CALIFORNIA'S EVOLVING WATER MARKETS
A CASE STUDY FROM 1977 TO 2000

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ABSTRACT

California's water markets have evolved in bursts driven by the opening of new projects and by drought, as traced here. However, California's legal and management institutions are convoluted, and confounded by the physical layout of the water supply system. Water market structures and activities can be classified in several ways to reflect geographic scope and complexity, as well as by trading mechanism. Trading activity is hindered by high transaction costs and risks, and only the creation of a series of Water Banks accelerated transfers during the extended drought of the early 1990s. In addition, trading activity has differed markedly, and predictably, among different types of water management institutions. Assessed-value-voting districts, which give greater representation to the large land owners that tend to benefit from water sales, were net sellers until the drought cut deeply into the district's own supplies, while popular vote districts, with more diffuse representation throughout the local economy, were generally net buyers until droughts substantially increased prices.

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Introduction

Water markets have been proposed by many as an important component for resolving California's water allocation dilemma. The institutional, legal and complexities of the state's water supply system have deterred the evolution of these markets, however. This analysis examines how these nascent markets performed from 1977 to 2000, a period marked by two droughts and initial optimism about their promise. Both the characteristics of the trades and of the participants are looked at to assess key parameters in these markets.

Howitt (1995) develops an institutional economic model that explains when markets might evolve quickly due to changes in economic conditions. In a setting where the expected benefits of defining and enforcing tradable property rights outweigh the institutional inertia and transaction costs of developing the property rights system, then a market is much more likely to evolve to a greater level of activity. Such conditions occurred in California with the 1976-78 and 1987-94 droughts. Spot market activity increased dramatically after 1980, and a series of Water Banks were instituted in 1991. The CVPIA at least in part was a result of institutional pressure created by then-existing drought conditions. The evolution of these market institutions can be analyzed further in the context of two paradigms discussed in McCann and Zilberman (McCann and Zilberman 2000). The first is the importance of market structure and participant characteristics, and the transaction cost and risks, in these markets. The second is how the governance structure of water districts, the predominant holders of water rights in California, can influence the willingness to participate in trades.

Several market-based programs have been implemented in California and other western states to reallocate water supplies and provide environmental restoration to waterways. These programs have taken many forms, including user fees and taxes, orchestrated markets, and barter

exchanges. Trading activity has generally been greatest in the Rocky Mountain states of Colorado, New Mexico, Utah, Nevada and Arizona (Colby 1990). The trend towards water markets in California gained additional momentum with two events. First was the creation of the State Drought Water Bank in 1991, and repeated operations in 1992 and 1994. These markets generated significant activity to mitigate effects of a long-term drought. Second was the passage of the Central Valley Project Improvement Act (CVPIA) in 1992, as well as the ensuing Bay-Delta Agreement consummated in December 1994 among the state and federal agencies, collectively called CALFED. The CVPIA for the first time legislatively authorized market-based transfers of Central Valley Project (CVP) water to entities other than project contractors, and instituted a restoration fund whereby water could be purchased for instream uses and other environmental restoration efforts. Using water markets in other Western U.S. federal water projects is being considered as well.

Advantages and Disadvantages of Water Rights Markets

The advantages of market-based water exchanges are similar to those for marketable permit programs designed to lower the cost of pollution control: Markets create greater opportunities for individuals to seek out least-cost solutions (Howe et al. 1986; Tietenberg 1985). Market-based policies that encourage water users to jointly pursue conservation investments and other efficiency-improving programs or transfers from one region to another can increase the availability of water in an economically and environmentally non-disruptive way.

However, market-based solutions to water-supply problems must address several important issues before they can become successful. Institutional and political issues barriers can be significant, and the physical relationship of surface and groundwater should be considered in designing such a market (McCann 1996). These issues can be separated into three categories.

First, potential gains from trades may be offset to a large extent by high transaction costs. Poorly defined water rights, environmental documentation requirements, and legal challenges can make perfecting a trade difficult and costly. For example, the Metropolitan Water District (MWDSC)-Imperial Irrigation District (IID) joint-implementation water conservation exchange took five years to negotiate. Yet it is reasonable to expect that some types of transaction costs will decline over time, as participants become more experienced, and as institutions and procedures evolve to streamline transactions. Nevertheless, one should expect that water markets, particularly for any transaction beyond spot sales, will look more like housing markets than stock exchanges in terms of liquidity, transaction costs and other measures of market proficiency (McCann 1996).

Second, market-based strategies to reallocate surface water or to provide for additional instream flows, unless carefully designed, pose the risk of trading one problem for another (Griffin 1991). For example, while surface water allocation may improve, groundwater overdraft may worsen. Because the two resources are physically and economically linked, market-based policies that directly impact one but not the other may yield unexpected and deleterious results. This is similar to the problem of a market-based air-quality management program that creates an incentive to substitute for volatile organic compounds (VOC or ROG) or chlorinated fluorocarbons (CFC) with other, potentially more toxic substances.

Third, market-based water transfers have met with considerable resistance from communities in selling regions (Bush 1988). Concern over "third-party" impacts the economic impacts to individuals or businesses not directly party to the exchange have become a focal point of debate over market-based programs to reallocate water. The idea that water can or should be bought and sold like any other good in the economy is both alien and frightening to

many. Pecuniary externalities from market transactions, the financial gains and losses incurred by those not directly party to a transaction[3] while accepted as an everyday fact of life of the private sector economy, are frequently contested when they result from market-based regulatory action. This is similar to the pollutant "hot spot" controversy that arises with trading of air pollution rights. The issue can be cast in terms of equity: Are improvements in overall economic efficiency and environmental quality being achieved at the expense of less politically and economically powerful groups? These groups generally perceive that they are. Whether this is true, however, is an empirical question that depends on the situation at hand. Studies measuring third-party impacts from the Drought Water Bank and other transfers, for example, found relatively small impacts on a regional economic scale (Dixon et al. 1993; Mitchell 1993). However, those impacts could be concentrated in certain communities (Lee et al. 1997; Mitchell 1995).

In addition, contesting parties may have different perceptions about how water rights should be defined and allocated (Colby 1995). Current diverters may perceive any change from the status quo as threatening to their existing investments and livelihood. Environmentalists may contend that the original allocations failed to consider the commensurate benefits to society from natural amenities. These arguments often reflect a difference in the premises more than in facts or expectations, and such differences are difficult to overcome in the political process.

A Brief Comparison of California and Rocky Mountain Water Markets

In California, the right to allocate, use or transfer a surface water right is generally held by a government entity (e.g., water districts or federal and state water agencies) rather than by

[3]The loss of sales for a hardware store due to a new hardware store locating around the block is an example of a pecuniary externality. Pecuniary externalities differ importantly from physical externalities in that they are an essential by-product of a market-based economy that relies on relative prices to guide investment, production, and

individual farmers or businesses, as is more common in the Rocky Mountain states. These institutions commonly respond to political rather than direct monetary incentives in choosing how to manage their resources (McCann and Zilberman 2000; McDowell and Ugone 1982; Rosen and Sexton 1993; Smith and Williams 1992; Thompson 1993). Also, a variety of types of rights have evolved from the California legal system based on vintage, development and location. Two forms of appropriative rights, along with riparian rights and project contracts may all coexist within the same surface-water basin (Sax et al. 1991). In addition, few groundwater aquifers are adjudicated and most users simply follow the rule of capture. In contrast in the Rocky Mountain states, usually only one or two types of rights are recognized and most groundwater basins are regulated in some form. California's convoluted legal institutions have tended to delay the development of water rights markets relative to those in the Rocky Mountain States.

A Short History of California's Water Markets

The common wisdom is that California's water markets did not exist in a viable form until quite recently. In fact, such markets have existed for most of this century, although not necessarily in the forms that exist elsewhere in the West (Bain et al. 1966). These markets have been incomplete, often missing the spot market component which is key to creating liquidity and conveying price information to market players. The California market has been dominated by the long-term contract market as manifested in the Central Valley (CVP) and State Water Projects (SWP). In addition, various pool exchanges have existed within these projects. The evolution of the Water Banks during recent droughts have been accompanied by the development of other types of non-project long-term contracts. Each of these markets interact

with each other in providing supply, encouraging transactions, and reflecting water's value of productivity.

California's water markets can be separated into at least seven types, ranked by increasing geographic scope and complexity:

- Intradistrict (e.g. Westlands Water District) least complex from legal and physical perspective
- Intraproject (e.g., among contractors on the CVP, SWP or Colorado River Project)
- Interproject (e.g., between the CVP and SWP, often at the wholesale level);
- Intra river basin among appropriators or riparian holders
- Water banks (e.g., Drought Water Banks and Turnback Pools)
- Interwatershed (e.g., Sacramento or San Joaquin Valley, or Colorado River)
- Statewide (e.g. across the Delta)

Intradistrict trades, e.g., the Westlands' electronic bulletin board, are the least complex from a legal and physical perspective. At the other end, transfers across the Delta from Northern to Southern California are the most complex, but are seen as key to solving the Bay-Delta dilemma

Table 1 shows how these markets can be cataloged by the matching mechanism for bringing together buyers and sellers, and the price settlement mechanism for establishing the transaction price. Other common commodity markets such as those used for housing, cars, financial instruments and energy are also listed for comparison. The market design tends to become more sophisticated and liquid as the matching mechanism moves from self-search to exchange (McCann 1996). The transaction price is better known *a priori* entering the transaction moving from bargaining to posted prices. California's water markets tend to rely on less liquid market designs, and to rely on either bargaining or a fixed price structure.

(Insert Table 1)

Long-term Water Transfers and Contracts

As Bain (1966) point out, long-term contract markets have existed in California at least since the development of the Colorado River Project with IID early in the twentieth century. The development and expansion of the CVP by the U.S. Bureau of Reclamation (USBR) and the SWP by the California Department of Water Resources (CDWR) were characterized by short periods when contracts were made available to local water supply agencies by the federal or state governments. The contracts had 30 to 40-year terms, bound both resource acquisition and delivery into a single product, and made little allowance or incentive for trading among contractors. The CVP contracts amount to at least 5.8 million acre-feet (MAF) annually (U.S. Bureau of Reclamation 1994), and SWP contracts to 4.2 MAF (California Department of Water Resources 1994b). Other long-term project contracts around the state include those between the City and County of San Francisco and various Bay Area cities and water agencies for Hetch Hetchy project supplies, and the agreements between MWDSC and local water agencies in Los Angeles which led to the construction of the Colorado River Aqueduct.

Similar long-term markets also developed in other utilities, such as natural gas and electricity, over the same period. Contracts for combined acquisition and transportation of the resource were common in these industries. However, these other industries are now evolving to provide disaggregated products. With natural gas, the 1978 Natural Gas Policy Act decontrolled natural gas production prices, and the collapse of the Organization of Petroleum Exporting Countries (OPEC) cartel in 1986 put further pressure on interstate pipelines to separate the commodity and transportation charges. The Federal Energy Regulatory Commission (FERC) formally disconnected the commodity and transportation markets with Order 436 in 1985 and

now a wide range of markets exist for natural gas. Electricity is now going through a similar transformation with the passage of the 1992 National Energy Policy Act and the issuance of FERC Orders 888 and 889 in 1998. California water markets may now be going through a similar transformation as state and federal agencies reexamine resource allocations and uses.

As originally designed, the CVP and SWP contract entitlements were intended to be minimum allocations from the projects, but recent political and physical constraints have transformed the contract entitlements into proportional allocations of year-to-year yields. Within these projects certain contractors have higher priorities to the projects' yield based on various criteria including contract vintage, whether the contractor relinquished a previous right to the project, and what the ultimate use is for the water supply.

As a result of excess supplies or demands created by the difference between the contract entitlements and actual agencies' needs, and from the difference in supply priority, internal markets have arisen in both the CVP and SWP. Within the CVP, contractors may buy or sell allocations with other contractors through the USBR in the San Joaquin Valley or various contractor associations in the Sacramento Valley (Gray 1990). The USBR limits the sales price to the appropriate contract rate plus a cost-based fee. The price only coincidentally reflects the true economic value of the water to the buyer or seller. In the SWP, when water supplies are available in excess of the firm project yield, contractors may exchange current supplies for future deliveries (California Department of Water Resources 1994b). The MWDSC, which holds the largest contract in the SWP, often allows the Kern County Water Agency (KCWA) to use the MWDSC excess in those years. Of course, these trades occur in years when the water is <u>least</u> valuable—during wet or above-normal runoff.

The MWDSC has been in the forefront of pursuing other long-term contractual

arrangements which do not involve "laying concrete," but rather using existing project facilities to allow purchases from the Central Valley or the Colorado River. MWDSC initiated a large scale conservation and transfer program with IID (Rosen and Sexton 1993). MWDSC agreed in 1988 to invest $113 million in conservation projects, and an additional $4 million per year over a 35-year period to receive an estimated 106,100 acre-feet (AF) per year (Metropolitan Water District of Southern California 1997c). MWDSC also has at least two ongoing groundwater banking agreements with two SWP contractors, delivering Colorado River Aqueduct water in exchange (Metropolitan Water District of Southern California 1997a). MWDSC staged ad test fallowing program with the Palo Verde Irrigation District, which lasted two years from 1992 to 1994 (Metropolitan Water District of Southern California 1997b). MWDSC recently signed a similarly structured long-term transfer with PVID. MWDSC has signed at least two long-term contracts in the Central Valley, which usually are groundwater banking agreements rather than rights transfers. One contract with Arvin-Edison Water Storage District, calling for up to 135,000 AF per year to be banked, was approved after eight years by the State Water Resources Control Board (SWRCB) in 1996 (Daily Republican Staff 1996). MWDSC is able to extract up to 128,500 AF per year during dry years (Israel and Lund 1995). MWDSC also has a short-term banking arrangement with Semitropic WSD in Kern County, with MWDSC storing 45,000 AF in 1992 for later use (California Department of Water Resources 1994a).

Short-term Water Transfers

Table 2 shows the pattern of short-term interagency water sales and exchanges in the Central Valley from 1977 to 2000, and the Sacramento River Index (SRI) of annual flows in MAF. Over 2,200 short-term interagency water transfers occurred between 1977 and 2000,

based on a compilation from numerous data sources by the authors.[4] In addition, approximately 150 long-term transfers have occurred since 1944, including the Central Valley Project and State Water Project contracts.[5]

(Insert Table 2)

The amount of sales increased in general over the period. In part, this was due to the extended dry period that began in 1985, with respites only in 1986 and 1993, and extending through 1994. However, the increase in trading activity was large in 1991, as the Water Bank alone did as much business as the entire water market had in any previous year. Whether this was due to the change in political and legal institutions or the creation of a centralized market mechanism is not discernable, as legislation implementing the 1991 Drought Water Bank also clarified authority and water rights protections for short-term transfers in general. It is notable however, that nearly all the trades in the 1991 Drought Water Bank that provided a significant boost to water transfer activity in general were carefully structured or defined specifically to avoid requiring SWRCB approval (Gray 1994). Whichever is the case, the influence of developing institutions on market performance is evident.

Water transfers often were instigated by direct agency contacts or with some assistance from private brokers. The trades either fell under one of three sections of the state Water Code, or were used to meet public trust considerations (Gray 1990). Little activity occurred before 1985, but the activity level appears to have quickly risen in 1988, just before the USBR and CDWR stepped in to facilitate further trading through other market mechanisms. Trading

[4] Documentation on sources for the database are available from the authors. Sources included reports and databases compiled by the California Department of Water Resources, U.S. Bureau of Reclamation and State Water Resources Control Board, several journal articles, and numerous press and newsletter articles.

[5] Little data exists on intra-agency activity, due in part to the informality of these types of trades. The Westlands Water District has been one agency with many such trades Olmstead, J., Sundig, D., Parker, D., Howitt, R., and Zilberman, D. (1997). "Water Marketing in the '90s: Entering the Electronic Age." *Choices*.

reached around 700,000 AF in that year, dipped for the next two years, and peaked again with the implementation of the State Drought Water Bank in 1991 (see discussion below). Of the amount proposed for transfer over that period, about 65% was actually sold. Much of the remainder failed to pass regulatory review, either from the SWRCB or by the lead agencies for the environmental impact reviews (Gray 1990).

The other market forum for short-term transfers is formal pools and banks. The USBR established a water bank in 1977 to buy from Sacramento River rights holders and to sell to CVP contractors (Gray 1990). The 1977 bank bought about 46,000 AF and sold 42,000 AF at about $61 per AF. Transaction costs amounted to about 20% of the selling price. The USBR also facilitated ongoing trades within and among its five larger CVP divisions (Gray 1990). The USBR only acted as a broker or intermediary by bringing together willing participants and reviewing the transfers for appropriate sales conditions. In addition, two contractor associations would acquire water from CVP contractors and then sell it to other contractors, acting as dealers in the market (Gray 1990; Lund et al. 1992). These associations however avoided "stock carrying costs" by only paying selling contractors after the sales of the excess water supplies.

The CDWR introduced the State Drought Water Bank in 1991, and operated the Bank in a similar fashion in 1992 and 1994. The 1991 Bank purchased as much water as had been transferred in any single year up to that point, and as a result almost 800,000 AF was transferred. The 1991 purchases shown in Table 2 include the entire Water Bank purchase of 732,000 AF, although only about 400,000 AF was actually sold for use in 1991, with 266,000 AF retained by CDWR as carryover in the SWP to 1992, and 66,000 AF spent in carriage losses (California Department of Water Resources 1993). However, it is important to note that this was still less than 20% of the amount actually delivered by the CVP and SWP even in that drought year. The

banks purchased 193,000 AF in 1992 and 222,000 AF in 1994 (California Department of Water Resources 1998, Table 3-17.). The 1992 activity in Table 2 shows only Water Bank purchases of 193,000 AF with 33,000 AF in carriage losses and 15,000 AF of carryover (California Department of Water Resources 1993).

The Effect of the Drought Water Banks on Market Institution Development

Establishment of the Drought Water Banks brought about institutional changes that affected the workings of the California water market. Legal, political and market exchange institutions were modified and even created that facilitated water trades. Even within the Water Bank itself the rules for trading changed with resulting impacts on water market activity.

The creation of the 1991 Drought Water Bank lead to two dramatic shifts in California water management. The first was the diminished resistance to water transfers by the California Department of Water Resources (CDWR) and one of its main patrons, the agricultural community. While leery of losing long-term water rights, rural communities became less threatened from short-term drought relief efforts in subsequent water banks (Coppock and Kreith 1992). The CDWR began to realize that despite the pressures of a five-year drought, they still had little support for constructing more dams for both environmental and fiscal reasons. To CDWR, the best alternative for acquiring large-scale supplies appeared to be transferring water supplies in the short term, but not the rights to those supplies at some future date.

The second was the creation of a centralized market to facilitate trades. Previously, buyers or sellers had to seek out prospective partners and to commence bilateral negotiations that could consume time and money, *a.k.a.*, transaction costs. Larger transfers were also subject to significant environmental review as well. Water transfers had to be approved by the SWRCB under one of at least four different Water Code sections (Gray 1990). The Water Bank placed

the CDWR as the chief agent that sought and accepted offers of sale and collected purchase requests. Because of the CDWR's position as both resource manager and state agency, it could more easily surmount these legal requirements. The transaction process was further assisted by drawing up a standard sales contract.

The State Drought Water Banks' Performance

The CDWR established the first Emergency Drought Water Bank late in the winter of 1991 as California was on the verge of its driest year in at least a century (California Department of Water Resources 1992). Entering March, the CDWR had requests for nearly one MAF of water to meet coming summer demand. In response the CDWR launched an aggressive purchase program acting as a "merchant" or "dealer." A merchant takes title to a commodity before reselling it at a price that covers the merchant's transaction and holding costs (Hackett 1993). The merchant must act on expectations about the market, including price and quantity demanded, and thus works best when demand is stable. However in the case of the Water Bank, a second "March Miracle" (the first occurred in 1989) partially relieved this demand by doubling the state's snow pack. In addition, the CDWR overestimated the price that water districts, particularly those that are agriculturally-dominated, would be willing to pay for Water Bank supplies. The asking price by the Water Bank was $175 per acre-foot, which contrasted recent short-term transfer prices ranging from $30 to $50 per acre-foot (Lund et al. 1992). Generally only urban water districts were willing to pay these higher prices. The CDWR believed that it was committed to the higher price offer although it soon realized its mistake (California Department of Water Resources 1993). These two factors eventually lead to an oversupply of water, with 732,000 AF being bought and 266,000 AF being held for year-to-year carryover. The 1977 Drought Water Bank set up by the USBR relied on a similar “merchant" mechanism,

although it did not offer a single price to all sellers and to all buyers.

The drought continued into 1992 and the CDWR established a second Drought Water Bank, but with two key changes in operations (California Department of Water Resources 1993). In response to the oversupply of water due to overestimating the market price, the CDWR moved to a "brokered" system. A broker brings together willing sellers and buyers, but does not take title to the commodity before the transaction is consummated as is the case with a merchant (Hackett 1993). Brokered systems match supply and demand as market conditions change, but market activity typically is less than under a merchant system because there are costs associated with searching for individual suppliers and delays in consummating transactions. Water districts interested in purchasing through the Water Bank first had to provide the CDWR with funds and commitments. The CDWR then arranged and monitored the trades. As a result, the offer price fell from $125 to $50 per acre-foot. The number of parties offering water also decreased from 348 to 14 (Lund et al. 1992). Much of this decrease, though, came about from new rules with limited how water could be supplied to the Water Bank.

This change in eligibility was made in response to complaints that the 1991 Water Bank had created significant local third-party impacts (California Department of Water Resources 1993; Coppock and Kreith 1992; Dixon et al. 1993; Howitt 1994; Lund et al. 1992; Mitchell 1993; Thompson 1993). The 1992 Water Bank did not purchase surplus water created by land fallowing; it limited sales to trading groundwater for surface water rights and to excess storage releases. Land fallowing had provided 51.2% of the water sales to the 1991 Water Bank (California Department of Water Resources 1993). Fallowing was dropped in response to complaints from local communities, most notably Yolo County which had been a primary source of water to the Bank. Total purchased water amounted to 193,246 AF in 1992, compared to

405,921 AF from similar groundwater exchanges and excess storage releases in 1991.

Table 3 compares the quantities, prices and transaction costs between the first two State Water Banks. The decrease in purchases is largely attributable to the fall in urban agency purchases and storage carryover reflecting overpurchasing in 1991. Agricultural districts increased purchases, in large part because the Bank's asking price fell 60%. Most of these 1992 agricultural customers were CVP contractors. A case in point was the purchase pattern by the Westlands. In 1991, Westlands bought 12,000 AF at the $175 plus transport costs per AF rate. In 1992, it bought 51,000 AF at $72.50 plus transport costs.

(Insert Table 3)

At least six types of transaction costs existed for the two Water Banks; these are listed in Table 4. Within the Water Banks, the CDWR charged an administrative fee to cover search and negotiation costs in purchasing the water and monitoring costs to enforce the purchase contracts. Also, the transport of the water suffered carriage losses, mostly attributable to Sacramento-San Joaquin River Delta outflow requirements. These carriage losses were substantial, averaging 16% to 19%. For pricing purposes, carriage losses were estimated to be up to 35%. A third internal cost, not captured in the Water Bank price, was the cost of holding excess supply "carryover" by the CDWR acting as a merchant. This excess inventory cost effectively added 32% to the cost of the 1991 Water Bank, but this was spread over all State Water Project contractors who paid for it in 1992, rather than solely to market participants. Another cost not reflected in directly in the Water Bank price was conveyance costs down either the SWP or federal CVP. The City and County of San Francisco, as a non-member of the SWP, was charged $200 per acre-foot to move water to its system (Lund et al. 1992). For farmers selling to the Water Bank, uncertainty over the security of their water rights after a temporary transfer lead to

their adding of a risk premium in deciding whether to participate. Farmers who held riparian rights—the most secure under California law—were much more willing to participate in the 1991 Water Bank than those that held appropriative rights or project contracts, who in turn were more willing than those holding groundwater rights (Howitt 1994). In addition, farmers and agencies that sold water from Yolo and Butte counties in the Sacramento Valley reimbursed the counties 2% of the purchase price, or about $2.50 per acre-foot in 1991 and $1 per acre-foot in 1992 and 1994 (California Department of Water Resources 1993).

(Insert Table 4)

Another State Water Bank was established in 1994 which was the fourth-driest year on record after a wet year in 1993. The 1994 Water Bank worked with the same rules as for 1992. About 230,000 AF was purchased again at about $50 per AF (Hansen 1995).

Preparations were under way for a 1995 Water Bank, with projected offer prices at $40 per AF. A new innovation was the offer to purchase an option at $50 per AF to be exercised in March if necessary (Jercich 1995). However, 1995 turned out to be an above-average year in runoff, and the Water Bank was never implemented.

The Solano County Drought Water Bank

As a comparative measure of transaction costs, the Solano County Water Agency instituted a similar water bank in 1991 to transfer water from agriculture to urban districts (Lund 1993). Three cities bought 13,400 AF at a cost of $200 per acre-foot. Due to starting later than the State Water Bank, the SCWA had to pay a higher price to farmers of $170 per acre-foot. The SCWA kept $30 per acre-foot to cover its administrative costs, an amount in excess of four times the rate charged by the CDWR.

The Characteristics of Water Market Participants

California's water resource management agencies and entities can be categorized in several ways. In relationship to the water resource itself, the entities can be classified by private individuals and companies, private mutual companies and utilities, retail special districts, wholesale special districts, water project managers, and environmental monitoring and enforcement agencies. These entities can be placed in a generally hierarchical structure relative to the source and uses of water. Individuals of course consume water, but they also may divert or pump directly. Private utilities and special districts sell water directly to individuals and may have their own supplies. They act as agents for consumers. Wholesale and project management agencies exist to develop a resource and convey water to retailers. Environmental agencies oversee all of these activities to protect common non-water resources.

A second classification system distinguishes among management decision processes for these participants. Individuals need only consult themselves (McCann and Zilberman 2000). Managers of private companies, including mutual water companies and utilities, generally must only make decisions that maximize company profits and shareholder returns. Individuals outside the company have little influence, except perhaps through the regulatory process. Special districts which rely on the property-ownership franchise and assessed-value-weighted voting (AVV) are more akin to the mutual water companies, except that the district managers do not get feedback from maximizing district profits—the legal non-profit limit eliminates this motive. These managers must be more attune to how water management decisions, such as water transfers, affect each farmer's individual profitability and well-being. Most retail special districts use the universal franchise, popular vote (PV). In these districts, the managers must consider not only the effects on their direct customers, but also on other voters who may be

indirectly affected by changes in water-use patterns, such as agricultural services businesses. Wholesale and project management agencies most often are governed either by appointed boards or by departments several layers below politically-elected officials. The objectives of these agencies are more likely to reflect the complexity of the political dynamics driven by their member agencies as well as the overall project goals (Zusman and Rausser 1994).

Table 5 shows the annual pattern of California water transfer sales classified by decision-making process used by participants for 1981 to 2000. Private individuals and companies did not participate in the water market, at least not at a formal level that required SWRCB approval, until 1990 when the recent drought worsened. The establishment of the Drought Water Bank apparently added legitimacy to private-public transfers. It also reduced the risk to water-rights holders of losing those rights when making short-term transfers. Howitt (Howitt 1994) found that farmers willingness to participate depended on how those farmers felt about the security of their water rights. The popular-vote districts, which include cities and urban water utilities, participated at a relatively steady rate through 1989. Sales jumped in 1990 and again in 1996. In part this reflects the activity within the Friant Division of the CVP, which is dominated by irrigation districts that have among the oldest water service contracts, which in turn are less likely to suffer reduced deliveries during drier years. However, in 1991, irrigation districts located in Northern California were among the largest sellers to the Water Bank. Assessed-value voting districts had a lower level of activity until the establishment of the Water Bank, at which point these districts made sales at similar levels to popular-vote districts. Popular vote district sales increased sharply after 1995, followed by an increase in sales from assessed-value voting districts after 1998. Most California and federal agency sales were among each other, in large part to meet public trust and environmental commitments. Sales by private water right holders

began in earnest in 1990, with a single large sale by La Hacienda, Inc. in Kern County to the Kern County Water Agency. In 1991, over 10 private entities sold water, predominately through the State Drought Water Bank. Private parties continue to be active sellers through 2000, but total sales never amount to more than 100,000 AF.

(Insert Table 5)

The increase in water transfers in 1996, despite the improved hydrologic conditions, appears to be driven by several factors. The Central Valley Project Improvement Act (CVPIA) passed in late 1992, included provisions for encouraging water transfers among CVP contractors and decreased the ability of local districts to prevent transfers. This helped facilitate an increase in sales by 1994. The Monterey Agreement signed by State Water Project contractors in 1994 allowed for the permanent transfer of up to 130,000 AF from agricultural to urban uses, facilitating an increase of such trades by late 1995.

Table 6 shows the annual patterns of water transfer purchases, again classified by decision-making process used by participants. Private rights holders generally did not make large purchases which needed formal SWRCB review. Popular-vote and assessed-value voting districts have similar totals sales levels over the period, but apparently the PV districts purchased more water supplies earlier in the drought. Westlands was the dominant buyer among AVV districts. The water service contractors on the Sacramento River were strong net sellers throughout the period.[6] Wholesale agencies began to make large purchases in 1990 as SWP supplies began to dwindle. California agency purchases include CDWR purchases made acting as the intermediary in the State Water Bank in 1991, 1992 and 1994 as well as large purchases made by the California Department of Fish and Game for wildlife refuges and salmon spawning.

[6] Post-1990 data allowed for greater distinction among transfer participants in this region.

The 1991 drought spurred a dramatic increase in buying by assessed-value voting districts, primarily by districts located in the Southern San Joaquin Valley. The significant jump in 1993 was due largely to an increase in buying activity by Westlands. Several irrigation districts accounted for a sharp increase in popular vote district purchasing activity in 1995 that continued through the remaining period. A second jump in 1996 was also dominated by Westlands. The revised Bay-Delta standards issued in 1995 changed CVP and SWP operations sufficiently that certain water contractors, particularly those in the newer CVP units, were much less likely to get their full contract deliveries. In particular, Westlands suffered delivery curtailments in virtually every year after 1996, so the district became a large net buyer in the water market. The irrigation districts in the CVP with more secure water delivery contracts often sold their water to Westlands in this period, and continue to do so.

(Insert Table 6)

Table 7 shows the transfer activity for two major types of retail agricultural water districts, irrigation districts which use popular voting, and California water districts which use assessed-value voting. Little activity occurred prior to the late-1980s drought. Since then the irrigation districts have generally been net sellers into the market, with the California water districts, exclusive of Westlands, have generally in rough balance. Westlands' purchases shift the latter districts to being net buyers. The irrigation districts in Northern California initially made large sales to the Water Banks. The districts south of the Delta dominate the sales after 1994 through intra-CVP transactions, often to Westlands.

The tendency of irrigation districts to be net sellers while California water districts are net buyers appears at first impression to run counter to the thesis in McCann and Zilberman (2000) that popular-vote district managers will act to protect more water-intensive agricultural activity,

while assessed-value-voting district managers will recognize that water sales revenues can be distributed to voters in proportion to the economic benefits and costs of the water transfers. However, the drought combined with institutional changes in CVP operations in particular apparently shifted the relative transaction positions of the popular-vote and assessed-value-vote districts. In part this shift reflects the fact that irrigation districts tend to hold older water service contracts with the CVP, and thus suffer reduced delivery cutbacks during extended droughts compared to the California water districts that tend to be located in the newer CVP units and the SWP. The "bite" of the extended drought started to affect the more highly-valued crops grown in the westside San Joaquin Valley districts, while the northern irrigation districts recognized that the rising water market prices brought substantially more direct economic benefits versus continued cultivation of relatively low-value crops such as rice, alfalfa and corn. In this case the economic situation may have shifted the political weights in the decision process beyond the inflection point from retaining water supplies to benefit the community toward the benefits from water sales that accrue to individual farmers through reduced water rates.

It is interesting to note that two irrigation districts which were significant participants in the 1991 (Glenn-Colusa) and 1994 (Richvale) Water Banks changed their voting franchise rules through state legislation from universal to land-ownership shortly after participating in the Water Banks. Such a change would remove formal resistance to water sales by non-farmers within the district. In fact this was the reason expressed in a Sacramento Bee article by a GCID director in 1994 (Mayer and Vogle 1994). If the holdings within these districts are about equally sized, then the benefits accruing to voters would approximate those of the assessed-value-voting districts such as the California water districts.

Conclusions

California's water markets began with long-term contracting used to facilitate project development. Just as with natural gas and electric utility markets, other types of market forums have evolved to allow more short-term trading. The extended drought from 1987 to 1994 pushed the development of these market institutions, including the formal institution of a centralized marketplace in the Water Banks. The two Water Banks provide an interesting comparison of the benefits and risks associated with a merchant-run (1991) or broker-facilitated (1992 and 1994) market structure. How each market structure addresses the risks from uncertainty created by natural events (e.g., the "March Miracles" in 1989 and 1991) is important in deciding which type is preferable. The State Water Project paid for an inflexible merchant approach in 1991, and in response shifted all of the risk to market purchasers in 1992 and 1994. The option pricing system proposed for the never-instituted 1995 Bank would have been an intermediate step.

Market transaction costs are significant relative to the economic value placed on water. In the case of the water projects, some commentators have argued that the costs are greater than the value achieved from water application (Wahl 1988). For short-term trades, the transaction costs can exceed 50% of the water sale price when including non-monetary factors such as carriage losses, environmental requirements, and storage carryover.

The water market activity patterns for different agencies and entities are not clear, but the patterns are consistent with the hypotheses that districts' electoral rules affect management decisions in predictable ways (McCann and Zilberman 2000). Private companies and individuals apparently were ready to sell large amounts once a forum was established that protected their water rights. Wholesale agencies largely relied on long-term project contracts until the drought forced them into the market. Popular-vote retail agricultural districts, such as irrigation districts, were generally net buyers to protect agricultural activity and associated local enterprises, at least

until the drought increased market prices substantially. Assessed-value-voting districts, such as California water districts, were net sellers until the drought cut deeply into their own supplies. This is consistent with a focus on owner-operators looking after a farm's bottom line rather than the dispersed impacts from farming on the community. A more detailed analysis of the economics within the agricultural districts that participated in the markets during this period could reveal the economic and political tradeoffs made by district managers under different governance rules.

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Table 1. Types of Market Designs

Matching Mechanism	Price Settlement Mechanisms		
	Negotiation/ Bargaining	***Auctions***	***Posted-Price***
Self-search	*- Interwatershed markets* *- Intra CVP markets*		
Brokers	Housing	Sotheby's	*1992 & 94 Water Banks*
Bulletin Boards	Used Cars	NASDAQ	*Westlands WaterLinks*
Dealers	New Cars	NYSE	Supermarkets *SWRCA/TCCWUA* *CVP/SWP* *1991 Water Bank*
Exchanges		Commodities RECLAIM Power Exchange California ISO	

Table 2. Summary of Water Market Activity in Acre-Feet

	Water Market Activity				Sacramento River Index (MAF)
	Spot Market	Banks & Pools		Total	
Year	Transactions	Sold	Bought		
1977	17,000	46,438	42,544	59,544	5.1
1978	-	-	-	-	29
1979	-	-	-	-	12.4
1980	-	-	-	-	22.3
1981	-	25,366	25,275	25,366	11.1
1982	65,309	106,738	102,173	172,047	33.4
1983	65,667	59,051	59,051	124,718	37.7
1984	11,486	33,769	31,269	45,255	22.4
1985	58,546	35,442	32,442	93,988	11.0
1986	36,270	91,965	78,202	128,235	25.8
1987	83,852	39,114	28,764	122,966	9.3
1988	643,343	58,179	48,523	701,522	9.2
1989	481,354	-	-	481,354	14.8
1990	598,570	-	-	598,570	9.3
1991	959,291	630,923	821,665	1,780,956	8.4
1992	426,446	165,582	193,000	619,446	8.9
1993	364,465	-	-	364,465	22.2
1994	520,541	230,759	222,000	751,300	7.8
1995	567,552	-	-	567,552	34.5
1996	1,039,791	-	-	1,039,791	22.3
1997	1,236,596	62,544	62,403	1,299,140	25.4
1998	790,788	99,233	198,720	989,508	31.4
1999	1,298,780	232,504	255,284	1,554,064	21.2
2000	1,386,132	282,305	174,572	1,668,437	18.9

Table 3. Comparison of 1991 and 1992 California Drought Water Banks

	1991 Water Bank	1992 Water Bank	*Difference*
Quantity Purchased	732,000	193,246	*(627,418)*
Excluding Fallowing	405,921	193,246	*(212,675)*
To Urban	307,373	39,000	*(268,373)*
To Agriculture	82,597	95,250	*12,653*
To Environment	50,000	24,518	*25,482*
Carryover	265,558	15,000	*(250,558)*
Purchase Price ($/af)	$125	$50	*($75)*
Admin. Costs ($/af)	$6.25	$5.00	*($1.25)*
Carriage Losses (%)	16%	19%	*3%*
Conveyance Charge	$475	$17.50	*($26.00)*
% Direct Admin. Cost	29%	31%	*2%*
Sale Price ($/af)	$175.00	$72.50	*($102.50)*

Sources: (California Department of Water Resources 1993; Israel and Lund 1995).

Table 4. Summary of California Water Bank Transaction Costs

Type	*Cost or Effect*
CDWR Administrative Charge	$5 to $22.50 per acre-foot
Carriage Losses	Add 16% to 19% to purchase price
Excess Carryover	Add 32% to 1991 Water Bank costs
Conveyance Charges	$20 to $200 per AF depending on whether buyer was SWP, CVP or outside contractor
Uncertainty over Water Rights after Transfer	Reduces willingness to sell to Water Bank
Local County Area-of-Origin Charge	2% of purchase price

Table 5. Water Transfer Sales by Decision-Making Entity

Year	Private	Popular Vote	Assessed Value Vote	Wholesale	Bank/Pool	California Agencies	US Agencies
1981	-	23,775	-	-	-	-	591
1982	-	88,747	-	60,308	-	-	15,134
1983	-	58,333	61,822	-	-	-	4,563
1984	-	23,969	-	685	-	-	18,204
1985	18	18,889	-	11,776	-	-	62,334
1986	-	54,958	7,763	-	-	-	59,979
1987	75	133,404	6,050	6,171	-	-	84,216
1988	1,950	43,837	16,250	83,000	-	-	551,785
1989	600	46,000	17,564	45,300	-	10	371,880
1990	99,450	158,725	38,678	31,020	-	164,662	228,819
1991	86,785	167,259	104,902	152,767	630,923	17,000	622,711
1992	77,920	152,449	30,761	36,237	165,582	3,000	133,580
1993	80,442	56,919	101,557	117,390	-	625	7,438
1994	49,403	180,573	78,975	26,796	230,759	15,856	113,292
1995	66,219	176,431	112,541	140,706	-	25,000	45,344
1996	25,600	304,826	135,975	75,630	-	162,149	181,031
1997	79,292	455,974	90,765	138,104	62,544	53,697	382,716
1998	90,376	262,842	71,358	344,642	99,233	31,165	10,087
1999	48,370	448,648	98,991	355,291	232,504	237,408	16,300
2000	31,864	443,304	277,224	109,855	282,305	382,000	201,329
Total	738,364	3,299,861	1,251,176	1,735,677	1,703,849	1,092,572	3,111,333

Table 6. Water Transfer Purchases by Decision-Making Entity

Year	Private	Popular Vote	Assessed Value Vote	Wholesale	Bank/Pool	California Agencies	US Agencies
1981	0	24,165	0	0	91	0	110
1982	5,000	88,574	309	0	4,565	0	65,741
1983	0	58,692	0	61,822	0	0	4,204
1984	2,369	28,180	685	0	2,500	0	9,124
1985	768	17,562	34,872	9,587	3,000	15,900	11,328
1986	0	69,124	20,240	11,500	13,763	4,000	4,073
1987	0	24,891	20,350	120,674	10,350	46,335	7,316
1988	2,753	131,797	14,407	38,977	9,656	479,596	19,636
1989	1,971	50,558	50,245	25,776	0	235,000	117,804
1990	7,141	58,896	30,302	378,538	0	173,928	72,549
1991	970	78,531	98,857	399,012	821,665	323,658	59,654
1992	0	39,327	18,456	70,976	193,000	126,632	171,056
1993	2,061	16,143	161,048	32,209	0	4,000	150,004
1994	7,704	29,537	158,776	81,059	222,000	4,508	199,330
1995	409	109,380	152,792	36,212	0	609	266,839
1996	338	100,782	530,028	44,930	0	0	269,076
1997	39,495	139,153	463,891	61,995	62,403	20	541,964
1998	59,666	80,770	350,122	48,165	198,720	19	215,209
1999	26,043	104,682	563,941	150,338	255,284	20,195	367,558
2000	9,103	194,767	510,835	334,303	174,572	0	506,862
Total	165,790	1,445,511	3,180,155	1,906,073	1,971,569	1,434,399	3,059,437

Table 7. Water Transfer Activity for Two Types of Agricultural Water Districts

	Irrigation Districts			California Water Districts				
				w/o Westlands		Westlands		Total
Year	Sold	Bought	Net Sales	Sold	Bought	Sold	Bought	Net Sales
1981	23,775	24,165	(390)	0	0	0	0	0
1982	88,690	88,517	173	0	309	0	0	(309)
1983	58,211	58,570	(359)	0	0	0	0	0
1984	22,187	26,398	(4,211)	0	685	0	0	(685)
1985	13,571	17,244	(3,673)	0	31,218	0	0	(31,218)
1986	43,197	68,340	(25,143)	7,763	20,240	0	0	(12,477)
1987	128,906	24,737	104,169	6,050	20,350	0	0	(14,300)
1988	39,031	131,797	(92,766)	8,250	12,500	0	0	(4,250)
1989	7,000	600	6,400	17,564	50,245	0	0	(32,681)
1990	108,814	2,231	106,583	12,464	30,302	0	0	(17,838)
1991	164,792	303	164,489	72,577	41,241	0	0	31,336
1992	130,485	0	130,485	22,038	18,456	3,250	0	6,832
1993	54,363	15,143	39,220	97,375	29,644	4,080	131,404	(59,593)
1994	225,262	21,661	203,601	72,868	52,311	0	106,417	(85,860)
1995	167,373	80,754	86,619	104,441	36,292	2,273	94,208	(23,786)
1996	392,326	100,350	291,976	86,530	34,613	0	429,485	(377,568)
1997	391,015	75,742	315,273	67,996	111,465	743	345,483	(388,209)
1998	116,140	39,688	76,452	60,868	86,530	300	247,992	(273,354)
1999	287,466	68,160	219,306	84,010	121,788	0	228,121	(265,899)
2000	295,153	123,681	171,472	189,818	177,162	0	301,890	(289,234)