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Ground Water Mining Law and Policy

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GROUND WATER MINING LAW AND POLICY*

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In 1975 irrigation accounted for eighty-three percent of the fresh water consumption in the United States,[1] and ninety-one percent of fresh water consumption in the West.[2] Although the major source of irrigation water traditionally has been surface water, the use of ground water for irrigation has increased dramatically. Ground water constituted thirty-eight percent of the water used for irrigation in the West in 1975, compared with twenty-one percent in 1955. During the same period, the quantity of ground water used for irrigation in the West increased from eighteen million acre feet[3] (maf) to fifty-six maf.

This increase in ground water use for irrigation has led to ground water mining in several western states, notably California, Texas, Nebraska, Arizona, and Kansas. Ground water mining or depletion occurs when withdrawals from an aquifer, a ground water formation, exceed net recharge. As ground water depletion occurs, the cost of pumping water from greater depths will increase. Wells will have to be deepened or replaced to continue yielding water. If ground water feeds streams, their baseflow will be reduced. Ground water pumping costs gradually will become so high that irrigators will be unable to afford full irrigation and will curtail withdrawals to reduce costs. Irrigation ultimately will be so expensive that it will be

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1. The source for the water use statistics in this section are C. MURRAY & E. REEVES, ESTIMATED USE OF WATER IN THE UNITED STATES IN 1975 24-25 (United States Geol. Survey Cir. No. 765, 1977) and K. MACKICHAN, ESTIMATED USE OF WATER IN THE UNITED STATES, 1955 6-9 (U.S. Geol. Survey Cir. No. 398, 1957).

2. As used in this article the "West" refers to the seventeen contiguous western states that follow the doctrine of prior appropriation to some extent in allocating rights to use surface or ground water, including: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

3. An acre foot is 325,851 gallons, enough water to cover an acre of land one foot deep. An acre foot of water would supply a family of five for one year and would irrigate a half acre of corn in most areas of Nebraska.

abandoned[4] unless a supplemental source of water is obtained. When ground water irrigation is abandoned in this way economic depletion of the aquifer has occurred.

As the National Water Commission observed, ground water mining "is not inherently wrong."[5] Economic and associated social problems will occur, however, when ground water is mined without considering its future value. If ground water aquifers or reservoirs were not hydrologically interconnected with streams, were owned or controlled by a single entity, and did not generate regional economic activity, the decison to mine or not could be left to the owner.[6] Presumably the decision to mine or not would be based on balancing the economic benefits from present use with the anticipated economic benefits from future use.[7] Ground water reservoirs, however, are often significantly hydrologically interrelated with streams, are rarely in a single ownership, and often generate regional economic activity.[8] Decisions about ground water mining do not affect only the overlying landowners, but also surface water users and regional economies benefiting from irrigated agricultural production. Irrigation historically has played an important role in stabilizing agricultural production and the associated regional economics during drought periods. The public impacts of ground water use create a tension between private incentives to mine ground water and public incentives to stabilize its use.

Ground water is a common pool resource, one for which the right to use (typically without charge) is shared with others.[9] Usually there is no significant ceiling on the amount each user may take.[10] Because the resource is not priced, there is no private incentive for any user to reduce current consumption to have more available for the future.[11] Any user who does so runs the risk that another user will take the resource for present use.[12] There is no private incentive to save for tomorrow, even if there is general agreement that

4. This occurred in southern Texas when interstate price controls on natural gas were lifted. Irrigators, using what in effect was price controlled natural gas to power irrigation pumps, could not afford to continue irrigation when the price of natural gas increased dramatically.

5. NATIONAL WATER COMMISSION, WATER POLICIES FOR THE FUTURE 239 (1973).

6. *Id.*

7. *Id.*

8. *Id.*

9. *Id.*

10. *Id.*

11. *Id.*

12. *Id.* at 239-40.

the future value of the resource is greater than the present value.[13] Two major social consequences of unregulated development of common pool resources are that (1) the resource is likely to be consumed at a rate faster than the optimum rate, and (2) local and regional economies dependent on the resource use will contract as depletion occurs.[14] The first consequence is the basis for state laws regulating oil and gas production.[15] The second consequence, referred to as the boom and bust syndrome, has been a traditional justification for federally subsidized "rescue projects" designed to import a supplemental water supply to an area mining ground water.

An economic analysis of ground water mining in Oklahoma and Texas suggests that restrictions on ground water use will lead to greater economic benefits than would unregulated ground water mining.[16] Such restrictions are not widespread in the West, however, principally because of political opposition from irrigators. Farmers traditionally have been given a high degree of independence in determining how land and water resources are used in agricultural production. Governmental water use regulations are perceived as limiting this independence. Irrigators have incorrectly assumed that such regulations necessarily threaten their economic interests. This attitude is probably the single most important factor preventing effective regulation of ground water mining.

States and the federal government have a common interest in preventing or controlling ground water mining. States are interested in managing ground water mining to achieve the greatest sustained economic benefit from ground water use. The adverse economic impacts of ground water depletion would be greatest at the state and

13. *Id.*

14. *Id.*

15. Oil and gas are generally considered to be the private property of the overlying landowner. This traditionally has meant that each landowner could withdraw as much of the mineral as he was able to without regard to the effect on other overlying owners. Because this uncoordinated development would reduce the quantity of oil or gas that could ultimately be recovered, states have regulated oil and gas production, either by administrative regulation by a state oil and gas commission, by the authorization of compulsory unitization agreements, or both. Unitization refers to allocating each overlying landowner a proportionate share of the profits from oil or gas production regardless of where the producing wells are located. The necessity of state regulation to achieve the optimum withdrawal of oil and gas at least suggests that such regulation may be necessary to achieve the optimum withdrawal of ground water.

16. H. Mapp & V. Eidman, An Economic Analysis of Regulating Water-Use in the Central Ogalalla Formation 58-63 (Agric. Exp. Stat., Okla. St. U., Technical Bulletin T-141, 1976). The authors concluded that if the amount of groundwater available were limited, establishing a graduated tax on ground water use would lead to higher net farm income than would unrestricted pumping or restriction of withdrawals.

local levels. The federal interest in ground water mining is somewhat different. If economic depletion of a ground water supply is unplanned, irrigators are likely to request the federal government to furnish a federally subsidized supplemental water supply to sustain an established irrigation-dependent economy which developed on the improvident use of ground water.[17] Federal rescue projects have taken the form of surface water irrigation projects where steamflow is dammed and transported to the area of need. Rescue projects relieve the mined area of the responsibility of living within the limits of its natural water supply and also reduce the economic incentives to use ground water more efficiently by providing a cheaper, subsidized supplemental water supply.

In most western states, ground water use is subject to some degree of state regulation. Effective regulations to deal with ground water mining, however, generally have not been established.[18] A politically more popular approach has been to develop a rescue project to import developed water supplies to augment diminishing ground water supplies. This has been accomplished in southern California with federal assistance through the Colorado River Project. Arizona and Texas are emulating the California experience in attempting to obtain a federal rescue project to cope with ground water mining through the Central Arizona Project and the High Plains Study, respectively. Federal provision of a rescue project in effect rewards an area for its improvident use of ground water, a policy that will hardly encourage states to develop policies to prevent or control ground water mining.

This article will examine the physical, economic, and legal effects of ground water mining. Traditional western water law doctrines will be evaluated relative to ground water mining. Regulating ground water development and use in control areas will be discussed,

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17. NATIONAL WATER COMMISSION, *supra* note 5, at 232. This concern is a legitimate one. In 1976 Congress authorized the High Plains Study to examine

> the depleton of the natural resources of those regions . . . presently utilizing the declining water resources of the Ogallala acquifer [sic], and *to develop plans to increase water supplies in the area* and report thereon to Congress . . . . In formulating these plans, the Secretary [of Commerce] is directed . . . to examine the feasibility of various alternatives *to provide adequate water supplies in the area . . . to assure the continued economic growth and vitality of the region.*

42 U.S.C. § 1962(d)-18 (1980)(emphasis added). For a discussion of the present status of the High Plains Study *see infra* notes 71-78 and the accompanying text.

18. G. SLOGGETT, MINING THE OGALLALA AQUIFER: STATE AND LOCAL EFFORTS IN GROUNDWATER MANAGEMENT (Agric. Exp. Sta., United States Dep't of Ag. & Okla. St. U., Research Report P-761, 1977).

as will development of supplemental water supplies. The appropriateness of federal, state, and local rescue projects will be considered, particularly regarding under what conditions a taxpayer subsidy would be justified.

I. PHYSICAL, ECONOMIC AND LEGAL EFFECTS OF GROUND WATER MINING[19]

Both surface water (the water in lakes, rivers and streams) and ground water (the water stored in ground water reservoirs or aquifers) are ultimately derived from precipitation. Rainfall and melting snow feed streams and lakes as overland runoff. Some precipitation soaks into the ground, slowly moving laterally until it either drains into a lake or stream, or percolates downward where it becomes a part of a ground water aquifer. The process of ground water storage in the West is slow because natural recharge is only a few acre inches[20] of water per year. When the storage capacity of an aquifer is reached, ground water may be discharged into a stream or lake, may be tapped by the roots of subirrigated plants, or may be evaporated from lakes and wetlands.[21]

This equilibrium condition may be altered by ground water development and use. When ground water withdrawals exceed ground water recharge the balance comes from ground water stored in the aquifer. Sustained reductions in ground water storage reduce ground water discharge and constitute ground water mining. Common effects of ground water mining include: declining ground water levels; increased pumping lifts and costs; and reduced aquifer discharge to streams or lakes, subirrigation, or wetlands. A new equilibrium condition may be established because of reduced discharge. In many

19. For a description of the hydrologic cycle and its relation to ground water written for a general auidence see H. BALDWIN & C. MCGUINNESS, A PRIMER ON GROUND WATER, (United States Geol. Survey 1963); J. Crosby, *A Layman's Guide to Groundwater Hydrology* in C. CORKER, GROUNDWATER LAW, MANAGEMENT AND ADMINISTRATION (National Water Commission Legal Study No. 6, 1971); L. LEOPOLD & W. LANGBEIN, A PRIMER ON WATER (United States Geol. Survey, 1960); Tripp & Jaffe, *Preventing Groundwater Pollution: Toward a Coordinated Strategy to Protect Critical Recharge Zones*, 3 HARV. ENVTL. L. REV. 1, 3-4 (1979).

20. An acre inch is 27,154 gallons of water, enough to cover an acre of land one inch deep.

21. In some ground water aquifers little or no discharge occurs. In these closed aquifers water pressure increases as ground water storage occurs. When wells are drilled into these closed aquifers (called artesian aquifers), the artesian pressure forces the water to rise in the well. If enough ground water is withdrawn from an artesian aquifer, artesian pressure will ultimately be reduced to atmospheric pressure. *See generally* H. BALDWIN & C. MCGUINNESS, *supra* note 19, at 8-10.

cases, however, an equilibrium may not be reached until withdrawals are reduced, either from the reduced capacity of an aquifer to yield water, or from reduced pumping.

Many of the physical effects of ground water mining have practical significance. Ground water pumping during the irrigation season causes temporary, seasonal water level fluctuations that may lead to well interference conflicts. While ground water levels may partially or completely recover before the next irrigation season begins, well yields may be impaired during the irrigation season. This may require the drilling of deeper wells or the installation of more powerful pumps to maintain ground water supply availability.

The resolution of well interference conflicts is a significant element of western ground water law.[22] An important component of a ground water right is (1) the extent to which a ground water user is protected in his original means of diverting ground water (*i.e.*, his original well and pump) and (2)when shortages occur, how ground water will be allocated among competing users. When withdrawals by other ground water users are made, water levels in previously installed wells may decline to the extent that the earlier user's well and pump stop yielding water. In most cases, the earlier user is able to restore his ground water supply by drilling a deeper well and installing a more powerful pump. In other cases, ground water supplies may be temporarily or permanently inadequate to supply all users. When well capacity is inadequate to continue yielding water but well yields may be increased by installing new wells or pumps, the legal issue is whether the earlier user is entitled to compensaton for the cost of increasing well capacity and higher pumping costs. When the aquifer is inadequate to supply all users the legal issue is how ground water will be allocated among competing users.

Western ground water law addresses the well interference conflict issue, although in a variety of ways. The doctrine of prior appropriation is the majority rule in the West,[23] although historically it

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22. *See* Aiken, *Nebraska Ground Water Law and Administration*, 59 NEB. L. REV. 917, 922-30 (1980).

23. CAL. WATER CODE §§ 1200-1201 (West 1971)(however, appropriation is not the exclusive basis of California ground water law, *see* Aiken, *supra* note 22 at 926; COLO. REV. STAT. § 37-90-137 (1973 & Supp. 1979) (apparently applying prior appropriation to non-tributary ground water outside of designated ground water basins, *see* 2 W. HUTCHINS, WATER RIGHTS IN THE NINETEEN WESTERN STATES (United States Dep't of Agric. Misc. Pub. No. 1206, 1974) 704; 3 W. HUTCHINS, *id.* at 236); IDAHO CODE § 42-103 (1977); KAN. STAT. ANN. § 82a-703 (1977); MONT. REV. CODES ANN. § 89-2916 (Supp. 1977); NEV. REV. STAT. § 534.020 (1973); N.M. STAT. ANN. § 75-11-1 (1968); N.D. CENT. CODE § 61-01-01 (1960); OR. REV. STAT. § 537.525 (1979); S.D. COMP. LAWS ANN. § 46-6-3 (Supp. 1979); UTAH

was preceded by the common-law overlying-rights doctrines of absolute ownership,[24] reasonable use,[25] and correlative rights.

The absolute ownership doctrine reflects the early judicial assumption that ground water movement was unknowable and that courts therefore had no factual basis upon which to deal with well interference conflicts. Under the absolute ownership doctrine, the owner of land overlying a ground water aquifer may withdraw ground water without regard to the effect it may have on the wells of other overlying owners. Under the absolute ownership doctrine, earlier users have no legal protection regarding well interference conflicts based on either well inadequacy or aquifer indequacy.

The reasonable use doctrine addresses well interference conflicts but only to a limited extent. Under the reasonable use doctrine, a landowner's right to withdraw ground water will be restricted only if it is wasteful, used on nonoverlying land, or both. Otherwise, the landowner may withdraw ground water without regard to the effect on the wells of other overlying owners.

The correlative rights doctrine addresses well interference conflicts in theory by prorating the available supply among ground water users when shortages occur. In practice, however, the correlative rights doctrine in California is part of the legal basis for integrating the use of ground water and imported surface water supplies, not a policy for restricting ground water use if well interference conflicts occur.[26] Under the correlative rights doctrine, the earlier ground water user has no legal protection regarding well interference conflicts based on well inadequacy, but theoretically may obtain judicial relief if well interference is based on aquifer inadequacy.

CODE ANN. § 73-3-1 (1968); WASH. REV. CODE ANN. § 90.44.040 (1962); WYO. STAT. § 41-144 (Supp. 1975).

24. *See* Vineland Irr. Dist. v. Azusa Irr. Co., 126 Cal. 486, 58 P.1057 (1899); Public Util. Comm'n v. Natatorium Co., 36 Idaho 287, 211 P.533 (1922); Emporia v. Soden, 25 Kan. 588 (1881); Mosier v. Caldwell, 7 Nev. 363 (1872); Vanderwork v. Hewes, 15 N.M. 439, 110 P.567 (1910); Metcalf v. Nelson, 8 S.D. 87, 65 N.W. 911 (1895); Houston & Tex. Cent. R.R. v. East, 98 Tex. 146, 81 S.W. 279 (1904); Herriman Irr. Co. v. Keel, 25 Utah 96, 69 P.719 (1902); Hunt v. Laramie, 26 Wyo. 160, 181 P.137 (1919); TERR. OKLA. STAT. § 4162 (1890).

25. *See* Maricopa County Mun. Water Conserv. Dist. No. 1 v. Southwest Cotton Co., 39 Ariz. 65, 4 P.2d 369 (1931); Katz v. Waikinshaw, 141 Cal. 116, 70 P.663 (1902), *aff'd on rehearing*, 141 Cal. 137, 74 P.766 (1903); Ryan v. Quinlan, 45 Mont. 521, 124 P.512 (1912); Olson v. City of Wahoo, 124 Neb. 802, 248 N.W. 304 (1933); Volkman v. Crosby, 120 N.W.2d 18 (N.D. 1963); Canada v. City of Shawnee, 179 Okla. 53, 64 P.2d 694 (1937); Bull v. Siegrist, 169 Or. 180, 126 P.2d 832 (1942); Horne v. Utah Oil Refining Co., 59 Utah 279, 202 P.815 (1921); Evans v. City of Seattle, 182 Wash. 450, 47 P.2d 984 (1935); Binning v. Miller, 55 Wyo. 451, 102 P.2d 54 (1940).

26. *See infra* notes 60-62 and the accompanying text.

Appropriation states vary in their approaches to well interference conflicts, although earlier users, "senior appropriators," generally are entitled to some protection. In theory, conflicts between ground water appropriators are resolved by requiring a junior appropriator to stop withdrawals when they interfere with those of a senior appropriator. In most states the senior appropriator must enforce his priority through litigation, although some states authorize administrative enforcement of ground water priorities.[27] Administrative restriction of new appropriations, through well spacing requirements or withdrawal limitations, may protect senior ground water appropriators when the proposed ground water appropriation might interfere with existing rights.[28] A common approach is to protect reasonable pumping depths, which does not protect the senior appropriator's initial well and pump, but does limit the extent to which ground water levels will be allowed to decline.[29] This protects senior appropriators regarding future ground water level declines but not regarding past ground water level declines.[30]

Seasonal well interference conflicts are not necessarily an indication of ground water mining because adequate supplies are often available by drilling deeper wells or by installing more powerful pumps. If water levels decline annually as well as seasonally, however, ground water mining is occurring. As water levels decline pumping costs will increase. This will gradually raise the irrigator's costs to the point that he will reduce his ground water withdrawals, improve his irrigation efficiency, grow crops using less water, or reduce his irrigated acreage. These changes in irrigation practices will occur gradually because depletion of ground water supplies generally

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27. MONT. REV. CODES ANN. § 89-2932 (Supp. 1977); NEV. REV. STAT. 534.110(6) (1973); OR. REV. STAT. § 537. 775 (1979); S.D. COMP. LAWS ANN. § 46-6.2 (Supp. 1979); WASH. REV. CODE ANN. § 90.44.130, .180 (1967); WYO. STAT. § 41-132 (Supp. 1975)(in control areas only).

28. COLO. REV. STAT. § 37-90-137 (Supp. 1979)(applies only to appropriation of nontributory ground water outside of designated ground water basins); MONT. REV. CODE ANN. § 89-2918 (Supp. 1977) (in control areas only); NEV. REV. STAT. § 534.110(7)(1973)(in designated basins only); N.M. STAT. ANN. § 73-11-3 (Supp. 1975)(Senior appropriators must tolerate some ground water level reduction, Mathers v. Texaco, Inc., 77 N.M. 239, 421 P.2d 771 (1967)); OR. REV. STAT. §§ 537.620(3), .620(4), .622 (1979); S.D. COMP. LAWS ANN. § 46-6-7 (1967); WASH. REV. CODE ANN. §§ 99.44.030, .090 (1962); WYO. STAT. § 41-140 (Supp. 1975)(in control areas only).

29. IDAHO CODE § 42-226 (1977); NEV. REV. STAT. §§ 534.110(3), .110(4)(1973); S.D. COMP. LAWS ANN. § 46-6-6.1 (Supp. 1979); WASH. REV. CODE ANN. § 90-44.070 (1962); WYO. STAT. § 41-141 (Supp. 1975).

30. Conflicts between surface and ground water users typically are resolved on the same basis as well interference conflicts. *See* Aiken, *supra* note 22, at 936-40.

occurs over decades. Similarly, the reduction in economic activity associated with the transition back to dryland agriculture will occur over a period of decades. Local and state economies will not experience a sharp decline, but will slowly change as irrigation is gradually reduced.

The major policy issue related to ground water mining is whether the inevitable consequences of mining should be postponed by regulation. If supplemental water supplies are not developed, reduced irrigation is the inevitable consequence of ground water mining. If irrigators will be forced by higher pumping costs to use improved irrigation methods, should regulations be established to accomplish that same result sooner? The advantage of doing so is that ground water supplies last longer than they would otherwise. The disadvantage is that irrigators incur higher costs sooner than they would if ground water use were governed only by the private costs and benefits of irrigation. The public cost of administering ground water regulations is an additional factor. The ultimate issue is whether current economic benefits should be forgone to sustain future economic benefits.

The ground water mining issue is not directly addressed by traditional western ground water law doctrines.[31] The absolute ownership and reasonable use doctrines permit ground water withdrawals to occur without regard to whether mining is occurring. Under the absolute ownership doctrine ground water withdrawals may be enjoined only if they are malicious.[32] Under the reasonable use doctrine a landowner's right to withdraw ground water may be enjoined only if it is wasteful, used on nonoverlying land, or both. The correlative rights doctrine addresses ground water mining in theory by prorating the "safe yield" of an aquifer among ground water users. In practice, however, the correlative rights doctrine in California is part of the legal basis for integrating the use of ground water and imported surface water supplies, not a policy for restricting ground

31. *See id.* at 930-35.

32. Contrast this with the administrative regulation of oil and gas production for the benefit of all overlying owners discussed *supra* note 15. The common law doctrine of absolute ownership is essentially the law of capture, giving each landowner all the oil, gas, or water he is capable of pumping before it is withdrawn by another overlying owner. The legislative imposition of the unitization theory (requiring proportional sharing of the profits of oil or gas production among all overlying owners) protects all overlying landowners from the disproportionate withdrawals by any single overlying owner. The common law version, however, provides no such protection.

water use if mining occurs.[33]

Appropriation states vary in their approaches to ground water mining. In theory, conflicts between ground water appropriators are resolved by requiring the junior appropriator to stop withdrawals when they interfere with those of senior appropriators. Similarly, restricting new appropriations when they may interfere with existing ground water appropriators may protect existing ground water users. Neither approach, however, will necessarily prevent ground water mining.

II. CRITICAL AREA REGULATIONS

Because of the inadequacy of traditional ground water law doctrines (which are basically modifications of surface water law doctrines) to deal with ground water,[34] several western states have enacted "critical area" legislation authorizing special ground water regulations in designated critical areas.[35] The general objectives of such legislation are to slow or stop ground water mining, to resolve administratively well interference conflicts, and to protect existing irrigation-based economies.[36]

Designating critical ground water areas is typically a state responsibility,[37] although designation procedures may be initiated by

33. *See infra* notes 60-62 and the accompanying text.

34. For a discussion of the physical differences between surface and ground water occurrence and their implicatons for water allocation policies, see Aiken, *supra* note 22, at 920-21.

35. ARIZ. REV. STAT. ANN. § 45-401 to -415; COLO. REV. STAT. 37-90-102 (1974); IDAHO CODE § 42-233a (Supp. 1979); KAN. STAT. ANN. § 82a-1036 (Supp. 1979); MONT. REV. CODES ANN. § 89-2914 (Supp. 1977); NEB. REV. STAT. § 46-656 (Reissue 1978); NEV. REV. STAT. § 534.020 (1973); N.M. STAT. ANN. § 75-11-13 (1968); OR. REV. STAT. § 537.735 (1979); TEX. WATER CODE ANN. tit. 2, § 52-021 (Vernon Supp. 1979); WASH. REV. CODE ANN. § 90.44.130 (1962); WYO. STAT. § 41-129 (Supp. 1975). New Mexico also authorizes regulation of ground water in artesian basins and formation of artesian conservancy districts. N.M. STAT. ANN. §§ 75-12-2 to -13-1 (1968). States without some critical area legislation are California, North Dakota, Oklahoma, South Dakota and Utah. Oklahoma legislation authorizing special ground water regulation in designated areas was subsequently repealed. *See* 3 W. HUTCHINS, *supra* note 23, at 437-39; Rarick, *Oklahoma Water Law, Ground or Percolating in the Pre-1971 Period*, 24 OKLA. L. REV. 403 (1971).

36. ARIZ. REV. STAT. ANN. § 45-401(A) (Supp. 1981); IDAHO CODE § 42-233a (Supp. 1979); TEX. WATER CODE ANN. tit. 2, § 52.117 (Vernon Supp. 1979); WASH. REV. CODE ANN. § 90.44.130 (1962).

37. ARIZ. REV. STAT. ANN., §§ 45.412 to -414; COLO. REV. STAT. § 37-90-106(1)(1974); IDAHO CODE § 42-233a (Supp. 1979); KAN. STAT. ANN. § 82a-1038 (Supp. 1979); MONT. REV. CODES ANN. § 89-2914 (Supp. 1977); NEB. REV. STAT. § 46-658(a)(Cum. Supp. 1980); NEV. REV. STAT. § 534.030(2)(1973); N.M. STAT. ANN. § 75-11-13 (1968); OR. REV. STAT. § 537-730 (1979); WASH. REV. CODE ANN. § 90.44.130 (1968); WYO. STAT. § 42-129(b)(Supp. 1975).

Texas takes the unique approach of establishing ground water controls through the forma-

either state officials[38] or upon the petition of local ground water users.[39] Criteria for designating critical areas vary considerably and include: (1) withdrawals approaching or exceeding an aquifer's "safe yield" or recharge,[40] (2) ground water level declines,[41] (3) conflicts between ground water users,[42] (4) water quality degradation,[43] and (5) land subsidence.[44] The ground water controls authorized in critical areas also vary considerably and include: (1) requiring state permits for new wells;[45] (2) restricting ground water development through permit denials,[46] well spacing requirements,[47] or well drilling moratoria;[48] and (3) reducing ground water withdrawals by en-

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tion of underground water conservation districts. TEX. WATER CODE ANN. tit. 2, § 52.021 (Vernon Supp. 1979). State officials do not have a significant role in ground water policy development and implementation.

38. ARIZ. REV. STAT. ANN. § 46.412 (Supp. 1981); COLO. REV. STAT. § 37-90-106(1) (1974); IDAHO CODE § 42-233a (Supp. 1979); KAN. STAT. ANN. § 82a-1036 (Supp. 1979); MONT. REV. CODES ANN. § 89-2914 (Supp. 1977); NEV. REV. STAT. § 534.030(2) (1973); N.M. STAT. ANN. § 75-11-13 (1968); OR. REV. STAT. § 537.730 (1979); WASH. REV. CODE ANN. § 90.44.130 (1968); WYO. STAT. § 41-129(b) (Supp. 1975). Texas and Nebraska are the only states in which ground water controls cannot be initiated by state officials.

39. ARIZ. REV. STAT. ANN. § 45-415 (Supp 1981); KAN. STAT. ANN. § 82a-1036 (Supp. 1979); MONT. REV. CODES ANN. § 89-2914 (Supp. 1977); NEB. REV. STAT. § 46-658(3)(Cum. Supp. 1980); NEV. REV. STAT. § 534.030(1) (1973); OR. REV. STAT. § 537-730 (1979); TEX. WATER CODE ANN. tit. 2, § 52.021 (Vernon Supp. 1979); WASH. REV. CODE ANN. § 90.44.130 (1968); WYO. STAT. § 41-132 (Supp. 1975).

40. ARIZ. REV. STAT. ANN. § 45-412(1) (Supp. 1981); KAN. STAT. ANN. § 82a-1036(b)(Supp. 1979); MONT. REV. CODES ANN. § 89-2914(1)(Supp. 1977); OR. REV. STAT. § 537.730(3)(1979); WASH. REV. CODE ANN. § 90.44.130 (1968); WYO. STAT. § 41-129(a)(i)(Supp. 1975).

41. KAN. STAT. ANN. § 82a-1036(a)(Supp. 1975); OR. REV. STAT. § 537.730(1)(1979); WYO. STAT. § 49-129(a)(ii)(Supp. 1975).

42. NEB. REV. STAT. § 46-658(1)(a)(Cum. Supp. 1980); MONT. REV. CODES ANN. § 89-2914(3)(Supp. 1977); OR. REV. STAT. § 537-720(2) (1979); WYO. STAT. § 41-129(a)(iii)(Supp. 1975).

43. ARIZ. REV. STAT. ANN. § 45-412(3) (Supp. 1981); KAN. STAT. ANN. § 82a-1036(d)(Supp. 1979); OR. REV. STAT. § 537-730 (1979).

44. ARIZ. REV. STAT. ANN. § 45-412(2) (Supp. 1981).

45. COLO. REV. STAT. § 37-90-107 (1974 & Supp. 1979); NEB. REV. STAT. § 46-659(1)(Cum. Supp. 1980); NEV. REV. STAT. § 534.050 (1975); TEX. WATER CODE ANN. tit. 2, § 52.114 (Vernon 1972).

46. COLO. REV. STAT. § 37-90-107 (1974 & Supp. 1979); IDAHO CODE § 42-233a (Supp. 1974); NEV. REV. STAT. §§ 533.370(4), 534.110(3) (1973).

47. NEB. REV. STAT. § 46-666(1)(c)(Cum. Supp. 1980); TEX. WATER CODE ANN. tit. 2, § 52.117 (Vernon Supp. 1979); WYO. STAT. § 41-132(a)(v)(Supp. 1975).

48. KAN. STAT. ANN. § 82a-1038(b)(1)(Supp. 1979); NEB. REV. STAT. § 46-666(4)(Cum. Supp. 1980); NEV. REV. STAT. § 534.110(7) (1973); OR. REV. STAT. § 537.730(1)(1979); WYO. STAT. § 41-132(a)(i)(Supp. 1975). Arizona does not establish a well drilling moratorium per se, but additional land cannot be irrigated in "irrigation non-expansion areas," in "active management areas," and during the consideraton of whether an active

forcing priorities,[49] reducing presently authorized withdrawals,[50] rotating withdrawals,[51] enforcing voluntary pumping agreements,[52] and purchasing and retiring ground water pumping rights.[53]

The difficulty of obtaining reliable informaton about ground water availability significantly affects the development of ground water policies including determining whether the critical area restrictions described above should be implemented. Information about surface water availability can be obtained by observing and measuring streamflow which greatly simplifies the task of surface water administration. Information about ground water availability, however, is not so easily obtained. The typical sources are geologic data from test hole drilling for oil and gas, and well logs from oil, gas, and water well installation. From these data, geologists can construct the geologic profile of an area which will include the location and general character of ground water aquifers.

These data typically are not available for analysis, nor are they geologically analyzed, until significant water well installation has occurred. This has important implications for the development of critical area ground water controls. Water rights in the West are typically administered on a complaint basis; state water officials will not administratively regulate water users unless a complaint if filed, often informally, by a senior appropriator. Ground water development will occur freely, subject, of course, to ground water availability, unless senior appropriators complain. If no complaints are made, ground water management concerns will not develop until irrigators begin to notice that water levels in their wells are falling. This may not occur for many years after ground water development has started. Water level declines are likely to lead to the formal monitoring of water levels on a regional basis to determine whether ground

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management area should be designated. ARIZ. REV. STAT. ANN. §§ 45-432, -452, -416 (Supp. 1981).

49. KAN. STAT. ANN. § 82a-1038(b)(2)(Supp. 1979); MONT. REV. CODES ANN. § 89-2915(1)(Supp. 1977); NEV. REV. STAT. § 534.110(6)(1978); OR. REV. STAT. § 537.730(a)(1979); WASH. REV. CODE ANN. § 90.44.130 (1962); WYO. STAT. §§ 41-132(a)(ii), -132(a)(iii)(Supp. 1975).

50. ARIZ. REV. STAT. ANN. §§ 45-541 to -545, -563 (Supp. 1981); KAN. STAT. ANN. § 82a-1038(b)(3)(Supp. 1979); NEB. REV. STAT. § 46-666(1)(a) (Cum. Supp. 1980); OR. REV. STAT. § 537.730(4)(1979).

51. KAN. STAT. ANN. § 82a-1036(b)(4)(Supp. 1979); NEB. REV. STAT. § 46-666(1)(b)(Cum. Supp. 1980); OR. REV. STAT. § 537-730(5)(1979); WYO. STAT. § 41-132(a)(iv)(Supp. 1975).

52. OR. REV. STAT. § 537.735 (1979); WYO. STAT. § 41-132(c) (Supp. 1975).

53. ARIZ. REV. STAT. ANN. § 45-566(A)(6), -567(A)(6) (Supp. 1981).

water mining is occurring or whether ground water level declines are a local phenomenon only. The significant point, however, is that serious ground water data collection may begin only after ground water users have noticed that ground water level declines have begun. Once geologic investigations (which may range in detail and sophistication from ground water level decline maps to computer projections of aquifer conditions for the next fifty years) have established the existence of ground water mining, irrigators may initiate voluntary water conservation efforts to improve irrigation efficiency, and state officials may establish control area regulations.[54] In the absence of such information, however, irrigation water management or control area regulations are unlikely to be developed.

The importance of ground water data as a prerequisite to effective ground water regulaton and management efforts cannot be overstated. In the parallel surface water situation, user conflicts can easily be documented by gauging whether sufficient water is flowing past a senior appropriator's point of diversion. If not, the withdrawals of upstream junior appropriators are restricted until the senior appropriator's needs have been satisfied. Streamflow can be depleted temporarily by appropriators, but this will last only until the next rain or until stored water is released from surface water reservoirs. The ground water situation is much different. There is typically little information regarding how much ground water is available, although annual ground water level declines can be documented through ground water level monitoring programs. This lag between the occurrence of ground water mining and the development of the necessary information for informed ground water regulation and management efforts ensures that mining problems will worsen before management efforts are instituted. This delay will make those management efforts more difficult to implement because less ground water and correspondingly fewer management options will be available.

Ground water controls are not usually embraced by irrigators. Development restrictions are favored by existing irrigators because their pumping rights will be protected from potential competitors. Development restrictions will be opposed by potential ground water

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54. Control area regulations may also be initiated when ground water users complain about well interference conflicts. Before ground water regulations are imposed, however, state water officials typically will require some documentation that well interference conflicts are actually occurring (*e.g.*, to establish that the failure of a well is related to water level changes caused by well pumping rather than being caused by mechanical failure of the pump, clogging of the well casing, *etc.*) before administrative action will be taken.

users who correctly argue that they are being regulated for the benefit of those who caused the mining problem in the first place. Use restrictions are also unpopular with irrigators who perceive them as threats to their economic livelihood, but this view ignores two facts. First, considerable room for improvement in irrigation efficiency is usually possible without substantial increases in irrigation costs.[55] Second, if withdrawals are not reduced through regulation, they ultimately will be reduced because of reduced aquifer capacity. The issue is whether regulation to extend aquifer life is preferable to forced reductions in withdrawals because of increased pumping costs, reduced aquifer capacity, or both.

III. SUPPLY AUGMENTATION

Ground water regulations are not a popular way to deal with ground water mining, at least among ground water users. The degree of political and economic sacrifice necessary to implement ground water controls ensures that they will not be embraced by irrigators. The more popular and politically palatable approach for dealing with ground water mining is to augment existing water supplies. This alternative is particularly appealing if the cost of developing additional supplies will be federally subsidized.

States have traditionally encouraged irrigation development, first by developing water laws protecting irrigation water uses[56] and later by authorizing the organization of irrigation and reclamation districts.[57] Reclamation districts typically are organized to facilitate development of federal reclamation projects. Reclamation districts also usually have the authority to levy property taxes against land within the district and to issue bonds. This financial authority would enable reclamation districts to develop surface water storage projects in the absence of federal subsidies if the projects were economically feasible or if state or local taxpayers could be persuaded to subsidize the costs of project development.

Supply augmentation related to ground water mining has been implemented on a large scale in southern California where imported Colorado River water has been made available for municipal and agricultural purposes through the federal Colorado River Project. Arizona and Texas are now attempting to obtain federal rescue

55. *See* Aiken, *The National Water Policy Review and Western Water Rights Law Reform*, 59 NEB. L. REV. 327, 329-33 (1980).

56. *See generally* Trelease, *Law, Water and People: The Role of Water Law in Conserving and Developing Natural Resources in the West*, 18 WYO. L.J. 3 (1963).

57. *See generally* 4 R. CLARK, WATER AND WATER RIGHTS §§ 340-46 (1970).

projects to cope with ground water mining. Because California is the prototype for western states in dealing with ground water mining through developing imported surface water supplies, the California experience will be briefly recounted.[58]

Because local ground water supplies have been inadequate to meet growing municipal and agricultural water needs, Los Angeles has imported surface water to augment native supplies for over seventy years. The first source of supplemental water was the Owens Valley. Surface water was imported to Los Angeles from the Sierra Nevada mountains through the 250 mile Los Angeles Aqueduct, completed in 1913. Although Los Angeles financed construction of most of the aqueduct and storage facilities, Owens Valley water was initially used for irrigation in the San Fernando Valley. Los Angeles was subsequently required to purchase irrigated land to obtain the Owens Valley water it had originally developed.

The second major source of supplemental water for Los Angeles is the Colorado River. As early as 1901, Colorado River water was imported to the Imperial Valley through the Imperial Canal for irrigation. Irrigation interests subsequently persuaded the federal Bureau of Reclamation to study the importation of Colorado River water to southern California. In 1921, the Bureau recommended construction of Hoover Dam in Boulder Canyon for flood control, water supply, and hydropower generation. The Bureau also recommended construction of a canal to deliver Colorado River Water to Imperial Valley irrigators. In 1922, Secretary of State Herbert Hoover met with the seven Colorado River basin states to negotiate an interstate compact apportioning Colorado River water between Upper Basin states (Colorado, Utah and Wyoming) and Lower Basin states (Arizona, California, Nevada and New Mexico). Arizona refused to sign the initial compact proposal, correctly concluding that California water development would prevent Arizona from acquiring as much Colorado River water as it would prefer. A six state Colorado River Compact, excluding Arizona, was executed in 1925, allocating 7.5 million acre feet (maf) per year each to the Upper and

58. For a discussion of water development efforts in southern California, *see* E. COOPER, AQUEDUCT EMPIRE (1968). Regarding the controversial Colorado River Project, *see* R.H. BOYLE, J. GROVES & T. WATKINS, THE WATER HUSTLERS 134-201 (1971); B. HOLMES, HISTORY OF FEDERAL WATER RESOURCES PROGRAMS AND POLICIES, 1961-70 53-60 (United States Dep't of Agric. Misc. Pub. No. 1379, 1979); Trelease, *Arizona v. California: Allocation of Water Resources to the People, States and Nation,* 1963 SUP. CT. REV. 158; Meyers, *The Colorado River,* 19 STAN. L. REV. 1 (1966); Hanks, *Peace West of the 98th Meridian — A Solution to Federal-State Conflicts over Western Waters,* 23 RUTGERS L. REV. 33 (1968).

Lower Basin states. Up to one maf of any annual surplus above fifteen maf could be appropriated by Lower Basin states. The Compact did not apportion water among the Lower Basin states. For this reason, Arizona did not ratify the compact until 1944 when it pursued construction of the Central Arizona Project.

The Compact was ratified by Congress in the Boulder Canyon Project Act of 1928.[59] The Act required California to limit its annual consumption to 4.4 maf plus half of any surplus available to the Lower Basin states. The Act was passed in part because Los Angeles successfully integrated irrigation and municipal water interests to support the Act. Los Angeles, in 1923, proposed that a second dam, Imperial Dam, and canal, the All-American Canal, be constructed to deliver Colorado River water to irrigators. Los Angeles also organized the Metropolitan Water District, representing municipal water districts from thirteen southern California cities, to support the Act and the Colorado River Project. The combined irrigation and urban interests were successful in obtaining passage of the Boulder Canyon Project Act which authorized the federal construction of Hoover Dam, Imperial Dam, and the All-American Canal. Parker Dam was subsequently authorized to complete the Colorado River Project. In 1931, voters within the Metropolitan Water District authorized construction of the Colorado River Aqueduct to deliver Colorado River water to the Los Angeles region. Construction of Hoover Dam began in 1931 and was completed in 1935. Parker Dam and Imperial Dam were completed in 1938. The Colorado River Aqueduct and the All-American Canal were completed in 1939 and 1940, respectively. Total project costs exceeded $400 million.

The availability of supplemental water has led to the integrated use of imported surface water and native ground water in southern California.[60] This includes the use of underground storage capacity created by ground water mining to store imported surface water underground. California Supreme Court decisions have facilitated the evolution of these integrated use policies by recognizing an exclusive right of ground water recharge entities to control withdrawals of water stored underground.[61] If rights to withdraw ground water are

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59. 45 Stat. 1057 (1928), *amended by* 43 U.S.C. § 617 (Supp. IV 1980).

60. *See* Aiken, *supra* note 22, at 934-35.

61. City of Los Angeles v. City of Glendale, 23 Cal.2d 68, 142 P.2d 289 (1943); City of Los Angeles v. City of San Fernando, 14 Cal.2d 199, 537 P.2d 1250 (1975). Regarding *Glendale see* Kreiger & Banks, *Groundwater Basin Management*, 50 CALIF. L. REV. 56 (1962). Regarding *San Fernando*, *see* Gleason, *Water Projects Go Underground*, 5 ECOLOGY L.Q. 625 (1976).

judicially determined and withdrawals limited to each user's proportionate share of the aquifer's "safe yield," recharge entities can charge water users for any ground water withdrawn in excess of the safe yield allocation. The safe yield adjudication process essentially establishes that any ground water withdrawn in excess of the safe yield allocation is recharged ground water for which the recharge entity is entitled to be paid.[62]

The development of effective institutions for integrating the use of supplemental surface water with native ground water supplies is an important water management technique. The attractiveness of this innovation should not obscure, however, that southern California ground water users have thus far managed to avoid water supply restrictions resulting from regulation of ground water development and use largely because of federally subsidized interstate surface water transfers.

Arizona is experiencing water supply problems similar to California's. Irrigation and agriculture are competing for diminishing ground water supplies. Because of irrigation and municipal demands, ground water in Arizona is being mined at a rate of over two million acre feet (maf) per year.[63] The proposed Bureau of Reclamation Central Arizona Project (CAP) would divert approximately 1.2 maf of Colorado River water to the Tuscon and Phoenix areas to provide water for irrigation and municipal purposes. Although Arizona originally opposed the federal Colorado River Project, it ratified the Colorado River Compact in 1944 to pursue development of the CAP. Congressional authorization of the CAP was delayed, however, because of legal uncertainty regarding whether Arizona had title to sufficient water under the Compact for the project. To clarify its Compact water entitlements, Arizona sued California in 1952. In the 1963 decision, *Arizona v. California*,[64] the U.S. Supreme Court ruled in favor of Arizona, which means that Los Angeles will lose approximately one maf if and when the CAP is constructed. While part of the CAP has been constructed, additional congressional funding authorizations are needed to complete the project.

The potentially most grandiose federal rescue project, proposing to import Missouri River water principally to the Texas panhandle, is the subject of the ongoing High Plains Study. Texas is second only

62. Regarding ground water recharge policies of other western states, *see* Aiken, *supra* note 22, at 935.

63. B. HOLMES, *supra* note 58, at 57.

64. 373 U.S. 546 (1963).

to California in the amount of ground water withdrawn and the number of acres irrigated. Ten maf of ground water were withdrawn in Texas in 1975, compared to eighteen maf in California.[65] Irrigation from the Ogallala aquifer in the Texas high plains, the panhandle region, began in the 1930's.[66] High plains water levels began to fall in the 1940's. State legislation authorized the formation of ground water conservation districts,[67] some of which have (1) restricted ground water development through well-spacing requirements and (2) indirectly restricted withdrawals through irrigation runoff control requirements.[68] The first state water development plan[69] concluded in 1966 (1) that intrastate water importation to western Texas would be insufficient to continue high plains irrigation and (2) that federally subsidized water importation from the Mississippi, Missouri, or Columbia rivers would allow high plains irrigation to stabilize or expand. These conclusions were included in the 1968 *Texas Water Plan.*[70] Texas has opted to pursue implementation of its water plan rather than impose ground water restrictions.

In 1976 Texas cooperated with other southern high plains states, particularly Oklahoma, in persuading Congress to authorize the High Plains Study (HPS) to study water importation to the high plains region.[71] The authorization for the study, however, reflects that some political compromises were necessary to obtain congressional approval. The justifications for the study are "to assure an adequate supply of food to the Nation" and "to promote the economic vitality of the *High Plains Region.*"[72] Study objectives are "to study the depletion of the natural resources of [the states using] declining [sic] water resources of the Ogallala aquifer" and "to develop plans to increase water supplies in the area and report thereon to Congress, together with any recommendations for further congressional action."[73] The study must "examine the feasibility of various alternatives to provide adequate water supply [sic] in the area in-

65. C. MURRAY & E. REEVES, *supra* note 1, at 24-25.

66. Regarding irrigation and water development activities in Texas *see* R. BOYLE, J. GROVES & T. WATKINS, *supra* note 58, at 18-129.

67. TEX. WATER CODE ANN. art. 2, § 52.021 (Vernon 1972).

68. *See* G. SLOGGETT, *supra* note 18, at 11.

69. State water planning has been used principally to identify where federal reclamation and flood control projects should be constructed. *See* Aiken, *supra* note 55, at 343-44.

70. R. BOYLE, J. GROVES, & T. WATKINS, *supra* note 58, at 50-62.

71. Pub. L. No. 94-587, § 193, 90 Stat. 2943 (1976), codified at 42 U.S.C. § 1962d-18 (1976), partially reprinted *supra*, note 17.

72. *Id.* (emphasis added).

73. *Id.*

cluding, but not limited to, the transfer of water *from adjacent areas* . . . to assure the continued economic growth and vitality of the region."[74] The study must include an evaluation of the costs and benefits of various actions and the costs of inaction. In evaluating water transfer options, existing water rights and future water needs of all affected areas must be considered.

The apparent congressional intent suggests that (1) the economic vitality of the region as a whole is the primary concern rather than the economic vitality of individual states within the region; (2) depletion of oil and gas reserves in the region is a valid factor for consideration; (3) sources of supplemental water could include the Missouri River but not the Columbia River; (4) future water needs of the exporting and importing basins should be considered equally (*i.e.*, no protection for basin of origin); and (5) environmental concerns, not mentioned in the study authorization, probably are subordinate to economic development concerns.

The Economic Development Administration (EDA) of the United States Department of Commerce is responsible to Congress for implementing the study. Because the six high plains states (Colorado, Kansas, Nebraska, New Mexico, Oklahoma and Texas) are responsible for conducting the study and have a stake in the outcome, administration of the study is governed by the High Plains Study Council.[75] Council membership includes the governors of the high plains states, three other representatives from each state (usually water rights officials, water planning officials, and state legislators), and EDA representatives. Each state has equal Council representation, making study domination by any single state difficult.

The HPS will examine six alternative development strategies: (1) baseline (no change), (2) voluntary and mandatory water use restrictions, (3) local water supply augmentation, (4) intrastate water transfers, (5) interstate water transfers, and (6) nonagricultural development options. The baseline and interstate transfers are the only alternatives for which published informaton is available.

The baseline scenario represents what would happen from 1977 to 2020 if the status quo were maintained: *i.e.*, no new ground water regulations, supplemental water supply projects, or technological in-

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74. *Id.* (emphasis added).

75. The source of information about HPS study administration and the baseline results is High Plains Study Council, *Six-State High Plains-Ogallala Aquifer Resources Study: Congressional Briefing [Paper]* (February 25, 1981). The congressional briefing paper is the only official HPS report issued to date.

novations. The baseline scenario assumes, however, that irrigation water use efficiency will improve considerably during the study period. Increasing irrigation costs are projected to give irrigators sufficient private economic incentives to adopt improved irrigation practices and technologies currently available. Irrigated crop prices are projected to increase in real terms, discounted for inflation, but not as rapidly as during the past decade. Increases in United States population and, more importantly, increases in agricultural exports are the primary reasons crop prices are expected to increase. The baseline scenario also evaluates regional oil and gas production.

The baseline results indicate that annual regional ground water withdrawals are projected to decline from twenty-two maf in 1977 to twenty maf in 2020. The number of acres irrigated is projected to increase, however, from twelve million to 13.5 million. The annual economic value of irrigated production is projected to increase from $4.5 billion to eleven billion, primarily because of increased crop prices. Annual natural gas production is projected to decrease from 5.5 billion cubic feet to 0.5 billion cubic feet. Annual oil production is also projected to decrease from 500 million barrels to fifty million barrels. The annual economic value of oil and gas production is projected to increase from $3.5 billion in 1977 to a peak of five billion in 2000 but is projected to decline to $1.5 billion in 2020.

The regional irrigation aggregates, projecting a net increase in the value of irrigated production, mask a substantial regional shift in the location of irrigation. Annual ground water withdrawals for irrigation are projected to decrease by nine percent by 2020. Most of the decrease will occur in Texas and Kansas, with an increase occurring in Nebraska. Annual ground water withdrawals in Texas are projected to decrease from eight maf to 4.8 maf, a forty percent reduction. Annual ground water withdrawals in Kansas are projected to decrease from three maf to 0.3 maf, a ninety percent reduction. Annual ground water withdrawals in Nebraska are projected to increase from eight maf to thirteen maf, a sixty percent increase.[76] The corresponding losses of irrigated acres in Texas and Kansas will be more than balanced by the increase in irrigation in Nebraska. Texas and Kansas are also likely to lose livestock feeding operations to Nebraska. Approximately six million acres will revert to dryland production, while additional acres will be only partially irrigated.

The baseline results suggest that regional economic vitality will

76. Annual ground water withdrawals in Colorado, New Mexico and Oklahoma are projected to average approximately one maf throughout the study period.

improve during the next forty years. The annual regional value of oil, gas, and irrigated production will increase from eight billion to $12.5 billion. If Nebraska were excluded from the region, however, the remaining high plains states would suffer a decline in the value of annual oil, gas, and irrigated production.

Interstate water transfers were evaluated by the United States Army Corps of Engineers. The Corps identified four possible water importation alternatives, primarily from the Missouri and Arkansas rivers.[77] The annual cost of imported surface water averages $600 per acre foot, several times what an irrigator could afford to pay. Implementation of any importation option would require a substantial subsidy.

The HPS resolution indicated two justifications for the study: maintaining an adequate food supply to the nation and maintaining the economic vitality of the high plains region. The baseline results indicate that regional crop production will increase, although exports and food prices will be higher. This suggests that United States food supplies will certainly be adequate, if somewhat more expensive. Regional economic vitality will also improve, although most of the increase in irrigated production will occur in Nebraska. If Nebraska were excluded, the rest of the region would decline economically, based on reductions in irrigation, oil, and gas production. Water importation to maintain irrigation in Texas and Kansas would require federal subsidies of up to $91 billion for construction, plus annual federal operation and maintenance subsidies of up to $13 billion. Federal subsidies of this magnitude cannot be justified on the basis of protecting either the nation's food supplies or the economic vitality of the high plains region. Whether subsidies of this magnitude are politically feasible during what may be a period of federal budg-

77. The Corps evaluated two alternatives for each route, a lower-cost, lower-volume option with a higher cost per acre foot of water delivered, and a higher-cost, higher-volume option with a lower cost per acre foot of water delivered. The first option would import 2.1 maf and 6.4 maf of Missouri River water from South Dakota to southwest Nebraska, northeast Colorado, and western Kansas at an annual average cost of $410 and $340, respectively. The second option would import one and six maf of Missouri River water from Missouri to western Kansas at an annual average cost of $880 and $352 per acre foot, respectively. The third option would import two maf and 6.8 maf of water principally from the Arkansas River in Arkansas to the northern Texas high plains at an annual average cost of $752 and $482 per acre foot respectively. The fourth option would import 2.4 maf and 7.2 maf of water from the Arkansas, Ouachita, Red, Sabine, and Sulfur rivers in Arkansas and Texas to the Texas high plains at an average annual cost of $785 and $695 per acre foot, respectively. These costs do not include the cost of delivering imported water to irrigators. These water distribution costs are probably the only costs the irrigators are likely to undertake themselves, acting collectively through an irrigation or reclamation district.

etary austerity remains to be seen, but it seems unlikely.[78] If a federal high plains rescue project is not launched, establishing ground water controls or improvements in irrigation efficiency may yet extend the life of ground water supplies in the high plains region. If not, Texas and Kansas will suffer the consequences of not imposing ground water controls to extend the life of ground water supplies.

IV. Policy Alternatives

Although ground water mining is slowly documented, it is a forseeable and inevitable consequence of extensive ground water development for irrigation and other high-volume uses. The basic questions for policy makers are whether to act or do nothing. General policy options include restricting ground water development or use, and supply augmentation.

Ground water restrictions are unpopular but essentially only require legally what reduced aquifer capacity would ultimately require physically: reduced ground water use.[79] Irrigation restrictions may be evaulated in different phases: (1) irrigation runoff controls, (2) irrigation scheduling, and (3) water quantity restrictions.[80] Reducing irrigation runoff is not difficult or expensive to accomplish and typically can be effected by capturing runoff in irrigation reuse pits for subsequent reuse. Runoff controls reduce ground water withdrawals for irrigation but also affect irrigation return flows. If the runoff would have percolated back into the aquifer, runoff controls may have little effect on net ground water withdrawals, although irrigators pumping costs will be reduced. If the runoff would have returned to a stream, runoff controls will reduce the water that would otherwise have been available to downstream water users. Irrigation scheduling, the next step in reducing irrigation water use, requires field monitoring of crop water needs and application of irrigation water only when natural precipitation is insufficient. Irrigation scheduling may be more expensive to implement than runoff controls and requires better water management by the irrigator. Net ground water withdrawals may be reduced somewhat to the extent crop

78. In addition, use of water from the upper Missouri River would be subject to existing use for navigation, Indian water rights, and potential use for energy development. Proposals to implement any of the transfer options would lead to interstate political conflicts over which state is allocated what quantity of water in addition to any funding controversies.

79. For a general discussion of ground water development and use restrictions see Aiken & Supalla, *Ground Water Mining and Western Water Rights Law: The Nebraska Experience*, 24 S.D.L. Rev. 607, 629-40 (1979).

80. For a general discussion of legal aspects of improving water use efficiency see Aiken, *supra* note 55, at 329-33.

water use and evaporation are reduced. Significant reductions in ground water withdrawals and a corresponding increase in aquifer life will not occur, however, until ground water withdrawals are restricted to the extent that irrigators are required either to change cropping patterns to include crops requiring less water or to reduce irrigated acreage. At this point, the value of irrigated production may be adversely affected, but the life of ground water supplies is more likely to be significantly increased.

The important issue relative to ground water controls is whether the cost of administering regulations and any economic benefits postponed due to ground water controls are outweighed by the future economic benefits achieved by extending aquifer life. Irrigation runoff controls and irrigation scheduling will reduce gross ground water withdrawals but may not have a significant effect on net ground water withdrawals. Ground water withdrawal restrictions, leading to growing crops requiring less water or a reduction of irrigated acreage, may reduce current economic benefits from irrigation, but those benefits will be sustained for a longer period.

Supply augmentation may be subsidized or unsubsidized. Federal subsidies are undesirable for two reasons: (1) there appears to be no national benefit from subsidizing irrigation in the West, and (2) federal rescue efforts reduce state and local incentives to control ground water use. Federal reclamation policy originally developed as a means to encourage settlement of the western frontier.[81] Federal irrigation water was provided to give homesteaders the means to settle and "reclaim" the arid West. The reclamation program received its greatest impetus during the Depression, when it was perceived, as were other public works programs, as a means of creating needed jobs. While the settlement and employment aspects of the federal reclamation program were sufficient justifications in earlier cicumstances, both fail as adequate justifications for continued federal subsidy of rescue projects today.

In addition to their cost, a further disadvantage of federal rescue projects is that they in effect reward areas that fail to control ground water mining. Continued provision of subsidized irrigation water will not encourage irrigators or states to control ground water use but will encourage ground water mining.

While federal subsidies through rescue projects are undesirable,

81. For a general discussion of the historical evolution of federal reclamation policy *see* B. Holmes, *A History of Federal Water Resources Programs, 1800-1960* (United States Dep't of Agric. Misc. Pub. No. 1233, 1972).

state or local subsidies may be more appropriate. After the irrigators, local and state economies benefit most from irrigation development. The existence of this economic benefit may enable irrigators to persuade local residents or state legislators to authorize reclamation bonds to construct supplemental water supply projects if ground water mining occurs. If irrigators fail to persuade others that the economic benefits from irrigation are worth protecting through state or local subsidy, perhaps those benefits are not as great as originally perceived. In any event, the difficulty of obtaining a state or local subsidy to provide a supplemental water supply may make irrigators more willing to consider ground water controls as means of dealing with ground water mining.