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Do Water Market Prices Appropriately Measure Water Values

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Do Water Market Prices Appropriately Measure Water Values?

ABSTRACT

Valuation of changes in water availability is an important issue in the western United States. Agriculture, industry, and expanding urban centers are exerting increasing pressure on limited water resources. Federal, state and local agencies are exploring and implementing a variety of water supply augmentation strategies in the western states, raising questions regarding the value of potential increments or decrements in water supply. Pressures for water transfers exist as water in many regions is fully appropriated and new and expanding uses can be accommodated only through transfer from established uses. In some areas, water is routinely transferred through private market exchanges. In other areas, institutions which govern water allocation slowly are being modified to facilitate market transfer of water rights. This research examines selected water markets in the western United States, observing water prices over time and evaluating the appropriateness of market prices as measures of the economic value of incremental changes in regional water supply.

Market characteristics which may distort prices as indicators of water values include imperfect competition, third party effects, uncertainty, and equity considerations. Western water markets exhibit these characteristics to varying degrees. Nonmarket valuation techniques are useful in supplementing price information generated by market transactions. Reliance on both market and nonmarket value information can help improve valuation of incremental increases in water supplies and assist in better policy decisions regarding supply augmentation proposals.

INTRODUCTION

Valuing incremental changes in water availability is an important task in the western United States as agriculture, industry and population growth exert increasing pressure on limited water resources. Federal, state and local agencies have an active interest in regional supply augmentation
strategies, including interbasin transfers and artificial recharge and recovery of imported water.¹ Seventy to eighty percent of water yield in the West is the result of snowmelt generated from high elevation forest, much of which is under public jurisdiction. Water yields can be significantly affected by timber harvest practices on these lands.² Management strategies on lower elevation rangelands which alter vegetation and thus evapotranspiration can also affect stream flow and groundwater recharge.³ Given the possibility of altered water availability, questions arise regarding the value of increments or decrements in regional water supply.

The objective of this research is to determine conditions under which water market transactions generate prices that reflect the marginal social value of water. The study identifies key market characteristics which affect the appropriateness of price as a measure of value. Market characteristics and prices from five case study market regions are described and contrasted in this paper. These markets illustrate the diverse hydrologic, institutional and economic conditions which govern water transfers in the West. The paper concludes with observations on the role market prices can play in valuing incremental changes in regional water supplies.

This article addresses water valuation using market prices. This is but one facet of a broader question—how should the benefits and costs associated with supply augmentation projects be evaluated? Analysis of market prices as possible measures of value contributes to understanding how benefits might be estimated. However, other complexities involved in evaluating watershed yield augmentation projects included the need to consider opportunity costs and distribution of project costs and benefits, along with evaluation of alternative means of accomplishing regional water management objectives.⁴ For instance, transfer of water from low-value to high-value uses can sometime substitute or complement supply augmentation. This study finds that water markets typically deviate substantially from the competitive market model, and prices may serve as only a rough approximation of the social value of additional water supplies. Market prices may not fully reflect changing conditions which affect long term supply and demand for water resources. In most cases use of market prices in project evaluations should be supplemented with other

¹. Saliba, An Overview of Economic Considerations in Artificial Recharge Programs, ARTIFICIAL GROUNDWATER RECHARGE (1985).
measures of value, such as water’s value marginal product in alternative uses, or contingent valuation of water in recreational uses.

MARKET PRICES AS MEASURES OF VALUE—A CONCEPTUAL FRAMEWORK

A measure of value should fully reflect potential beneficiaries’ willingness to pay for incremental increases in water supply, as well as any positive or negative side effects (externalities) associated with the supply increase. Prices in perfectly functioning competitive market will reveal buyers’ willingness to pay for the marginal (the last) unit purchased. Figure 1 shows hypothetical urban, agricultural and aggregate demand functions for water at a fixed point in time. The downward slope of the curves reflects the typical economic assumption of diminishing marginal utility. The value of the first units of water made available is high. However, as more units of water become available to a particular water user, that individual or firm is willing to pay less and less for each additional increment of water. Different types of water users exhibit different levels of demand. Urban residents (illustrated by \( D_u \) in Figure 1) attach a higher marginal value to the first increments of water they use than most farmers would be willing to pay for those same increments.

Irrigated agriculture also has a downward sloping demand curve for water (shown as \( D_a \) in Figure 1). The negative slope reflects the fact that the first quantities of water available to a farm are the most valuable. They are applied to crops which yield the highest net returns. Additional water will be applied to the next most profitable set of crops, and so on. The aggregate water demand curve, \( D_A \), is the horizontal summation of the agricultural and urban demand schedules. Given a supply curve represented by \( S_1 \), the market clearing price for water occurs at \( P_1 \). The market price is equal to or more than the unit value water users would place on additional supplies if the supply curve shifted out to \( S_2 \). Willingness to pay for additional units of water could be substantially lower than \( P_1 \), depending on the shape of the total demand curve to the right of \( Q_1 \). Data on current market transactions give little information about the shape of the demand curve beyond \( Q_1 \). As Figure 1 illustrates, even where markets are perfectly competitive and generate no externalities, observed prices serve only as an upper bound for what current market participants might be willing to pay for additional supplies.

Figure 1 portrays water demand, supply, and price formation in a static framework. As population and income levels grow or agricultural commodity prices and production technologies change, demand and supply curves shift and new prices evolve. From a dynamic perspective, observed prices emerging from existing demand and supply relationships could
$D_U$ represents urban demand
$D_I$ represents irrigated agricultural demand
$D_T$ represents total demand and is the horizontal summation of $D_I$ and $D_U$

$0 \leq DU, DT \leq 0$

$P_1 - P_2$

$D_T$

$S_1$

$S_2$

$Q_1$

**FIGURE 1**
Water Demand and Supply

In a static framework $P_1$ serves as an upper bound on the marginal value of additional units of water made available by an expansion of supply from $S_1$ to $S_2$. Willingness to pay for additional supplies depends on the shape of the aggregate demand curve to the right of $Q_1$.

either overestimate or underestimate the marginal value of water supply increases in the future.\(^5\)

Water transactions do not take place in well-functioning competitive markets such as those shown in Figure 1. In general, water markets will not generate prices that fully reflect the costs and benefits of water transactions to all parties affected. A distinction must be drawn between private and social measures of value associated with water. A price negotiated between a buyer and a seller of a water right reflects the values of the units of water exchanged to each party and can serve as an indicator of water value for the agents involved in the transaction.\(^6\) A social measure

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\(^5\) For a more complete discussion of water supply and demand in the Southwest, see M. KELSO, W. MARTIN & L. MACK, WATER SUPPLIES AND ECONOMIC GROWTH IN AN ARID ENVIRONMENT 28-49 (1973).

\(^6\) In a smoothly functioning competitive water market, price is uniquely determined by convergence of buyers' and sellers' marginal values. In actuality, a negotiated price will lie between the buyers' maximum willingness to pay for units of water exchanged and the minimum amount the seller is willing to accept in payment for water transferred. In a transfer from a farmer to a city water supply organization, for example, a farmer's lowest reserve price would be based on the value
WATER MARKET PRICES

of value, however, also takes into account impacts on parties affected by the transaction who were not part of the price negotiation process. This could include neighboring well owners whose depth-to-lift is affected adversely, local fishermen whose trout habitat is disrupted, future water users whose access to water will be altered due to current market activities, or local governments which experience declining tax base as water sales shift resources out of the local economy. Four market characteristics which may prevent market prices from representing social values are discussed in this paper. These characteristics include imperfect competition, externalities, uncertainty and equity. Table 1 describes these characteristics and provides examples of each characteristic in the case study markets.

If one or more water users, suppliers or government agencies can significantly affect market prices and conditions for water transfers (imperfect competition), then observed prices may deviate from maximum willingness to pay for marginal units of water. If water transfers positively or negatively affect third parties and these effects (externalities) are not taken into account in market transactions, prices will not reflect full social values. Market prices give the upper bound of the value of an increment in supply only to the extent that those prices represent all uses and users of water affected by the transfer. Prices are unlikely to reflect instream water uses (recreation, hydropower production, and provision of aquatic habitat) unless these uses are represented in market transactions. Lack of information regarding future water availability and legal conditions for water transfers can also distort market prices. Uncertainty reduces willingness to pay when individuals cannot ascertain precisely what legal rights and restrictions are associated with a water purchase. In addition, distributional considerations may affect the appropriateness of observed prices as measures of social values. Water transfers have an impact on local economic activity both in the communities of origin and the communities receiving the water. Young, Mumme, and Ingram discuss the impacts of water transfers on local economies. Market prices may arise from a distribution of income and access to water which is considered inequitable. If public agencies are working to improve the condition of specific classes of water users, market prices as a measure of value may be inconsistent with distributional objectives for the region. For instance, of the marginal product of water in agriculture if a small proportion of his rights are sold. In addition, farmers may view water rights as an appreciating asset and add speculative value into their reserve price. See Gardner & Miller, Price Behavior in the Water Market of Northeastern Colorado, WATER RESOURCES BULL. 557-62 (1983).

7. Instream flows have been recognized as a beneficial use in Colorado and their value may eventually be reflected in market prices as different organizations (including the Colorado Water Conservation Board) acquire water rights to increase or maintain stream flows.

8. For discussions of the local economic impacts of water transfers, see Young, Direct and Regional Impacts of Competition for Irrigation Water in the West, Presented at the Conference on Impacts of Limited Water for Irrigated Agriculture in the Arid West (1982). See also Mumme, & Ingram, Commodity Values in Southwest Water Management, 4 POL. STUD. REV. (1985).
<table>
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<th>Characteristics</th>
<th>Descriptions</th>
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<td>Imperfect Competition and Market Restrictions</td>
<td>Market participants or public agencies restrict price levels and other conditions of market transfer, and observed prices may reflect these restrictions.</td>
<td>In northeastern Colorado, municipal water departments and water districts are under public pressure not to profit from renting their unused water supplies back to farmers. Most simply rent excess water at cost rather than attempting to charge market clearing prices.</td>
</tr>
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<td>External Effects of Market Activities</td>
<td>Market prices do not take into account the values of parties external to the price negotiation process or impacts of transfers on third-parties.</td>
<td>In the Lower Sevier River basin of Utah, changing water use patterns by the Intermountain Power Project has improved water quality for irrigators by reducing salinity in the river.</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>Uncertainty regarding future water supplies, demand, and the legal framework that governs water transfers will affect market decisions and observed prices.</td>
<td>Significant quantities of additional water supplies were denied to users in Nevada when the federal government decided to use Stampede Reservoir for maintaining fish habitat in the Truckee River instead of allocating the water for consumptive purposes. The ensuing scramble for alternative sources of water has helped push water rights prices to unprecedented levels.</td>
</tr>
<tr>
<td>Equity and Conflict Resolution</td>
<td>Economic and legal barriers to market participation can create inequitable access to water. Water allocation decisions may serve as a form of conflict resolution and be made on political rather than economic grounds. Market prices may not fully reflect distributional and political considerations.</td>
<td>Many instream uses of water have never been legally recognized and are increasingly threatened by increased consumptive uses offstream. In southwestern New Mexico, unique riparian habitat in Gila River is endangered by a proposed dam. Pyramid Lake Indians in Nevada have no water rights to protect their traditional fishing grounds, and have turned to extensive litigation to maintain minimum flows in the Truckee River system.</td>
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controversies regarding Native American water rights in the Southwest illustrate the need to attend to equity issues. 9

To summarize, there are several potential problems in considering water market prices as measures of marginal social value. First, in a perfectly competitive market observed price represents market participants’ willingness to pay only for the marginal unit of water currently available. Collective willingness to pay for additions to the existing water supply could be substantially lower than the market price. Second, market activities may generate externalities so that effects of water use and transfer are poorly reflected in market prices. Some externalities arise because individuals affected by water transfers or supply increases are not market participants and impacts on their well-being are not reflected in market prices. Also, observed prices may be influenced to varying degrees by imperfect competition and legal or hydrologic uncertainties. Finally, market prices may reflect inequitable access to water and income-earning opportunities.

WATER MARKET ACTIVITY

Each of five water market regions is briefly described with respect to location, major water sources and uses, institutions that govern water allocation and transfer, and available price data. Figure 2 identifies the five market areas which are located in Nevada, Utah, Colorado, Arizona and New Mexico. The specific regions studied were selected based on several criteria. Each area is characterized by economic scarcity of water, well defined institutional and geographic boundaries, and availability of public and private sources of information on water transfers and prices. Lack of secondary sources containing detailed price information necessitated extensive fieldwork. Price data obtained from individuals familiar with market transactions was a major source of information.

An effort has been made to make price observations as comparable as possible over time and across market areas. Prices have been adjusted, using the Gross National Product [GNP] price deflator, to 1986 dollar values. In addition, several conventions have been adopted to allow the comparison of different water rights in terms of common units of measure.

Water rights may be transferred in perpetuity (sold) or temporarily (leased). Water values differ when water is sold or leased because rental prices reflect annual or seasonal values only, whereas sales prices reflect sums of discounted streams of values over extended periods of time.

Unless otherwise noted, transactions described in this study are sales rather than leases.

In quantifying water rights, it is important to distinguish between diversion rights and the consumptive use portion of a water right. Diversion rights refer to the maximum quantity of water which may be withdrawn per unit of time from a water source. Consumptive use refers to the portion of that diversion right which may be removed permanently from the hydrologic system through evaporation, transpiration, or other means. The difference between diversion and consumptive use is the "return flow," or the portion of the diverted water which returns to the system and is available for appropriation and use by others. In many areas, transfers of water are limited to quantities equal to the consumptive use portion of the water right. This limitation is enforced in order to protect other water users from having their own water rights adversely impacted as a result of the transfer. If water is transferred completely out of the hydrologic system of origin, or if the rate of consumptive use differs between the original use and the new use, the quantity of divertable water that the seller of a right gives up in a transfer will usually not be the
same as the quantity of water that the buyer is able to divert. Unless otherwise indicated, all descriptions of transfers refer to the quantity of water that may be diverted for use by the buyer.

Water rights are quantified by flow rate, by absolute volume, and sometimes by both. Flow rates are usually measured in terms of cubic feet per second, while volumetric limits are usually measured in terms of acre feet per year. Water users are concerned not only with the rate of flow or the volumetric limit of a water right, but also with the capacity of the water resource to satisfy their rights. If the hydrologic capacity of the water resource varies significantly over time, or if many other water users have a senior claim to rights from the same water resource, then the yield of a particular water right may not always be equal to the full limit of the right. The long-term average yield of a water right often is less than the maximum flow rate or volumetric limit of a water right. Unless otherwise indicated, all water transfers in this study are quantified according to their long term average yield, in acre feet per year.

Truckee Basin, Nevada

The Truckee River flows from Lake Tahoe in the Sierra Nevada Mountains into Pyramid Lake in the northwest Nevada desert. The Carson River flows just south of the Truckee Basin. Water from the two river systems is used conjunctively in the Truckee-Carson Irrigation District [TCID], located downstream and about 50 miles to the east of the Truckee Meadows. The cities of Reno and Sparks form the core of a rapidly expanding regional population in the Truckee Meadows.

The majority of water used in the area is primary flow or storage from the Truckee River. Rights to the Truckee River were adjudicated under the Orr Ditch Decree of 1944.10 Reno and Sparks receive water from Sierra Pacific Power Company, a privately owned utility. The Washoe County Government provides some water service to outlying communities. Irrigators are supplied with Truckee River water delivered by private ditch companies. Lake Tahoe and Boca Reservoir serve as area-wide regulatory and storage facilities for the Truckee River. In addition, Sierra Pacific owns and operates one small reservoir and jointly owns and operates another reservoir with the Truckee-Carson Irrigation District.

Approximately fifteen to twenty percent of the water used in Reno and Sparks is groundwater. While Sierra Pacific is considering increased groundwater withdrawals in the future, current efforts focus on augmenting their Truckee River surface water rights. In addition to its existing surface water rights, Sierra Pacific has a right to pump up to 12,000 acre

feet of groundwater per year. Recent withdrawals have varied between 8,000 and 10,000 acre feet per year. Another 2,000 to 3,000 acre feet of groundwater are pumped by individual irrigators and private water companies. In certain areas of the Truckee Basin, groundwater quality is poor because it contains heavy metals. Groundwater overdraw is carefully avoided in the Reno-Sparks area because of the danger of drawing poor quality water into portable water supplies.\footnote{11}

About 50,000 acre feet of Truckee River surface water rights are used by Sierra Pacific to serve urban areas and 300,000 are used for irrigation annually. Up to 300,000 acre feet per year of Truckee River water flows into Pyramid Lake.\footnote{12} The Pyramid Lake Indian Reservation and the Truckee-Carson Irrigation District are the major Truckee River water users located outside the Reno-Sparks area. Indian, irrigators, and municipal users of the Truckee River have been locked in continuing litigation over water resources since the early twentieth century.\footnote{13} Growth of the Reno-Sparks area has brought increasing numbers of nonagricultural enterprises with a high willingness-to-pay for water. Institutional barriers have precluded the transfer of water rights from TCID to the Reno-Sparks area, forcing these communities to support growth by reallocating water resources locally.

A federal watermaster oversees the administration of the Truckee River in compliance with the Orr Ditch Decree. In 1978, the State Engineer closed the groundwater basin to further appropriation. Transfers of surface water and groundwater rights are subject to approval by the State Engineer. Approval procedures seek to prevent impairment of existing water users' rights. The State Engineer consults with the federal watermaster on transfers of surface water rights in the Truckee River under the directives of the 1935 Truckee River Agreement.

Until the late 1970s almost all transfers of surface water rights involved the sale of irrigation rights to Sierra Pacific. By 1979, Sierra Pacific became aware that it was not acquiring water rights fast enough to keep up with the growing demand for its services.\footnote{14} Increasing awareness of the scarcity of water has driven prices up more than twenty-fold since 1979 and has brought many new actors into the market. The Nevada Public Service Commission, Sierra Pacific, the State and the local governments now require developers to provide water rights in exchange for

\begin{footnotes}
\footnote{12} Personal communication with Gary Stone, Federal Watermaster for the Carson and Truckee Rivers, May 1, 1985.
\footnote{13} McNeeley, \textit{Economic and Institutional Aspects of Water Transfers in Northwest Nevada}, \textit{AGRICULTURAL EXPERIMENT STATION BULL.} B27 (1971).
\end{footnotes}
Developers acquire Truckee River water rights from both within and around the periphery of the service area of Sierra Pacific. These rights are dedicated to the cities of Reno and Sparks as a precondition for development project approval. Rights acquired by the local governments are leased for ninety-nine years to Sierra Pacific. Sierra Pacific’s long-term leases of water rights from the cities are based on an assumed nominal market value of $1,500 per acre foot.

Prices paid for water rights by Sierra Pacific averaged about $100 per acre foot between 1946 and 1959, rose to over $150 per acre foot between 1960 and 1964, fell to $140 per acre foot between 1965 and 1970, and fell again to less than $75 per acre foot by 1979. Price offers by Sierra Pacific rose to over $100 per acre foot in the early 1980s but higher offers from other buyers, primarily real estate developers, left few individuals willing to sell at that price. As late as 1983, Sierra Pacific was still refusing to pay more than $200 for water rights while observed market prices ranged from $850 to over $2,000 per acre foot.

A potentially large pool of water rights available for transfer in the Reno-Sparks area are the irrigation water rights appurtenant to lands that have already been subdivided for urban development. Before the sharp increase in the market value of water rights around 1980, and before Reno and Sparks required the dedication of water rights as a pre-condition for approval of any development, water rights usually were conveyed along with land. Sierra Pacific routinely granted water service on subdivided parcels of these lands. Water rights remained with each parcel, though they were no longer in use. Over 30,000 acre feet of unused irrigation water rights are estimated to be distributed, most of them in parcels of only a few acre feet, over thousands of acres of highway rights of way, commercial establishments, and residential lots.

Since early 1985, the cities of Reno and Sparks have been soliciting urban owners of these old irrigation rights to sell them. The price offered is set by joint agreement of Reno and Sparks with Sierra Pacific at a nominal value of $422 per acre foot. The low offer price is meant to reflect the high transactions costs, primarily the title search, involved in transferring small quantities of water rights appurtenant to lands which have often been subdivided and which typically have changed hands.
several times. As of the end of 1986, the program of acquiring unused irrigation water rights in the Reno-Sparks urban area had met with only limited success. Sparks had purchased about fifty acre feet of rights, and Reno acquired about 325 acre feet. Apparently there are two reasons for the lack of success. The first is that many holders of water rights resist selling their rights in the belief that prices will rise significantly in the future. The second is that several private water brokers operating in the Truckee Meadows have been outbidding the cities. Typically the price offered by the brokers range between $600 and $800 per acre foot, less a brokering fee. The brokers assemble several small water rights into a larger package for resale to a local developer. Prices for these brokered packages of urban water rights have exceeded $2,000 per acre foot.

Sierra Pacific is considering various alternatives for acquiring additional water rights from sources outside the Truckee Basin. These include purchase of surface water rights in Sierra Valley, California, and groundwater rights in Warm Springs and Honey Lake, Nevada. Ranches in Sierra Valley, California are irrigated by surface water rights from a number of sources, including the Truckee River. Since Truckee River water rights tend to be spread relatively thinly over many acres, the company would have to purchase large parcels of land from dozens of different owners to secure an adequate supply of surface water rights. The high cost of the water rights (in excess of $2,000 per acre foot) along with local opposition to the purchase and legal uncertainties associated with transporting water across the state line, have diminished interest in this particular alternative.

Acquisition of distant groundwater rights appears to be a more promising alternative. In 1986, Sierra Pacific concluded an agreement with a landowner in the Warm Spring Valley, located approximately twenty miles northeast of the Truckee Meadows. Pending approval of the transfer by the State Engineer and authorization of the purchase by the Public Service Commission, Sierra Pacific will buy 2,100 acre feet of groundwater rights. The company also retains an option to purchase up to an additional 700 acre feet of groundwater rights. The purchase price of $1,150 per acre foot, which is considerably less than the current value of over $2,000 per acre foot for Truckee River rights, reflects the high cost of transporting and treating the groundwater relative to local surface water supplies. Funds for purchasing the rights have been placed in escrow pending approval of the sale and transfer. In the meantime, the seller may collect the interest accruing on the money.

19. Personal communications with Sandy Landeck, Property Management Agent for the City of Sparks, Nevada, Apr. 29, 1985 and May 22, 1986. See also supra note 11.
20. Supra note 19.
21. Supra note 18.
22. Supra note 11.
A second possible source of distant groundwater is in the Honey Lake Valley, located about thirty-five miles north of the Truckee Meadows. Due to the high cost of developing this water supply, Sierra Pacific does not expect to offer to pay more than $500 to $600 per acre foot. Proposed transfers of groundwater out of Honey Lake Valley have been extremely controversial, because the groundwater basin lies partly in Nevada and partly in California. In early 1987, the State Engineer called a three-year moratorium on all water transfers and appropriations of groundwater in the Honey Lake Valley pending the results of a comprehensive study of the Basin’s hydrological capacity.  

**Lower Sevier Basin, Utah**

The Sevier River flows north from the high plateaus of southwestern Utah, terminating in the Sevier Desert one hundred and forty miles southwest of Salt Lake City. Four mutual stock irrigation companies—Delta, Melville, Abraham and Deseret [the DMAD companies], control virtually all surface flow rights on the lower stretch of the river. Each company operates its own canal system within a designated service area but they jointly own and manage several reservoirs. River salinity levels have exceeded 3,000 parts per million but delivery costs are low and water quality is usually adequate for irrigation. Until recently, water delivered by DMAD was used exclusively for irrigation. In 1980, the Intermountain Power Project [IPP] bought twenty percent of DMAD company stocks, thousands of acre feet of privately held groundwater rights, and eighty percent of the water stock in another ditch company upstream of DMAD. The total package of water rights, with a yield of 45,000 acre feet per year, cost approximately $2400 per acre foot. The water will be used for cooling a new coal-fired power plant which begins operations in the late 1980s. The projected size of the power plant operation was reduced after IPP had already purchased the water rights. Consequently, about half the water rights owned by IPP are not needed for power plant operations. IPP currently rents unused water to irrigators and plans to continue this practice.  

The Cox Decree of 1936 apportioned flow and storage rights along the lower Sevier River. A river commissioner oversees water use and water transfers to assure compliance with the decree. All appropriated water rights in Utah are appurtenant to land and their transfer for use on other

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23. *Id.*


25. Personal communication with Manuel Perez, Managing Engineer for the Intermountain Power Project, Delta, Utah, May 7, 1985.

lands requires proceedings before the State Engineer. Water rights represented by water company mutual stocks, however, are appurtenant to that company's entire service area and may be transferred freely for use on different parcels within that service area. Seasonal water transfers are permitted anywhere within the four companies' combined service areas. They may be rented by anyone who will use the water within these boundaries. Water rentals have occurred among members of the four DMAD companies since the 1950s.

The DMAD companies, IPP, and individual water users own groundwater rights. Irrigation companies occasionally pump groundwater directly into the river in order to dilute saline surface water for irrigation use. Transfers of groundwater rights from one location to another or from one purpose to another, must go through proceedings established by the State Engineer's office. Groundwater rights may only be transferred within the same aquifer. This restriction applies both to aquifers in different geographical locations and to deep versus shallow aquifers which overlie one another. The lower Sevier River area is divided into low- and high-impact groundwater regions. Water rights may be transferred out of the high-impact region (so that less water will be pumped there) but cannot be transferred into it. This provision is designed to preserve future groundwater supplies in the vicinity of Delta, where demand for groundwater is expected to grow and concerns have been raised about groundwater overdraft.

The vast majority of water transfers are seasonal water rights rentals among irrigators. Studies conducted between 1948 and 1964 indicate that there has been no long-term upward or downward trend in the real price of surface water. Short-term price fluctuations, documented since the 1940s, have followed the hydrologic cycle of the river. Rental prices are, as expected, higher in dry years and lower in wet years. Over the last several decades rental prices have varied between seven and seventy-five dollars per acre foot. Sales of mutual water company stocks (nearly always for irrigation) and groundwater rights purchases have generated prices ranging from $300 to over $2,400 per acre foot since 1978. Prices rose sharply in the period preceding and immediately after IPP's purchases in 1980, but leveled off to between $300 and $500 per acre foot in 1984 and 1985.

28. Personal communication with Warren Tenney, Secretary-Manager for the DMAD Water Companies, Delta, Utah, May 6, 1985.
29. Personal Communication with Kirk Forbush, Assistant Area Engineer for the Utah Dept. of Natural Resources and Energy, Division of Water Resources, Richfield, Utah, Aug 1, 1985.
Effects on water prices which might result from the entrance of IPP into this market (both as a purchaser of water stocks and as a renter of water rights to irrigators) have been masked by an unprecedented wet cycle that began in 1983 and persisted through 1985. The rental market resumed in the middle of the 1986 irrigation season, but water was still abundant and trading activity was light.

Northern Colorado Water Conservancy District, Colorado

The Northern Colorado Water Conservancy District [NCWCD] lies north of Denver and east of the Rocky Mountains. Urban centers include Boulder, Fort Collins, Loveland, Longmont and Greeley. Irrigation is extensive but has been declining in the face of urban growth.

Groundwater is generally of poor quality and is used primarily as a supplemental irrigation water source. Surface water is preferred for municipal use. Surface water supplies originate as snowmelt and runoff from the Rocky Mountains. Surface water quality is high, but natural seasonal flows are erratic and highly variable. The majority of water supplied comes from surface water delivered by different kinds of water service organizations. The Colorado-Big Thompson [C-BT] project is the largest single supplier in the area, delivering an average of 225,000 acre feet of water annually from mountain reservoirs on the west slope of the continental divide to the NCWCD on the eastern slope. C-BT does not operate local distribution systems. Instead a large and sophisticated array of diversion, storage, distribution, and treatment facilities are owned and operated by a variety of organizations—such as mutual water stock companies, municipal water systems, water districts, and water user associations. The substantial investment in infrastructure is a response to the abundant but seasonal nature of the regional water resources.

Irrigated agriculture traditionally has been the major water use in the area, but growing demand by industry, power generation, and rapidly expanding cities characterizes a significant shift in water use. Urban growth and land acquisition since the late 1950s have converted increasing quantities of irrigation water rights to municipal uses. Cities obtain water rights through purchase of water company stock, dedication of water rights by developers in exchange for water service, and wholesale acquisition of water service organizations, especially irrigation companies whose service areas became urbanized. Although the C-BT project originally was developed as a supplementary water supply for irrigation, approximately one-third of C-BT allotments now are in municipal or industrial ownership.32

Primary surface water flows, storage rights, and groundwater that is

“tributary,” that is, hydrologically related to surface flows, are regulated by the State Engineer on the basis of prior appropriation. Most groundwater rights in the NCWCD area are considered tributary to surface stream flows. Most were filed after the rivers were fully appropriated and are, therefore, junior to surface water appropriations. C-BT water is used to offset fluctuations in natural surface water flows on the eastern slopes. C-BT annual releases may range from 155,000 to 310,000 acre feet. In dry years on the eastern slope the governing board of the NCWCD will release more C-BT water, and less in wet years.33

Water rights transfers in Colorado must be approved by a state water court, but this procedure generally is unnecessary in the case of intra-company water stock transactions. Water rights represented by company water stock are, therefore, very marketable rights. The larger the company service area, the larger the area over which the water may be marketed without court proceedings. The high value attached to C-BT water lies in the fact that the project functions as a mutual stock water company, with the largest service area of any such organization in Colorado. Water rights controlled by the Colorado-Big Thompson project (represented by shares, or “units,” each one entitling the holder to 1/310,000 of the water delivered by the project in a given year) may be used or transferred anywhere within the NCWCD. The market price of a unit of C-BT water serves as a benchmark against which all other water rights and water rights prices in northeastern Colorado are evaluated.

Water service organizations derive their water supplies either from their own adjudicated flow and storage rights, or from holding stock in other water service organizations. The portfolio of water rights owned by the city of Fort Collins, for example, includes shares of North Poudre Irrigation Company stock, units of C-BT, shares and interests in miscellaneous smaller water companies, as well as its own direct flow and storage rights.

The marketability of water rights within the NCWCD is strongly affected by the ease with which the water can be physically transported to the desired point of use at the desired time. The variation in the price of water rights supplied by various organizations is related to the size of the organization's service area and the flexibility of the water right in use and transfer. The size of an organization's service area affects the spatial flexibility of its water, and the extent of an organizations' storage facilities affects the temporal flexibility of its water deliveries. Both spatial and temporal flexibility are important determinants of water values. C-BT units and North Poudre Irrigation Company shares, because of their flexibility and easy transferability, are the most marketable kinds of water

In a typical year annual water supply available for municipal use is in excess of demand. Excess municipal water is rented to irrigators. Information on rental prices is difficult to obtain because, unlike sales, rentals are not carefully recorded. However, available evidence indicates that water rental prices in the NCWCD have remained low relative to the market value of most water rights. This is due to the relative abundance of rental water in most years, the fact that most water is rented to agricultural users who are unwilling to pay high prices, and to public pressure against earning "excessive" profits from rentals.

Southern Arizona

In Arizona, several distinct types of water rights have been purchased by users in the Tucson and Phoenix Active Management Areas [AMA's]. These include irrigation rights that can be converted to Type I non-irrigation groundwater rights, Type II nonirrigation groundwater rights, groundwater rights originating outside of the AMA's, surface water flows, and reclaimed sewage effluent.

No irrigation rights, whether they are groundwater or surface water rights and whether they are located inside or outside an AMA, can be purchased without simultaneous purchase of the land to which they are appurtenant. Purchasers of irrigated farmland located within an AMA may convert the groundwater rights on the land to "Type I" nonirrigation groundwater rights. Type I rights are limited to a maximum rate of with-
drawal of three acre feet per irrigated acre per year, or the quantity which had been permitted for irrigation, whichever is less.\textsuperscript{37} There are no specific quantity limitations on groundwater rights acquired outside an AMA. Buyers who wish to export groundwater from lands located outside of AMA's are limited only to those quantities of water they can put to "beneficial use."\textsuperscript{38}

Within the Tucson AMA, the market for Type I rights is dominated by the city of Tucson. Tucson has been purchasing and retiring irrigated farmland in the neighboring Avra Valley since the early 1970s. Assuming that the land has no value apart from the water rights, and assuming an exportable yield of three acre feet of groundwater per irrigated acre, prices for Avra Valley water have increased from a range of $400 to $500 per acre foot in the early and mid-1970s to a range of $650 to $1,000 per acre foot in the 1980s. By the end of 1986 over 20,000 acres of irrigated and nonirrigated land had been acquired, with a total exportable yield of approximately 55,000 acre feet.\textsuperscript{39}

There are several factors which complicate the evaluation of water rights prices in the Avra Valley. Prices emerge from transactions occurring between a single buyer, the City of Tucson, and a limited number of potential sellers, the Avra Valley farmers. The cost of each acquisition included irrigated land, nonirrigated land, and all improvements, and it is, therefore, difficult to assign a value to the water rights alone. Future water values in the Tucson area will be affected by the Tohono O'Odham [Papago] Tribe's water rights. The 1982 Southern Arizona Water Rights Settlement Act gave the Tribe rights to 76,000 acre feet of water annually, to be delivered by 1992. Some of this water will come from the Central Arizona Project, some may be treated effluent from the City of Tucson (to be used in water exchanges, since it cannot be transported to the reservation through existing facilities or the CAP canal), and another portion will come from new groundwater withdrawals. The Act allows for leasing of tribal water rights to water users within the Tucson Active Management Area under specific conditions and with the approval of the Secretary of the Interior.\textsuperscript{40} The potential availability of significant quantities of leased water in the Tucson area creates a great deal of uncertainty regarding future water transfers and prices. Given all these considerations, observed prices for retired irrigation rights and agricultural properties do not appear promising as measures of future water values in the Tucson area.

\textsuperscript{37} \textit{Ariz. Rev. Stat. Ann.} Id. at §§45-469.
\textsuperscript{38} \textit{Ariz. Rev. Stat. Ann.} Id. at §§45-453.
Numerous purchases of farmland in the Pinal and Phoenix AMA's for Type I conversion have occurred. In 1985 the city of Mesa, located in the Phoenix AMA, purchased over 11,000 acres of irrigated farmland, located in the Pinal AMA, with a yield of about 30,000 acre feet in Type I nonirrigation water rights. Average prices paid per acre foot were about $1,000 per acre foot. Mesa's purchase has given rise to numerous concerns in Pinal County about the local economic impact of the farmland sales. Of primary concern are the effects of farmland retirement on the local and county tax base, secondary impacts of reduced farming activity on other local businesses, and the loss of water rights for future economic development. Mesa is working to overcome the negative impacts of farmland, retirement, and water transfer in two ways. The city has committed itself to making voluntary cash contributions to Pinal County and to local irrigation districts in lieu of property taxes, which the city is legally exempted from paying. Mesa is also planning eventually to convert the agricultural CAP allocation on the farmlands it owns to nonagricultural allocations, and to leave this allocation of one acre foot of water per acre on the rural land for use in future nonagricultural development.

In 1985, a Phoenix-area investment group purchased a farm in the Phoenix AMA with 2,240 irrigated acres. The irrigation water rights are convertible to Type I nonirrigation rights with a yield of 6,180 acre feet per year. The purchase price averaged slightly under $1,300 per acre foot. In 1986, the same investment group purchased another farm in the Phoenix AMA with 6,070 irrigated acres and a yield of 15,340 acre feet in Type I nonirrigation rights, for approximately $1,000 per acre foot.

Type II rights are held by golf courses, mines, hospitals, dairies, sand and gravel operations, power plants, and other municipal businesses which obtain supplies of groundwater independently of municipal water service organizations. In contrast to other water rights in Arizona, Type II nonirrigation groundwater rights are not strictly appurtenant to land. They are easily transferable to other locations within the same AMA.

Although the absence of appurtenancy rules would appear to make Type II rights more marketable than other water rights in Arizona, the supply and demand for the rights is limited and the volume of Type II water rights transacted is small. The supply of Type II rights is limited because they constitute only a small proportion of the total water rights in Arizona's Active Management Areas. Another limitation on the supply of Type II rights is related to certain restrictions on their transferability. Type II rights designated for mining and power generation purposes may not be transferred to any other use. Transfers of Type II rights are restricted

to the whole quantity of the right, that is, they may not be fractured and
sold piecemeal.\textsuperscript{43}

The demand for Type II rights is limited because they are of interest
to only a relatively small number of water users in Arizona. Generally,
they are not attractive to municipal water purveyors, who have little
incentive to purchase local water rights. Existing municipal water pro-
viders with AMA's hold "service area" water rights, which allow them
to pump as much groundwater within their service areas as they need to
serve their customers. Water providers in AMA's who have purchased
water rights have done so because their local wellfields and surface water
supplies were approaching or were already at full capacity, not because
they are legally restrained from additional local groundwater pumping.
Demand for Type II water rights is, therefore, limited mostly to inde-
pendently supplied nonagricultural water users and to new water service
organizations with no established service area water rights. Typical prices
in the Tucson and Phoenix AMA's between 1984 and 1987 have ranged
from $500 to $1,500 per acre foot.

Several other purchases of groundwater and surface water rights have
taken place in Arizona outside of the Active Management Areas, mostly
in La Paz County in west central Arizona. In 1984 the city of Scottsdale
purchased the 8,400 acre Planet Ranch, with an estimated yield of 13,500
acre feet of surface water rights, for about $900 per acre foot. The city
hopes to transport water from out of the Bill Williams River to the CAP
aqueduct, which would then carry the water to Scottsdale.\textsuperscript{44} The Crowder-
Weiser Ranch, consisting of 6,100 acres of state leased land and 3,920
acres of private land, was purchased by a real estate development company
in 1985 to support projects in the Phoenix Area. A series of small ac-
quisitions by the same developer totalling an additional 3,700 acres of
private land continued through 1986. The total yield of transportable
water rights from the Crowder-Weiser Ranch is estimated to be 51,140
acre feet of groundwater per year. The first lands with water rights were
purchased at an an average price of over $950 per acre foot. Subsequent
purchases cost slightly over $500 per acre foot.

In December, 1986, the city of Phoenix concluded negotiations for the
purchase of 16,000 acres (2,000 acres of state land leases and 14,000
acres of private land) in the McMullen Valley of eastern La Paz County,
for slightly over $30 million. The city estimates that between six and
seven million acre feet of recoverable groundwater are in storage in the
aquifer underlying the lands. Approximately 30,000 acre feet of water

\textsuperscript{43} Id. at §§ 45-474.

\textsuperscript{44} Personal communication with Leonard Dueker, Executive Assistant to the City Manager,
per year will be transported to the city by the year 2005.\textsuperscript{45} Since the McMullen Valley lies outside the Active Management Area system, legally Phoenix is free to pump as much water as it wants, so long as the water is being put to "beneficial use." However, groundwater exporters can be held liable to pay damages to third parties who demonstrate that the export of the water is causing them harm.\textsuperscript{46}

Another emerging water market in Arizona is the leasing of sewage effluent. Pima County, in the Tucson AMA, has been selling up to 3,500 acre feet per year of treated effluent to farmers in the Cortaro-Marana Irrigation District for several years at nominal price of $5 per acre foot. In 1987, the price will rise to at least $10 per acre foot. Tucson city policy encourages all large commercial water users to use effluent whenever possible. New golf courses in the Tucson service area are now required to irrigate their turf with effluent.\textsuperscript{47} In 1986, Tucson provided effluent to commercial water users for $372 per acre foot.

An agreement for the sale of large quantities of effluent was signed in 1973 between Palo Verde nuclear power station, located west of Phoenix, and several Phoenix-area cities. The contract includes four separate purchase options, which, if exercised, would provide as much as 140,000 acre feet of effluent annually to Palo Verde through the year 2040. The cost for the effluent was fixed at $30 per acre foot, a sum now considered inadequate. A series of lawsuits challenging the validity of the contract may ultimately reopen negotiations and allow the cities to establish a higher price for the effluent.\textsuperscript{48}

\textit{Gila-San Francisco Basin, New Mexico}

The Gila and San Francisco Rivers drain the southwestern corner of New Mexico. The Gila-San Francisco Basin is sparsely populated, but Silver City, a town of about 20,000 people, is located nearby. The Gila-San Francisco Basin effectively has been closed to additional groundwater appropriations since the late 1960s. New groundwater wells may still be developed, however, by converting a surface water right to a groundwater right and changing the point of diversion to the desired well location.\textsuperscript{49}

\textsuperscript{45} Personal communication with Carrol Reynolds, Planning Engineer for the city of Phoenix, Arizona Water Department, Dec. 22, 1986. See also James M. Montgomery, Consulting Engineers, Inc., City of Phoenix Water Resources Study, McMullen Valley (1986).
\textsuperscript{46} \textsc{Ariz. Rev. Stat. Ann.} §§45-544 & §§45-545. (1986 Supp.). \textit{See also supra} note 45.
\textsuperscript{47} Personal communication with Kirk Guild, Planning Division for the City of Tucson, Arizona, Jan. 9, 1986. \textit{See also} Tucson Water, Generalized Effluent Reuse Policies (1982). \textit{See also} City of Tucson Ordinance No. 6411; Tucson Water: Schedule of Rates and Charges (1986).
Since the 1960s, as changes in land use have created demands for water distant from old irrigation ditches, many surface water rights have been retired and exchanged for groundwater rights. In addition, the State Engineer still routinely issues permits for limited indoor household use of groundwater. These permits are not considered appropriated rights.

Rights to the Gila and San Francisco river systems were adjudicataed in the early and mid-1960s as a result of the settlement of the Colorado Basin lawsuit, *Arizona v. California*. Approximately 30,000 acre feet of Gila and San Francisco River water may be used in New Mexico’s Gila-San Francisco Basin. Surface water on the Gila, the San Francisco, and tributary streams usually is delivered by ditch companies and is used almost exclusively for irrigation. The major exception is a large block of surface flow rights used for mining operations by the Phelps Dodge Corporation. Towns and residential subdivisions depend entirely upon groundwater. Most other rural domestic and industrial users depend on their own private groundwater supplies. There are no significant surface water capture and delivery systems other than those serving Silver City and the Phelps Dodge mine. Ditch companies generally serve only a few neighboring farms. Storage facilities on the Gila-San Francisco system are limited to small reservoirs, mostly privately owned.

Until the mid-1960s, agriculture was the major user of water in the Gila-San Francisco Basin. The pattern of water use changed substantially in 1968, when Phelps Dodge acquired land and approximately two thirds of all the water rights appurtenant to lands in the Gila portion of the basin. Other nonagricultural commercial and household water users have since entered the market to acquire water rights.

The largest water rights holders in the basin are the Phelps Dodge copper mine, which uses about 11,000 acre feet per year, and Silver City. Silver City is not located in the basin itself, but transports approximately 800 acre feet of water annually across the continental divide from wellfields in the Gila-San Francisco. Other water users include a few smaller mining operations, some irrigation, and a scattering of small rural communities, private homesteads, and small subdivisions.

In 1986, Phelps Dodge announced that it had purchased Kennecott’s interest in the Chino mine in the Mimbres basin, and that it planned to phase out its mining operations at its Tyrone mine in the Gila-San Fran-

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50. Personal communication with David Alison, Office of the State Engineer, District 3, Deming, N.Mex., Mar 8, 1985.


52. The Pacific Western Land and Cattle Company (a subsidiary of the Phelps Dodge Corporation) purchased large tracts of land during the 1950s and 1960s in what later became the Gila-San Francisco Basin. The company developed extensive water rights for irrigation prior to the State Engineer’s declaration and closing of the basin in the mid to late 1960s. Phelps Dodge transferred most of the irrigation water rights to its mine in 1968.
Approximately half of the over 11,000 acre feet of water rights owned by Phelps Dodge in the Gila-San Francisco will no longer be used for mining within ten years, and within twenty years the mine will be shut down completely, freeing up all of the water rights for alternative uses. The mine has considered transferring some of its rights to domestic purposes on company land that may be sold for retirement homes, but it is unlikely that all or even most of Phelps Dodge’s water rights could be used for that purpose. The future of the supply and demand for water rights over the next few decades in the Gila-San Francisco Basin is, therefore, highly uncertain.

Water rights in the state of New Mexico are under the jurisdiction of the State Engineer. Any change in the point of diversion, purpose of use or place of use of a water right must be approved by the State Engineer. As a federally adjudicated area, the Gila-San Francisco faces stringent controls. Appropriation of new water rights for outside domestic use, something routinely granted elsewhere in the state, is not permitted. Households with independent water systems cannot maintain lawns, gardens, orchards, or fishponds unless existing water rights are acquired from another user. The Gila-San Francisco Basin, therefore, has an active market for domestic water rights. Domestic, municipal, and industrial water rights are most commonly acquired through the purchase and retirement of irrigation rights.

Water rights in the Gila-San Francisco Basin are appurtenant to specific parcels of land, but they may be owned and transferred separately from the land. Rights may not be transferred into or out of the particular sub-basin (the Gila and the San Francisco) where they were established. However, quantities of water equal to the consumptive use of any water right (except a domestic water right) may be transported to any location inside or outside the Gila-San Francisco Basin, subject to the approval of the State Engineer.

Water rights purchases by area mines have constituted the largest volumes of water transferred over the past fifteen years (but represent only a small number of transactions). Prices from these transactions are difficult to document, because mining companies are generally unwilling to disclose information on their purchases and sales. Some data on private sales to the mines were made available from area realtors and other individuals. Most transactions recorded by realtors took place within the past ten years.

54. Supra note 53.
56. Personal communication with Hilton Dickson, Attorney for Silver City, New Mexico, Apr. 11, 1985.
and involved small quantities of water rights, frequently equal to an acre foot of water or less.

The typical price for an acre foot for water rights ranged between $1,500 and $1,800 in the early 1970s. Prices remained fairly constant until the late 1970s, when they rose to a range of $2,000 to $3,200 per acre foot. Prices have declined since the early 1980s to a range of $1,100 to $1,800 per acre foot.

**COMPARISON OF PRICES ACROSS MARKET AREAS**

Price data for sales of perpetual water rights compiled as a part of this study are summarized in Table 2. Water rights prices are a function of the interaction between demand and supply-side forces in any given market area. Demand side forces reflect expansion and contraction of water-using activities, which in turn depend on the vitality of the regional

<table>
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<th>Year</th>
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<th>Colorado*</th>
<th>Nevada*</th>
<th>New Mexico*</th>
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*Note: ND indicates not data available.*
### WATER MARKET PRICES

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<tr>
<th>Year</th>
<th>Arizona Valley</th>
<th>Arizona Type II</th>
<th>Arizona C-BT</th>
<th>Colorado Truckee River</th>
<th>Colorado San Francisco</th>
<th>Nevada DMAD</th>
<th>New Mexico DMAD</th>
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NT indicates no transactions occurred in this market during the year indicated. ND indicates no price data were obtainable for transactions occurring during the year indicated.

*Data on the sale of Type II nonirrigation water rights were obtained from investment managers, real estate developers, attorneys and other private individuals. The market for Type II rights began to develop in 1984. Data on the city of Tucson’s acquisition of Avra Valley farmland for conversion of irrigation water rights were provided by city officials. Tucson began buying Avra Valley farmland in 1971.*

*Data on sales of C-BT units were obtained from public water districts, municipal water agencies, and real estate brokers in the area.*

*Summary information on water rights acquisitions and prices between 1945 and 1979 were obtained from records provided by Sierra Pacific Power Company. Data on purchases occurring since 1979 were obtained from reports filed by Sierra Pacific with the Nevada Public Service Commission and from attorneys, engineers and private individuals. Price data for transactions prior to 1979 are based on Sierra Pacific acquisitions. Other buyers did not enter this market until the 1980s.*

*Descriptive data on water rights transfers, excluding price information, were available from records in the State Engineer’s office. Price data on a portion of these transfers were collected by contacting individuals involved in the transactions. Records of water rights purchases by Silver City and by the state of New Mexico are public information.*

*Data on transfers of groundwater rights and ditch company water stock were collected from real estate brokers, attorneys, bankers and other private individuals in the study area. The quantity and price of the water rights purchased by the Intermountain Power Project are public information.*

*The weighted average observed price paid for water rights in the San Francisco sub-basin in 1982 was distorted by one relatively large transaction in which the price was approximately $350 per acre foot. In other, smaller transactions occurring in the same year, prices ranged as high as $3,265 per acre foot.*

Economy, price levels for energy, minerals and agricultural commodities, population and income trends and other factors. Supply-side forces reflect changes in water availability and in the costs of pumping groundwater, developing new surface water supplies, contracting for public project water and pursuing other alternatives to market acquisition of water rights. Differing demand side forces were dominant in the study areas over various periods of time—energy development in the Lower Sevier Basin in the late 1970s, rapid urbanization in Central Arizona and Eastern Colorado during the 1960s and 1970s, mining expansion in the Gila-San Francisco Basin during the 1960s and 1970s. On the supply-side, Arizona, Colorado and Utah water prices are affected by expectations of new water supplies from the Central Arizona Project, the Windy Gap Project, and the Central Utah Project, respectively. Anticipation of new water supplies can decrease incentives to bid water away from existing rights holders.
Prices tend to be lower when the predominant buyer for the water rights is irrigated agriculture, as with DMAD stock in Utah until the IPP purchase, and nonagricultural water users do not compete significantly for water with irrigators. Prices tend to be higher where expanding nonirrigation water users face institutional barriers and/or physical supply limits in seeking additional water supplies. In the Gila-San Francisco Basin of New Mexico and the Truckee Meadows in Nevada, for instance, water supplies are constrained by legal and hydrologic constraints on water supply development and water users have few alternatives to market acquisition when they desire additional water.

The interaction of shifting supply and demand for water along with the variety of institutional arrangements among the study areas cause many different types of price responses to be observed. In southern Arizona, where declining groundwater tables and high energy prices are perceived as making water resources scarcer than in many other areas studied, water rights prices still remain relatively low. Institutional uncertainties involved in transferring water rights and the existence of alternatives to water rights transfers (the primary alternative being water service from the Central Arizona Project) reduce incentives for market transfers.

Northeastern Colorado provides an example of how perceptions of water scarcity may rapidly increase water rights prices even though long-term supplies remain relatively inexpensive and abundant. A speculative boom in the mid-1970s drove real prices for water rights to unprecedented levels by the early 1980s, although the gradual transfer of water rights from agricultural to nonagricultural use continued without any major change. Widespread concern that increasing urban water demand was quickly outstripping supply led to sharp increases in prices. Gardner and Miller suggest that prices peaked at values equal to the capitalized marginal demand for water by municipal users. As urban growth accelerated, agricultural right holders believed that they each had a high probability of being able to transfer their water rights to municipal or industrial water users and were no longer willing to sell at prices that reflected only water's value in irrigation. For a brief period of time the value of the water in urban uses was fully capitalized into market prices.

Shifts in demand for water rights, or the expectation of upward shifts in demand for water, have led to rapid water rights price changes in other market areas as well. The impact of a large new water buyer can be observed in Utah water prices as the Intermountain Power Project entered the Utah market in the late-1970s. Prices in Gila-San Francisco Basin, which had been slowly rising for a number of years, took a sudden turn

57. Supra note 6.
upwards in the late-1970s when the Exxon Corporation began to acquire water rights for its new mining operation.

It is instructive to consider not only what forces drive water rights prices up, but also what forces allow them to fall. Water rights prices in northeastern Colorado fell in the 1980s at least partially in response to the impending completion of the Windy Gap Project, declining interest rates, and a faltering farm economy. In addition, some observers believe that cities began to recognize they had acquired adequate water rights to meet foreseeable needs and that continued acquisition of agricultural water rights might have undesirable effects on the regional economy and on the maintenance of attractive agricultural greenbelts around urban communities. In Utah, the scaling back of the IPP to one-half its planned size cut into the speculative bubble that had risen around the project and prices fell. The stabilization of water rights prices in Nevada's Truckee Meadows, following price escalation in the early 1980s, may be a signal that panic buying of water rights has slowed since private and government organizations agreed upon a system to facilitate an orderly transition of water rights from agricultural to municipal use. In New Mexico's Gila-San Francisco Basin, real prices have declined since Exxon and Boliden completed their acquisition program and since the closing of the Phelps Dodge mining operation has been announced.

A relaxing of existing restrictions on market transfers could have important impacts on market prices. For instance, water rights in Denver and its suburbs sell for twice the price of C-BT units and water development costs for proposed projects in the Denver area are up to six times more per acre foot than the going price for C-BT water. If C-BT water could be transferred outside of the Northern Colorado Water Conservancy District, its price would undoubtedly rise.

In summary, legal, economic, and hydrologic considerations all affect water demand and supply and thus market price levels. Prices can fall and rise rapidly as regional economic and institutional conditions change.

MARKET CHARACTERISTICS AND IMPLICATIONS FOR VALUING WATER

Imperfect Competition and Market Restrictions

The market areas studied differ tremendously in numbers and kinds of buyers and sellers, relative influences of various buyers and sellers, frequency of transactions, and degree of institutional restrictions on market activities. For example, in both the Truckee River and the Lower Sevier River Basins, utility companies are dominant market participants and may

58. Water Market Update 14 (Apr. 1987.)
59. Id.
influence water rental and sales prices. One might hypothesize that dominant market actors function as price setters, sending price signals that are followed by other market participants. The Intermountain Power Project has been an important market participant in the Lower Sevier Basin, both as a purchaser of water rights and a renter of water to farmers, and its large purchases in 1980 did temporarily influence price levels. Sierra Pacific, the sole water buyer for many years in the Truckee Basin, failed in its efforts to continue to buy water rights at low prices when new buyers entered the market and bid up prices. Sierra Pacific's low offers attracted few sellers and had little effect on market prices. Efforts by the cities of Reno and Sparks to acquire abandoned irrigation rights in urban areas at below market clearing prices have been equally unsuccessful.

The numbers of buyers and sellers and frequency of transactions affect the quantity of price data available. A specific price may be a more reliable measure of water value if there are a large number of transactions that confirm that price. In regions with sporadic market activity and price data, use of market prices should be supplemented by estimation of waters' marginal value product in various uses or inferential techniques to determine recreation and other nonmarket values of water.

Imperfect competition may result not only from the activity of dominant buyers and sellers, but also from public policy. Within any given market area, different water rights are subject to different transfer restrictions. For example, Type II rights in Arizona may be transferred separately from the land to which they are appurtenant but must be sold as a whole rather than piecemeal. Arizona irrigation rights, on the other hand, are strictly appurtenant to land, but a farmer may sell a portion of (rather than the entire quantity of) his irrigation rights so long as the appurtenant land is also sold to the water rights buyer. Colorado transmountain diversion water can be transferred without considering the impacts on downstream users of return flows, unlike native flow rights. Transfers of Lower Sevier River surface water rights can be implemented more readily than transfers of groundwater rights in the Lower Sevier Basin.

The nature and degree of imperfect competition resulting from either

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60. C. Howe, D. Schurmeier & W. Shaw, Innovations in Water Management: An Ex Post Analysis of the Colorado-Big Thompson Project and the Northern Colorado Water Conservancy District, unpublished manuscript (1982). See also supra note 34.

61. Groundwater rights in the Lower Sevier Basin generally are individually owned and are appurtenant to specific parcels of land. Any proposed change in the point of diversion, place or purpose of use of these rights requires proceedings before the State Engineer, who may decide to limit or prohibit the transfer. In contrast, nearly all surface water rights on the Lower Sevier River are controlled by the four DMAD mutual stock water companies, and the rights are appurtenant to the companies' collective service areas. Water represented by stock in any one of the companies may be transferred anywhere within the four company service area without requiring proceedings before the State Engineer. Since the transfer of water to IPP in 1980, DMAD water may be used either for irrigation or nonirrigation purposes.
dominant buyers and sellers, or from public policies that restrict transfers, must be evaluated on a case-by-case basis. Prices generated in a competitive market with many buyers and sellers, none of whom can unilaterally influence price levels, are a better basis for estimating water values than are prices generated in highly restricted markets dominated by a few participants. However, since no market area included in this study approaches the competitive ideal, prices need to be interpreted with caution and supplemented with nonmarket value information.

**External Effects of Market Activities**

Laws and institutions in each market area seek to minimize the impact of water transfers on neighboring water users. Examples of rules that seek to prevent externalities include well-spacing regulations and requirements for engineering studies to demonstrate absence of third-party effects associated with proposed transfers. Such rules are designed to protect other rights holders by focusing on return flow levels and groundwater drawdown. They generally are not designed to prevent impairment to instream uses of surface water, such as recreation, or to other water values not protected by vested rights. External beneficial effects of market activity do occur. For example, transfer of C-BT units from irrigators to cities (which have lower consumptive use and are upstream of irrigated areas) has increased return flows for users downstream of cities. Another example, irrigation water quality in the Lower Sevier River has improved since IPP began to use its water rights. External effects of water transactions usually are not fully reflected in market prices. To the extent that significant negative and positive effects of market activity exist, prices will not accurately measure social values.

**Uncertainty and Imperfect Information**

All markets studied are characterized by varying degrees of uncertainty and incomplete access to market information. The efficiency of a competitive market and the degree to which prices accurately represent values rests on the assumption that either market participants can obtain accurate information on prices and attributes of water commodities or that there exist perfectly functioning contingency markets to allocate risks associated with imperfect information. These conditions are fulfilled for few, if any, commodities and certainly do not hold for water markets. Legal, hydrologic, and economic uncertainties affect market behavior, market prices, and the degree to which prices may be useful indicators of value.

Unclarified legal issues create an environment in which market participants cannot be sure what they may and may not do. This uncertainty may discourage expanded market activity. One example of the effect of
uncertainty on willingness to pay for water involves the previously described purchase of Planet Ranch by the city of Scottsdale, Arizona. Current estimates place the quantity available for transfer at about 13,500 acre feet per year. However, the precise quantity of water rights Scottsdale acquired in its purchase and the proportion of those rights that may be transported to Scottsdale raise complex legal issues that have not yet been settled. In response to this uncertainty, Scottsdale included a clause in the purchase contract specifying adjustments in the ultimate sales price for the ranch should the water rights prove to be less than originally estimated. The purchase agreement calls for a reduction in the total sales price of $870 for each acre foot of water rights transferred less than the planned 13,500 acre feet.62

The Arizona and Utah markets provide contrasting examples of access to market information. The Arizona Department of Water Resources keeps records of Type II water rights holders which may help buyers and sellers to find one another, though there is no central clearing house for communicating bids and offers. Recorded transfers are few in number relative to those recorded in Utah water markets. Arizona water markets are still in the early stages of development so that potential buyers and sellers have little experience and historical information on which to base expectations about water values and market processes. In Utah's Lower Sevier Basin, irrigation company records provide information on ownership and rental patterns, and company offices have served as informal clearinghouses helping prospective buyers, sellers, and renters to locate one another. Historical records on the hydrologic cycle of the river system, along with reservoir management planning and several decades of market activity, give water users a basis for expectations about future water availability and market trends.

Hydrologic uncertainty is inevitable in surface water markets since flows may vary significantly from year to year. This uncertainty is mitigated to varying degrees by storage facilities and interbasin diversion projects. One of the principal objectives of Colorado's C-BT Project is to reduce uncertainty associated with erratic and seasonal natural streamflow. Uncertainty affects groundwater markets when there is incomplete knowledge on aquifer capacity, rates of overdraft, energy prices and other factors that affect the long-term expense of pumping groundwater. Hydrologic uncertainty affects how much individuals are willing to pay for a water right. Senior surface water rights are generally more valuable than junior surface water rights which are more vulnerable to seasonal and year-to-year variations in flow. For example, for a brief period in 1981-1983, Sierra Pacific based their price offers for water rights on

62. Supra note 44.
priority dates, with the most junior rights valued twenty-five percent less than the most senior rights.\textsuperscript{63} Price data from the Gila-San Francisco market in New Mexico indicates significantly higher prices are paid for senior water rights (those with priority dates before 1930) than for junior water rights.\textsuperscript{64}

Economic uncertainty affects market prices because prices reflect expectations about future conditions. For instance, changing expectations regarding future municipal growth and associated shifts in water demand affect water prices near urban areas. The marginal value product of water to irrigators rises and falls with crop prices, and water values for mining and other industrial processes fluctuate with economic conditions affecting those industries. With respect to valuing water, this implies that one needs to identify social and economic factors that are influencing expectations and observed prices. For instance, a short-run rise in prices due to expectations that a new industry may enter the area would not be a good indicator of long-run water values until prices stabilize after expectations either are or are not realized. However, a long-term dampening of prices due to stagnation in a water-using sector of the economy (copper mining, for instance) should be incorporated when evaluating supply augmentation projects.

\textit{Equity and Conflict Resolution}

In market areas where Native Americans hold a significant portion of water rights, absence of tribal participation in water market transactions implies that the values of a substantial water interest group will not be reflected in market prices. In any region where potential beneficiaries of supply augmentation projects are not market participants, estimation of project impacts on these groups is necessary for a thorough assessment of supply augmentation. Market prices provide no information on the water values of individuals and groups who are not involved in market processes.

Allocation of water to a specific area or group may serve as a tool for conflict resolution. Both the Central Arizona and the Central Utah Projects are viewed by some observers as strategies for resolving conflicts among water user groups rather than as economically beneficial supply augmentation measures. Augmented supplies may be developed and allocated on the basis of political rather than economic considerations. Decisionmakers sometimes implement supply augmentation projects when water transfers might be a lower cost alternative for providing water to expanding uses.

\textsuperscript{63} Supra note 19.

\textsuperscript{64} Bush and Saliba, \textit{Commodity Identification and Price Behavior in Western Water Markets}, Univ. of Ariz. (1986).
In these situations it could be inferred that the conflict resolution and other political values stemming from supply augmentation are perceived to justify the project.

**Practical Considerations in Using Market Prices**

Assume that there are no *a priori* reasons to suppose that market prices are not appropriate measures of water value. What practical problems would complicate use of market prices to value water? The diversity of institutional settings in which market activities occur has practical implications for using prices as measures of value. First, there is no *a priori* reason to believe that prices emerging in one market setting will be relevant to water values in a different setting. Second, even within the same market region, prices observed for one type of water rights do not necessarily convey useful information about the value of a different type of water right. This underscores the importance of identifying the institutional structures which will govern allocation, pricing, transfer and use of new water supplies as a first step in valuing supply increases.

Another practical difficulty involves understanding the nature of the various water "commodities" being transferred. Water rights in most markets tend to be heterogenous. That is, the characteristics (such as priority of use, quality of the water resource, flexibility in use and transfer) which give them value as market commodities differ from one water right to the next.

Even if water commodities are relatively homogenous, or if the heterogenous characteristic of different water commodities are well understood, there are other informational problems associated with using market prices to value water. Obtaining data on water transfers and water market prices can be difficult. Although most water transfers are documented by state water agencies, water districts, or other water service organizations, it may not be clear from the records which transfers involved a market transfer of rights. Furthermore, few organizations record price data. Price information can sometimes be obtained only by contacting buyers and sellers. Prices may show significant variation from year to year, season to season, and region to region. Some prices may reflect only the transfer of water while others may include the transfer of real estate or other property along with the water rights. It may be difficult to determine which, if any, market prices (and at what points in time) are appropriate measures of value.

Every market is influenced to some degree by one or more of the four market characteristics summarized in Table 1. In addition, practical considerations affect collection and interpretations of price data. One of the

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65. *Supra* note 64.
implications of this research is that observed prices, even where they are readily observable, cannot be used as measures of value until price formation processes and market characteristics are well understood. Observed prices typically deviate from a social value of water, suggesting that market information be supplemented by other measures to assess water values.

**Other Indicators of Water Values**

Techniques for estimating the marginal value product of water in agricultural production generally rely on programming methods due to the absence of a wide range of observed water prices for agriculture. Kelso, Martin, and Mack developed aggregate marginal demand curves for irrigation districts in Arizona to compare the value of water in agriculture and related sectors of the economy. Howitt, Wilson and Adams used a quadratic programming model of field crop production to derive a demand schedule for irrigation water in California’s Central Valley. Gardner and Miller compute the marginal value product of irrigation water in the C-BT service area by a residual computation method, subtracting the costs of all inputs except water from gross farm income.

A number of researchers have developed models of municipal water demand. Howe and Linaweaver, in an early study using cross-sectional data from twenty-one metropolitan areas, found that price elasticity of demand differed substantially between indoor and outdoor use as well as between eastern and western metropolitan areas. Methods of estimating urban demand functions continue to be refined. Martin’s (and others) critique the use of conventional regression analysis to estimate demand in areas where water rates follow a block rate schedule and outline an interactive regression procedure which produces unbiased estimates of demand function co-efficients in a block rate setting. Municipal demand functions allow examination of the marginal value of water at differing levels of supply and are thus an important valuation tool.

Methods for valuing water in recreational and other instream uses are being developed and applied. Krutilla, Bowes and Sherman describe a procedure to estimate the instream energy value of increased flow from augmentation projects. Martin and Cory comment on this study, em-

66. Supra note 5.
68. Supra note 6.
71. Supra note 4.
phasizing the importance of comparing water augmentation projects to agricultural water transfer policies in terms of both net social benefits and the incidence of benefits and costs on taxpayers, agriculture, and municipal and industrial interests. Daubert and Young apply contingent valuation methods to instream flows and find that seasonal reallocation of flows between irrigation and recreation could increase social benefits associated with surface water use.

Lack of household, industry, and farm level data on water demand at varying prices prevents the widespread use of empirically estimated water demand functions to value water in alternative uses. Lack of widely accepted methodologies and absence of data make estimation of instream values difficult. In spite of the difficulties with estimating water’s value in alternative uses, market prices should be supplemented with nonmarket approaches to valuing water whenever possible.

**SUMMARY AND CONCLUSIONS**

Western water transfers take place under diverse institutional, economic, and hydrologic conditions. Water markets are characterized by various degrees of imperfect competition, third-party impacts, uncertainty, imperfect information, and distributional impacts. These characteristics affect the appropriateness of market prices for use as measures of value. Are prices set or constrained by government policies or dominant market participants? If so, then market prices are not competitively determined. Do market transfers impose uncompensated costs or benefits on third-parties? If so, then observed prices do not include all values associated with the transfers. Is market activity dampened by hydrological, institutional and economic uncertainties? If so, then the level of trading and market performance will reflect these uncertainties, and this may distort prices as a measure of values.

While nearly all market prices deviate from an ideal measure of willingness to pay, observed prices may serve as a rough indicator of the marginal value of additions to regional water supply if the additional volume of water made available is small relative to the region’s total supply. For small supply increases, observed prices may approximate current market participants’ marginal willingness to pay for additional water supplied. However, market prices still will not reflect nonmarket water use and third-party impacts of market activities. If the additional

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72. *Id.*
74. The 5 market areas described in this article, along with other market areas, are evaluated in more detail in B. Saliba & D. Bush, *Water Markets in Theory and Practice: Market Transfers, Water Values and Public Policy* (Westview Press 1987).
volume of water is significant relative to existing supplies, estimates of water’s marginal value may be more difficult. The possibility that substantial increases in water supply could attract new water users into a region and change the structure of demand for water must be considered. For instance, rapid urban growth in southern Arizona is stimulated by the perception that the Central Arizona Project ensures a reliable and adequate regional water supply for expanding cities.

Institutional arrangements which govern allocation, use, and transfer of water determine who bears the costs and who reaps the benefits of water supply development. Information regarding how much new water will be available to various user groups, how water will be priced, and what restrictions will be placed on water use and transfer is essential to the valuation process.

Estimating benefits of additional water availability using market prices and nonmarket information on water values are only one step in evaluating a supply augmentation proposal. The impacts of the proposed project must be identified. Will the project affect the welfare of regional residents, apart from the increased water supply? Impacts involving environmental quality, employment, and recreational opportunities must be included in evaluating the costs and benefits. Will the supply augmentation project affect relative income and access to water among cities, farmers, industry, Native Americans, or other major water interest groups? Projects which aid in resolving water use conflicts may have social and political value not typically reflected in economic evaluations. The overall merits of water supply enhancement must be gauged by weighing direct and indirect benefits against all costs associated with the project. As a final step in the evaluation process, supply augmentation proposals should be compared with alternative water management strategies, such as increased water conservation and transfer of existing supplies from lower-valued uses to higher-valued uses. Such a comparison may indicate that supply augmentation is not the most efficient means to accomplish regional water management objectives.