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Groundwater Rights in an Uncertain Environment: Theoretical Perspectives on the San Luis Valley

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ABSTRACT

A costly dispute has been generated by a proposal to establish new groundwater rights in the aquifer system underlying Colorado's San Luis Valley for the purpose of transferring groundwater to Colorado's Front Range cities. This paper compares the insights of three theoretical perspectives on such disputes over groundwater rights. The authors examine the effects of the nature of the resource on the definition, exercise, and defense of property rights to groundwater. Evidence is drawn from the San Luis Valley case to assess the utility of the theoretical perspectives in contributing to understanding the evolution of institutions governing groundwater use.

INTRODUCTION

The aridity and climatic variability of much of the western United States have resulted in continuing competition for control of the region's water resources. While the scarcity of western water makes it a potentially valuable commodity, variability of supply both directly diminishes the value of any given water source and increases the cost of defining and enforcing the rights of competing users. Surface water availability is subject to significant natural variability as well as to the effects of competing uses. Groundwater is often used where precipitation and surface water sources are inadequate or unreliable, and its use provides a form of insurance against the effects of climatic variability. Groundwater resources, however, are not immune from natural variability, and groundwater use also entails competition among users. Uncontrolled pumping by competing users of an aquifer may substantially reduce the value of the resource over time.

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As the economy and demography of the western United States have changed, growing urban and environmental water demands (e.g., minimum instream flows) increasingly compete with irrigators and other traditional water users. The legal institutions and contractual agreements that govern the allocation of water in the arid and semi-arid West have evolved to manage competition for scarce water. Nevertheless, costly conflicts occasionally arise. Are such conflicts the result of inadequate institutions governing the allocation of groundwater, surface water or both? Are they inherent in the nature of these resources or are they simply a part of the continuing evolutionary process by which rights to the use of these resources are defined, defended and exercised?

This paper compares insights on these questions, particularly as they relate to groundwater resources, provided by three different theoretical perspectives. The theoretical perspectives we examine are: 1) an "optimal control" economics perspective which addresses the potential contribution of privatization to the best use of a resource over time, 2) a "transaction cost" perspective on the nature of property rights which emphasizes the costs of defining and enforcing those rights, and 3) a perspective derived from the work of Elinor Ostrom on the local governance of common property resources which we call "the Ostrom perspective." These differing theoretical perspectives, which we describe in detail below, are used to analyze an ongoing conflict over groundwater rights in the San Luis Valley in south-central Colorado (Figure 1).[1]

This paper uses the San Luis Valley case to explore the nature of groundwater and how that nature affects the definition, exercise and defense of groundwater rights. The paper next assesses the respective contributions of the three theoretical perspectives to an understanding of the evolution of institutions governing groundwater use.

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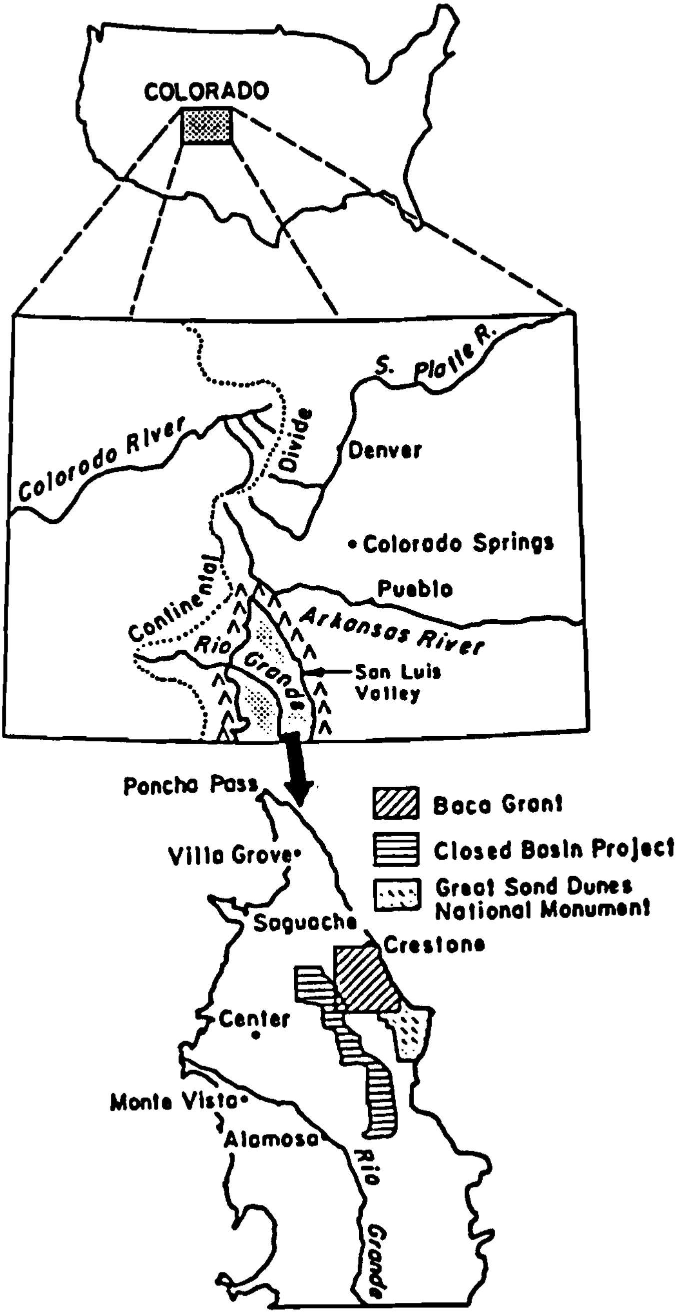
1. The San Luis Valley is located in the upper Rio Grande Basin. It is bounded on the west by the San Juan Mountains and on the east by the Sangre de Cristo Range. The Valley has an average elevation of 7,500 feet and receives an average of 7 to 8 inches of precipitation annually. Irrigated agriculture has a long history in the Valley, and despite a relatively short growing season, it remains a major part of the Valley's economic base. Livestock production is also important in the Valley. The Valley's primary crops are hay, potatoes, and grain (Colorado State University Cooperative Extension, Colorado's Bountiful San Luis Valley, undated). Consumptive water use by irrigated crops is estimated to be approximately 1 million acre-feet per year. *See* HRS Water Consultants, Inc., San Luis Valley Confined Aquifer Study (1987); G. Hearne & J. Dewey, Hydrological Analysis of the Rio Grande Basin North of Embudo, New Mexico, Colorado and New Mexico (Water Resources Investigation Report 86-4113, U.S. Geological Survey, 1988). With approximately 750,000 irrigated acres, the gross value of the Valley's crop production was $221 million in 1989. *See* S. Schuff, *High Stakes*, 8 Colorado Rancher and Farmer (1 October 1990).



THE SAN LUIS VALLEY

The case in question resulted from an attempt by a private company, American Water Development Incorporated (AWDI),[2] to establish the right to drill wells into a system of hydrologically interconnected aquifers underlying the San Luis Valley for the purpose of annually extracting up to 200,000 acre-feet of water. The company proposed to export much of this water from the Valley by building a pipeline over Poncha Pass, at the Valley's northern end. The water would then be available for sale to Denver and other "Front Range" Colorado cities along the eastern slope of the Rocky Mountains.[3] This proposal has been vehemently opposed by the majority of San Luis Valley residents as well as by state and federal agencies and environmental interest groups.[4]

The company's plans have been at least temporarily stalled by the recent ruling of Judge Robert W. Ogburn of Colorado's Division 3 Water Court. The judge ruled on 22 November 1991 that AWDI had failed to demonstrate that the groundwater it would develop was "nontributary" under Colorado law and thus could be developed as a matter of ownership of the overlying land. This decision was reached quickly after the end of six weeks of testimony in one of the most costly and hotly contested cases in the Court's history.

While many of the Valley's residents and other opponents of the proposed project are celebrating this decision as a victory, most realize that water export plans are far from dead. In particular, the company's last-minute decision to withdraw its claims for "tributary" groundwater (i.e., hydrologically connected to surface water) has left those claims available for consideration at a later date. The legal significance under Colorado law of the distinction between tributary and nontributary groundwater will be discussed below.

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2. AWDI is a private water development firm incorporated in 1985 for the purpose of acquiring the Baca Ranch in Colorado's San Luis Valley. *See* District Court, Water Division 3, Colorado, Case No. 86-CW-46 Concerning the Application for Water Rights of: American Water Development Inc., The Baca Ranch Company, and the Baca Corporation, In Saguache County-Deposition of D. Williams, Jr. (7 February 1990). AWDI's business is to assist municipalities in eastern Colorado acquire water supplies suited to their specific needs. *See* AWDI, *Meeting the Needs of Colorado's Front Range* (submitted to L. Berkowitz, Metropolitan Denver Water Authority, 1989).

3. The Metropolitan Denver Water Authority has recently indicated its willingness to pay capital costs of up to $6,000 per acre-foot for reliable new supplies delivered into the Denver system (letter from D. Shaffer, President of AWDI, to L. Berkowitz, President, MDWA, 13 November 1989). The capital value of a reliable water right for agricultural use within the San Luis Valley appears to be less than $500 per acre-foot. *See* D. Foster, *Group Seeks Diversity for San Luis Economy*, Rocky Mountain News (8 August 1990).

4. B. Scanlon, *Truce Urged in Water Fight*, Rocky Mountain News (19 August 1991).

The controversy over AWDI's proposal is the most recent chapter in a long history of conflict and litigation over water use in the San Luis Valley.[5] Furthermore, the possible resurrection of AWDI's plan may be only one of many potential future challenges to the security of water rights now used for irrigated agriculture in the Valley. A prolonged drought or long-term climate change, for example, could reduce the security of these rights and rekindle a long-standing interstate dispute between Colorado, New Mexico and Texas regarding Colorado's water delivery obligations under the Rio Grande Compact.[6]

The San Luis Valley case is not unique, but rather illustrative of the costs that can be incurred in defining and enforcing water rights in a complex, variable and interconnected[7] hydrologic system. Each of the theoretical perspectives discussed below provides a different approach to understanding the nature of these costs, as well as their role in the San Luis Valley case and in the evolution of institutions governing groundwater use and management in general.

GROUNDWATER AND GROUNDWATER RIGHTS

The Nature of Groundwater Resources

Groundwater is extracted from underground water-bearing geologic formations or "aquifers". Aquifers differ in their particular characteristics. For example, some aquifers have negligible rates of recharge, so that any use of water necessarily entails drawdown and higher extraction costs for all future uses. Other aquifers may recharge more rapidly, but the recharge rate may vary greatly from year to year and may be difficult or impossible to measure accurately. Pressure heads (which affect the cost of pumping) and aquifer transmissivity, which describes the ease with which water moves within the aquifer, may vary between aquifers as well as within a single aquifer. An aquifer may consist of several hydrologically interconnected layers, each with different water quality and other hydrologic properties. An aquifer may vary in thickness and its areal extent may be difficult to determine. There may be hydrologic connections to surface water bodies such that an aquifer

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5. D. McFadden, *Aspects of San Luis Valley Water in 1989, Administrative, Investigative and Litigative,* Water in the Valley: A 1989 Perspective on Water Supplies, Issues and Solutions in the San Luis Valley, Colorado (Colorado Ground-Water Association, 1989).

6. The Rio Grande Compact governs the allocation of water from the Rio Grande River among Colorado, New Mexico, and Texas.

7. Interconnections can occur between an aquifer and adjacent surface water sources or between different layers in an aquifer separated by semi-permeable strata. Pressure gradients determine the direction of movement of water within an interconnected system. Waters and Water Rights §18.02 (R. Beck ed. 1991 ed.) [hereinafter Waters].

may gain water from surface water seepage at certain points and lose water to the surface at others. Discharge from an aquifer can take the form of direct losses to evapotranspiration or contributions to stream flows, with the rates and proportions of such discharge being dependent on the water level in the aquifer and hence on aquifer pumping. In addition, high water tables and surface contact points can support wetlands.

Highly variable aquifer characteristics, as well as natural variations in recharge and discharge rates, make it difficult and costly to determine the effects of one party's use of groundwater on other users of groundwater and on interconnected surface water systems.

Groundwater Rights

Difficulties in the definition and enforcement of groundwater rights have arisen both from the "invisible" nature of the resource and from the inevitable but difficult to define linkages among groundwater users. Tarlock[8] provides this observation:

> *It is difficult to assign exclusive rights to a resource when, for physical reasons, one claimant's consumption inevitably interferes with another's legitimate consumption. A groundwater basin is not like a coal reserve which can be divided among different landowners; groundwater must be shared at all times by a large number of users. One pumper's use affects both the quantity and pressure rates available to other pumpers.*

In the early 1800s, when groundwater hydrology was viewed as a nearly unfathomable mystery, English courts established the "absolute ownership" principle by which ownership of land provided a nominally absolute right to the development of any groundwater that could be withdrawn from that land.[9] The lack of any limits on withdrawal and use of the resource meant that there was no liability for damages to other groundwater users. The English principle became the foundation of early American groundwater law.[10]

As conflicts over the consequences of the absolute ownership rule became more frequent, many American courts moved toward a "reasonable use" standard. According to that standard each overlying landowner is allowed to make reasonable use of the resource in view of the similar rights of others.[11] However, as long as the water is used on

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8. A. Tarlock, *Supplemental Groundwater Irrigation Law: From Capture to Sharing*, 73 Kentucky L. Rev. 695 (1985), at 699.
9. Waters, *supra* note 7 at §21.02.
10. *Id.*
11. *Id.*, at §23.01(b).

the overlying land in a manner deemed by the courts to be reasonable and beneficial (and not transported for use in another location), there is essentially no limitation on the quantity of water withdrawn, and water may be drained from underneath adjacent land without liability.[12] Most eastern states have adopted this general rule, as have the western states of Arizona, Nebraska and Oklahoma.[13]

Another approach based on overlying land ownership is the "correlative rights" doctrine developed by the California courts.[14] Under this doctrine "[a]ll pumpers have rights of equal dignity. There is no temporal priority among overlying pumpers, and overlying owners do not have a right to the maintenance of the natural water table."[15] However, if an aquifer is being depleted, overlying owners may be required to reduce their use on a co-equal basis.[16] If water is available in excess of the needs of the overlying landowners, it may be transported for use on non-overlying lands.[17]

Most western states apply the basic principles of prior appropriation in allocating groundwater.[18] Claimants typically acquire water rights under a permit granted by the state authority, after such authority determines that unappropriated water is available and no injury to other water users will result.[19] The permit application specifies the quantity of water to be withdrawn (and/or the maximum rate of withdrawal), the well location, and the purpose and place of use.[20] As with surface water, seniority of the right establishes priority to withdraw water in the event of shortage. However, an injured senior appropriator must usually demonstrate well-to-well interference to enforce its priority, and will not be protected in the use of an "inefficient" means of diversion.[21] Appropriation rights are better defined than other types of

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12. *Id.*

13. D. Aiken, *Nebraska Ground Water Law and Administration*, 59 Nebraska L. Rev 917 (1980).

14. Waters, *supra* note 7 at §22.02(a).

15. A. Tarlock, Law of Water Rights and Resources (1989), at 4-16.

16. T. Anderson, O. Burt & D. Fractor, *Privatizing Groundwater Basins: A Model and Its Applications*, in Water Crisis: Ending the Policy Drought (T. Anderson ed, the Johns Hopkins University Press, 1983).

17. *Id.*

18. Tarlock states that Idaho, Kansas, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming apply prior appropriation principles to groundwater, *supra* note 15, at 6-3. Colorado applies prior appropriation rules to "tributary" groundwater.

19. See, *e.g.*, Alaska Stat. §46.15.065.

20. Waters, *supra* note 7 at §24.02(b)(1).

21. Tarlock, *supra* note 15 at §6.04 (3).

groundwater rights but they, too, fall well short of setting out clear guidelines for sorting out conflicts among competing uses.

Inadequate management of groundwater pumping under general rules has led many states to authorize the use of special management areas in which a state or management area authority establishes special rules. Depending on the state, groundwater development in these areas may be subject to permit requirements, well spacing requirements, well construction standards, allocation preferences, limited pumping rates, restriction on place of use, water use monitoring and reporting, and other similar requirements.[22]

Historically, the law of surface water and groundwater developed separately. Colorado is one of the few states to statutorily recognize the hydrologic connection between groundwater and surface water and the only state to define rights to develop certain groundwater dependent on the effect on surface water.[23] Aquifers containing "tributary" groundwater discharge to surface streams that support surface water diversion rights.[24] Tributary groundwater is thus hydrologically interconnected with surface water. Therefore, the State Engineer must administer rights to tributary groundwater so as to prevent injury to senior rights to surface water and groundwater.[25] In contrast, "nontributary" groundwater is available for development by the overlying landowner under a separate legal system. To qualify as nontributary groundwater, withdrawal of the water over a 100-year period must not cause an annual depletion to a natural stream of more than 1/10 of one percent of its annual rate of withdrawal.[26] Since there is often a considerable time-lag between the use of groundwater and its effect on a surface stream, the law directs the State Engineer to restrict pumping of tributary groundwater only where such a restriction will avoid actual injury to senior surface rights.[27]

THEORETICAL PERSPECTIVES

The Optimal Control Perspective

Economists have devoted considerable attention to the potential effects of different property rights regimes on the allocation of

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22. J. Bowman, *Groundwater Management Areas in the United States*, 116 J. Water Res. Planning & Management 484 (1990)

23. Colorado Revised Statutes §37-92-102(a) & 103(11); §37-90-103(10.5) (1990)

24. Waters, *supra* note 7 at §20.05.

25. Tarlock, *supra* note 15 at §6.06 (1)(a).

26. Colorado Revised Statutes §37-90-103(10.5) (1990).

27. L. MacDonnell, *Colorado's Law of "Underground Water": A Look at the South Platte Basin and Beyond*, 59 Univ. Colorado L. Rev. 579 (1988).

groundwater.[28] Much of this literature has relied on "optimal control" modeling[29] to define the allocation of groundwater use over time that would maximize the net present value of the resource. This literature identifies circumstances under which the actual time-path of water extraction from both recharging and non-recharging aquifers will diverge from that considered to be economically optimal. In general, it suggests the possibility of faster than optimal depletion where individual water rights are inadequately delimited.[30]

This literature has made valuable contributions to clarifying the nature of the problems posed by uncontrolled access to a common aquifer and to identifying necessary elements for the efficient operation of a regime of privatized groundwater rights. For example, Gisser and Sanchez[31] showed that the practical significance of the problem of faster than optimal depletion depends upon the size of the aquifer relative to demand for the water. They found that there may be no appreciable difference between competitive (no-control) and "optimally controlled"[32] rates of pumping where the aquifer is large relative to demand which, in turn, is limited either by a restrictive definition of rights, or by the high cost of transporting the water for use elsewhere. Gisser[33] used this finding to argue that quantified individual rights defined on the basis of consumptive use, as is the case in parts of New Mexico[34], can come close to achieving an optimal time-path of water use, particularly in aquifers where natural recharge and discharge are negligible. He notes, however, that some groundwater rights may eventually have to be retired in order to achieve an efficient steady-state or safe-yield in a recharging aquifer.

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28. For example, see E. Bagley, *Water Rights Law and Public Policies Relating to Ground Water 'Mining' in the Southwestern States,* 4 J. Law & Economics 144 (1961); O. Burt, *Economic Control of Groundwater Reserves,* 48 J. Farm Economics 632 (1966); G. Brown, *An Optimal Program for Managing Common Property Resources with Congestion Externalities,* 82 J. Political Economy 163 (1974); V. Smith, *Water Deeds: A Proposed Solution to the Water Valuation Problem,* 26 Arizona Rev. 7 (1977); M. Gisser, *Groundwater: Focusing on the Real Issue,* 91 J. Political Economy 1001 (1983); supra note 16.

29. For a general exposition of optimal control models see M. Intriligator, *Mathematical Optimization and Economic Theory* (Prentice-Hall, 1971).

30. See, e.g., Burt, *supra* note 28.

31. M. Gisser & D. Sanchez, *Competition versus Optimal Control in Groundwater Pumping,* 4 Water Resources Research 638 (1980).

32. An optimal control model involves determining the optimal time-path of extraction that will maximize the net present value of the use of a dynamic resource. For a renewable resource such as a recharging aquifer, the optimal rate of extraction ultimately converges to a steady state where the rate of inflow (both natural and return flow) equals the rate of natural outflow plus extractions.

33. Gisser, *supra* note 28.

34. *Id.* at 1012-1015.

The type of quantification considered by Gisser is simply a limitation on annual consumptive use without explicit assignment of rights to the actual stock of water in the aquifer. Gisser notes that under such a regime, there is no assurance that aggregate demand has been fixed at an optimal level. In particular, he notes the possibility that the net present value of the resource might be increased by allowing an entrant to establish a new groundwater right rather than being required to purchase an existing right. Because the new user would increase the aggregate demand, the rate of drawdown would accelerate. This would impose increased costs on all prior users. However, if the net present value of the new use exceeded the costs imposed on prior users, the gains to the newcomer would be sufficiently large to allow potential compensation to existing users. Gisser proposes allowing existing holders of quantified groundwater rights to bargain with potential new users to establish a mutually acceptable entry fee to be paid to the existing users. Such a system would foster movement toward an optimal aggregate level of demand. He argues that if such a system were ever established, conservancy districts could act as bargaining agents for existing users.[35] In addition, if drawdown is already perceived to be too rapid, these districts could adjust the level of aggregate demand downward by making assessments for the purpose of purchasing existing groundwater rights for retirement.[36]

Others have carried the idea of quantified individual groundwater rights further. Smith[37] proposed that individual rights could be defined as being composed of two components: a proportion of the long-run average net natural recharge and a share of the total recoverable volume of water in the aquifer.[38] Shares might be determined either on the basis of use during some base period or on the basis of ownership of land overlying the aquifer. Individual pumping would then be metered and the individual's stock would be adjusted annually by subtracting the amount used and by adding the appropriate share of estimated net natural recharge, which would vary from year to year.

Anderson et al.[39] noted that Smith's proposal would eliminate externalities, specifically the problem of premature depletion, only in a very simple aquifer where pumping costs are zero (regardless of the volume of water in storage) and where the aquifer has smooth sides and a flat bottom so that it is as thick at its perimeter as it is at the center.

35. *Id.* at 1018.
36. *Id.* at 1022.
37. Smith, *supra* note 28.
38. *Id.* at 8.
39. Anderson et al., *supra* note 16.

They argue that a more realistic depiction of an aquifer would include pumping costs that increase with aggregate use.[40] The aquifer is also likely to be thicker in the middle so that as the aquifer is drawn down, individuals located at the perimeter may lose access to the stock of water regardless of their own conservation efforts.[41] Given these complications, they argue that the stock portion of individual rights should be calculated by first estimating the ultimate steady-state level of the stock of groundwater, _*, from an optimal control model and then assigning stock rights only to the difference between _* and the current stock, assuming that the latter is larger. While they acknowledge that such a quantification scheme would not be perfect, in that it would not eliminate such problems as the effects of pumping on the rights of parties at the perimeter of the aquifer, they argue that it would greatly reduce the problem of over-extraction. They also argue that by placing decisions in private hands, the proposed system would reduce information requirements relative to any attempt by a centralized bureaucracy to impose optimal-control management.[42]

In addition to these proposed benefits, the proponents of fully quantified individual groundwater rights argue that the transfer of water to more highly valued uses would be facilitated by quantification, particularly where rights are defined on the basis of consumptive use. They argue that such clear quantification would largely eliminate the adverse hydrologic effects of transfers on other rights.[43]

Among the insights that can be gained from this literature is the point that where demand is large and/or growing relative to the size of the resource, some form of exclusivity or limitation on aggregate withdrawals is likely to be required to prevent depletion at a rate faster than would be considered optimal by the current generation of users. In addition, Gisser[44] notes that the preferences of the current generation regarding the optimal rate of depletion may not adequately reflect the interests of future generations. Although he does not develop this suggestion, it implies that full privatization may not be socially optimal and that some reservation of groundwater stocks for future use may be desirable.

The work of Anderson and his co-authors suggests that in order to quantify individual groundwater rights in a manner that would eliminate most externalities, reliable information would be required on net natural recharge, the stock of water in place, the effects of changes in

40. *Id.* at 240.
41. *Id.*
42. *Id.* at 241.
43. Gisser, *supra* note 28 at 1012-1015; Anderson et al., *supra* note 16 at 238.
44. Gisser, *supra* note 28.

the groundwater stock on pumping costs and rates of return flow from alternate uses. In addition, to estimate x*, the optimal stock of groundwater at steady state, for the purpose of determining the portion of the total stock that should be privatized, regulators would need to accurately estimate current and future demand for the water, although Anderson et al. argue that adjustments could be made later as better information becomes available. It should be noted that information on each of these elements may be difficult and costly to obtain. Nevertheless, Anderson et al. assert that "... where water is scarce, these costs are not likely to be the constraints on efficient property rights."[45] However, they provide little empirical support for that assertion. The literature based on optimal control theory generally does not directly consider the costs of gathering physical data and market information nor other transaction costs in the evaluation of the various quantification proposals. Thus, while this literature emphasizes the benefits of carefully defining groundwater rights, less attention has been given to the question of how such a system might be established and to the costs that might be encountered in the process.

The Transaction Cost Perspective

Recent theoretical work on the nature of property rights makes the cost of information and other transaction costs an explicit part of the analysis. This emerging field of economic thought focuses on the costs of defining, exercising and enforcing property rights in the presence of continuous competition to capture the stream of benefits that can be generated by valuable assets such as scarce natural resources.[46] This literature suggests that fully exclusive private property rights are much rarer than is commonly supposed. Barzel, for example, argues that it is important to recognize that property rights are not absolute nor are they determined exclusively by law, since:

> [t]he rights people have over assets (including themselves and other people) are not constant; they are a function of their own direct efforts at protection, of other people's capture attempts and of government protection.... rights are never complete,

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45. Anderson et al., *supra* note 16 at 236.

46. *See*, for example, R. Coase, *The Problem of Social Cost*, 3 J. Law & Economics 1 (1960); A. Alchian, *Some Economics of Property Rights*, 30 II Politico 816 (1965); S. Cheung, *The Structure of a Contract and the Theory of a Non-Exclusive Resource*, 13 J. Law & Economics 49 (1970); O. Williamson, The Economic Institutions of Capitalism (The Free Press, 1985); Y. Barzel, Economic Analysis of Property Rights (Cambridge University Press, 1989); T. Eggertsson, Economic Behavior and Institutions (Cambridge University Press, 1990); D Allen, *What Are Transaction Costs?*, 14 Research in Law & Economics 1 (1991).

because people will never find it worthwhile to gain the entire potential of 'their' assets.[47]

Assets can be seen as having multiple dimensions, the rights to which may be owned by different parties. In addition, since the cost of defining and enforcing rights will vary from one dimension of an asset to the next, rights with respect to one dimension may be more securely defined and enforced than rights to other dimensions of the same asset. The dimensions of an asset that are not effectively defended as private property lie in the public domain, and their value is vulnerable to capture by parties other than the nominal owner.

Proponents of this theoretical perspective view property rights as molded by transaction costs which are defined as the costs of capturing, enforcing and transferring such rights. Where measurement is costly and where the value that an individual can derive from an asset is affected both by natural variability and by the actions of other individuals, the enforcement of exclusive individual rights becomes especially difficult. In such circumstances, competing efforts to capture the potential value of a resource may tend to dissipate that value.[48]

The creation of rules of access and enforcement mechanisms can reduce this dissipation. Therefore, a question of central interest to the "transaction cost" theorists is: under what circumstances will self-interested individuals cooperate to create such rules and mechanisms? The transaction cost approach suggests that as the potential value of a resource increases, there will be increased efforts to capture the value of certain dimensions of the resource to which property rights are not already clearly defined and enforced. Where these efforts lead depends upon how costly it is to organize to alter rules of access and to enforce them, and whether or not any party has a comparative advantage in exerting control over the resource. If such an advantage exists, its possessor may become the effective owner of the resource.[49] In the absence of such a "natural" owner, increased dissipation of value can be expected where the costs of organization, rulemaking and enforcement are prohibitive. Conversely, more carefully delineated rules of access can be expected where such actions are not prohibitively costly. A change in circumstances, such as a change in political system or an improvement in measurement technology, can change the relative likelihood of these alternate outcomes.[50]

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47. Barzel, *supra* note 46 at 2.
48. Barzel, *supra* note 46 at 5-6.
49. *Id.* at 6.
50. *Id.* at 114.

Groundwater resources fit the description of a resource for which it is difficult to define and enforce individual rights. The amount of water available and the pressure head fluctuate with both naturally varying conditions and with use, and it is often costly to measure the relative magnitude of these influences. Thus, the transaction cost perspective would predict that as demand for groundwater increases, greater efforts will likely be made to more carefully delineate individual rights, but this may also be coupled with efforts to increase joint or central decision-making authority over some aspects of the aquifer's use as a means of economizing on measurement and enforcement costs.[51]

The Ostrom Perspective

Elinor Ostrom's work on the governance of common property resources[52] is closely related to the transaction cost approach. Ostrom addresses the questions of how and under what circumstances parties making use of a common property resource will cooperate to devise and enforce rules of access in order to avoid "the tragedy of the commons."

Ostrom begins by noting that much previous theoretical work has concluded that only privatization or central governmental control could eliminate tendencies toward overexploitation and depletion of resources held in common. She argues that contrary to the predictions of simple game-theoretic models, there are many empirical examples of stable and well-functioning systems for the self-governance of commonly owned resources. She notes, however, that such success stories are by no means universal. The question of interest thus becomes: what accounts for the difference? Why does effective self-governance arise in some situations but not in others?

Ostrom takes an empirical approach to addressing this issue. Her analysis is confined to small scale resource systems generating a flow of resource units extracted by multiple appropriators, where each individual's use reduces the availability of resource units to others.[53] She defines such a system as a "common property resource" (CPR) if the users maintain joint access rather than partitioning the resource into discrete privatized holdings.[54] She argues that joint access is likely in

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51. *Id.* at 72.

52. E. Ostrom, Governing the Commons: The Evolution of Institutions for Collective Action (Cambridge University Press, 1990).

53. *Id.* at 31.

54. Note that the transaction cost perspective, as outlined above, implies that there may not be a black-and-white distinction between private property and common property. Nominally private assets may have some dimensions from which other parties cannot be excluded and others for which substantial costs may be undertaken to maintain exclusive control. Ostrom (*Id.*) also notes that resource units, once extracted from a CPR, are likely to

circumstances where the resource is large and indivisible and/or where the costs of excluding appropriators from its use or from enjoying the benefits of system improvements are high relative to the value of the flow of resource units that the system may be capable of generating.[55] She notes that a CPR may be either a natural system such as a fishery or a forest or a produced system such as a system of irrigation canals and diversion works.

Ostrom compares actual cases in which local self-governance is (a) robust and well-functioning, (b) functioning but fragile, or (c) non-existent despite evidence of significant resource damage as a result of uncontrolled access. This comparison leads Ostrom to conclude that a variety of factors affect a local community's ability to achieve effective joint governance of a CPR. She finds the broad institutional setting within which the local community operates to be important, particularly whether or not higher levels of government recognize the authority of the local community to engage in self-regulation of their resource use. Her analysis thus tends to focus on the importance of the rules that govern how collective decisions are made. She argues that the relative success of efforts to manage CPRs hinges on the ability of the collective decisionmaking process to devise operational rules appropriate to particular circumstances and to respond as those circumstances change.

Other important factors include the nature of the resource itself, the level of demand for resource units, the homogeneity of the community of appropriators and the strength of their ties to the locality. She argues that where there are enduring patterns of mutual interdependence on multiple levels, individuals may internalize an aversion to cheating on the rules governing use of the CPR. This would tend to reduce costs of monitoring and enforcement.

Ostrom argues that the process of institutional change may best be understood as driven by changes in such factors, since they affect the expected benefits and costs of alternative sets of rules governing the use of a CPR. She notes, for example, cases in which rules that once adequately restricted use of a CPR broke down when a central regime withdrew support for the local rules or where there was a sudden increase in the market value of resource units or an influx of appropriators from outside the local community.[56] Elements found by Ostrom to be common to the robust self-governing institutions include the effective exclusion of outsiders, rules tailored to specific localized conditions, and the presence of conflict resolution mechanisms. Ostrom

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be treated as the private property of the appropriators.

55. *Id.* at 30-32.

56. *Id.* at 149-167, 173-178.

also argues that the flexibility of resource-governing institutions to deal with new opportunities and problems as they arise is particularly important for the long-term sustainability of a CPR.

Ostrom emphasizes the importance of costly and incomplete information. She notes that particular institutional choices such as strict limitations on the time of use or requiring all resource units to be marketed at a central point can reduce the cost of acquiring information about the state of the resource as well as economize on the cost of monitoring the actions of the users and enforcing rules of access.

Among the "robust" cases examined by Ostrom are some aquifers in southern California. She found that despite considerable heterogeneity of interests among the groundwater users, locally negotiated water-rights settlements in the Raymond, West and Central Basins near Los Angeles had succeeded in stabilizing those aquifers and preventing further saltwater intrusion. These settlements were reached by locally driven, incremental processes that were promoted by a supportive political environment. The settlements involved quantifying the rights of the appropriators on the basis of agreed proportional cutbacks relative to their previous use. Once quantified, these rights became transferable, and active water markets now exist in these basins. However, Ostrom argues that this system is not equivalent to full "privatization" because: "[n]o one 'owns' the basins themselves. The basins are managed by a polycentric set of limited-purpose governmental enterprises whose governance includes active participation by private water companies and voluntary producer associations. This system is neither centrally owned nor centrally regulated."[57] Active recharge programs are among the activities that are collectively managed in these basins.

Summary and Implications

Each of the perspectives discussed above emphasizes slightly different aspects of the relationship between groundwater allocation and property rights. In general, proponents of all three perspectives appear to agree that an increase in demand for groundwater from the entry of new users may impose additional costs on existing users. The ability of existing users to prevent the imposition of these costs depends upon the definition and enforcement of their rights. Furthermore, advocates of each perspective acknowledge that the difficult problems of groundwater management stem from the inherent hydrologic interdependencies between groundwater users. That is, if the water underlying one individual's property is hydraulically connected to the water underlying the property of other parties, each party's use may affect the availability

57. *Id.* at 136.

of water to others. Such impacts may include a decrease in water table elevations, ranging from a few inches to several feet, and/or a change in water quality.

The perspectives differ in their assessment of the importance of transaction costs. Anderson and his co-authors explicitly argue that too much attention has been given to the possible importance of transaction costs as a source of groundwater conflicts and that these costs should not bar effective privatization in water-scarce areas.[58] Other proponents of privatization from the optimal control perspective also appear to believe that transaction costs will not be important, as these researchers do not explicitly incorporate such costs in their analyses. If this is correct, it implies that the privatization schemes they envision will readily be adopted whenever water becomes sufficiently scarce and valuable. However, proponents of privatization working from the optimal control perspective argue that major institutional barriers to privatization exist, but they do not explicitly identify these as arising from transaction costs. Thus, costly disputes and dissipation of the value of the resource can occur within their framework, but they are seen as the result of inadequate institutions. As such, these problems may be resolved by policy changes, and therefore much of this optimal control-based literature is aimed at proposing such changes.

The other two perspectives summarized above emphasize the likely importance of transaction costs for groundwater allocation, particularly where the resource is complex and subject to natural variability. In cases where the costs of better defining individual rights are high, both the transaction cost perspective and the work of Ostrom suggest that costly disputes and increased dissipation of value are likely to occur as demand for a jointly-used resource increases. Both of these approaches are somewhat less sanguine than the optimal control perspective about the possibility of easy policy solutions, although Ostrom attempts to identify the characteristics of successful strategies for the management of CPRs, with the apparent goal of providing policy guidance.

To theorists adhering to the transaction cost perspective, the problems of costly disputes and value dissipation are likely to be viewed as part of the natural evolution of property rights as demand for the resource increases over time. An implication of this theoretical work is that when the potential value of a resource increases, greater efforts will

58. Anderson et al., *supra* note 16 at 236. However, Anderson argues that transaction costs may have significant impacts on water allocation in other situations. *See* for example, T. Anderson & R. Johnson, *The Problem of Instream Flows*, 24 Economic Inquiry 535 (1986); T. Anderson, *Introduction: The Water Crisis and the New Resource Economics*, in Water Rights: Scarce Resource Allocation, Bureaucracy, and the Environment (T. Anderson ed, 1983).

be devoted to attempting to capture that value. Not only may parties who have not previously made use of the resource attempt to assert a claim, but existing users can be expected to increase their efforts to protect their own rights. The policy recommendations derived from the transaction cost literature would therefore likely focus on devising ways to economize on costs generated by this competitive process.

The transaction cost perspective emphasizes the potential costliness of acquiring information about the nature of a resource and about the effects of one party's actions on others. Therefore, aquifer variability is particularly important to transaction cost theorists, as measurement and enforcement costs tend to increase with such variability.

Ostrom's perspective also emphasizes the importance of transaction costs and the effects of resource variability on those costs. In her analysis, resource variability and uncertainty about the state of the resource create problems regardless of the particular rules in place governing its use. Ostrom finds that the operational rules currently in place may be less important to the long-term viability of a CPR than the ability of users to (1) effectively monitor the resource, (2) gather information about its use and sensitivities, and (3) alter the rules governing use in response to new information.

Ostrom suggests that the identity of the players is also important, since personal trust and mutual interdependence within a cohesive community may lower the cost of enforcing individual rights to a shared resource. This argument implies that where these elements are missing, costly disputes are more likely.

AWDI AND THE SAN LUIS VALLEY

This section describes the sources and evolution of an ongoing conflict over the groundwater resources of the San Luis Valley. Each of the perspectives described above contributes to an understanding of this conflict. However, since much of the conflict revolves around disagreements over hydrologic "facts", and since it is costly to obtain the data necessary to resolve such disagreements, the perspectives that emphasize the importance of transaction costs are particularly relevant.

In 1986, AWDI filed its plan to drill wells into a deep aquifer underlying the company's extensive landholdings in the San Luis Valley of southern Colorado, and to export groundwater to growing cities along the dry eastern slope of Colorado's Rocky Mountains (the Colorado Front Range). These plans for AWDI's "Baca Project" were encouraged by AWDI's expectations that urban water agencies would purchase this water at a price that would make the project a profitable venture. Forecasts of rapid population growth in the Denver metropolitan area and in other Front Range cities, and increasing environmental constraints on the development of new surface water reservoirs,[59] undoubtedly enhanced the investors' profit expectations. AWDI based its application for the necessary water rights on hydrologic studies suggesting that the water-bearing formations underlying the Valley contain an enormous volume of water scarcely tapped by present groundwater users.[60]

The aquifer system in the San Luis Valley is multilayered (Figure 2). A shallow "unconfined" aquifer receives substantial recharge from surface streams and return flow from the Valley's surface water irrigation system.[61] This aquifer has also been heavily tapped for irrigation, particularly on the western side of the Valley, where its level appears to be closely connected to the flow of the Rio Grande.[62] The extreme seasonality of streamflows and the relative lack of surface water reservoirs on the Upper Rio Grande system historically resulted in substantial reliance on sub-irrigation techniques.[63] This involved heavy applications of surface water on irrigated land when it was available in the spring to raise the water table into the root zone.[64] Over the years, sub-irrigation with surface water has increasingly been supplemented with and replaced by irrigation from wells, allowing larger crop acreages to be carried through the late summer when surface water is unavailable.[65] Now, some of the Valley's irrigation districts and ditch companies encourage their members to divert their surface water into recharge pits when it is unneeded for their crops in order to recharge the unconfined aquifer and maintain a high water table.[66] Conjunctive use of variable surface water supplies and closely interconnected groundwater is thus a significant feature of the current water-use regime in the Valley. The widely used system of sub-irrigation supplemented with groundwater use is sensitive to climatic variability. When coupled with

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59. S. Rhodes, K. Miller & L. MacDonnell, *Institutional Response to Climate Change: Water Provider Organizations in the Denver Metropolitan Region*, 28 Water Resources Research 11 (1992).

60. AWDI, The Baca Project: Background and Technical Consultants (American Water Development, Inc., 1991).

61. W. Powell, Ground-Water Resources of the San Luis Valley, Colorado (Geological Survey Water-Supply Paper 1379, U.S. Department of the Interior, 1958), at 61-70.

62. *Id.* at 56, 69-70.

63. J. Helgren, S. Smolnik and E. Richardson, *Artificial Recharge in the Alamosa-La Jara Irrigation System*, Water in the Valley: A 1989 Perspective on Water Supplies, Issues and Solutions in the San Luis Valley, Colorado (Colorado Ground-Water Association, 1989), at 146-149.

64. McFadden, *supra* note 5 at 111-112; Powell, *supra* note 61 at 45.

65. G. Hearne & J. Dewey, Hydrologic Analysis of the Rio Grande Basin North of Embudo, New Mexico, Colorado and New Mexico (Water Resources Investigations Report 86-4113, U.S. Geological Survey, 1988).

66. Personal communication, David Robbins, counsel for Rio Grande Water Conservation District, 29 January 1992.

the pattern of restricting surface water use to meet interstate compact obligations, variable runoff leads to interannual variability in the use of groundwater, in recharge rates and in the level of the water table in the unconfined aquifer.

A series of blue clay layers separates the unconfined aquifer from a deeper "confined" aquifer, which consists of several layers, each at least partially separated from the others by confining beds.[67] There are numerous small domestic and stock-water wells and some large capacity irrigation wells in the confined aquifer, many of which are under sufficient artesian pressure to flow to the surface.[68] There are hydrologic connections between the shallow and deep aquifers, although the extent of these connections is subject to dispute.

Only part of this aquifer system is thought to be hydrologically connected to the Rio Grande River.[69] Near Crestone, there is an area referred to as the "Closed Basin" where surface streams and the unconfined aquifer are hydrologically separated from the Rio Grande Basin by a surface divide and a subsurface barrier. The latter takes the form of a pressure gradient that may be an artifact of the long history of irrigation with surface water on the alluvial fan of the Rio Grande.[70] While irrigation ditches bring water from the Rio Grande[71] into the Closed Basin, there is currently no significant return flow to the Rio Grande. Instead, the only discharge from the Closed Basin occurs through evapotranspiration from crops and natural vegetation and evaporation from soil and water surfaces.[72]

During the late 19th and early 20th centuries, drainage water from surface water irrigation operations, as well as upward leakage from numerous uncased wells penetrating the deep artesian aquifer, caused the water table in the Closed Basin area to rise to such an extent that much of the land in the area became waterlogged or salinized, and thus unsuitable for agriculture.[73] Furthermore, some of the lakes and extensive wetlands in the area were created and are now maintained by the contribution of irrigation return flow to the high water table.[74] AWDI has proposed to drill its wells into the deep aquifer in the Closed Basin area.

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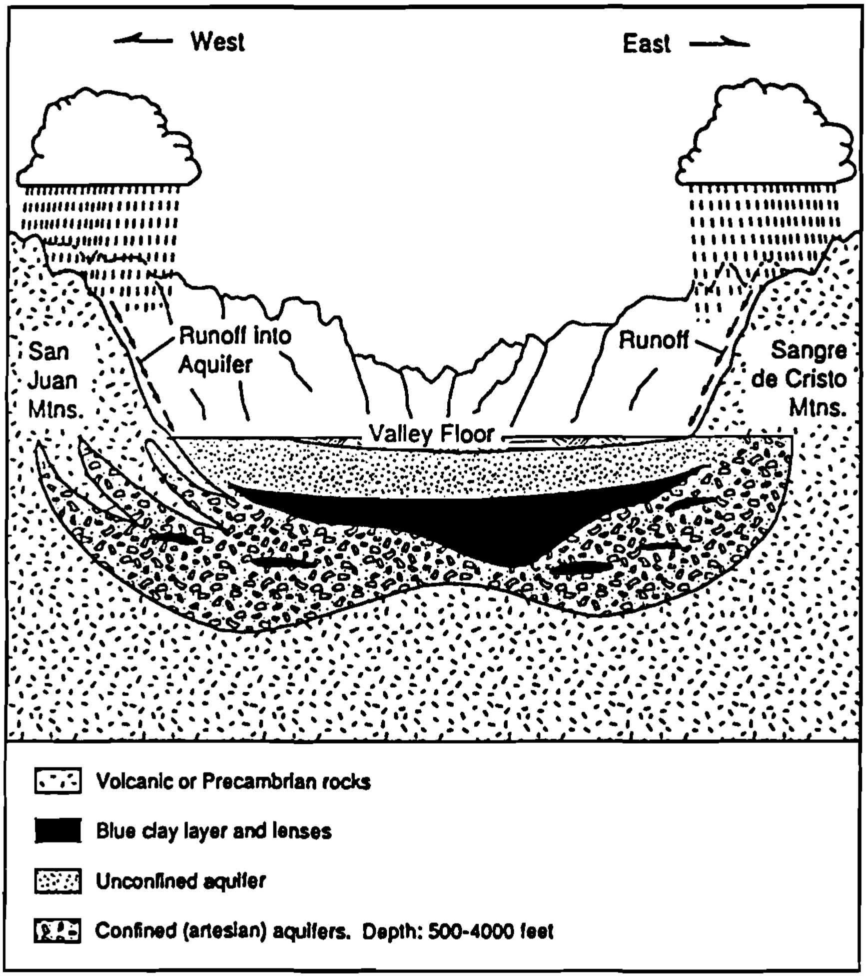
67. Hearne and Dewey, *supra* note 65.
68. Hearne and Dewey, *supra* note 65 at 81; Powell *supra* note 61 at 25-29.
69. Hearne and Dewey, *supra* note 65 at 42.
70. *Id.* at 42.
71. *Id.* at 42.
72. *Id.* at 43.
73. Powell, *supra* note 61 at 56-57.
74. McFadden, *supra* note 5 at 112.

CROSS SECTION OF SAN LUIS VALLEY



The groundwater resources of the San Luis Valley have long been recognized as valuable. Before the turn of the century, more than 2,000 artesian wells had been developed in the Valley.[75] A major drought in the 1950s prompted another wave of groundwater development, primarily involving large-capacity wells drawing water for irrigation from the confined aquifer.[76] At that time there was no state regulation of groundwater development.

In 1957, the Colorado legislature required that permits for new wells be obtained from the state engineer.[77] In 1965, the legislature directed the State Engineer to administer rights to tributary groundwater within the surface water priority system.[78] In response to a Colorado Supreme Court decision requiring demonstration of material injury to senior surface water rights before the state engineer can regulate tributary groundwater rights,[79] the legislature included several provisions in the 1969 Water Right Determination and Administration Act[80] aimed at promoting groundwater uses that will cause no injury to senior surface water rights.[81]

Armed with this new authority, the state engineer in 1972 stopped issuing permits for new appropriations from the San Luis Valley confined aquifer in order to help ensure compliance with the Rio Grande Compact.[82] A series of low-water years in the 1950s and the effects of a subsequent rapid increase in groundwater use caused Colorado to violate its delivery obligations under the Rio Grande Compact.[83] In 1966, Texas and New Mexico brought suit against Colorado in the U.S. Supreme Court for the accumulated underdelivery of 944,000 acre-feet. This resulted in a stipulated agreement in 1968 by which Colorado committed to curtail water uses as necessary to achieve its delivery obligation.[84] As a result, the state engineer began limiting surface water diversions from the Rio Grande and its tributaries. Believing that groundwater withdrawals from both the confined and unconfined aquifers affected flows in the Rio Grande, the State Engineer also developed proposed rules in 1975 calling for a phasing out of the large-capacity wells in the San Luis Valley

75. Alamosa La Jara Water Users Protection Association v. Gould, 674 P.2d 914 (Colo. 1983).

76. Hearne and Dewey, *supra* note 65 at 74, 76-77.

77. Ground Water Law of 1957, 1957 Colo. Sess. Laws, ch. 289 §5.

78. Act of May 3, 1965, 1965 Colo. Sess. Laws, ch. 318, §1.

79. Fellhauer v. People, 167 320, 447 P.2d 986 (Colo. 1968).

80. Colorado Revised Statutes, §37-92-101 *et seq.* (1990).

81. MacDonnell, *supra* note 27 at 588.

82. Rio Grande Compact, P.L. No. 96, 53 Stat. 785 (1939); Colo. Rev. Stat. §37-66-101 (1990).

83. McFadden, *supra* note 5.

84. Texas v. Colorado, 391 U.S. 901 (1968).

over a five-year period, unless these wells could be operated without injury to senior surface rights. While the Colorado Supreme Court eventually upheld these regulations with some modifications in 1983,[85] the state engineer has never implemented them.

AWDI filed its application for water rights with the Division 3 Water Court in Alamosa on 31 December 1986.[86] It initially proposed to withdraw 200,000 acre-feet of water annually from 112 large-capacity wells located on lands that it owns within the Closed Basin. The proposed uses of the water included irrigation in the Valley, as well as municipal, industrial and other uses outside the basin.[87]

AWDI based its claim for water on four separate legal theories. One was that its water rights arose from Spanish and Mexican law because the Baca Ranch, which it owns, derived from a Spanish land grant.[88] If so, then AWDI would have the right to absolute and undiminished use of all groundwater that it could develop with wells located on the ranch. Another claim stated that an act of Congress in 1860 which authorized the selection of the Baca Ranch as replacement for lands granted under Mexican law in New Mexico removed this land from public domain status and thus gave its owner an absolute right to the underlying groundwater. The Water Court dismissed these claims in 1990.

In addition, AWDI argued in the alternative that its claims should be supported on the basis of appropriation as tributary groundwater, or by virtue of its overlying land ownership as nontributary groundwater. In an amended application filed in 1990, AWDI added an additional basis that included the implementation of measures necessary to offset any injury associated with its development of tributary groundwater. However, AWDI withdrew its tributary groundwater claims at a conference immediately preceding the trial in 1991. Thus, the trial focused specifically on the claim for nontributary groundwater, which requires AWDI to show that the groundwater it proposes to extract is so remotely connected to surface water that its development would have only a negligible effect on surface flows in a 100-year period of withdrawals.

In 1990, AWDI amended its application in several respects. First, it increased the number of wells from 112 to 132. It continued its ultimate claim to withdraw 200,000 acre-feet of water per year, but proposed a Phase I during which withdrawals would be limited to 60,000 acre-feet

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85. *See supra* note 77.

86. AWDI, *Concerning the Application for Water Rights of: American Water Development, Inc., the Baca Ranch Company, the Baca Corporation, in Saguache County* (District Court, Water Division 3, Alamosa, Colorado, Case 86CW46, 1986).

87. *Id.*

88. *See supra* note 75 for material in this and the following two paragraphs.

per year. Approximately half of that water would be used to irrigate 10,000 acres of land in the San Luis Valley. The other 30,000 acre-feet would be exported to cities along the Front Range of Colorado.

At the time of trial, approximately 80 individuals, water-user organizations, and state and federal agencies had entered this suit as objectors. Colorado law requires owners of water rights to take an active role in protecting their rights against possible injury from prospective new developments and from the transfer of existing rights to new uses.[89] The party proposing the new development or the changed use carries the burden of proving non-injury,[90] but objectors nonetheless must present evidence of injury if they wish to protect their rights.

The central dispute at the six-week trial in the fall of 1991 was whether AWDI's proposed groundwater withdrawals would deplete flows in any of the surface streams in the Valley. AWDI argued that the streams in the Closed Basin are not hydrologically connected to any underlying aquifer. In support of its application, AWDI argued that the vast quantities of water available and the structure of the underlying geologic formations would assure that its groundwater withdrawals would not affect surface flows.[91] In particular, it argued that major faulting in the deeper formations causes water to move vertically rather than horizontally.[92] Its pumping would tend to draw water from above and below, rather than laterally. Moreover, AWDI argued that while surface streams in the Closed Basin lose water to the unconfined aquifer, the groundwater is neither a source of recharge to any stream, nor do changes in its level affect stream losses. However, in its opinion issued 10 February 1992, the Division 3 Water Court found that the groundwater proposed for development by AWDI was tributary, since its withdrawal would deplete the flow of natural streams within the San Luis Valley at a rate considerably greater than one-tenth of one percent of the annual rate of withdrawal. The Court rejected the argument that faulting would diminish the effects of the pumping on the adjacent waters. It also made specific, factual findings that surface streams in the Closed Basin area are hydrologically connected to the underlying groundwater. In addition, the Court found that the groundwater in the unconfined aquifer should be considered part of the "natural stream" that may not be affected by nontributary groundwater development.

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89. Colo. Rev. Stat. §37-92-302 (1)(b).

90. Colo. Rev. Stat. §37-92-305 (3); *Application for Water Rights of Cities of Aurora and Colorado Springs, In Eagle, Lake and Pitkin Counties* 799 P.2d 33, 37 (Colo. 1990).

91. AWDI, *supra* note 60.

92. J. Hill, *The AWDI Trial: Brogden Describes 'Vertical Gradient'*, Valley Courier (18 October 1991).

Underlying the AWDI case were fundamental differences of opinion about the nature of the Valley's hydrology and the effects of climatic variability on recharge and about the ability of the system to support groundwater exports on the scale proposed by AWDI. Hydrologic modeling of the system is a relatively recent endeavor, and much uncertainty remains about the nature of the confined aquifer, its hydrologic connections to the overlying unconfined aquifer and surface waters (including the Rio Grande), its sources of recharge and their interannual variability. Uncertainty and disagreement also remain about the potential impact of the proposed project on the Valley's wetlands as well as the role of the confined aquifer in maintaining the geological stability of the nearby Great Sand Dunes National Monument.

The fact that the hydrology of the system is complicated and poorly understood suggests that the cost of measuring the true impacts of AWDI's water withdrawals on natural ecosystems and on other water users is not trivial. The measurement problem is further complicated by the variability of recharge to and discharge from the system. Interannual variations in precipitation and in the use of surface water and groundwater in the Valley cause fluctuations in the level of the water table in the unconfined aquifer as well as in the artesian pressure of the confined aquifer, although these changes are never uniform across the Valley. Presumably, fluctuations in the Valley's aquifer system, outside of the Closed Basin, will eventually affect the flow of the Rio Grande River.

Farmers in the Valley argue that the difficulty of determining the source of variability in the hydrologic system would be the biggest impediment to AWDI's proposed compensation scheme. As Melvin Getz, the Secretary-Treasurer of the Rio Grande Water Users Association, argues:

> *... if an artesian well, located on my ranch 50 miles from the project area quits flowing five years after AWDI starts pumping the aquifer, is it due to their pumping or the drought? Who will decide? Will a computer model, whose output is varied by an operator's assumptions, make the decision?*[93]

Holders of vested water rights are not the only interests that can potentially be damaged by the AWDI project. Local business owners and residents of the Valley's small towns as well as several environmental groups were among the most vocal opponents to the project. The business owners and townspeople apparently believe that the export of

93. M. Getz, *San Luis Valley Showdown: A Local Resident's Perspective*, Water Court Reporter (University of Denver College of Law, 1 December 1990).

water from the Valley would reduce agricultural activity and tourism, causing their incomes to fall.

AWDI made some conciliatory offers in an attempt to garner the good will of Valley residents. In addition to the terms of AWDI's amended application, the company proposed to invest in a local development program that would keep part of the project's water, and part of its increased economic value, in the San Luis Valley.[94] Although some local residents were willing to participate, the development program and the amended application apparently did little to quell opposition to the project.[95]

LESSONS FROM THE THEORETICAL PERSPECTIVES

Why did AWDI's proposed project generate so much costly contention? Existing groundwater pumpers and the other objectors in the case obviously felt that their interests would be seriously damaged if the water court allowed the project to proceed. The theoretical perspectives outlined above suggest that this perceived vulnerability arises from the nature of the groundwater resource and from the nature of property rights to the resource, and perhaps to some extent from the identity of the players. This section examines the possible contributions and shortcomings of these various theoretical approaches in contributing to an understanding of the San Luis Valley case.

This case suggests that the difficulty of establishing and enforcing property rights to the Valley's groundwater derives largely from the nature of the resource. In groundwater basins in general, the inherent interconnections between users and the cost of accurately measuring the variable characteristics of the resource create obstacles to the complete specification and enforcement of groundwater rights. Thus the nature of the resource affects the costs of defining, monitoring and enforcing individual rights. In turn, these costs affect the structure, behavior and course of development of institutions governing groundwater use. Where groundwater rights are incompletely defined and enforced, increasing demand for the resource or other changes in circumstances may lead to conflicts.

The growing potential value of the San Luis Valley's groundwater to urban users along Colorado's Front Range led AWDI to attempt to establish rights to a portion of the resource that the company views as unowned and available for capture. That attempt resulted in a costly

94. D. Foster, *Valley Water Plan Reduced: Company Vows to Take Less from San Luis*, Rocky Mountain News (21 August 1990); *see also* Foster, *supra* note 3.

95. D. Foster, *Reduced San Luis Valley Water Plan Still Opposed*, Rocky Mountain News (1 September 1990); *see also* Foster, *supra* note 3.

dispute. While no exact figures are available, it is widely believed that parties on both sides spent several million dollars for legal fees, hydrologic studies and the gathering and dissemination of other types of information. While some of this activity generated valuable information, a substantial portion of these expenditures probably served to dissipate the potential value of the Valley's water resources.

Theorists working from the optimal control perspective would tend to view this dissipation of value as evidence of institutional inadequacy. Adherents to this perspective might argue that this dispute could have been avoided. Instead, mutually beneficial water transfers or a negotiated entry fee could have been arranged if only the property rights of existing users of the resource had been better defined and enforced.

The optimal control perspective does not directly address questions of institutional change, but rather tends to view the definition and allocation of property rights as exogenously determined, perhaps by government fiat, and stable once chosen. While theorists basing their work on optimal control make some effort to explain the existence of particular property rights institutions, they primarily focus on the effects of such institutions rather than on their origins and evolution.

Adherents to the transaction cost perspective would likely question the argument that property rights to the San Luis Valley's groundwater should have been better defined in advance in order to avert such costly disputes. To them, the lack of property rights which previously were sufficiently well defined to prevent the value-dissipating conflict over AWDI's proposal provides evidence that prior to the controversy, water users did not expect to gain from further investment of resources in clarifying and enforcing the dimensions of individual groundwater rights. Indeed, the Valley's water users apparently believed that the State Engineer's policy of denying permits for new large capacity wells had effectively closed the Valley's aquifer system to new appropriation. This, together with expected completion of the Closed Basin Project[96] and a fortuitous series of wet years that had eliminated Colorado's accumulated water debt to the downstream states[97] seemed to promise new stability and security to the Valley's water users. For their own purposes, the Valley's water users may have viewed the

96. The recently completed Closed Basin Project is intended to pump as much as 117,000 acre-feet (144 x 10^6 m^3) annually into the Rio Grande River in order to assist Colorado in meeting its Rio Grande Compact obligations to New Mexico and Texas.

97. Elephant Butte Reservoir in New Mexico received enough inflow to necessitate a spill in 1985. Under the terms of the U.S. Supreme Court Stipulation governing repayment of Colorado's water debt (*supra* note 84), the spill was sufficient to eliminate the debt (*supra* note 5).

existing system of unquantified groundwater use rights, relatively unmonitored withdrawals and little available hydrologic information as reasonably adequate.

AWDI's proposal, however, abruptly disrupted the tenuous equilibrium established in the Valley. Since questions of water rights are settled in Colorado by the state's system of water courts rather than by the State Engineer, the policy of denying new well permits provided existing users with little protection against an applicant with substantial financial resources. The transaction cost perspective predicts that when the potential value of a resource increases, greater efforts will be devoted to attempting to capture that new value. Not only may new entrants like AWDI attempt to assert a claim, but existing users can be expected to increase their efforts to protect or expand their own rights. The San Luis Valley case appears to be an example of this competitive process.

The transaction cost theorists see property rights as determined endogenously and continuously. Rights are determined by a constant interplay of the efforts of nominal owners of assets, with the assistance of public institutions, to exercise and enforce their rights against the efforts of other parties to capture the value of those assets. Costly disputes are predicted to arise, under particular conditions, when there is sufficient increase in the potential value of the resource. Therefore, such disputes contribute to the process by which property rights are defined and enforced. In the San Luis Valley case, the opposition of irrigators, environmentalists and small town interests to AWDI's proposed project arises from the fact that they cannot have completely secure rights to the water resources whose services they now enjoy, making the value of these services vulnerable to capture. This insecurity is evidenced by the fact that these parties are incurring considerable expense to defend their interests against the possible impacts of the AWDI project. Their actions have substantially increased the cost to AWDI of establishing the proposed new property right. These combined costs entail some dissipation of the potential gains from this project.

While the transaction cost perspective outlines a theory of the evolution of property institutions in response to changing conditions, Ostrom's work attempts to put empirical flesh on that outline as it pertains to common property resources. Her work also more carefully defines and documents important interactions between different levels of decision making. Of particular relevance for the San Luis Valley case is the importance that she attaches to the presence or absence of local rule-making authority. From Ostrom's perspective, the situation in the San Luis Valley would likely be viewed as a case of institutional fragility. The temporary and uncertain balance that the Valley's water users had achieved between groundwater withdrawals, surface water use and the water rights of downstream parties was vulnerable to disruption by

AWDI's proposal. Ostrom would predict value-dissipating conflicts to be quite likely in a setting like Colorado's San Luis Valley where there is little local rule-making authority over groundwater use and where water rights decisions are made primarily by the courts. While this system ostensibly protects vested water rights, it may oblige the holders of those rights to incur considerable costs in their defense. It may also place barriers in the way of creative local solutions to groundwater problems by making it more difficult to use local democratic processes to create rules governing groundwater use. Since the current community of groundwater users does not have clear authority to exclude outsiders such as AWDI, and since no mechanisms are in place for the local development and enforcement of rules governing groundwater use, the principles that Ostrom identified as characterizing robust self-governance institutions are missing in the San Luis Valley.

Theorists from all three perspectives see the nature of the resource as an important source of difficulty. However, adherents to the optimal control perspective assume that the characteristics of the resource are relatively well known and agreed upon by all users. Where there is uncertainty about such factors as variable recharge rates and the total volume of water in storage, the optimal control theorists implicitly assume that users nonetheless agree regarding the probability distributions for these factors and that the objective truth can eventually be discovered at relatively low cost. Such assumptions are highly questionable for the San Luis Valley case.

Indeed, it is precisely the type of physical data required for privatization as envisioned by Anderson et al.[98] that is the subject of the San Luis Valley dispute. Therefore, the optimal control perspective does not address the problems underlying the San Luis Valley conflict. There, the fight is over how a resource of relatively unknown dimensions should be apportioned among current and potential future users in an environment where it may be extremely difficult to determine the actual effects of the proposed use on parties with an existing stake in the resource.

The transaction cost perspective provides an explanation of the rejection of AWDI's proposed compensation plan by owners of existing wells. It suggests that their skepticism rests on an understanding that measurement of true impacts in the presence of natural variability may be prohibitively costly. Given this problem, current water users distrust AWDI's compensation offer since they have no guarantee that their claims for compensation will go unchallenged. On the other hand, given costly measurement, it is also possible that AWDI might compensate existing users even if they are not truly harmed.

98. Anderson et al., *supra* note 16.

Ostrom's work contributes the further insight that since AWDI's investors and corporate officers are outsiders to the Valley's farming community, there are no ongoing ties of mutual interdependence nor shared behavioral norms that tend to guarantee promises and lower enforcement costs. Therefore, the fundamental mistrust of AWDI and its promises apparent among Valley residents evidences a problem likely to be encountered whenever representatives of urban interests enter rural areas in search of additional water supplies.[99]

The transaction cost perspective predicts that individuals will attempt to devise institutions and contractual arrangements that will minimize the dissipation resulting from competing efforts to capture the value of scarce assets. However, such efforts are somewhat difficult to identify in the San Luis Valley case, although AWDI's offer to compensate other well owners and invest in a local development program might constitute an attempt to reduce opposition and thus lower the cost of securing the right to proceed. The company apparently viewed its proposed local development program as an offer to share part of the gains from the project with the Valley's residents. To the extent that AWDI's proposal would entail a sharing of the net social gains, it would exceed the requirements of Colorado's "no injury" rule. The fact that AWDI believes that such an offer might be the least costly way to achieve its objective suggests that the anticipated gains from the project are also, to some extent, vulnerable to capture by other parties.

Further efforts to reduce dissipation of value may become evident in the future as the Valley's water users and state officials use the experience gained from the recent dispute, as well as the newly generated body of hydrologic information, to address the potential effects of future water development proposals. The case has already resulted in a proposed state constitutional amendment aimed at enhancing the authority of local water conservancy districts to restrict water transfers.[100] The particular proposal under consideration appears to be a rather blunt instrument that may be unnecessarily restrictive to water transfers. By giving conservancy districts only a yes or no choice over

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99. In another recent case, farmers in the Arkansas River Valley of southeastern Colorado spurned a $120 million offer for controlling interest in a ditch company that supplies irrigation water in two counties. The offer came from a company that sought to resell its share of the water to Front Range cities. Farmers were suspicious of the offer, fearing both direct and indirect impacts of selling their water. *See* D. Frazier, *Farmers Face a Flood of Problems in Selling their Water*, Rocky Mountain News (17 February 1992).

100. J. Stern, *Pastore Bill to Govern Water Transfers*, Valley Voice (August 1991). Senator Pastore has eliminated several ambiguities in the language of the proposed amendment and now intends to bring the revised version before the state's voters in 1994. See N. McMahon, *Amendment opinions vary in Valley, state*, Special Report: SLV Water, supplement to the Alamosa News, October 1992.

proposed water transfers rather than full authority to negotiate compensation for damages, the proposed amendment could prevent net socially beneficial transfers. Furthermore, by not allowing conservancy districts to determine the aggregate level of groundwater demand and to negotiate entry fees with new users as suggested by Gisser,[101] the amendment could impair rather than improve the allocation of Colorado's water resources.

In addition, it should be noted that neither Gisser's proposal nor the proposed amendment to Colorado's state constitution gives any recognition or voice to parties whose interest in the aquifer is unrelated to their own extraction of groundwater. The desire of environmental interests and state and federal authorities to prevent damage to wetlands and the Great Sand Dunes National Monument, for example, have played an important role in the San Luis Valley case. Such diverse interests are not addressed by the proposed constitutional amendment and it is not readily apparent how they could be accommodated within privatization schemes such as proposed by Anderson et al. or Gisser.

CONCLUSION

As we reach the limits of developable surface water supplies in many areas of the West, groundwater development is becoming increasingly attractive to meet new demands. This trend is illustrated by the efforts of the city of Las Vegas to claim groundwater in rural areas of Nevada,[102] purchases of rural lands by Arizona cities to obtain groundwater rights,[103] and the proposed AWDI development in the San Luis Valley. In each case substantial disputes have arisen, highlighting inadequacies in existing institutional arrangements for groundwater development.

Proponents of privatization have suggested that these disputes could be avoided by creating better defined private property rights to use groundwater.[104] By making explicit the protectable extent of the right, it is asserted, any additional development could occur only in a manner that would not measurably diminish existing rights. Moreover, such well defined rights would be easily transferable, thereby helping to assure that water uses can change as necessary to meet new needs.

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101. Gisser, *supra* note 28.

102. J. Christensen, *Will Las Vegas Drain Rural Nevada?*, 22 High Country News (21 May 1990).

103. G. Woodard & C. McCarthy, *Water Transfers in Arizona*, in The Water Transfer Process As a Management Option for Meeting Changing Water Demands (Vol. II, Natural Resources Law Center, University of Colorado, 1990).

104. Anderson el al., *supra* note 16 at 228-229; Gisser, *supra* note 28 at 1026-1027.

The proposed large-scale groundwater development in the San Luis Valley, however, illustrates the shortcomings of a simplistic private property rights solution. The hydrologic system in the San Luis Valley is highly complex and little is known about some of the aquifer's characteristics. Critical factors such as the manner and amount of recharge, climate-related variability, and interactions between groundwater and surface water are also poorly understood. This creates difficulties for the mathematical simulation of the effects of groundwater withdrawals. Moreover, not all uses of groundwater are private or direct. In the San Luis Valley there was considerable concern about the wetlands that depend on groundwater for their existence. Furthermore, some believe that the spectacular 800 foot sand dunes protected in the Great Sand Dunes National Monument depend on groundwater tables underlying the area. In addition, the possibility that groundwater development would reduce flows in the Rio Grande raises the further issue of interstate compact obligations to New Mexico and Texas.

Transaction cost economists caution against assuming that property rights are, or should be, completely defined. The importance of defining these rights depends on the value to be gained in relation to the costs entailed by the definition process. The transaction costs associated with better defining water rights are substantial in complex situations such as in the San Luis Valley. This perspective suggests an incremental approach to the definition of groundwater rights based on the net benefits that result.

The institutional challenge is to facilitate this incremental approach in a manner that encourages maximization of benefits, net of transaction costs, for all of the affected interests. The Ostrom approach suggests that this result can best be accomplished through direct, interactive participation by the interested parties themselves. Her work, however, also indicates the difficulties of this approach in complex settings such as that represented by the San Luis Valley.

Groundwater laws and institutions will change and develop in response to increasing demands. They should also develop along with a better understanding of the resource itself. Early legal notions of absolute ownership of groundwater derived from ignorance of the effects of groundwater withdrawals. Rules for allocation subsequently evolved to reduce the most serious weaknesses of the earlier legal approach. The clear trend has been to limit and better define the withdrawal right and to clarify the protection that right enjoys in relation to other users and uses. Such efforts will be further prompted by additional interest in groundwater development. These efforts should be guided by an awareness of the potentially broad range of interests implicated by large-scale groundwater development and by a comparison of the benefits in relation to the transaction costs involved.