implement well spacing requirements. Well spacing requirements may be imposed on a statewide basis in Colorado,[148] Nebraska[149] and Oklahoma[150] by state agencies. More

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140. NEB. REV. STAT. § 46-659(1) (Supp. 1983).

141. *Id.* at § 46-660.

142. *Id.* at § 46-666(1).

143. TEX. WATER CODE ANN. § 52.114 (Vernon 1972).

144. *Id.* at §§ 52.116, 52.118(2)(b)(c).

145. *Id.* at § 52.115.

146. *Id.* at § 52.114.

147. Johnson, *Texas Groundwater Law: A Survey and Some Proposals*, 22 NAT. RESOURCES J. 1017, 1020 (1982) [hereinafter cited as Johnson].

148. COLO. REV. STAT. §§ 37-90-111, -130, -137(2) (1973 & Supp. 1983).

149. NEB. REV. STAT. §§ 46-609(1), 46-651(1) (Supp. 1982).

150. OKLA. STAT. ANN. tit. 82, § 1020.17 (Supp. 1983).

restrictive requirements may also be imposed by either state or local agencies in districts or control areas in Colorado[151] and Nebraska.[152] Spacing requirements in Kansas,[153] New Mexico[154] and Texas[155] are imposed only in districts rather than on a statewide basis.

Well spacing requirements may be imposed in Oklahoma on a statewide basis, but they are not mandatory. The Water Resources Board may order well spacing before issuing drilling permits, insuring proper allocation of water relative to the land overlying the groundwater basin or subbasin.[156] So far the board has not made any spacing requirements.[157]

Different levels of government may impose spacing requirements in Colorado and Nebraska, and the requirements may also pertain only to specific areas. The Colorado Ground Water Commission, which is responsible for administering water in designated groundwater basins, has, under its statutory authority permitting adoption of regulations pertaining to those basins,[158] adopted rules that wells be one-half mile apart.[159] The State Engineer, when issuing drilling permits outside designated groundwater basins, requires only 600 feet between wells.[160] The Ground Water Commission is authorized to adopt well spacing requirements specifically tailored to groundwater management districts within the designated groundwater basins,[161] but has not done so.[162]

Nebraska has a statewide statutory requirement specifying that no irrigation well be drilled within 600 feet of another irrigation well,[163] and that no irrigation or industrial well be

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151. COLO. REV. STAT. § 37-90-130(2)(a) (1973).

152. NEB. REV. STAT. §§ 46-666(1), 46-673.09 (Supp. 1982 & Supp. 1983).

153. KAN. STAT. ANN. § 82a-1028(o) (1977 & Supp. 1983); Peck, *supra* note 57, at 66-67.

154. N.M. STAT. ANN. §§ 72-12-3(E), 72-12-20 (1978).

155. TEX. WATER CODE ANN. § 52.117 (Vernon Supp. 1984).

156. OKLA. STAT. ANN. tit. 82, § 1020.17 (Supp. 1983); Okla. Regs., *supra* note 128, Rule 845.1.

157. Roles Interview, *supra* note 40.

158. COLO. REV. STAT. § 37-90-111 (1973 & Supp. 1983).

159. Danielson Interview, *supra* note 52.

160. COLO. REV. STAT. § 37-90-137(2) (1973).

161. *Id.* at § 37-90-130(2)(a).

162. Danielson Interview, *supra* note 52.

163. NEB. REV. STAT. § 46-609(1) (Supp. 1982).

drilled within 1,000 feet of any public water supply well.[164] Natural resources districts in which control areas or management areas have been designated may, with State Department of Water Resources approval, adopt well spacing requirements more restrictive than statewide requirements.[165] Two control areas now use spacing requirements of 3,300 feet in critical townships.[166]

Kansas, New Mexico and Texas well spacing requirements pertain only to certain areas and are not applicable statewide. Such regulations in New Mexico are promulgated and enforced by the State Engineer for each of the three declared underground water basins. The State Engineer denies permits for new wells if they would be close enough to impair an existing well's prior appropriation.[167]

District regulations in Kansas and Texas govern well spacing. Such regulations in Kansas are approved by the Chief Engineer after recommendation by the groundwater management district's board of directors.[168] All three groundwater management districts overlying the Ogallala have well spacing requirements approved by the Chief Engineer and based upon safe yield or depletion formulas.[169] Minimum spacing in one district depends on the depletion of the aquifer in the area surrounding the proposed well at the time of permit application. The minimum spacing requirement increases as the percentage of depletion of the aquifer increases.[170] Well spacing in another district is based upon the withdrawal rate of water per minute,[171] and in another it depends upon the acre-feet of groundwater withdrawal requested in the permit.[172]

Underground water conservation districts in Texas may

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164. *Id.* at § 46-651(1).

165. *Id.* at §§ 46-666(1), -673.09 (Supp. 1982 & Supp. 1983).

166. Cook Interview, *supra* note 74.

167. N.M. STAT. ANN. § 72-12-3(E) (1978).

168. KAN. STAT. ANN. § 82a-1028(o) (Supp. 1983).

169. KAN. ADMIN. REGS. §§ 5-21-3 (1979), 5-23-3 (1982), 5-23-4 (1983); Peck, *supra* note 57, at 71-77.

170. KAN. ADMIN. REGS. 5-21-3(a) (1979).

171. *Id.* at § 5-23-3(a) (1982).

172. *Id.* at § 5-24-3(a) (1983).

adopt well spacing regulations.[173] Regulations for spacing wells in the High Plains Underground Water Conservation District No. 1 are based upon casing size and well yield. An 8-inch well (560-1,000 gpm) must be at least 400 yard from another well, while a 4-inch well (70-265 gpm) may be 200 yards from an existing well. In this district, spacing is the only restriction on irrigation well permits.[174]

C. Quantity Restrictions on Withdrawing Groundwater

Restricting the amount of water an irrigator may pump from a well is another method for controlling the rate of groundwater depletion. All states place some quantity restrictions on irrigators. Most states could enforce the restrictions with a metering program, but not all do. Thus, it is possible that more than the restricted amount of groundwater is pumped. Regulations governing the quantity of withdrawal are promulgated and enforced by state agencies in New Mexico and Oklahoma, by state and local agencies in Colorado, Kansas and Nebraska, and by local agencies in Texas.[175]

The New Mexico State Engineer has promulgated regulations for the state's three declared underground water basins, limiting the amount of groundwater withdrawn to insure adequate supplies for a 40-year period from the time of declaration.[176] Statutes permit the State Engineer to require metering of groundwater withdrawn in underground water basins,[177] but only municipal and industrial usage is actually metered. Even though metering could be required for irrigators, currently it is not.[178]

Temporary well drilling permits issued in Oklahoma generally restrict withdrawal to 2 acre-feet of water annually for each acre of land owned or leased by the applicant, with that amount reduced if water in the aquifer would not meet needs

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173. TEX. WATER CODE ANN., § 52.117 (Vernon Cum. Supp. 1984).

174. *Texas Proposal, supra* note 101, at 1020.

175. *Mining, supra* note 4, at 13.

176. Mathers v. Texaco, Inc., 77 N.M. 239, 421 P.2d 771 (1966); Grant, *supra* note 139, at 5-6.

177. N.M. STAT. ANN. § 72-12-27 (1978).

178. O'Dell Interview, *supra* note 33.

for the next 20 years.[179] Regular permits limit withdrawals to a percentage of the maximum annual yield of groundwater in the basin or subbasin equal to the percentage of the permit holder's land that overlies the aquifer.[180] The Water Resources Board is authorized to require metering wells if so requested by a majority of the landowners within the basin or subbasin.[181]

Jointly promulgated state and local regulations govern withdrawal amounts in Colorado, Kansas and Nebraska. The Colorado Groundwater Commission may promulgate regulations establishing reasonable groundwater pumping levels in nontributary designated groundwater basins[182] and limit withdrawals of designated groundwater in order to prevent unreasonable injury to prior appropriators.[183] Two restrictions have been placed on wells in the Northern High Plains Groundwater Basin. First, a permit for a new well is not issued if the depletion rate of that well would exceed 1.6 feet per year per 100 feet of average depth (40 percent depletion in 25 years) within a 3-mile radius.[184] Second, not more than 2.5 acre-feet may be appropriated annually for each acre to be irrigated unless it can be demonstrated that more could be put to a beneficial use.[185] Depletion rules have not been formulated for the Southern High Plains Groundwater Basin, but the annual appropriation is restricted to 3.5 acre-feet for each acre irrigated.[186]

Groundwater management districts within designated groundwater basins may, with the approval of Colorado's Ground Water Commission, lower the pumping restrictions from those of the entire basin[187] and require measurements on

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179. OKLA. STAT. ANN. tit. 82, § 1020.11(B) (Supp. 1983-84); Okla. Regs., *supra* note 128, Rule 840.3.

180. OKLA. STAT. ANN. tit. 82, § 1020.9 (Supp. 1983); Okla. Regs., *supra* note 128, Rule 840.3.

181. OKLA. STAT. ANN. tit. 82, § 1020.19 (Supp. 1983).

182. COLO. REV. STAT. § 37-90-111(1)(b) (1973).

183. *Id.* at § 37-90-111(1)(a).

184. Fundingsland v. Colorado Ground Water Comm'n, 171 Colo. 487, 491, 468 P.2d 835, 838 (1970).

185. Danielson Interview, *supra* note 52.

186. *Mining, supra* note 4, at 8.

187. COLO. REV. STAT. § 37-90-130(2)(a) (1973).

the amount of water withdrawn.[188] One groundwater management district tried mandatory well metering, but strong opposition from irrigators has resulted in a lack of enforcement. Thus, although groundwater management in Colorado includes authority to meter irrigation wells, it is current practice only on wells irrigating more acres than approved on the original permit.[189]

The Chief Engineer in Kansas has adopted regulations restricting the quantity of groundwater withdrawn from two of the three groundwater management districts overlying the Ogallala upon recommendations of those districts' boards of directors.[190] The rate of depletion in one district may not exceed 40 percent of the groundwater in 25 years within 2 miles of the well,[191] while in another district the depletion rate of groundwater may not be more than 2 percent per year within a 2-mile radius of the well.[192] Permissible groundwater withdrawals may be reduced by the Chief Engineer in intensive groundwater use control areas.[193]

Statutory authority exists for the Kansas Chief Engineer to require the installation of meters or other measuring devices throughout the state.[194] Under their authority to require the installation of devices to measure the quantity of groundwater used,[195] one of the three groundwater management districts overlying the Ogallala requires metering.[196]

In Nebraska, natural resources districts in which groundwater control areas have been formed may, with the approval of the Department of Water Resources, regulate the permissible total withdrawal among groundwater users for time periods, allocate such withdrawals among groundwater users, and require the installation of devices to measure groundwater

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188. *Id.* at § 37-90-131(2).

189. *Mining, supra* note 4, at 8.

190. KAN. STAT. ANN. § 82a-1028(o) (Supp. 1983); KAN. ADMIN. REGS. §§ 5-23-4 (1982), 5-23-2 (1983); Peck; *supra* note 57, at 72.

191. KAN. ADMIN. REGS. § 5-23-4 (1982).

192. *Id.* at § 5-24-2 (1983).

193. KAN. STAT. ANN. § 82a-1038(b) (Supp. 1983).

194. *Id.* at § 82a-706c (1977).

195. *Id.* at § 82a-1028(L) (Supp. 1983).

196. KAN. ADMIN. REGS. §§ 5-23-6, -7 (1982).

withdrawal.[197] Annual groundwater allocations are made to irrigators in one of the three control areas formed by the districts; flowmeters are required on wells in the other two control areas. One control area limits groundwater withdrawal to a specific amount for each irrigated acre.[198]

Local underground water conservation districts in Texas have authority to promulgate regulations applicable to their districts, and under that authority they may regulate the amount of groundwater withdrawn from wells.[199] None of the three districts overlying the Ogallala Aquifer exercise this authority.[200]

D. Controls on Waste of Groundwater

Prohibiting the waste of groundwater — for example, requiring the installation of tailwater pits for collecting unused irrigation water from fields and pumping it back through the irrigation system — is another regulatory activity of management agencies. All six states overlying most of the Ogallala Aquifer have statutes either prohibiting waste of groundwater or allowing local agencies to adopt regulations for such purposes. New Mexico and Oklahoma prohibit waste on a statewide basis, while Kansas and Texas delegate the authority to regulate waste to local agencies. Colorado and Nebraska statutes give authority over waste to both state and local agencies.

New Mexico statutes only stipulate that it is unlawful to waste groundwater and penalize for its misuse.[201] Oklahoma statutes also prohibit waste, and the statutes list several different examples of waste, including taking or using groundwater in any manner that cause it to be lost for a beneficial use, or using it in an inefficient manner resulting in excessive losses.[202]

Local agencies regulate waste in Kansas and Texas. Groundwater management districts in Kansas may adopt regulations for the conservation and management of ground-

197. NEB. REV. STAT. § 46-666(1) (Supp. 1983).
198. Aiken, *supra* note 81, at 963-66.
199. TEX. WATER CODE ANN. § 52.117 (Vernon Supp. 1984).
200. Johnson, *supra* note 147, at 1020.
201. N.M. STAT. ANN. § 72-8-4 (1978).
202. OKLA. STAT. ANN. tit. 82, § 1020.15 (Supp. 1983-84).

water;[203] all three districts overlying the Ogallala have adopted regulations concerning waste and tailwater control.[204] Two Texas statutes pertain to waste of groundwater: one authorizes underground conservation districts to make and enforce rules for conserving, preserving and protecting groundwater and for the prevention of its waste,[205] and the other allows districts to develop comprehensive plans for the most efficient use of groundwater and for controlling and preventing waste.[206]

State and local agencies control groundwater waste in Colorado and Nebraska. With the approval of the Ground Water Commission, groundwater management districts within designated groundwater basins in Colorado may adopt regulations to conserve, preserve and protect groundwater; to require development of comprehensive plans for efficient use of groundwater and control and prevent its waste; and to require construction and operation of various conservation measures.[207] Neither the commission nor any of the districts have utilized this authority.[208] The State Engineer may require all flowing wells in designated groundwater basins be equipped with valves to control the flow of water, and may also require that wells be constructed and maintained to prevent groundwater waste.[209]

Nebraska statutes require each irrigator in the state using groundwater to take action to control or prevent runoff.[210] Irrigation runoff controls, while authorized statewide, have been delegated to natural resources districts for implementation. The districts adopt regulations, with the approval of the Department of Water Resources, to minimize runoff due to groundwater irrigation. These rules prescribe standards for determining improper runoff, procedures to prevent it, and remedial and enforcement measures.[211] A common practice is to

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203. KAN. STAT. ANN. § 82a-1028(n) (Cum. Supp. 1983).
204. KAN. ADMIN. REGS. §§ 5-21-2 (1979), 5-23-2 (1982), 5-24-4 (1983).
205. TEX. WATER CODE ANN. § 52.101 (Vernon Supp. 1984).
206. *Id.* at § 52.108(a).
207. COLO. REV. STAT. § 37-90-130(2) (1973).
208. *Mining, supra* note 4, at 6.
209. COLO. REV. STAT. § 37-90-110(1) (1973).
210. NEB. REV. STAT. § 46-664(1) (1978).
211. *Id.* at § 46-665(2).

install tailwater pits to collect runoff and recirculate it through the irrigation system.

VI. Summary and Conclusions

The amount of land under irrigation in the six states overlying the major portion of the Ogallala Aquifer is expected to increase from 14.3 million acres in 1977 to 18 million acres in 2020. During this period it is estimated that 23 percent of the 3.04 billion acre-feet of water stored in the aquifer in 1977 will have been used, and that the three southern aquifer states will have depleted 50 percent of their stored water. With the decline in groundwater level, farmers will have to consider reducing irrigated acreage and leaving pumping time and application rates constant; maintaining the same acreage and pumping time, but reducing the application rate; or maintaining the same acreage and application rates, but reducing pumping time.

Irrigated cropland in the Ogallala grew from 3 percent of the area's harvested cropland in 1940 to 41 percent in 1978, thereby making agriculture highly dependent on water for irrigation. Crop yields resulting from irrigation have increased 3 to 4 times over dryland farming yields. More than 15 percent of the nations's total value of wheat, corn, sorghum and cotton and 38 percent of the total value of livestock are produced in the area. Production of crops and their total value is expected to increase by the year 2020.

All six states in the Ogallala have adopted groundwater management legislation. State agencies control groundwater management in New Mexico and Oklahoma. Regulatory powers of the New Mexico State Engineer extend only to declared underground water basins; the Oklahoma Water Resources Board exercises statewide powers.

State and local agencies share groundwater management in Colorado, Kansas and Nebraska. The Colorado Ground Water Commission manages groundwater in designated groundwater basins, while the State Engineer controls groundwater outside these basins. Groundwater management districts may be formed within the basins, and the commission may approve regulations adopted by the districts. The Chief Engineer in Kansas has primary regulatory power over

groundwater use and may create groundwater management districts. A district may recommend that the Chief Engineer adopt groundwater management regulations specifically for that district. Natural resources districts in Nebraska share groundwater management responsibilities with the Department of Water Resources. That department may designate groundwater control areas within districts, after which districts may adopt regulations to manage groundwater in the control areas.

Local agencies manage groundwater in Texas; the underground water conservation districts promulgate their own rules. Management outside these districts is virtually nonexistent.

All six states exercise various regulatory powers in managing their groundwater. Colorado, Kansas and Nebraska require a state agency permit to drill irrigation wells anywhere in the state. State agency permits are required in New Mexico only in declared underground water basins, and local agency permits are required in Nebraska groundwater control areas and in Texas underground water conservation districts. Because of these geographic restriction in the latter three states, only a small portion of their area is subject to permit requirements.

Well spacing requirements may be imposed on a statewide basis in Colorado, Nebraska and Oklahoma. More restrictive requirements may also be imposed by either state or local agencies in districts or control areas in Colorado and Nebraska. Spacing requirements in Kansas, New Mexico and Texas are imposed only in districts rather than on a statewide basis. Oklahoma does not impose well spacing requirements on a statewide basis. Because of the geographic limitations and the lack of mandatory requirements in four states, spacing requirements are effective only in Colorado and Nebraska.

All states place some restrictions on the amount of water irrigators may pump from wells. Regulations governing the quantity of withdrawals are promulgated and enforced by state agencies in New Mexico and Oklahoma, by state and local agencies in Colorado, Kansas and Nebraska, and by local agencies in Texas. Restrictions, however, apply only to certain geographic areas in all states except Oklahoma.

Waste of groundwater is prohibited statewide in New Mexico and Oklahoma, Kansas and Texas delegate regulatory authority to local agencies. Colorado and Nebraska give authority over waste to both state and local agencies.