WEA communics, 7-86; Brain & Martin

Brajer & Martin.

how many times do we need to prove that pricing in hist. was?

and not-so-recent

1. Excellent survey of recent work.

Catalogue of positions taken by shallow thinkers cd. be shortened. / Partly bec. is so depressing. ~~Also~~ Partly so familiar. If one is to do it, wd. suggest quantitative approach: is criticism waxing or waning? – e.g. farming produces food.

2. Presumption is no doubt correct, long term shift from farm – city is needed. But it needs heavy qualifying.

a. Some cities are water hogs too: S.F., L.A., MWD using State filings, Boulder? ...

b. Shifts w-in agr. are needed, too. Surely, from old to new: from "things like" rice & alf. to "things like" – what? [Whatever I said, some-one wd. object the ~~farmers can sell~~ crop is already in surplus, in which case let the cities have it.] In ag., can still say, some lose less than others.

c. Many cities put water to farm use, after grabbing, to hold for future urban use. "Chinatown". Cvo. crescent.

d. ☆ Some cities make deals w. ~~other~~ farmers to help them dev. farm wtr: S.F. and Tucd.; ~~L.A.~~ MWD and Kern Cty. WHPPS.

e. Some urban uses are not losers. IPA. Congrat. Brajer & Martin for precautionary parens. p. 9.

(But utter vagueness re prop. of "$175 / a.f." – fund or flow?)

3. General pattern: ag. releases wtr. prematurely; cities ~~(and Kern Cty.)~~ grab wtr. prematurely. (so does expanding agric. in Kern Cty.)

A confirmed Pollyanna wd. say there are offsetting. But both demand too much. Thus create illusion of wtr. scarcity in midst of abundance.

Colo. R. e.g. -- oversubscribed bcs. every diversion is subsidized. Negative pricing.

Other reasons:

a. No prop. tax on wtr. rts., usually. Best of both worlds.

b. Antic. appreciation. When i-g → 0, we need it! Read from Makrowitz. Cf. p. 23, inf. value on wtr. rts.

c. Specn. in land. State & local govt. is run by land specs. They need wtr. to validate spec. bcs. Double-barrelled specn.

B & M suggest integrating other disciplines, & I applaud, wd. lead to these considns.

3 problems. (I forget 2nd)

4. Sign of advancing age, when hear "new" become suspicious & skeptical. Wtr. mkt. idea was the rage when my dtr. born & she's 29 & holding.

Conservative fashion then was to say yes, we're all for it & already doing it. Or, Pollyanna, 1st gen

is max. possible. Both those defenses were too absurd to last more than 30 yrs. faced w. massive counter-evidence so maybe that's what is new. (Although I see Dunning claims mkt. freed up in L.A. must modify refute that.)

5. Esply. useful mtrl. on N.M., pp. 18 ff. hydrology. uncertainty

6. Applaud emph. on heterogeneity of aquifers. p. 14 Egg-carton model goes too far, but implied refutn. of Vaux & Knapp is on target. Was very gentle & indirect w. them, than guilty of half the crimes he lists, 13-15, & a few more.

7. Return flows.[20] ∴ Flash yr. trifecta ...

8. Suggestions.
   a. Zuidema. 21
      Land is stationary.
      L.V. ± Δ reflects Zuidema bias.
      It's measured anyway, so don't be concerned.
   b. Fixed K is stationary
      Can't recover value when mkt is gone.
      Argues vs. subsidizing migration.

9. Indians?

Give whole country back, then tax it heavily.

May work out w. a diff. wrinkle: sell to Japanese, then tax.

10. "Comm. Value of wtr?" Not peculiar

~~Acme~~ · Forest Svc. ie

La Rue Bourbon, le vieux Carré, "fragile"

Military bases, prisons, slaughter houses...

Bruges & Montréal.

1. Water is diff.: bcs. not taxed.
2. p. 1 - ? rehashes old match.
3. p. 9, not clear if $1750/a.f. is historical or in prep?
4. Decr wtr. may ↓ farm output!
5. Urban demands can be premature - + have been, and are.

Ag. releases post-maturely and cities demand prematurely, both at once. Offsetting?
No, both demand too much. Bcs.

a. No tax
b. Both subsidized.
c. Specn - in wtr, in land.

6. Ca. 1958, fashion was to say yes, wtr. shd. be xfrble - + it already is. Chicago types were saying only 10% improvement is possible, etc. Buying may be doing same.
7. When I hear "new" I get suspicious. Ecsts. have bn. promot'g wtr. mkts. for 30 yrs. at least.
8. Comm. stability arg. not peculiar to wtr.

Forest Service
La Rue Bourbon, le vieux carré, "fragile".
Military bases
Prisons, slaughter houses,

Hall

1. "Rien" a Faustian beginning.
   Myself when young

2. What are we called on to do?
   Forecasting prices is only one thing
   Taxes is another.

3. W+r. + energy share common trait: scarcity ∆ yields
   So no worry.

4. Cryptic. What driving at? Power of politics.

Hall.

1. Impressive survey. Seems to have read every technical piece ever written, digested immediately, + seen clear thru author's pretensions, riddles + conundrums.

2. Flattering, assumes we all do. ectcs. daily + have the tools to recognize the most recondite refs.
But in case we don't, not to worry.
Prelude to Faust. "Rien".
"Myself when young..."

3. Conclusion: It's all politics.
Don't think he really believes that, + may extend conclusion later.

4. Cryptic. What driving at?
He always is. The clues are always there, like Conan Doyle, when he says "Elementary, my dear Gaffney." But where? Baffling.
Feel stupid as Dr. Watson
Will fall back on fact I got Brazin/Martin first, comment on that.

Norgaard.

1. appl and

a. Neo-class. neglects time.

Birth of neo-cl. was attended by divorcing out relations of sequence, e.g. wages-fund doctr. and pd. of prodn.

∴ Hence, no macro. A "glitchless" world.

b. Intergen. equity.

Wish he had said more, specified what kinds of rights. Pay rent, or ~~neglect~~ collect it?
Cf. Mill on Irish rts. to land of Ireland.

A jurist from host city (who also had a theol. style). Prophet of St., said "In world inhab. by succeeding gens, nothing so absurd as to base land titles on prior approp."

Cavalier attitude to posterity shown by H. Clay.

c. Anti-anti-Dennis Meadows, Limits to Growth. Meadows led w. chin, but didn't deserve lynch-mob treatment, (reflected no credit on the lynchers).

d. Shadow prices shd. be used, include subsidies, military protection.

2 ways of alloc'g land:

1.) Price. Phenomenal A.

Norgaard, 2

1. Army - navy - air force - marines. Even greater Δ. This is when Tony Scott mazzled me. e.

2. Suggestions for improvement.

A. Better to solve a small problem than scold others for fumbling big ones.

Sermon quality: "We have ... not done the things we ought, and there is no ___ in us".

Ponderables, imponderables -- typos?

Future of human race. - but doesn't tell us what it is. Personally I think anyone who thinks we'll survive long enough to run out of resources is an optimist.

B. Rethink strong statement that substn. doesn't abate scarcity.

Mat's sort of like denying gains from trade ~~Agri~~ among regions. E.g. B.C. hydro to S.C.

Better e.g. Dear wtr & dear energy both wd. Δ yields per acre.

Nagaard

C. Specify who is guilty of what: citus., particulars. A traffic ticket written this way wd. not hold up in court.

E. g. omission of purchased capl. Who omitted it from what?

John Dewey wd. shriek at this ramshing soliloquy.

D. So what? Policy. Tax.

To me, uncertainty argues for unit of prodn. tax.

E. Scarcity in future makes ress. dearer not cheaper.

E. Why recycle from AEC?

Nagaard

but who are "we"? p. 9

1. A sermon, "we have ... not done the things we ought"
   Punishable, unpunishables -- Typos?
   Future of human race.
   Debt to ~~$~~ posterity. (Henry Clay)
2. Recycled from AEA.

3. Implies res. optimism is excessive, I agree.
attack on Meadows was lynch mob behavior.

4. RFF left out all subsidies.

5. ~~Future gens. have rts.~~ p. 5 – but what kind?
   To pay rent, or collect it?
   ~~Prop~~ A jurist. from our host city, also, had a third. style
Prophet of S.F. said "In a world inhabited by succeed; gens.,
prior occupn. & approp. is absurd basis for prop. in
land"

6. "No policy (change) can follow" p. 8 if owners lack
omniscience.
   No, argues for net proceeds tax > prop. tax.

7. Problems – but no solutions, p. 9, 10
Criticizes omission of purchased R – ~~by~~ who omitted
it from what? Vague

8. Nothing re military costs.
2 indices to scarcity:
price of sites
cost of fighting .. the other way of allocating land.

9. Substitn. does not abate scarcity. 12
O' states, E.g., subst. Canadian hydro for S.C.
~~sit-to~~ thermal we gain more than they lose.

Dick Newcomb Miss.

DeVarke Harris Penn State

Mike Rieber

ALLOCATING A SCARCE RESOURCE: WATER IN THE WEST

Vic Brajer and Wade Martin, June 1986

Preliminary Draft: Please do not circulate or quote publicly.

I. Introduction.

Western water institutions have been the source of much debate in recent years. A major issue in this debate has been whether water allocation should be governed by pure market forces or centralized management. In many instances this discussion has boiled down to one fundamental issue: Should water be treated as an "economic good" and allocated via the market, or is water somehow "different," therefore making a market allocation suboptimal, or inefficient?[1] This basic question must be answered in order to achieve the optimal institutional framework for allocating both the surface and ground waters of the arid western United States.

But there's more to it!

The approach of treating water as an economic good has been defended by the so-called "New" Resource Economists.[2] With respect to the arguments made by this group, we propose to show that while their call for freely transferable water rights and unimpeded market allocation of water can be defended theoretically, given certain assumptions, it is precisely our inability to assume away certain conditions that makes it impossible to reach Pareto optimality. Namely, certain hydrologic, social, and legal factors all contribute to the creation of a myriad of external effects which preclude attainment of an optimal economic solution.

Even keeping within these realistic constraints, however, the economist still has a valuable contribution to make to public policy, by pointing out ways in which water can be moved to higher-valued uses and exposing some of the more inefficient uses of this vital resource. We feel that by working along with other physical and social scientists, and policy-makers in an interdisciplinary

setting, with the goal of perhaps changing the legal/institutional setting which hampers attainment of optimal economic solutions, the economist can accomplish more than through the theoretical demonstrations of abstract economic principles.

An important consideration in this debate focuses on the concept of scarcity. The following section will discuss the nature of water scarcity in the West. Section three will then offer an analysis of the hydrologic uncertainty and the external costs affecting the decision-making process (which are especially important in the case of groundwater allocation). Section four presents an analysis of the external benefits associated with the use and development of water resources, and is followed by section five's consideration of the legal uncertainty generated by judicial and administrative rulings. Finally, a concluding section highlights our principle observations.

II. Water Scarcity

That water is perceived as being extremely "scarce" in the West certainly cannot be questioned. This attitude is manifested in part by the dialogues of many Westerners which imply that "if you have water, you have a chance; if not, you are done for."[3] New Mexico State Engineer Steve Reynolds has tersely described water as "simply the limiting factor."[4] Utah Governor, Scott Matheson, has asserted that "water has suddenly surpassed time as the traditional Western luxury and we have little time left to take charge of the small amount of water that gives us life."[5] And recently, Gerald D. Seinwill, of the (now defunct) U.S. Water Resources Council, said that "water is the most serious long-range problem now confronting the nation."[6] Seinwill and other reputable, knowledgable individuals have warned of a water crisis of international dimensions in the 1980s and 1990s, of a magnitude comparable to the oil crisis of the 1970s.[7]

Certainly, water is scarce, as is any other natural resource, or any resource used in any productive process, for that matter. What has accentuated this scarcity issue, however, is the simple fact that Western water has traditionally been valued on a cost basis.[8] Such a valuation only provides a partial assessment of the true "value" of water as a vital renewable public resource. Economic value has been "placed upon other natural resources (oil, coal, minerals) in the ground and even renewable resources (corn, wheat, soybeans), but water eludes us."[9] Simple economic theory dictates that any resource artificially priced below its equilibrium price will encounter excess demand.

In the case of water, ascertaining its true value, especially at the farm level, is practically impossible, given the bewildering array of subsidies that are used along its delivery route. It is not difficult to name over fifty different segments in the national water hierarchy that take part, in some form, in the hidden overhead cost of water, for example, the U.S. Environmental Protecition Agency, the Department of the Interior, the Department of Agriculture, Federal and State commissions, and State regulatory departments, among others.[10] Federal subsidies enter water management at every point of the hydrologic cycle--cloud seeding programs, matching fund construction on watersheds, action agency programs for improved water management, research and development, and pollution control programs. Many local water distributors are thus supported by local taxes, receive water subsidized by State and Federal taxes, and market water to the public with no recognition of the value added by such subsidies.[11] In a recent report for the Natural Resources Defense Council, LeVeen and King demonstrate that the actual subsidies provided to California agriculture from the Bureau of Reclamation (via the Central Valley Project) are far beyond what even Congress intended, resulting in nearly $1.5 billion of "hidden and illegal expenditures of public funds."[12]

Unfortunately, even economists have contributed to the scarcity "misunderstanding" by implicitly holding water prices constant in many of their analyses. Many Western State water plans contain supply-demand projections for twenty, thirty, and even fifty-year periods which are based on simple linear extrapolations for future demand (usually holding real water prices constant), and current estimates of water supply (see Appendix for examples). In these

studies, expected water "deficits" are typically left as problems to be resolved by possible future importation, thereby reflecting the attitude that has influenced water allocation policy since the turn of the century--that problems are to be solved by supply augmentation, rather than by demand reduction.

Results such as these presented from the various State Water Plans have the potential to create considerable uncertainty regarding the exact meaning of water "scarcity," by implying that at some point in time there will not be enough water, or that we will "run out." Being alleged experts in the study of "scarcity," economists owe it to the public and the body politic to put the water scarcity issue into proper perspective, and into a form that is meaningful. But, if the results of studies such as those cited above present misleading, or inaccurate, conclusions, what meaning is to be derived from assertions that "water is scarce?"

Black, for one, argues that because of the importance of farm production to the nation's food supply and to general economic activity, water must continue to be made available for irrigation.[13] Advocates of this position can easily make a compelling case to the layperson, based on the following types of arguments. A 1978 study showed that in the period from 1973-77, the West provided 55 percent of the fresh fruits and vegetables marketed in 41 major U.S. cities, and in addition, in 1980 provided 40 percent of the value of agricultural exports, both feeding others throughout the world and offsetting our balance of trade deficits.[14] Furthermore, irrigated western crops have significantly higher yields than dryland crops or crops grown in the East. Irrigation also permits many more types of crops to be grown--California farmers

alone raise over 200 different commercial crops. "The entire country is able therefore to enjoy fresh western lettuce in January, or avocadoes, or citrus fruit."[15] In short, "irrigation provides stability to farmers, to ranchers, and to consumers, ensuring that crops will be available, of high quality, and at a stable cost, no matter what the vagaries of the weather."[16]

Substantial indirect benefits are also asserted to derive from the agricultural sector. When "the benefits of indirect inputs such as the stimulation of new houses, manufacturing, and wholesale and retail trade, are added to the direct project requirements, it is clear that the nation's investment in western water development has provided substantial national economic stimulation."[17] A series of studies conducted by the Bureau of Reclamation show that 95 percent of all major industrial groups and a wide number of occupation groups are used in providing the materials, equipment, transportation, labor, and other inputs needed to construct western water projects, and that virtually every state in the nation provides needed materials and equipment.[18]

Despite the attractiveness of this line of reasoning, upon closer examination the argument that Western food production is vital to the nation's economy is not a compelling one. In the first place, cash receipts from the sale of farm products average only about 5 percent of the final sale of goods and services in the United States each year.[19] Secondly, less than one-fifth of crops produced and sold in the U.S. (about 19 %) come from irrigated lands.[20] A ten percent reduction in the irrigated sector therefore implies that this figure might decrease to about 17 percent.

While a shifting of water resources away from agriculture to industrial and urban uses will undoubtedly occur, the reallocation to higher-valued uses simply implies enhanced economic growth, at not only state and local levels, but also at the national level. It is difficult to believe that the nation's food supply is in any jeopardy as a result of marginal shifts of irrigated land out of crop production. Nowhere is this more evident for example, than in the production of food and feed grains, where carryover stocks are at their largest levels since the early 1960s.[21] While there may be some site-specific exceptions (southern Arizona and the Ogallala area, for example), in general, agriculture will probably not be seriously affected in the forseeable future, given the gradual nature of the adjustment, and the gains that will likely occur through increased conservation efforts and applications of new technologies.

That these marginal adjustments can be expected to occur is manifested in two ways. First, much evidence indicates the existence of a "normal" demand relationship where water is concerned. Stated more simply, we all know that people react to higher prices of a commodity by using less of it. For example, a great deal of evidence suggests that municipal water demands are responsive to price, both in the short and long run. In 1967, a study by researchers at Resources for the Future, Inc. demonstrated significant differences in water use patterns between households that were metered (thereby putting a price on each gallon used) and those that were not.[22] In the areas where households were not metered (a fixed monthly fee usually being charged), not only was average daily water use much higher than in metered households, but maximum daily use rates and peak hour use were much higher. To investigate the permanence of

price effects, Hanke gathered and analyzed data from two major meter routes in Boulder, Colorado, prior to and after the installation of meters.[23] The analysis showed a dramatic, permanent drop in water usage. More recently, another study has produced evidence to suggest that a ten percent increase in the price of water would produce from a 3.75 to a 12.63 percent decrease in municipal water consumption.[24]

In several other studies, the price responsiveness of agricultural irrigation demand has also been demonstrated fairly convincingly. A number of studies done in different areas of California over a period of more than a decade all indicate considerable farmer response to changes in water prices. Moore (1962), for example, constructed linear programming models for farms on the eastern side of the San Joaquin Valley in Tulare County and found that for the range of prices considered (zero to $30 per acre-foot), demand elasticity was equal to -0.65.[25] On a larger scale, a group of researchers tested for the impacts of alternative futures on the demand for agricultural water in seventeen Western states using a large, multi-equation linear programming model. As price was raised from $7 to $30 per acre-foot using this model, the resulting elasticity estimates ranged from -0.17 to -0.56 with an overall average of -0.37.[26] Finally, in evaluating regional resource use for agricultural production in California in 1961-1965 and for projected levels in 1980, a spatial linear programming location model constructed by Shumway, King, Carter, and Dean actually indicated an elastic demand for water, in contrast to the other studies cited here.[27]

Of course, there are important policy implications contained in these elasticity estimates. Gardner notes that if the demand for irrigation water is as "elastic" as the numbers presented indicate, farmers may reduce their water use by a far greater amount than expected by water planners over the coming years as agricultural water prices rise.[28] Such reductions could offset the current predictions of severe supply shortfalls calculated under the assumption of near-perfectly inelastic needs for agriculture.[29] Of course, if the demand for irrigation water is elastic, future price increases will actually reduce total water bills.

As a second manifestation of the marginal adjustments that are expected to occur as water becomes more scarce, one can note that in many instances in the West, water is already moving to higher- valued uses (or at least to users who are willing to pay higher dollar amounts for the water). In a recent major water rights purchase for a large fossil-fuel steam power plant to be located near Delta, Utah, for instance, the Intermountain Power Project paid local farmers $1750 per acre-foot for 45,000 acre-feet of irrigated water to be converted to industrial use.[30]

Municipal users can also afford to pay higher amounts for water. In several of the groundwater basins of Southern California, for example, provisions have been made for the transfer of allowed pumping allocations and such transactions have frequently occurred. During the first nine years of water-master service in the Central Basin in Los Angeles County, several hundred leases or sales took place, ranging in magnitude from one acre-foot to close to a thousand acre-feet of water.[31] In the twenty years between 1960 and 1980, the value of

a share of Colorado Big Thompson water increased nearly eighty times, from $30/share to a high of $2350/share.[32] In Santa Fe, New Mexico, the right to an acre-foot sold for $10,909 in 1975 compared to $900 in 1963.[33] Finally, it can be seen that in Albuquerque there currently exist few problems directly related to water scarcity because years ago the city acquired rights to San Juan/Chama water, which are used to offset the impact of municipal wells on the flow of the Rio Grande. Presently, the city has purchased surface water rights from farmers and is leasing those rights back to them until such time as the city may need to retire those rights to offset the impact of its pumping on the river.[34]

Of course, the above-cited evidence tends to contradict the extreme interpretation of the argument that water is "different" from other natural resources inasmuch as we "can't get along without it." What the studies tend to emphasize is a simple economic fact: every individual, farm enterprise, and industry has numerous uses of water, and depending on the cost to the user, these economic agents will use certain quantities, applying the water first to the vital or high value uses first, and then to less important things. Therefore, as the price of water rises, all else equal, less water will be used to some extent; we will indeed get along with less and less water as it becomes more expensive. In most "economic" projections, the inability to anticipate specific responses to price changes means that the demand estimates used may substantially overstate future water demands.

We are not implying that water is not scarce, merely that the manifestations of this scarcity have perhaps been exaggerated in many writings on the

so-called water problem. As has been noted, many of these writings have even been by economists. What kind of information, then, can the economist offer to the public and to public decision-makers to bring some easily-understood dimension to the meaning of "scarcity?" A more appropriate way of demonstrating the exact meaning of "scarcity," (and a method that was used in the recent study concerning State appropriation of groundwater in New Mexico) might be to present qualitative descriptions of alternative water "futures" to be expected under differing assumptions regarding water demand and supply. As we continue to mine closed aquifers, for example, we can expect several manifestations of growing water scarcity. First, continued withdrawals of water will obviously exhaust remaining supplies of unappropriated water. When there is no more appropriated water, "new" water uses can be introduced only by the "new" user obtaining (purchasing) the right to pump water from an entity that already owns a water right. Most likely, such "new" uses will be municipal and industrial uses. One might expect the development of new uses to cause a reduction in irrigated agricultural activity in the groundwater basin as municipal/industrial users purchase water rights from farmers.

For reasons cited below, it is likely that the agricultural sector might be capable of responding, for example, to a ten percent reduction in levels of water use without substantial reductions in irrigated acreage;[35] this is accomplished by essentially substituting capital investments, such as lined canals, for water. Simply stated, farmers can sell 10 percent of their water rights and use the cash to put in lined canals, more efficient distribution

systems, and other technological innovations. With these improvements, they can be as productive as before but use 10 percent less water.

When reductions in agricultural water use go beyond 10 percent, these reductions will inevitably cause the retirement of agricultural lands and changes in the character of local institutions and lifestyles. At the point where 25 percent of agricultural water use has been transferred to municipal and industrial uses, for instance, farmers are going out of business, communities are looking for an alternative tax base, and basic lifestyle changes are being made. Of course, as water becomes increasingly scarce, with more and more agricultural water rights purchased from farmers, the price of water rights will rise; urban water users will pay more and more for water. Also, continued mining of closed aquifers will lower water tables, increasing still further the costs of obtaining water; rural and urban residents will face increasingly higher water bills. Thus, the major effects, or manifestations of scarcity caused by increased pumping from the closed aquifers will be reductions in irrigated agriculture and a basic change in the economic, socio- institutional and lifestyle characteristics in the affected areas.

We feel that these are the types of analyses that public officials and the public in general can easily understand.

III. Hydrologic Uncertainty and External Costs

Any form of resource management, whether done by private economic actors in the marketplace, or by some central (judicial or administrative) authority in a regulatory setting, requires at least some minimum amount of information on which decisions can be based. In the case of groundwater (as opposed to surface water) the collection and evaluation of this information can be a massive undertaking. The hydrology of aquifers is far less predictable and much less understood than is the hydrology of surface supplies. This uncertainty impinges on the attainment of an optimal economic solution in two fundamental ways: first, the actual amount of groundwater in existence is unknown, and will probably become known only after considerable development has occurred; second, the hydrologic effects of such development will be difficult to analyze with any precision. In light of the potential importance attributed in economic analysis to external costs, this can be an extremely important consideration.

Quantity Uncertainty. The current amount of available groundwater "supplies" in New Mexico, that is, supplies defined as being outside the "appropriation system,"[36] is estimated to be between 135 million acre-feet and 155 million acre-feet. To put this figure into perspective, one can note that this amount of water is over four hundred times the current annual consumptive use of water from the Rio Grande system in New Mexico, which is approximately 345,000 acre-feet. Nonetheless, these figures do not necessarily imply that New Mexico is a "water rich" state to the extent that it need not be concerned with optimal allocation levels. First of all, the state's water resources are not evenly distributed. While the Mesilla Bolson in the south-central basin

is apparently blessed with a tremendous amount of groundwater (estimates range as high as 60 million acre-feet)[37], the eastern counties overlying the Ogallala aquifer are faced with rapidly declining water levels as that aquifer is mined, and in the northwest part of the state, natural constraints severely limit the amount of good quality groundwater that exists. Further, the prospects for intrastate, interbasin transfer are unclear at this time.

Moreover, supply estimates such as those presented above should be viewed with caution given the difficulties involved in determining the exact amount of usable water in a groundwater basin. In principle, determining the quantity of water in storage available to wells is simple: multiply the volume of saturated material by the specific yield.[38] In reality, both of these factors (yield and storage) vary continuously. In the Ogallala formation, for example, the thickness of the zone of saturation ranges from less than 50 feet in many places to more than 250 feet in eastern Lea County. Fairly detailed data on water-level fluctuations in observation wells, along with data on pumpage, are essential in keeping track of the status of groundwater resources. This information is published regularly by both the U.S. Geological Survey and the State Engineer. But still more information is needed on all phases of groundwater hydrology to even begin to understand the dynamics of such a complex system. This includes saturated thicknesses and hydrologic characteristics in areas of few wells, hydraulic properties of alluvial materials, quantity of water discharged by phreatophytes, amount of recharge from irrigation water, relationship of ground and surface water (in the case of tributary aquifers), and perhaps most important, water quality. The extent of this hydrologic un-

certainty can be appreciated by noting that in certain basins, for example the San Juan basin of northern New Mexico, current hydrologic estimates for unappropriated groundwater range between 1.5 million acre-feet and 21.5 million acre feet![39]

One final example of the hydrologic uncertainty that can potentially hamper the attainment of an optimal allocation in relation to groundwater is the so-called "bubble" of water that exists in many stream-related (tributary) aquifers. The term "bubble" refers to the finite amount of water that can be initially removed, or mined, from a tributary aquifer in excess of a permanently sustainable pumping flow. The existence of this bubble is a consequence of the time lag between the initiation of pumping from a groundwater well and the point at which the full effect of the groundwater withdrawal reaches the stream to which the aquifer is tributary. The size of the bubble is a function of a number of factors, including the hydrologic characteristics of the aquifer and the distance from the well to the stream.[40]

Although this bubble is by its nature only temporarily available it should be noted that it may be of considerable size. In the Rio Grande above Otowi Bridge, for example, the State Engineer's Office has estimated that there may be 13.8 million acre-feet available in the bubble.[41] And in the Rio Grande, Pecos, and San Juan river systems, the effect of the bubble is to render any determination of specific amounts of unappropriated water to a range encompassing 27 million acre-feet on the low side, and 46 million acre-feet or more on the high side.[42]

New Mexico municipalities, most notably Albuquerque, already follow a practice of using the bubble in that the location of their groundwater wells takes advantage of the delay in pumping effect upon the stream. Obviously, reliance upon bubble supplies postpones, at least for a short period, the arrival of stress conditions in any particular basin. It is even possible that the temporary postponement gained through use of the bubble may be quite large, depending on hydrologic and economic conditions.

External Costs. Simple economic theory demonstrates that with groundwater being a common property, or common pool, resource, its unregulated development will necessarily involve certain externalities, because no one user must bear the full consequences of the increased pumping costs, well interference or pollution that result from his own actions. At the same time, each user is forced to bear costs imposed by the actions of neighboring pumpers. Consequently, a socially efficient use of the resource is not attained--private users deplete the aquifer more rapidly than they would if they were forced to take all of the costs of their actions into account.

While the existence of this externality is potentially an important ingredient in determining the feasibility of reaching economically efficient allocations, considerable confusion still seems to exist in the economics literature regarding its magnitude. A number of studies have attempted to empirically estimate externality effects and the corresponding benefits which might be realized from groundwater management, but as of yet no consistent conclusions can be drawn from the literature.

Kelso (1961) and Renshaw (1963), for example, show that ad hoc groundwater management policies can actually result in economic losses.[43] Studies by Young and Bredehoft (1970,1972) and by Howitt (1979), on the other hand, suggest benefits from groundwater management of $100-$130 per acre and $153-$454 per acre, respectively, for regions of Colorado and California.[44] In a study of the Pecos River basin in New Mexico, Gisser and Sanchez (1980) demonstrate that the benefits of optimal management may be negligible compared to a free market (competitive) solution.[45] And finally, using a dynamic optimization model to investigate the expected benefits from groundwater management in the southern San Joaquin Valley of California, Knapp and Vaux (1982) show that such management benefits might indeed be substantial.[46]

On a more theoretical level, for the Ogallala aquifer, Beattie (1980) presented an interesting argument concerning the common-pool externality problem, by hypothesizing that the Ogallala aquifer was more like an egg carton that a bathtub, due to the limited lateral movement of water through the formation and the correspondingly steep cones of depression around most High Plains irrigation wells.[47] The implication of this so-called "egg carton" theory, of course, was that if this view were correct and understood by irrigators, farmers would not accelerate withdrawal rates for fear of losing their groundwater to neighbors--that is, no significant common-property externality problem would exist.

More recently, however, Alley and Schefter (1986) examine in detail the movement of groundwater in the High Plains aquifer in reponse to irrigation pumping decisions by individuals and small groups of farmers.[48] Using fairly

complex hydrologic techniques, they demonstrate that even though the lateral movement of groundwater is slow and the effects of an individual well on pumping lifts at other wells decrease exponentially with distance, an irrigator in the High Plains still has very limited control over the depletion of groundwater under his land, due to the cumulative effect of other pumpers.

These empirical findings, which seemingly lend no support to the "egg carton" hypothesis, nevertheless help accentuate an important point regarding the overall externality question-- namely, in what manner should the question be analyzed? While empirical economic studies have demonstrated a variety of results, most of them have used very simple approaches to modelling the aquifers and the movement of water within them. Such models assume hydrologic uniformity and do not adequately account for the different conditions faced by irrigators in different parts of a basin. One exception is the work of Young and Bredehoft (1970) which did combine an economic model with a groundwater simulation model. Even their study, however, does not specifically examine the externality issue from the point of view of the individual farmer.[49]

We should emphasize here that the use of economic tools and the contributions of the economist still remain key ingredients in the analysis of optimal allocation of groundwater resources. For example, the works of both Feinerman and Knapp (1983), and Knapp and Vaux (1982), by investigating the effects of various allocation devices (quotas versus pump taxes) on irrigators, excellently demonstrate the usefulness of the economic perspective in analyzing the desirability of various groundwater management schemes.[50] Equally as important, they have also demonstrated that empirical results obtained from these

models are extremely sensitive to the various hydrologic and economic parameters assumed. Without meaningful hydrologic data and realistic modelling representations of the involved aquifers, however, any results obtained must be viewed somewhat tentatively. It seems clear that given the potential magnitude of this externality issue, more work needs to be done in the area where hydrology and economics are inextricably interconnected to produce any meaningful social policy recommendations.

Finally, we note that the extent of external costs is not limited to increased pumping costs due to falling water levels and well interference. There are other important negative externalities involved which, due to their potential significance in the West, deserve special mention. First, the removal of groundwater can cause the overlying land to subside. Nationally, subsidence has affected approximately 8500 square miles of land in various regions of the country, mostly in the Gulf Coast and in certain valleys located in the western United States. The maximum recorded subsidence was observed in the San Joaquin Valley in California, where the surface fell approximately 29 feet between 1926 and 1972.[51] Subsidence leads to an array of surface damage, including flooding, the "tilting" of surface lands and structures, damage to wells, extensive cracking on the surface, and disruption in the operation of pipelines, canals and aqueducts.[52]

Second, the development of an aquifer may reduce the quality of its waters. The complex geologic and hydrologic structure of aquifers creates special groundwater quality problems that do not occur with respect to surface water. While pollution of surface waters can be reduced by allowing natural surface

Bunker Hill Basin!

flow to "flush" out pollutants, the fact that an aquifer is a "stock" resource implies that a even a one-time introduction of pollutants may damage the entire resource. With aquifers generally being more complex and larger than surface reservoirs, such effects can also be more wide-ranging and certainly more difficult to predict. It is interesting to note that in some cases the quality of an aquifer can be reduced even when withdrawals do not exceed natural recharge--that is, where no mining actually takes place. In coastal areas, for example, the removal of any groundwater can result in salt-water intrusion--the recharge of the aquifer from formations saturated with sea-water.[53]

IV. External Benefits and Social Considerations

As has been asserted, giving operational meaning to the theoretical "optimum" use of water involves several problems. The calculation of an optimum rate requires some type of comparison between benefits and costs. Problems pertaining to the determination of the external costs of groundwater development have already been discussed. As was the case with costs, the public (social) definition of benefits may also differ from those of an individual appropriator. Any divergence between private and social benefits can of course lead to conflicts in the determination of an optimal use rate.

Estimating the total benefits derived from water use involves the consideration of not only direct benefits to water users, but also return flows and related secondary benefits as well.[54] Many figures obtained on direct benefits neglect to allow for value generated from the return flows, and subsequent reuse, of irrigation water initially applied. In some areas of the west, these

"Flush yr. toilets ..."

return flows could be as high as 50 percent, and depending upon the timing of the flows, could result in the generation of twice as many agricultural benefits as originally estimated.

In calculating secondary benefits, it is important to recognize that there exist backward and forward economic linkages involved on the benefit side of water applications. Direct water users are related to other sectors of their local, regional, and even national economies. As their activities contract or expand, so can the activities (and incomes) of those they supply or from whom they buy. In estimating these types of benefits, it is important to address the following kinds of questions:

(1) Which related industries will expand or contract?

(2) Do any economies of scale exist in these industries?

(3) What type of capital and labor immobilities exist, and how are they finally resolved?

The land is immobile.

The economic and social bases of many Western communities depend on agriculture. Irregardless of how well irrigators are compensated for their water rights, the departure of enough irrigators (farmers) from an area will result in a number of third-party effects, as related incomes and tax revenues are lost to the community, for example. However, it is not clear that these effects will be significant enough to warrant additional consideration from the economist. Traditionally, economists have accounted for these social externalities through the use of input-output analysis and the estimation of various multipliers, which are designed to measure precisely the types of secondary benefits which are being considered here. Further, in most cases, one would expect that the

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marginal displacement of agriculture to take place over a fairly long period of time. Aside from the case where factors of production are completely immobile (a difficult assumption to justify in the long run), these factors will have time to move to new areas. Workers will relocate, and entrepeneurs will depreciate capital assets and move on. It follows then that there would be no secondary benefits lost in the long run as agriculture is displaced from a particular region. In any case, an argument can be presented for the relative inability of these "unaccounted-for" secondary benefits to impede on the attainment of the socially efficient solution.

Community Value of Water. Recently, a number of references have been made to the "community value" of water. The essence of this argument is that water is not just a commodity, but rather is "a necessary prerequisite for the development and maintenance of the economy and social structure which make a society possible,"[55] the implication being that a value placed on water-related secondary benefits using strict economic criteria may be incomplete. In the case of Indian control of water, for example, many believe that there is a more fundamental consideration involved that is not economic in nature. Consider the words of Wendell Chino, President of the Mescalero Apaches, who states:

> In the nineteenth century, direct force was used to take over Indian lands. The danger today is more subtle. Under the cloak of legal strategy and executive department policy decisions, a real threat is stalking all Indian leaders. These decisions regarding legal strategy and policy are designed to dry up the water from what little land is left to us. We must be alert. We must protect our own rights. The consequences of losing our water would be as serious as those following the loss of our lands in the nineteenth century.56

However, the notion of community value of water is not merely a restatement of the issue of Indian water rights. The valuation of water in more than economic terms is not limited to the case of Indian rights or even to the rural poor of the Southwest minorities, for that matter. In an examination of six irrigation communities in the American West and in Spain, Maass and Anderson note that:

> Economic growth...is in the case of irrigation agriculture so competitive with other objectives that farmers typically refuse to treat water as a regular economic good, like fertilizer, for example. It is, they say, a special product and should be removed from ordinary market transactions so that farmers can control conflict, maintain popular influence and control, and realize equity and social justice.57

Water scarcity in arid lands has traditionally raised basic questions about resource use and distribution, questions that could be answered only by institutionalizing arrangements to produce socially sanctioned decisions. Spanish water law, from which much of our present Western water law is derived, went to great lengths to protect the public interest and to place it above private parties claims, and even above claimants invoking the doctrine of prior appropriation.[58] In a study of poverty in the Southwest, it is suggested that together with providing for common defense, security of life and property, and enforcement of law, one of the most basic tasks of a political community is to oversee the maintenance and distribution of water supplies. With water and society being so inextricably intertwined, particularly in the arid West, a threat to the system for allocating water is therefore seen as a threat to the communal enterprise.[59]

An example of the application of these ideas can be currently seen in the political action taken by local interests in northern New Mexico's Rio Arriba County. Here, new development has been, for the time being, disallowed on the basis of community value arguments. The stated purpose of their actions are to "protect the unique culture which has developed within Rio Arriba County by ensuring that all subdivisions are created in harmony with this culture, and contribute positively to it rather than detract from it."[60] They further note that:

> ...the transferred water rights from traditional uses, such as irrigation by the acequias to residential subdivisions or commercial uses, will generally not promote the public welfare because of its adverse effects on the communities of the county.
>
> When water rights are removed from the land, there is no irrigation. Without irrigation, the land will be lost. Without the land base, the family will disintegrate, and without the families, the communities, too, will die. Once lost, the culture could never be regained.[61]

These communal values that many Westerners place upon water certainly seem to lend support to the "water is different" argument. Water is being viewed not only as a market resource, but also a social good, and in certain areas of the West, emotions are ambiguous as to which view is dominant. At the very least, these attitudes suggest that perhaps water can not be treated simply as a market commodity, subject to typical supply and demand analysis, and to calculations of economic efficiency, but rather that it must be treated also in the terms many Westerners perceive it "...as being too important to be evaluated exclusively in terms of economic welfare."[62]

The argument can take on a national flavor as well. Many feel that without irrigation, many ranchers and farmers would be forced out of business, resulting in serious impacts on the West. In this respect, it has been noted that cowboys and homesteaders are not only a vital part of the West's history, its value and its ways of life, but agriculture also provides diversification and long-term stability to the West's boom and bust resource-based economy.[63] While this seems to contradict earlier assertions made regarding the significance of marginal adjustments out of irrigated agriculture, it is important to emphasize that the figures cited earlier did not fully capture all related effects. Consideration of the community value may increase the value of the agricultural sector considerably.

In making an attempt to place this issue of community value in some sort of perspective, we note that on the one hand, some economists argue that the whole notion of "community value" is merely a new, fancy jargon for a concept that has already been defined and measured--namely, secondary benefits. They would probably argue that the fact that water rights in northern New Mexico have not yet been sold simply indicates that the price has not risen high enough. On the other hand, some feel that this community value is not only a non-market good, but a non-utilitarian good as well. That is, water represents a good for which the normal assignment of utility does not apply (in effect, implicitly assigning an infinite value to the ownership of water rights).

We feel that there does seem to be enough evidence regarding the existence of this community value to prevent its quick dismissal from some sort of scientific scrutiny. While its measurement (if even possible) may lie outside the

realm of traditional economic analysis, and may more appropriately fall within a social-institutional type of analysis, this only again serves to support the main thesis concerning the complexity of the water allocation process and the need for a multi-disciplinary effort. In concluding, we note that two reports on water policy prepared at the University of New Mexico, one released in September 1985, and the other to the 1986 Legislature in January 1986, both recommend that the state consider the importance of preserving Northern New Mexico's irrigated land for historical and cultural reasons,[64] thus providing further evidence that water, and its role in Western agriculture, is indeed more than economic in nature.

IV. Legal/Institutional Uncertainty

It has been demonstrated that uncertainties caused by certain hydrologic and social factors make the attainment of an optimal social allocation of water difficult to achieve. There are also uncertainties related to the legal/institutional processes currently governing the use of western water which have the same implications for the standard notion of economic efficiency. In this section, several of these legal uncertainties are examined. They are seen to result primarily from inconsistencies in the application of legal principles from state to state, and the incomplete definition and assignment of ownership (property) rights to the use of water.

Generally, most of the western states have adopted some version of the prior appropriation doctrine. Despite this general pattern, however, there is not complete consistency between states. In a survey of state groundwater laws

conducted by the National Center for Groundwater Research, it was found that specific state laws and regulations varied significantly among the western states, with only one of the responding states (Oklahoma) actually having a comprehensive groundwater law.[65] Further, in many states, there is a pronounced absence of law and policy toward the use of groundwater, and the two most populous states in the West, California and Texas, have virtually no formal groundwater rights law.[66] There is, however, a growing awareness of the need for laws within each state to be able to realistically respond not only to the physical occurance and distribution of groundwater (including the interrelationship between ground and surface water), but also to reflect the relevant economic and social aspects of water development and user rights.

Several states are moving toward developing management strategies that will improve both planning and regulation of groundwater in the future. For example, the Arizona legislature passed the Groundwater Management Act of 1980, a comprehensive law for statewide management and conservation of groundwater. California is also currently reviewing and debating more integrative approaches to surface and ground water management.[67] Finally, Montana, Texas, and Colorado all have actively acquired proprietary interests in their water resources, while at the same time maintaining their authority to plan for and manage use.[68]

These efforts notwithstanding, the existence of different legal and administrative systems can have a profound influence on the attainment of an economically efficient allocation of water. This is especially true where interstate aquifers are involved. In such cases, residents of different states using groundwater from a single aquifer may face drastically different incen-

tives and restrictions. An excellent example of this can be seen along the Texas-New Mexico border, where Texas has traditionally allowed virtually unrestricted pumping, while New Mexico has employed a more conservative permit system.[69] Consequently, users from these two states, while sharing the same rate of aquifer depletion, realize different rates of use. In such a situation, attaining an optimal allocation of the water can be extremely difficult. Even equitable apportionment, being based on physical measures, fails to take into account the fact that the water in an underground aquifer has economic as well as physical dimensions. The first appropriator to exercise his water right receives the resource with the highest "economic quality," and therefore, still has the same incentive, as does the pumper from a common pool, to "use it or lose it."[70]

Another relevant factor in analyzing the economic implications of various legal principles and decisions is that the courts often view water as being more than a commodity, and attempt to balance economic and political efficiency. The concept of beneficial use has long been interpreted by New Mexico courts to recognize non-pecuniary values associated with water use, so long as unreasonable burdens are not placed on other users' needs. In Keeney v. Carillo, for example, the court rejected an economic efficiency test to determine an appropriator's "due diligence." Also, the federal court in Jicarilla Apache Tribe v. United States refused to tie beneficial use exclusively to economic feasibility, stating that "Albuquerque could sell the water at a loss or even give it away without depriving it of its character as a beneficial use."[71]

Decisions such as these do not undermine the notion of economic efficiency if they are viewed as a use of the political system to partially account for the various types of non-market benefits which may be tied to water use and development, as was mentioned in the previous sections. What does hamper the achieving of economic efficiency, however, are the uncertainties that have been raised by the incomplete assignment of property rights to water resources.

Early descriptions of aquifers by New Mexico courts reflected the view that the state owned the water in the ground. In the 1982 Sporhase v. Nebraska case, however, the Supreme Court rejected the view that the public trust doctrine created a proprietary interest for the state in its water supplies, concluding that the notion of state ownership was merely a "legal fiction."[72] The Sporhase decision held that simply leaving water in the ground does not make the state the owner of its water resources in any proprietary sense, and that storage alone does not generally constitute a use of water because there is no actual application to beneficial use. The motivation behind the ruling seems to be the Court's belief that speculation in water rights should be avoided because it precludes more substantial present uses (again, treating water as being "different").

In addition, a second 1982 Supreme Court decision, Colorado v. New Mexico, injected more uncertainty into state water allocation decisions. In that decision, the Court indicated that interstate stream apportionments would not necessarily give established, prior uses in one state priority over new, more efficient uses in another state.[73]

The denial of state ownership of water as expressed in Sporhase and Colorado v. New Mexico, along with the long-standing recognition of proprietary federal reserve rights as decided in Winters v. United States, have introduced considerable uncertainty into the water rights market and the water allocation process, and have limited the powers of the states in making allocations under the prior appropriation doctrine. Many feel that the Sporhase decision is also unfortunate in that it penalizes a state with a fairly progressive water law system (New Mexico) and rewards one with a wasteful system (Texas).[74] Furthermore, the establishment of unappropriated groundwater as literally being unowned has profound economic implications.

Interestingly, over fifteen years ago, Gaffney noted that in most states property rights in water are ambiguous and, "to the extent they are clearly defined, not intelligently defined. The ambiguity is exploited by the possessors of superior rights to maximize their own position...This begins by their gaining enjoyment of a public resource without ever paying the public anything for it."[75] He went on to call for the need for states to define property rights in water.

Obviously, this need still exists today for groundwater in the state of New Mexico. With the courts having forbid the state from prohibiting export of groundwater, the city of El Paso stands first in line for appropriations which total nearly 250,000 acre-feet annually. By using commerce clause analysis, the courts have implicity created a situation wherein the unappropriated groundwater in southern New Mexico is treated as a common property resource, which over time will be extracted at a rate which exceeds the economically and

socially optimal one. In recognition of the importance of this ownership issue, the New Mexico Water Law Study Group recommended state appropriation as the best action available to the state to make the most efficient use of its groundwater resources.[76]

For New Mexico, state participation in the water market is seen to be the best alternative to the institutional mechanisms that currently exist. The state market participation doctrine is not a method for "getting around" the commerce clause, but instead recognizes the existence of the interstate market and simply anticipates operation within it. Through this mechanism, the state could capture the equity interest in water resources that it has carefully created through water regulation and investment of its taxpayers' capital.[77]

The advantages of state control have been pointed out before. In arguing for state, as opposed to federal or local, control of water resources, Hrezo and Hrezo contended that states possessed three advantages in the formulation of distributive policies:

> First, state governments are close enough to affected groups to accommodate competing interests and develop and enforce statewide policy goals. They also can provide the basinwide perspective essential to recognizing the water resource as a hydrologic unit. Lastly, they can integrate water policy goals and processes with other important state aims such as economic development, land management, or coastal zone management.78

As has been noted, many states are currently engaged in water resources planning. Furthermore, this storm of activity is not limited to the western

states--riparian states are also taking the necessary steps to create proprietary rights in their water resources.

As a final point regarding legal uncertainty, we note that there is still a considerable amount of uncertainty generated by the existence of Indian rights. Disputes over Indian water rights currently affect the availability of water for urban use in Tucson, Phoenix, Albuquerque, and Salt Lake City; for energy development in the San Juan, Powder River, and Uintah basins; for the expansion of hydro-power sources for Seattle and Tucson; and for the maintenance of non-Indian agricultural development in Arizona, Nevada, and Washington.[79] A myriad of lawsuits involving water rights are pending in state and federal courts as tribes seek fulfillment of the original government promises made to them to make their reservations "livable, viable, self-sustaining communities."[80] Unfortunately, past litigation has proven to be expensive and time-consuming. Nevertheless, until Indian water rights are determined, state officials will be unable to determine whether water is available for appropriation, and the sale and transfer of existing rights will be impeded, since the prospective buyers cannot be certain they are receiving secure rights.[81]

VI. Conclusion

Issues of water allocation encompass such far-ranging factors that economic analysis alone cannot provide all of the answers. Economists as a group are being pretentious in claiming that the problem should be addressed within the narrow confines of one discipline. An interdisciplinary research effort is necessary, one which considers not only economic, but also hydrologic, political, social, and legal factors.

Of course economics has a valuable contribution to make to this effort. Giving a reasonable perspective to the water scarcity issue, demonstrating the extent to which water subsidization has evolved to a point far different from that originally intended, providing economic insights into the growing uncertainty regarding which legal factors should govern water use, and giving operational meaning to the notion of economically efficient water use in the face of tremendous hydrologic uncertainty are just some of the important tasks at hand in the West. We feel that the economist cannot simply describe ideal economic results, but must work to point out areas where economic analysis relates to the complex, changing legal, institutional, social, and political mileu.

There is no question that considerable benefit can be achieved by including more market-like incentives into even the present water management system. However, care must be exercised in determining how much transferability of water rights is allowed. Many of the New Resource economists advocate a totally free transfer. This position ignores the fact that in many cases Western water rights were never allocated on efficiency grounds in the first place, but in-

stead were intended to reflect social as well as economic factors. The consideration of this social value of water corresponds in turn to the proposed concept that water is somehow "different."

That water has been treated as though it were different (legally, politically) cannot be disputed. As economists, we can measure (or at least purport to measure) many things. But just because we cannot measure something does not mean that it does not exist. As lovers of the outdoors, we recognize the existence of option value, yet as resource economists we know that the measurement of this concept proves to be overwhelmingly elusive. Can not the same be said for the community (social) value of water, and the value of subsidizing irrigated agriculture in the West?

From a traditional economic viewpoint, one might be tempted to say that water should not be treated any differently than any other economic good. The fact that empirical studies have consistently revealed negative demand elasticities, strong responses to water price changes by consumers, and that those with the greater ability to pay can attract water rights indicates that, all else equal (that is, absent any institutional, political, social, or legal restraints) the demand for water is negatively-sloped. So in one respect, then, one might conclude that no, water is not different.

The pervasive social, political, hydrologic, and legal uncertainties that do exist, however, combine to create a situation in which substantial external costs and benefits become associated with the use and development of our water resources. To the extent that these externalities are of greater magnitude, perhaps, than those connected with the use of other natural resources, a fairly

compelling case can be presented for the "water is different" argument. As we have seen, there are considerable difficulties involved in measuring and even identifying all of the relevant social costs and benefits.

Water allocation in the West is clearly undergoing a transition, and the importance of using our water wisely cannot be overstated. Where does the economist fit into the process? He fits not by advocating unrealistic solutions based on overly restrictive assumptions, but by integrating sound economic reasoning into the necessarily complex interdisciplinary forum that is required to reach a solution.

APPENDIX: PROJECTED STATE WATER DEFICITS

Texas. In the 1985 Texas State Water Plan, for example, annual water "deficits" are projected for the irrigation water using sectors in each of the following basins:

PROJECTED WATER DEFICITS IN TEXAS WATER BASINS

Basin	1990s	2030s
	(000s of acre-feet)	
Canadian River	14	1,195
Red River	108	2,493
Brazos River	784	2,508
Colorado River	795	1,987
Rio Grande	353	1,383
Total	2,054	9,566

Source: Texas Dept. of Water Resources, "Water for Texas: Planning for the Future," Austin, Texas, February, 1983.

Obviously, the magnitude of these deficits is quite large. By 1990, for example, expected deficits in in these selected Texas basins alone are nearly six times greater than New Mexico's total depletions from the Rio Grande (345,000 acre-feet/year).

Similar studies were compiled for the states of Arizona, and Oklahoma. In each case, expected water "deficits" were left as problems to be resolved by possible future importation. Such studies reflect the attitude that has influenced water allocation problems since the turn of the century--that problems are to be solved by supply augmentation, rather than by demand reduction.

Oklahoma. Adjacent to New Mexico's northeastern boundary, Oklahoma's Northwest Planning Region includes an area that is heavily dependent on

groundwater from the Ogallala aquifer. With population in this region being projected to increase by 33 percent between 1977 and 2040, the corresponding growth in urban water demand leads to substantial anticipated water deficits, as shown below.

ESTIMATED WATER DEFICITS IN OKLAHOMA'S NORTHWEST DISTRICT

Year	Water Deficit (acre-feet)
1990	253,000
2000	385,000
2020	748,000
2040	1,089,000

Source: Oklahoma Water Resources Board, "Oklahoma Comprehensive Water Plan," Publication No. 94, Oklahoma City, Oklahoma, April 1, 1980.

Arizona. Of Arizona's six Planning Districts, those in the eastern half of the state are given attention. As can be seen below, potential water deficits in the three regions could potentially amount to nearly 1.7 million acre-feet annually under the adoption of the "high-growth" scenario in each Planning District. It should be noted that these estimates were compiled before the Central Arizona Project came on line; also they are dependent in part on the effectiveness of Arizona's new groundwater legislation.

ESTIMATED WATER IN ARIZONA PLANNING DISTRICTS

Region	1990	2020
	(000s of acre-feet)	
II	63-152*	44-339
V	57-49	27-599
VI	126-508	33-734

(* Range represents low and high-growth assumptions concerning future water demand).

Source: Arizona Water Commission, "Arizona State Water Plan: Alternative Futures," Phase II, February, 1977.

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28. Gardner, B.D., "Water Pricing and Rent Seeking in California Agriculture," in Water Rights, Anderson, ed., p. 89.

29. Ibid.

30. Western Governors' Policy Office, op.cit., p. 26.

31. See Dunning, H.C., op. cit. n.1

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33. See Khoshakhlagn, R., F.L. Brown, and C. DuMars, Forecasting Future Market Values of Water Rights in New Mexico, New Mexico Water Resources Research Institute Report No. 092, November 1977.

34. See DuMars, C., et.al, State Appropriation of Unappropriated Groundwater: A Strategy for Insuring New Mexico a Water Future, New Mexico Water Resources Research Institute and University of New Mexico Law School, January 1986, p. 232.

35. The reasonableness of this ten percent figure for water use in New Mexico has been substantiated by a variety of sources. For example, see Lansford, R., et.al, High Plains-Ogallala Aquifer Studies, New Mexico Water Resources Research Institute Reports (for various New Mexico counties), New Mexico State University, 1983.

36. DuMars, C., et.al, op.cit., p. 9.

37. See Wilson, L., Water Supply Alternatives for El Paso, a report prepared for El Paso Water Utilities by Lee Wilson & Associates, Santa Fe, New Mexico, 1981, p. C-7.

38. The "specific yield" of an aquifer is the quantity of water that a formation will yield under the force of gravity, if it is first saturated and then allowed to drain; the specific yield ratio is the percentage of the above-described yield to the volume of water in the saturated material.

39. DuMars, C., a Letter to the Advisory Board of the New Mexico Water Law Study Committee, November 11, 1985.

40. See Brown, F.L., "Managing Nonrenewable Tributary Supplies," an unpublished report prepared for the New Mexico Water Law Study Committee, September, 1985.

41. See The Impact of Recent Court Decisions Concerning Water and Interstate Commerce on Water Resources of the State of New Mexico, University of New Mexico Institute of Public Law, Appendix A, 1983.

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Comments on Norgaard's paper

A. Things worth applauding

1. Norgaard is right to criticize neo-classical economists for neglecting time. The birth of neo-classical economics was attended by Clark's attack on the Austrian period of production, later reconfirmed by Knight's quarrel with Hayek. Earlier, the "wage-fund" doctrine had been rejected, which doctrine, with all its faults, was the macro-economics of the classical economists. Neo-classical economics following Clark focused on relations of co-existence, to the virtual exclusion of relations of sequence over time. It also downplayed all questions of distribution, including the intergenerational questions posed by Norgaard.

2. RN is right to look at rights of future generations, and right that most of our current thinking neglects the question. But I wish he had said more about what rights he means, and how those are to be distributed among members of the following generations. Does he mean rights to pay rent for resources, or to collect it?

Merely to invoke future generations is not to say anything new today.

3. He is right to demand a fairer hearing for Dennis Meadows, Jay Forrester et al. They led with their chins in Limits to Growth, true, but they did not deserve the lynch-mob treatment they received from most economists (e.g. at Toronto, AEA, 1972).

4. Yes, shadow prices should be used for resources. The prices have risen greatly, but the hidden subsidies even more. If we allocate a reasonable share of our military spending to protecting resource sources, the shadow prices are startling.

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B. Suggestions for improvement

1. It is better to solve one small problem than to scold others for fumbling big ones. This is mainly a critical sermon with little positive contribution.

2. It is wrong to say that substitution does not abate scarcity. That is like denying all gains from trade among regions. Thus, bringing surplus B.C. Hydro energy to southern Calif. does abate energy scarcity down south.

3. RN needs to specify just who is guilty of what, with citations and particulars. A traffic ticket written like this paper would never stand up in court.

4. So what? That classic question is never answered in this rambling soliloquy. If John Dewey is right that "Ideas are plans to solve problems that arise in a social context" then this paper contains no ideas.

It is obviously wrong to say that "No policy (change) can follow" if owners lack omniscience (p.8). What follows is an argument for some form of taxation that shares in the uncertainty.

5. Scarcity in the future tends to make resources today dearer, not cheaper as alleged.

6. Is this paper being recycled from an earlier AEA meeting?

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In summary, I do not find this paper publishable. It falls far short of RN 's capability, as demonstrated in earlier works.