BREN SCHOOL OF ENVIRONMENTAL SCIENCE & MANAGEMENT

UNIVERSITY OF CALIFORNIA
SANTA BARBARA

PWS

Progressive **W**ater **S**olutions

A Group Project submitted in partial satisfaction of the requirements for the degree of
Master's in Environmental Science and Management
By

ZOË CARLSON
DANIEL CROCKER
SARA SOLIS
ALEXANDRA SPEERS
MATTHEW YOUNG

Committee in charge:
GARY LIBECAP

March 19, 2010

THIS PAGE LEFT INTENTIONALLY BLANK

PWS

Progressive **W**ater **S**olutions

As authors of this Group Project report, we are proud to archive this report on the Bren School's website such that the results of our research are available for all to read. Our signatures on the document signify our joint responsibility to fulfill the archiving standards set by the Bren School of Environmental Science & Management.

ZOË CARLSON

DANIEL CROCKER

SARA SOLIS

ALEXANDRA SPEERS

MATTHEW YOUNG

The mission of the Bren School of Environmental Science & Management is to produce professionals with unrivaled training in environmental science and management who will devote their unique skills to the diagnosis, assessment, mitigation, prevention, and remedy of the environmental problems of today and the future. A guiding principal of the School is that the analysis of environmental problems requires quantitative training in more than one discipline and an awareness of the physical, biological, social, political, and economic consequences that arise from scientific or technological decisions.

The Group Project is required of all students in the Master's of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

GARY LIBECAP

March 19, 2010

THIS PAGE LEFT INTENTIONALLY BLANK

Abstract

Groundwater provides about one third of California's water resources. Currently, this resource is poorly regulated and not optimally used. Markets can be useful tools for managing natural resources, but informal markets for groundwater are inefficient and underused. This inefficiency provides an opportunity for improvement. Structured markets in which users can choose to buy, sell, or lease groundwater pumping rights need to be an integral part of the solution to California's groundwater management problem. A business is well-suited to facilitate markets for groundwater rights. Progressive Water Solutions LLC (PWS) will be a groundwater brokerage and consulting firm. Through an innovative online *H_2O Exchange*, PWS will provide groundwater rights holders with a central marketplace to trade pumping rights, offer historical market information to inform user bids, and streamline the process of transferring pumping rights. The *H_2O Exchange* will help water users maximize profits while providing incentives for water conservation. Four groundwater basins were used as case studies to determine the efficacy of the *H_2O Exchange*. The results indicate that a centralized exchange for groundwater would be most beneficial to water users, and profitable to PWS, in basins where 1) water rights are clearly defined, 2) there are many rights holders, and 3) there is a large volume of groundwater rights available for trading. Based on this market analysis, PWS will initially target nine groundwater basins for implementation of the *H_2O Exchange*. As the markets are established, PWS will provide its expertise to groundwater basins beginning to define groundwater rights.

THIS PAGE LEFT INTENTIONALLY BLANK

Acknowledgements

We would like to acknowledge and thank the following people for their help and advice in the completion of this project:

Gary Libecap (UCSB)
Russ McGlothlin (Brownstein Farber Hyatt Schrek)
Chris Coburn (County of Santa Cruz)
Arianne Rettinger (Resource Conservation District of Santa Cruz County)
Bob Wilkinson (UCSB)

THIS PAGE LEFT INTENTIONALLY BLANK

MASTER'S THESIS REPORT: BUSINESS PLAN

PWS, LLC

Water Brokerage Consulting

THIS PAGE LEFT INTENTIONALLY BLANK

Executive Summary

PWS LLC addresses an urgent need for water resource management systems that are environmentally, socially, and economically sustainable.

Introduction

Solving Water Resource Problems

Water resource management is a critical challenge in California because of the state's water scarcity and complex water rights system. Projected urban growth and climate change are expected to further exacerbate water management problems in the future. Californians currently get about one-third of their water from groundwater. The relative lack of regulation on groundwater extractions has led to aquifer depletion in many California groundwater basins. One mechanism for maximizing the availability of groundwater for those who need it most is a market system. However, existing groundwater markets are inefficient and do not capture the monetary value of groundwater. Progressive Water Solutions LLC (PWS LLC) transfers the intrinsic value of water into monetary value and distributes it efficiently through an innovative market structure.

Opportunity

PWS LLC empowers groundwater rights holders by providing a mechanism for groundwater use, investment, and conservation to benefit individual groundwater users while achieving groundwater basin management targets.

PWS LLC comprises two functions: BROKERAGE of groundwater rights and CONSULTING for improved groundwater management structure.

BROKERAGE

Transfers of groundwater through a third party can yield highly profitable, mutually beneficial exchanges. PWS LLC operates as a clearinghouse for groundwater rights transfers, thereby increasing flexibility in groundwater use, compensating for conservation measures, providing a forum for more efficient distribution of groundwater rights, and creating a platform for sustainable management.

CONSULTING

Well-designed groundwater markets can be a tool for increasing conservation and groundwater use efficiency. PWS LLC will provide insight regarding the benefits of groundwater markets to managers, attorneys, and other involved parties in basins undergoing the adjudication process (the legal process for defining groundwater rights).

Target Market

BROKERAGE: *Water Users*

Value: PWS LLC addresses groundwater rights holder's need for flexibility in exercising their rights. Benefits include: ease of water transfers through a single clearinghouse, accessibility to a large number of buyers and sellers, efficient distribution of groundwater rights, compensation for conservation, flexibility in water use, and security in land use planning and investment.

Compensation: PWS LLC will generate revenue by taking a percentage of the cost of each facilitated transfer.

CONSULTING: *Water Management Agencies*

Value: PWS LLC addresses water management agencies' need for creative strategies in meeting ever-increasing demands on groundwater resources. Specifically, PWS LLC will provide insight in designing management plans for the adjudication process and improving management plans in basins that are already adjudicated.

Compensation: PWS LLC will generate revenue by charging consulting fees to water management agencies, attorneys, and other interested parties.

Contents

Business Overview

Vision

Creating innovative solutions for groundwater basins to promote flexible, sustainable, and efficient water use.

Mission

Increase efficiency in groundwater use and distribution
Serve groundwater rights holders and water management agencies
Facilitate groundwater transfers

Problem

Water Scarcity in America

Water scarcity is one of the most critical challenges facing Americans. The future promises continued population growth, increased urban development, and climate change. Water is arguably our most valuable natural resource because it has no substitutes, we consume it directly, and it is used in virtually every segment of the economy. In order to ensure a prosperous future, Americans must ensure reliable water supplies.

California's Water Crisis

California is the most populous state in the nation and the eighth-largest economy in the world, and so a dependable water supply is highly consequential. Adding to California's water crisis is the fact that about 75% of the state's rainfall occurs in northern California, but 80% of the agricultural and urban demand for water exists in central and southern California. Water is distributed through the most complex water storage and transport system in the world in an attempt to satisfy demand all over California. The system's dams, reservoirs, pumping plants, and aqueducts transport roughly half the state's water, sometimes hundreds of miles. This redistribution system is very expensive to maintain and is insecure with growing scarcity.

Groundwater in California

The majority of the water distributed through California's transport infrastructure is surface water from rivers, streams, and snowmelt. Another source of water for Californians is groundwater. The groundwater stored in underground aquifers supplies 30% of the state's urban and agricultural water needs during average years and over 40% in drought years.

When more groundwater is extracted than can be naturally replaced over many years, overdraft occurs. Basin overdraft can result in a variety of negative consequences such as land subsidence, reduced surface flows, impaired water quality from seawater intrusion in coastal basins, and higher pumping costs.

Groundwater Management Through Adjudication

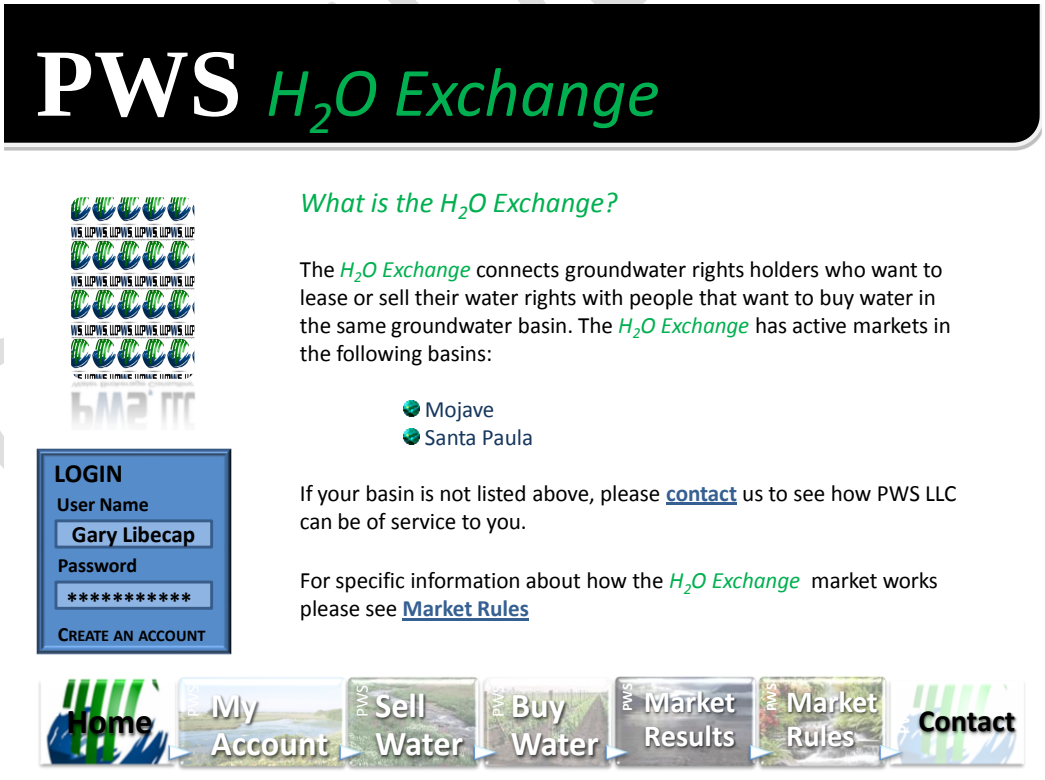
At present, there is no way to limit individual users' groundwater extractions as long as water use is "beneficial and reasonable" except through basin adjudication by way of a lawsuit. Adjudication is the process through which the total amount of groundwater extraction rights in a basin is limited to an amount that does not result in overdraft, and the groundwater rights of all the users in the basin are defined through a court Judgment. Though adjudication is an effective way to limit total groundwater extraction, the allocation of rights to individual users is not always efficient. Some users get fewer groundwater rights than they want, and other users get more groundwater rights than they need.

Solution

PWS LLC addresses water scarcity concerns across California by working with water users and water managers on a local groundwater-basin scale. PWS LLC serves water users through brokering groundwater transactions and water managers through our consulting services.

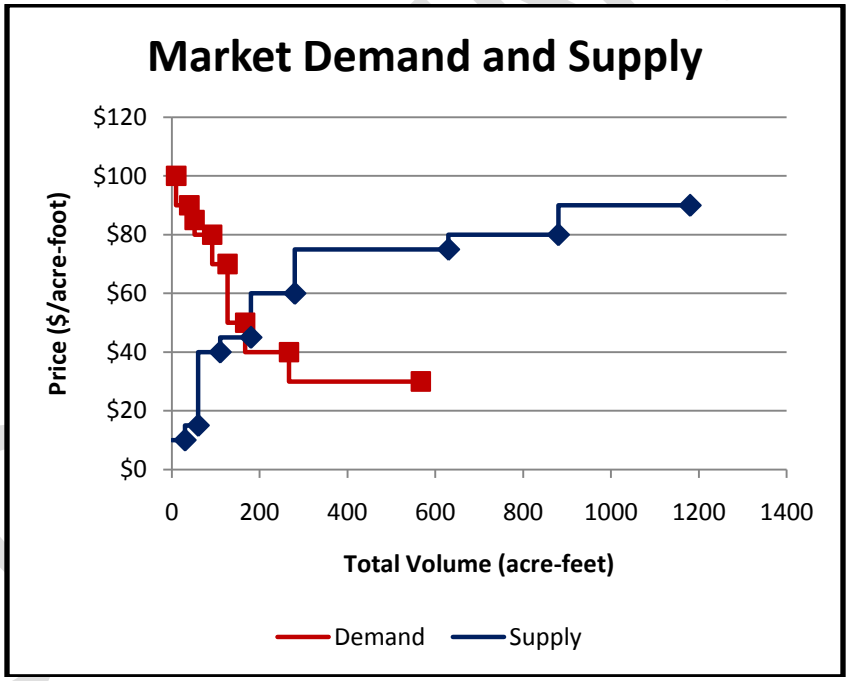
BROKERAGE

PWS LLC will set up water rights markets in adjudicated basins and facilitate transfers of groundwater rights through a transparent, easy to use, online trading board—the *H_2O Exchange*-shown below. PWS LLC will take a percentage of each trade facilitated.



The H_2O Exchange

1. Individual users (buyers and sellers) set up an account, specifying
    a. Personal identification information
    b. Amount of groundwater rights they hold under their basin's adjudication
2. When a user wishes to buy or sell water, they will specify the
    a. Type of transfer (permanent, short-term, long-term)
    b. Amount of water they wish to buy/sell
    c. Maximum price they will pay / minimum price they are willing to accept
3. The algorithm will calculate the optimal transfer distribution among users
    a. The algorithm will run a piecewise supply-demand function in order to determine the optimal transfer distribution
        i. The algorithm will sum the total water demanded at each price (willingness to pay for buyers, willingness to accept for sellers) and create the supply-demand function (see graph below)
    b. The algorithm will thus determine the market's price for water, and match buyers and sellers using that price



Note: This graph is produced from hypothetical data entry points.

4. Market Rules
    a. In order to maximize market activity, the *H_2O Exchange* will run for two weeks at least once a year, and may run more frequently if user demand is high in a given client basin. The *H_2O Exchange* will run at the end of each client basin's water year (end of October) or fiscal year (end of June), depending on the basin's operating schedule.
    b. Groundwater will be transferred in units of acre-feet in order to maximize the amount of water transferred
    c. The algorithm will minimize the number of trades required to satisfy all eligible buyers' and sellers' demands
    d. Users must legally commit to selling/buying water if the market price falls within their specified boundaries before the *H_2O Exchange* runs
    e. Buyers who specified a willingness to pay lower than the market price calculated by the *H_2O Exchange* and sellers who specified a willingness to sell higher than the market price calculated by the *H_2O Exchange* are ineligible and may not participate in that cycle of the market.

CONSULTING

PWS LLC will contract services in future adjudications of groundwater. Since well-designed groundwater markets can be a tool for increasing conservation and water use efficiency, PWS LLC will provide insight regarding the benefits of groundwater markets to managers in basins undergoing adjudication process by

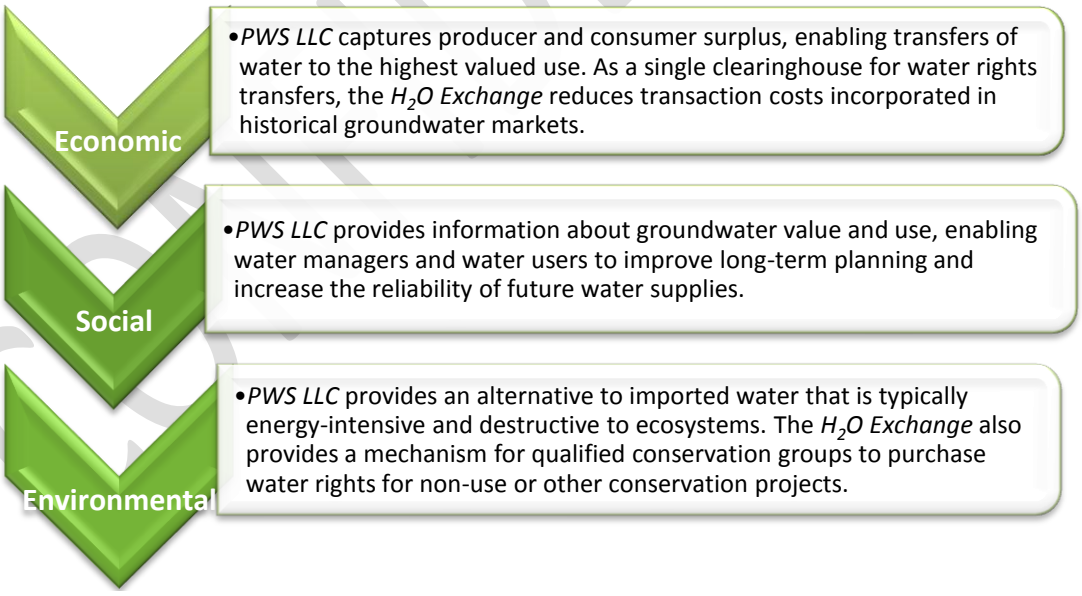
1. Collaborating with attorneys hired by government entities or other interested parties for adjudication.
2. Designing and quantifying benefits of market systems as a 'physical solution' (a legal requirement in the process of adjudication to ensure that adequate water supplies are available post-adjudication).

PWS LLC will charge consulting fees to water management agencies, attorneys, and other interested parties for services rendered.

Value Proposition

PWS LLC
adds value to water users by improving upon existing informal markets, allowing them to capture the value of buying or selling water rights through the
H_2O Exchange.

In adjudicated basins, there is a limit to the amount of groundwater that can be extracted in a given year. Each user has defined groundwater rights, but their rights might not match their demand for water. This leads to economic, social, and environmental shortfalls. PWS LLC addresses all of these shortfalls as shown below:



In most basins, there is not an established groundwater market or clearinghouse. Consequently, users do not know the market price for water or how to participate in exchanges.

PWS LLC adds value to water users by allowing them to capture the value of buying or selling water rights through the *H_2O Exchange*.

The *H_2O Exchange* increases access and transparency in adjudicated basins with existing groundwater markets as well as adjudicated basins where groundwater markets were not previously established. This provides sellers with an additional revenue mechanism, made available through increased efficiency in water use. In addition to short-term revenue, the ability to sell rights through a transparent market adds value to unsold water as an asset. Buyers of water benefit from increased security in long-term planning through transparency in water market trends, groundwater availability, and increased efficiency of water use. Potential buyers of groundwater rights through the market also gain value through increased flexibility in the supply of water that can be used in short and long-term planning.

PWS LLC addresses the needs of water management agencies, attorneys, and other interested parties through consulting services. By providing an alternative to costly importation and infrastructure projects, PWS LLC assists parties in drafting management strategies that allow for adjudication agreements at lower costs. By increasing the efficiency of groundwater use, there is less need for surface storage and transportation, freeing associated land and development funds for other projects.

Target Market

PWS LLC serves water rights holders in adjudicated groundwater basins and groundwater basins that are moving to adjudicate in California. The *H_2O Exchange* will only be used in adjudicated basins because groundwater rights are clearly defined and transferable; therefore a market can exist.

BROKERAGE

PWS LLC targets groundwater rights holders that may participate as buyers and/or sellers of these rights.

Buyers

To target groundwater rights holders wanting to buy short-term, long-term, or permanent groundwater rights, PWS LLC will extensively research water allocations in each client groundwater basin. Furthermore, PWS LLC will determine predicted water demand and supply by analyzing historic market activity in adjudicated basins and analyzing groundwater extraction rates in adjudicating basins.

PWS LLC will target the following groundwater users:

1. Agricultural growers with fertile land and adjudicated rights that do not meet their demand for water.
2. Water-intensive industries.
3. Urban users, cities, and municipalities.
4. Conservation groups, fisheries groups.

Sellers

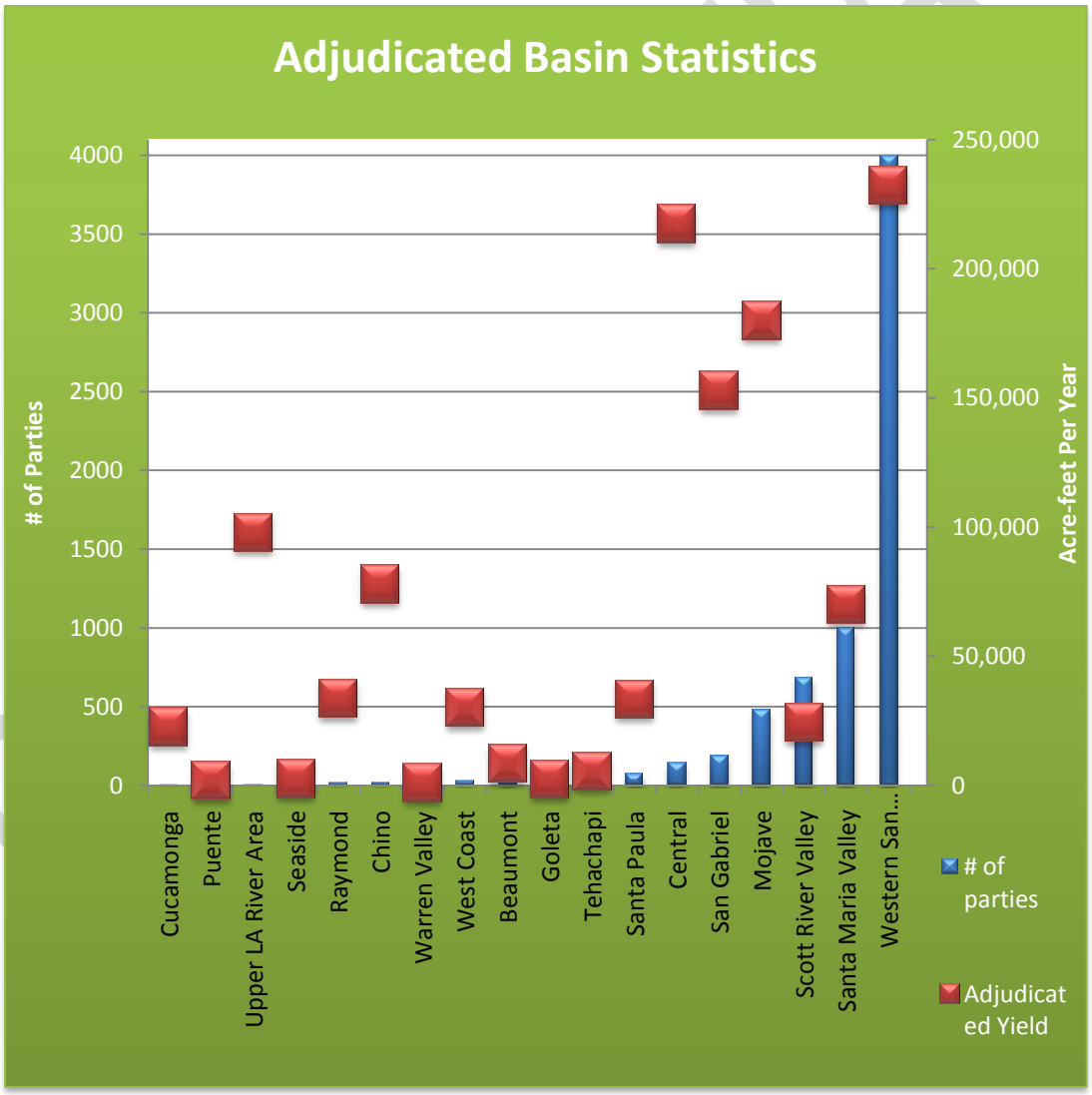
To target groundwater rights holders wanting to sell short-term, long-term, or permanent groundwater rights, PWS LLC will extensively research water allocations in each groundwater basin. Furthermore, PWS LLC will determine predicted water demand and supply by analyzing historic market activity in adjudicated basins and analyzing groundwater extraction rates in adjudicating basins.

PWS LLC will target the following groundwater rights holders:

1. Seasonal agricultural growers and industries.
2. Extensive water rights holders.
3. Marginal land owners.

SUMMARY OF CALIFORNIA MARKET (Brokerage)

The feasibility of a market for groundwater management is dependent on the legal rights and the management systems within the groundwater basin. There are 22 currently adjudicated basins in California where groundwater rights are clearly defined. The management structure of 18 of these is currently compatible within a market system. The size of potential groundwater markets within each of these 18 basins varies based on (1) the number of parties holding groundwater rights, and (2) the amount of groundwater available for use by all water rights holders as shown in the figure below.



CONSULTING

PWS LLC targets water management agencies that are undergoing the process of adjudication. Specifically, PWS LLC will look for adjudicating basins that do not have outside sources of water to serve as a 'physical solution'. PWS LLC will also look for basins that have a strongly involved water management agency that will likely play a part in managing the basin after adjudication.

SUMMARY OF CALIFORNIA MARKET (Consulting)

Through working with the Pajaro Valley Water Management Agency, PWS LLC has identified the need for our consulting services in non-adjudicated basins that are in a critical state with (1) high conflict, and (2) limited or costly options for additional water supplies. PWS LLC anticipates that five such basins will undergo adjudication in the next ten years, thus the potential market for PWS LLC consulting ranges from one to five basins in the next ten years.

Industry Outreach and Communication

AGRICULTURAL USERS

Concern

Agricultural users' concerns include:

1) Insufficient water supply for growing desired crops.
2) Basin-wide groundwater use in excess of the sustainable yield resulting in reduced individual land productivity and increased risk of land subsidence or seawater intrusion.

Solution

PWS LLC enables agricultural users to capture the monetary value of their rights, thus encouraging participation in the groundwater market and making more water available to those who value it most (e.g. lettuce grower in need of water for the growing season).

INDUSTRIAL USERS

Concern

Industrial users' concerns include

1) Insufficient water supply for business operations.

Solution

PWS LLC enables industrial users to capture the monetary value of their rights, thus encouraging participation in the groundwater market and making more water available to those who value it most (e.g. users who need water to run a successful business).

MUNICIPALITIES

Concern

Municipalities' concerns include

1) Insufficient water supply for residential use.
2) Insufficient water supply for future water demand given projected population growth.
3) Insufficient water supplies for economic growth.

Solution

PWS LLC will create a clearinghouse for groundwater rights, thus encouraging more users to participate and make previously utilized water available for sale and alternative use. Thus, PWS LLC will facilitate the reallocation of water to those who value it most.

CONSERVATION GROUPS

Concern

Conservation groups' concerns include

1) Diminished groundwater availability for ecosystem services.
2) Discrepancies between the court-allocated sustainable yield and the quantity of water necessary for ecosystem services.
3) Land subsidence, seawater intrusion, and other environmentally disruptive events resulting from over-extraction of groundwater (in adjudicated basins where the court-allocated yield is not equal to the scientifically-determined safe yield).

Solution

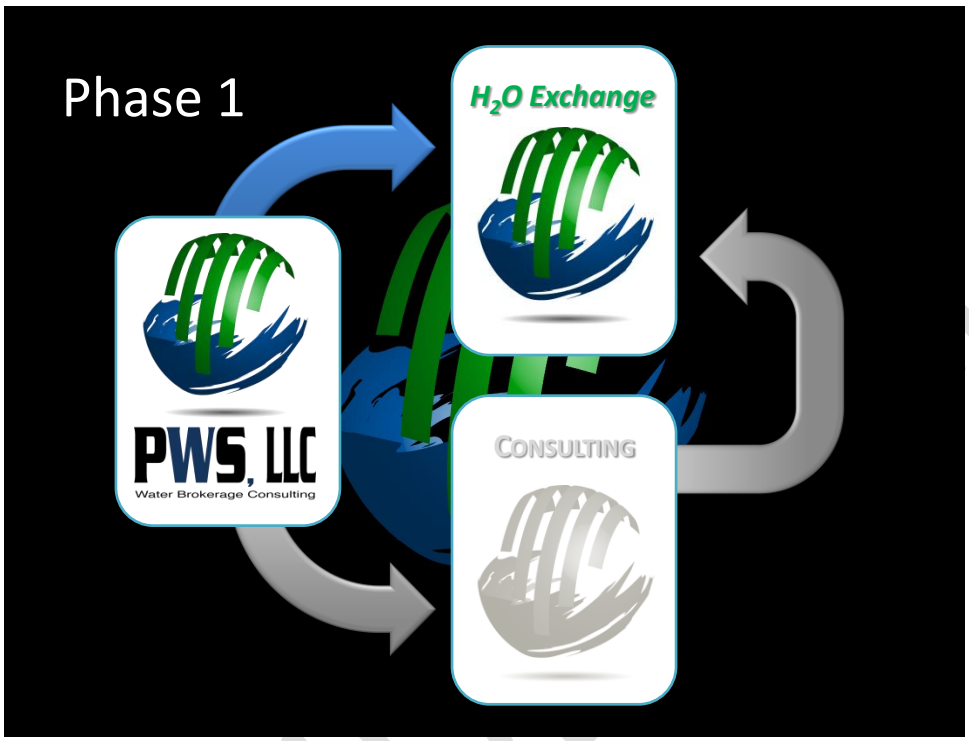
PWS LLC allows conservation groups to purchase short-term, long-term, and permanent transfers of groundwater rights, provided they are legally permitted to do so. The groups may then leave the groundwater un-extracted and partially prevent negative environmental effects of extraction of groundwater beyond the sustainable yield.

Marketing and Sales Plan

PWS LLC will market services and engender sales through a three-part process:

1) In the first phase, PWS LLC will introduce the *H_2O Exchange* to adjudicated basins.
2) In the second phase, PWS LLC will provide consulting services to water management agencies in adjudicating basins and propose the *H_2O Exchange* as a 'physical solution' in a stipulated judgment.
3) In the final phase, PWS LLC will expand our market to other states and potentially provide administrative services to Watermasters. In all cases, PWS LLC will appeal to each industry to targeted groundwater users (agricultural users, industrial users, municipalities, and conservation groups).

Phase 1



There are 22 adjudicated groundwater basins in California. PWS LLC has identified 16 of those as potential client basins (please see APPENDIX 2 and APPENDIX 4 for an overview of adjudicated basins and detailed case studies on several potential clients). PWS LLC will implement the *H_2O Exchange* in these potential client basins in a tiered approach, securing one to two additional client basins per year.

PWS LLC will use a top-down and bottom-up approach to engage clients:

PWS LLC's relationship with each court-appointed groundwater basin Watermaster will be crucial. When PWS LLC enters a groundwater basin, it will establish contact with the Watermaster. Through the basin Watermaster, PWS LLC will contact groundwater rights holders and other interested parties to familiarize potential clients with the benefits of the *H_2O Exchange*. In conversation with the Watermasters in our case studies, several expressed a need for a separate entity to process water transfers in order to relieve the Watermaster of administrative duties that do not provide them revenue. Consequently, Watermasters would welcome the introduction of a third party water rights broker. They support the utilization of an organized water market for improved groundwater allocation in the basins (please see APPENDIX 2 for more information).

PWS LLC will also approach clients through government and interest group (such as Farm Bureaus, pumpers associations, water management agencies, conservation groups) events and workshops. Communication with these interest groups will be focused on the service that PWS LLC provides to water rights holders for increased flexibility, immediate financial compensation, and long-term fiscal security.

Through the bottom-up approach, PWS LLC will be branded as the "innovators" that enable a more efficient allocation of groundwater and make more water available for use—not a bureaucratic agency. In doing so, PWS LLC will use guerilla marketing techniques by approaching clients through direct contact and personal connections. Additionally, PWS LLC will utilize analytic site visitations, community forums, and local newspapers, and literature included in utility bills to educate water users in the groundwater basin about the benefits of groundwater rights market. Finally, PWS LLC will work with large agricultural organizations, industrial organizations, and municipalities to capture the attention of water rights holders in the basin. As a result, PWS LLC will focus intensely on involving the community in more efficiently allocating groundwater, compensating users for reducing groundwater use, and providing incentives for conservation.

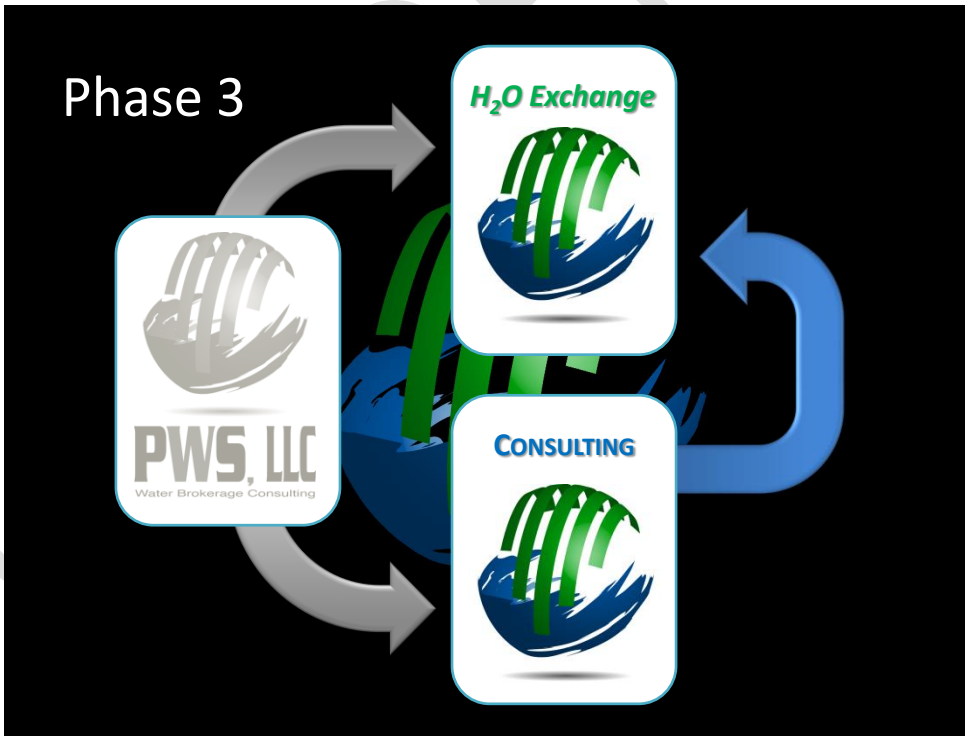
Phase 2

Of the 513 hydrologically-defined groundwater basins within California, only 22 are adjudicated. However, California is facing a severe water crisis and many groundwater

basins are already stressed. PWS LLC predicts that many groundwater basins will move to adjudicate within the next decade. PWS LLC will identify basins that are moving to adjudicate, then provide consulting services and propose the *H_2O Exchange* as a 'physical solution' in a stipulated judgment.

Once PWS LLC identifies a groundwater basin that is moving to adjudicate, PWS LLC will establish a working relationship with the local water authority. In most adjudications, the local water agency eventually has a prominent role in administrating the basin, often in the position of court-appointed Watermaster. In contacting such agencies, PWS LLC will bring innovative new solutions to water allocation and management challenges. PWS LLC will communicate to the agency the ability to minimize political discord in the process of adjudication and allow a more speedy adjudication when outside sources of water are not available. Furthermore, groundwater basins experiencing water crises often have deteriorated relationships with local water management. Such tension prevents effective management and worsens the crisis as involved parties become mired in heated discourse. Thus, PWS LLC will accentuate our ability to overcome tension among stakeholders and come to solutions acceptable to most members of the community.

Phase 3



After PWS LLC has established effective water markets in adjudicated and adjudicating basins, PWS LLC will begin expanding the target market to groundwater basins in other states. Furthermore, PWS LLC may begin providing more administrative services to Watermasters (i.e. accounting and collection of extraction fees).

Contacts

1. Pajaro Valley Water Management Agency
2. Mojave Basin Watermaster
3. Santa Paula Pumpers Association/United Water
4. Chino Basin Watermaster
5. West Coast Basin Watermaster
6. Agricultural users and other interest groups
7. Water suppliers
8. Conservation agencies

Competitive Analysis

An initial analysis of the market shows that PWS LLC has an excellent competitive edge.

SWOT Analysis

Strengths, Weaknesses, Opportunities, Threats

In conducting a competitive analysis, PWS LLC analyzed various firms that facilitate water transfers and could potentially work on the creation of water markets. PWS LLC aggregated all competitors into three categories: water consulting firms, law firms specializing in water law, and water trusts/non-profits specializing in water conservation.

WATER CONSULTING FIRMS

Water consulting firms generally have extensive, robust teams that can look carefully at all aspects of environmental problems. They have in-house GIS expertise to do quantitative analysis of groundwater basins. Additionally, they are well-versed in market valuation of water. Many are well-known and respected with a strong national presence. These firms could expand into facilitating water transactions and also into market creation. However, they are not currently active in California adjudicated groundwater basins. Additionally, because they are paid by individual clients, they do not deal with multiple stakeholders and thus are unlikely to work as a broker at an individual basin scale.

Potential Competitors

Located across the northern United States, *WestWater Research* (WWR) is a transaction and asset-valuation advisory company to the water market sector. WWR focuses on water-asset sales and acquisition, water resource economics, water right and asset appraisals, and project finance services. WWR assists corporate and public clients source and structure funds for water projects. The company specializes in water right transfers, water banking, water conservation, water storage contracting, and alternative water asset sales and acquisitions. WWR has a robust, experienced team with backgrounds in water marketing, regulatory policy, and water-asset valuation. WWR has advised on more than five hundred million water transactions throughout the United States.

Located in Denver, Colorado, *BBC Research and Consulting* transfers water supplies from agricultural to municipal use and is playing a growing role in meeting the water needs of expanding municipal populations. Since the 1980s, BBC has helped initiate new water markets and estimated the value of water supplies for lease and purchase. BBC has hands-on experience with a variety of water marketing strategies, including dry-year options and leases. BBC designs rate structures and values resources and facilities. BBC also values water and power resources and facilities ranging from U.S. Bureau of Reclamation projects to individual water rights. BBC has helped initiate new water markets and estimated the value of water supplies for sale and purchase.

WATER LAW FIRMS

Groundwater transactions are not often legally contentious in adjudicated basins. However, transfers of rights are complicated and often convoluted, especially when groundwater rights were tied to land deeds before adjudication. In performing groundwater transactions, particularly in processing transfers, expertise in California water law and years of experience is a huge strength. Water law firms have extensive knowledge in local adjudications. Furthermore, they have the ability to quickly perform groundwater transfers. Nevertheless, because they serve single clients, except in the case of a lawsuit with multiple filings, they do not approach groundwater transactions from a basin-wide perspective. Furthermore, they have no direct experience in market creation, and brokerage is outside of their core area of expertise. Since groundwater transfers also do not provide their core business, water law firms will not directly compete with us.

Potential Competitor

Brownstein Hyatt Farber Schreck's Water Group is a conglomerate of highly experienced water lawyers that has represented both public and private water producers, suppliers and providers, including municipalities, wholesale, and retail water agencies, public utilities, industrial users, real estate and land developers, vineyards, ranchers, land owners, and various water-related public policy organizations for decades. The Water Group has intimate knowledge and understanding of water resources. Clients rely on the group to serve as legal counselors, project managers, and business advisors. The group's attorneys have served as counsel in major matters involving the use of water throughout the United States, including the West, the Great Lakes region, and the Southeast. The group's attorneys also have experience internationally in the areas of water law reform and trans-boundary litigation. The Water Group has expertise in complex water transactions, regulatory compliance, litigation and legislative advocacy. It includes more than 30 attorneys with specialized water practices and licenses throughout the country.

The Water Group handles matters of water rights, water supply management and planning, water quality regulation and enforcement, water transfers and conveyance, acquisition and disposition, water reclamation and recycling, water quality remediation and damage recovery, infrastructure construction and finance, public agency law, investor-owned utilities, utility assets and management, customer rights, and private equity. The Water Group provides the full range of legal services involving water-related transactions, including evaluating users' existing and prospective water rights, acquiring new water supplies, negotiating and preparing purchase, transfer and exchange agreements, permitting surface water rights, developing and implementing groundwater management systems, developing required local and regional planning documents, evaluating water supply availability in the land development context, and creating and dissolving water utilities and other corporate structures used to utilize, manage, and deliver water.

Competitive Advantage

PWS LLC will set up water rights markets in adjudicated basins and facilitate transfers of groundwater rights by creating an online trading board (the *H_2O Exchange*). The *H_2O Exchange* will enable individual users (buyers and sellers) to create an account. They will then be able to transfer groundwater rights by specifying the amount of water they wish to buy/sell, the type of transfer (permanent, short-term, long-term), and the maximum price they will pay / minimum price they will sell for. The *H_2O Exchange* will calculate the optimal transfer distribution among users and PWS LLC will then process the transfers.

PWS LLC has a unique competitive advantage as a result of the *H_2O Exchange*. We will be providing

1) A central clearinghouse for groundwater transfer. This allows water users to
    a. Have a better knowledge of the market value of their groundwater
    b. Easily find buyers/sellers of groundwater, so as to maximize transfers
2) An easy, convenient, and inexpensive way to perform water transfers.
3) A mechanism for maximizing efficient groundwater use and minimizing total water use in the groundwater basin.

PORTER'S FIVE FACTORS

The competitive structure of groundwater use in adjudicated basins is highly conducive to PWS LLC. An analysis of Porter's Five Factors reveals a good competitive advantage.

Barriers to entry are high. Access to inputs (water rights) is very limited since they are owned by others reluctant to part with them. Furthermore, court-ordered management of adjudicated basins presents barriers to the creation of a water market, and the local Watermaster may be reluctant to cooperate with another entity providing a mechanism for water allocation. Switching costs are low for the customers, since there is no formal market at present. However, once one market is established, switching costs will be high since customers will experience diminished ability to transfer if all the customers are not gathered in one market. Key barriers to entry for PWS LLC to overcome will be 1) building trust with customers and business partners to establish brand identity, 2) achieving a minimum number of participants to ensure a functioning market, and 3) enabling a proprietary learning curve (knowledge of the area, needed water distribution, legal processes, and operation of water markets).

The threat of substitutes is low. There are no current equivalent substitutes. However, threats do exist. Consulting firms may branch out their business and begin establishing consolidated water markets in adjudicated basins as PWS LLC expands. Furthermore, water law firms will continue to engage in contentious groundwater transfers. Lastly, water users will continue to transfer groundwater on their own, at least until the *H_2O Exchange* becomes the only means of transferring water in an adjudicated basin.

Supplier power is both high and low. Because there is no differentiation of inputs, suppliers may easily band together to achieve a mutually beneficial result fairly easily. The likelihood of this happening is low for several reasons. Suppliers have a low level of information. Furthermore, they are not concentrated. There is very little possibility of forward integration, and economies of scale are not necessary for participation in the market. The greatest supplier power stems from high price elasticity.

Buyer power in this industry is low because bargaining power is low and price sensitivity is low. There will always be more demand for water than there is supply. Demand (especially in urban use) is close to inelastic. Regardless, there is no backward integration and there is limited information. Few substitutes are available and competition among buyers is high.

Consequently, PWS LLC has a good competitive advantage and the market is ready for a new entrant.

PORTER'S VALUE CHAIN ANALYSIS

PWS LLC was created to help manage groundwater in adjudicated basins by increasing transparency of the groundwater market and better compensating rights holders for reductions in groundwater use in order to help allocate groundwater in the most efficient manner, ensure greater stability of water resources over the long-term, and improve the environmental quality of groundwater basins.

With these values in mind, PWS LLC adds value at each stage of Porter's Value Chain Analysis. First, inbound logistics are represented by our strong human capital. The team is composed of a strong advisory board, legal expertise, and Bren School of Environmental Science & Management graduate students—educated to help solve and manage environmental problems. Operations uses an innovative technology platform designed to create transparency and ensure efficiency in groundwater trading. PWS LLC's analysis revealed that as water use is shifted to reflect the real market value, water will be more efficiently allocated—helping to ensure long-term water supply in the most cost-effective manner. Finally, PWS LLC will provide local services that are efficient and catered to the needs of each groundwater basin.

Willingness to Pay

Groundwater transfers through Watermasters typically take a considerable amount of time. Currently, arduous paperwork, potentially multiple lawyers, and trouble in finding buyers and sellers make even simple water transfers difficult. As water scarcity increases, willingness to pay will also increase, driving people to find the least-cost alternative to obtaining water. California not only has scarce water resources, but also an increasing population that will put further strain on the limited resources. Thus, water users will be increasingly willing to pay for services that enable them to obtain the market value for their water and to easily find groundwater rights for sale or lease at the market value.

Barriers to Entry

Once rights holders invest in a "user profile" and start groundwater transfers on the *H_2O Exchange*, the website will attract more customers and switching costs will increase dramatically. Additionally, by working directly and having a strong relationship with the Watermaster in each groundwater basin, we will become the accepted groundwater broker and a critical part of the basin management plan. Finally, the *H_2O Exchange* process will be patented and the name trademarked.

Credibility

Our strong multidisciplinary educational background and our experienced board will increase the credibility of PWS LLC. Once we have a successful presence in one groundwater basin and a good relationship with the Watermaster, other basins will be assured of PWS LLC's authority and reliability. Effectively transferring groundwater rights will increase our credibility the most. Once the *H_2O Exchange* has run once, word-of-mouth marketing will bring more rights holders to the market in following auctions.

Financial Analysis

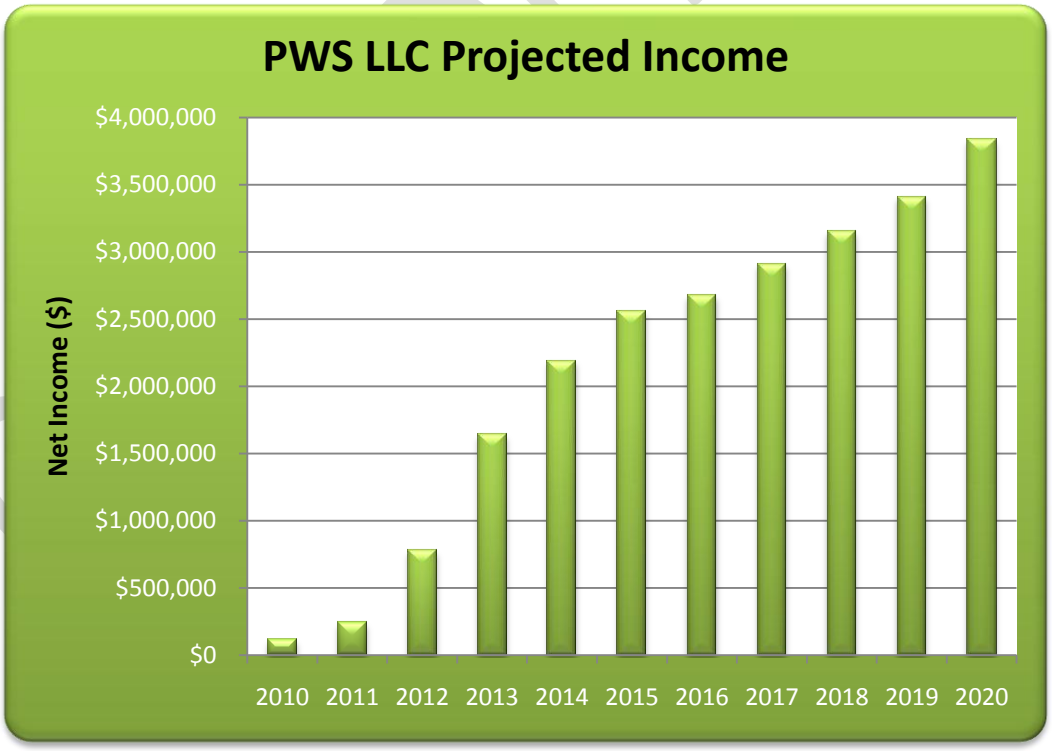
An initial financial analysis of the PWS LLC venture suggests outstanding profitability. The business requires very little up-front capital and is in the black within two years. We request an initial investment of $142,000 and project a five-year return on investment of 300%.

PWS LLC projects a minimum net income of $3,800,000 per year by 2020 with an excellent potential for expansion and the accumulated capital to enable rapid growth.

The following financial tables demonstrate that PWS LLC will be very lucrative.

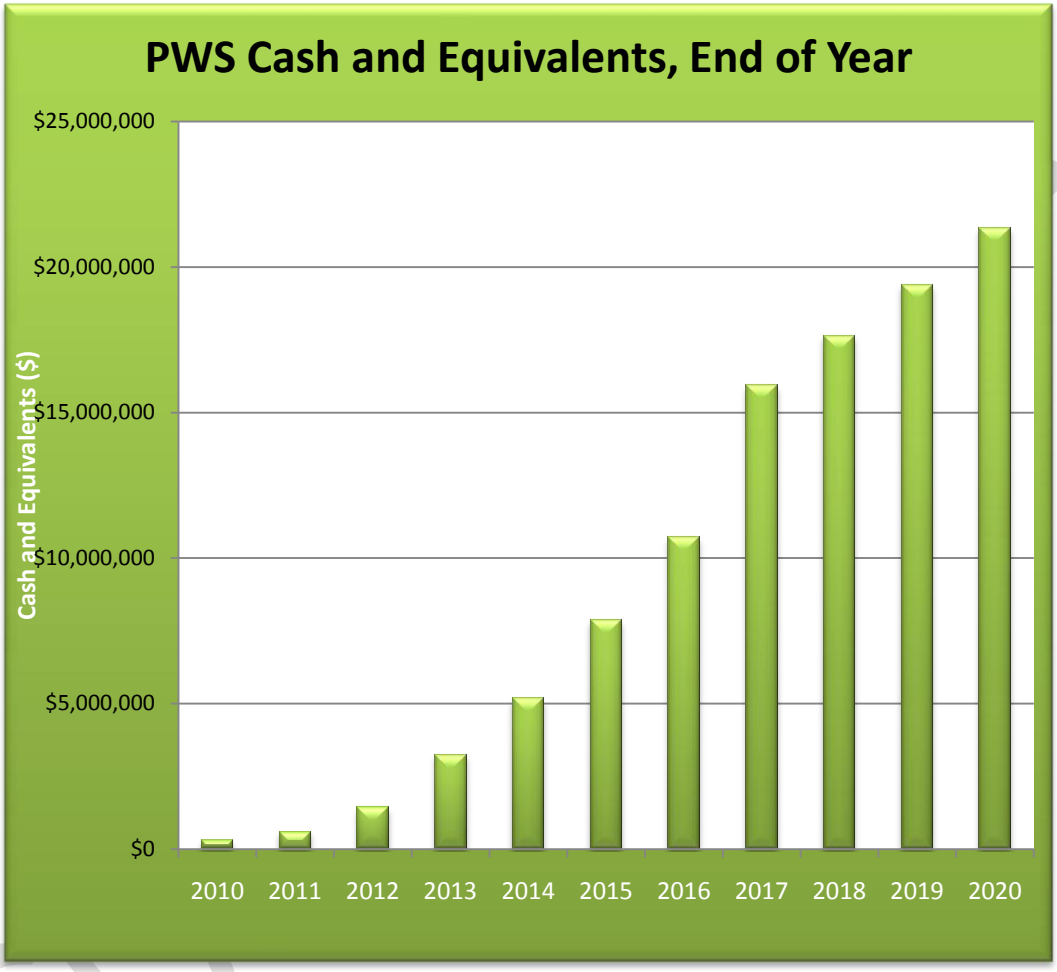
Projected Income Statement

PWS LLC will make a total net income of $115,000 in the first year of operation, after paying back upfront capital at a 25% interest rate. PWS LLC is seeking $140,000 in funding in year 1. By year 5, PWS LLC will make a net income of over $2 million. By 2020, PWS LLC will make a net income of $3.8 million. In year 1, PWS LLC will operate in one groundwater market. In year two, PWS LLC will operate in three. Thereafter, PWS LLC will expand into one to two groundwater basins per year until year 2020. In year 4, PWS LLC will begin taking on consulting projects for adjudicating basins. Also in year 4, PWS LLC will begin buying land to use for conservation projects or future groundwater banking.



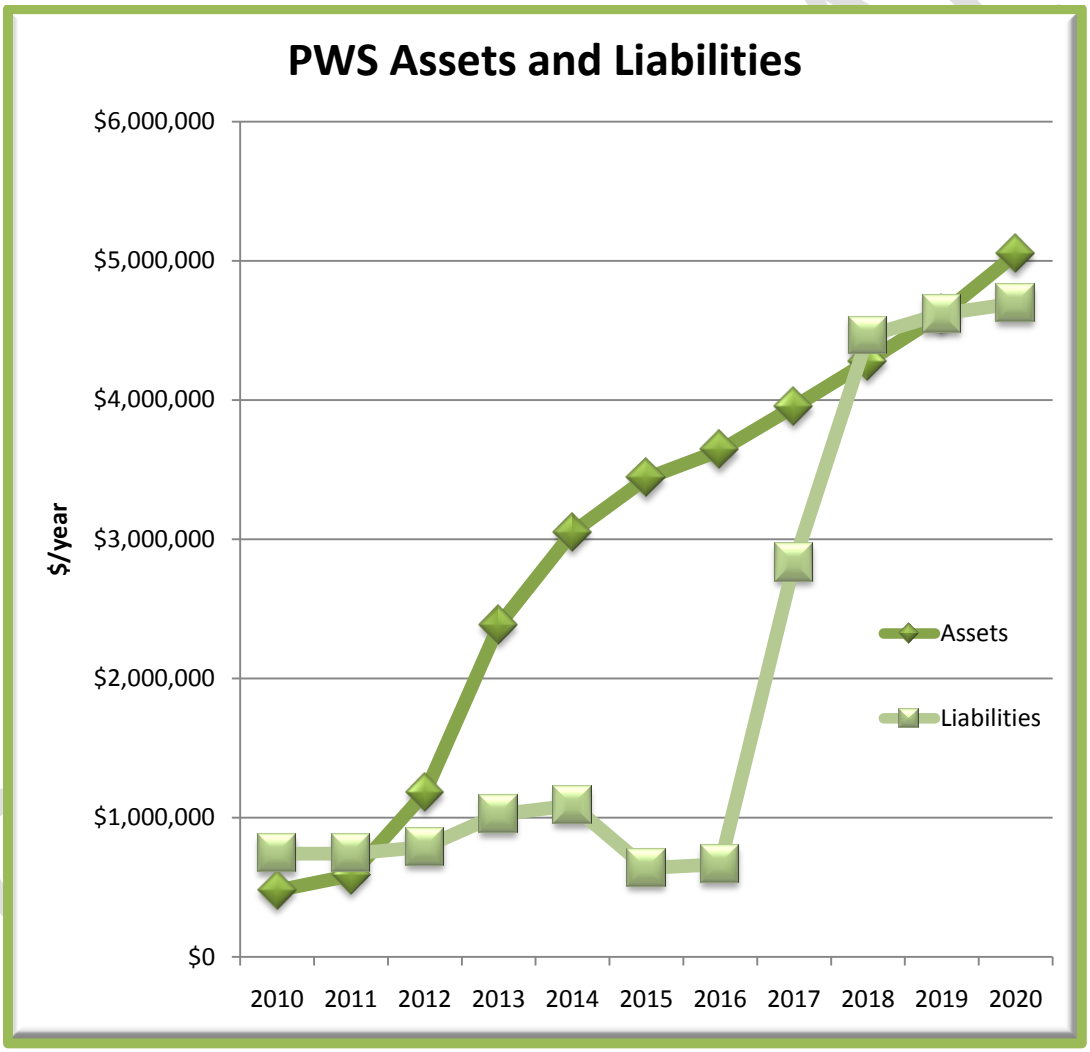
Projected Cash Flows

Cash flow projections demonstrate our potential for success. PWS LLC will quickly build cash reserves, will pay off our long-term debt in 2014, and will likely have the potential for an IPO in year 2017. Thereafter, potential for expansion will include groundwater markets in other states and trans-state transactions.



Projected Balance Statement

PWS LLC will have very little liability until the inclusion of shareholder's equity. We will pay off our long-term debt in 2014, but our assets will exceed our liabilities before that point. PWS LLC will also have little assets beyond IP until year 2013 when we begin buying land for conservation efforts and future business opportunities. Liabilities will increase with an IPO, but will again decrease with relation to assets as PWS LLC expands.



Methods

In order to project gross revenue we analyzed the market potential of four potential client basins (please see the appendices for each case study). Of the four case study basins, we determined that three could support a market. Using past groundwater transfer price and volume data, past Metropolitan Water District of Southern California replacement water prices, and projected increases in cost of extraction (please see each case study for more detailed explanation of methods), we determined the price and volume market potential in each basin. We categorized the other 22 adjudicated groundwater basins according to each of the four case study basins, and assumed the same price and volume market potential for each basins grouping.

PWS will charge 2% of the price of each transaction, and charge a $50/hour consulting fee.

Assumptions

1) All projections are conservative. Groundwater transactions, number of adjudicating basins, number of client basins, and groundwater price increases could be much higher than projected.
2) We assume that each potential client basin will participate in our market.
3) We assume that at least three groundwater basins, likely much more, will adjudicate within the next decade.
4) We assume that groundwater law and the California Legislature's policy of local groundwater control will not significantly change within the next decade.
5) Our projections do not take into account the increasing price and decreasing supply of surface water beyond upper bound replacement water price projections.

Long-Term Development and Exit Strategy

Goals

PWS LLC is an innovative concept that targets a growing market. PWS LLC assumes that many more groundwater basins in California will move to adjudicate the groundwater rights in the next ten years. PWS LLC aims to create a reputation of innovative market techniques, transparency, and good management strategies during that time so as to become the leader in groundwater rights management in California.

In the longer-term, PWS LLC plan on expanding to other states with high water demand and adjudicated groundwater rights, such as Texas, Colorado, New Mexico, Nevada, Utah, and Arizona.

Strategies

PWS LLC will initially concentrate on brokering groundwater transfers within adjudicated basins. As business expands, PWS LLC will move to consulting and potentially other administrative services for the court-appointed Watermasters.

Risk Evaluation

As with any new venture PWS LLC involves risk. There are three main potential obstacles to creating an effective business.

First, PWS LLC depends on an expanding market of adjudicated basins. However, California is facing extreme water shortages, and it is highly likely that adjudications will happen with greater speed and frequency in the near future (there is already evidence of such a trend).

Second, PWS LLC depends on the participation of groundwater rights holders in the market. However, as discussed in the Value Proposition and Competitive Advantage sections, groundwater rights holders have high incentives to participate.

Third, water allocation in California is a contentious issue and very litigious. PWS LLC is acting (indirectly) as a mediator between parties. There is some risk for litigation. However, PWS LLC has excellent counsel, and will take steps to minimize the risk of any legally inappropriate action.

Overall, the venture has moderate risk.

Exit Strategy

Ideally, PWS LLC will expand into 18 groundwater basins in the next 12 years. At year ten, PWS LLC will consider a conducting an IPO.

Team and Advisory Board

Team

Zoë Carlson
Zoë Carlson is a graduate student at the Bren School of Environmental Science and Management at the University of California Santa Barbara. She is specializing in corporate environmental management and political economy of the environment and pursuing an eco-entrepreneurship focus. Zoë holds an undergraduate degree in Earth Systems Science and Policy with a focus on Watersheds from California State University Monterey Bay. She has over four years of experience working in the Pajaro river watershed and surrounding counties with the Natural Resources Conservation Service and the Resource Conservation District of Santa Cruz County. As a native to central California, Zoë is passionate about sustainable water resource allocation to agriculture, urban users, and the environment throughout the state.

Daniel Crocker
Daniel Crocker is a graduate student at the Bren School of Environmental Science and Management at the University of California Santa Barbara. He is specializing in Water Resource Management. Daniel holds a Bachelor of Science in Environmental Conservation form the University of New Hampshire. Prior to coming to California he served in the Peace Corps in Paraguay and taught environmental education in Massachusetts.

Sara Solis
Sara Solis is a graduate student at the Bren School of Environmental Science and Management at the University of California Santa Barbara. She is specializing in Conservation Planning. Sara holds a Bachelor of Arts in Environmental Science from Claremont McKenna College. She has nearly three years of experience in groundwater remediation and environmental consulting.

Alexandra Speers
Alexandra Speers is a graduate student at the Bren School of Environmental Science and Management at the University of California Santa Barbara. She is specializing in corporate environmental management and pursuing an eco-entrepreneurship focus. Alexandra holds a Bachelor's degree in environmental science with a specialization in natural resource management from the University of Colorado Boulder. She is conversant about water allocation impediments and is enthusiastic about finding communally beneficial solutions.

Matthew Young
Matthew Young is a graduate student at the Bren School of Environmental Science and Management at the University of California Santa Barbara. He is specializing in Water Resources Management. Matthew holds a Bachelor of Science in Physical Geography from the University of California Santa Barbara. He has nearly six years experience in groundwater remediation and environmental consulting.

Advisors

Gary Libecap
PROFESSOR, BREN SCHOOL OF ENVIRONMENTAL SCIENCE AND MANAGEMENT
Gary Libecap joined the Bren School of Environmental Science and Management after more than twenty years at the University of Arizona, Tucson, where, in addition to teaching business, law, and economics, often in a natural resource context, he developed and directed the nation's top-ranked entrepreneurship program. His interdisciplinary focus and expertise in issues related to entrepreneurship and sustainable business practices led to his critical role in developing the Eco-Entrepreneurship focus at Bren. He has been president of the Economic History Association, the Western Economics Association International, and the International Society for the New Institutional Economics, and he holds high-level appointments at several top institutions around the country. Professor Libecap's current research is focused on the legal, economic, and policy aspects of water allocation in the western United States.

Russ McGlothlin
ATTORNEY AT LAW, BROWNSTEIN FARBER HYATT SCHRECK
Mr. McGlothlin is a Shareholder in Brownstein Hyatt Farber Schreck's Santa Barbara office and a member of the Water & Public Lands and Renewable Energy Practice Groups. His experience includes a broad range of water use issues in California and the western United States, including water right permitting, adjudication of groundwater rights, conjunctive water use, water transfers, water quality, recycled water projects, and environmental matters, including CEQA and ESA compliance. Mr. McGlothlin represents private companies, municipalities, special districts and individual landowners with transactional negotiations, litigation and administrative agency proceedings. In his practice, he has defended groundwater water rights in several groundwater basin adjudications, assisted in post-judgment proceedings in multiple on-going groundwater basin adjudication judgments, prosecuted water rights applications and petitions before the California State Water Resources Control Board, and negotiated and drafted a variety of transactional agreements concerning water resources. He is the author of several chapters concerning California groundwater law within the Groundwater Water Resources Agency's Groundwater Management Handbook. He also regularly speaks on water law-related matters before industry groups and publishes related articles within trade publications.

Chris Coburn
WATER RESOURCES ANALYST, COUNTY OF SANTA CRUZ
Chris Coburn works as the Water Resources Program Analyst for Santa Cruz County. His work at the County focuses on the administration of various water quality and fisheries projects and the management of beach water quality research and protection efforts. Prior to his work with the County, Mr. Coburn served as the Water Quality Protection Program Director for the Monterey Bay National Marine Sanctuary. Mr. Cobrun earned a Master's Degree in Environmental Science and Management with an emphasis in Water Resources Management from the Bren School of Environmental Science and Management at the University of California at Santa Barbara. He also has a Bachelor's Degree in Biopsychology also from UCSB.

Arianne Rettinger
PROGRAM MANAGER, RESOURCE CONSERVATION D. SANTA CRUZ COUNTY
In her role as Pajaro Watershed Program Manager, Ms. Rettinger puts her skills to work for local growers, and has the opportunity to assist growers in finding solutions to their resource conservation problems. Being a native of Monterey, CA, she has grown up understanding the importance of preserving our region's ecosystems and resources, while recognizing the economic importance that agriculture plays in our central coast region. Ms. Rettinger's academic credentials include a B.A. degree in Biology and a certificate degree in Marketing from the University of California, Santa Cruz and a Master Degree in Environmental Science and Management from the University of California at Santa Barbara's Donald Bren School with an emphasis in Coastal and Marine Resource Management. Her other main interests include ecological assessment, restoration of declining habitats, and the effects of land and marine based pollutants on ecosystems and industry.

Robert C. Wilkinson
Dr. Wilkinson advises various government agencies on water policy, climate research, and policy issues. He currently serves on the public advisory committee for California's State Water Plan and he represents the University of California on the Governor's Task Force on Desalination. He also advises the California Energy Commission on climate research, and for the past five years he has served as coordinator for the climate impacts assessment of the California Region for the US Global Change Research Program and the White House Office of Science and Technology Policy.
Dr. Wilkinson is also a Senior Fellow with the Rocky Mountain Institute, and he is a founding member of the California Environmental Dialogue and a founding participant in the Aspen Institute's The Environment in the 21st Century. He consults for corporations, governments, foundations, and non-profit organizations in the U.S. and internationally. In 1990, Dr. Wilkinson established and directed the Graduate Program in Environmental Science and Policy at the Central European University based in Budapest, Hungary. He has worked extensively in Western Europe and in every country of Central Europe from Albania through the Baltic States and throughout the former Soviet Union including Siberia and Central Asia. He has also worked in Australia, New Zealand, Japan, South Africa, and China.

Special thanks and to the Bren school
Eco Entrepreneurship Advisory Council for their generous review and support through the creation of this plan.

Additional thanks to Loretta Tam and Ainsley Close
for their contributions in the conception phase of the business.

Supporting Research Appendices

Extensive research has been conducted throughout the development of this business plan on the legal, political, and physical status of water in California. Detailed market research was also conducted to determine the feasibility and profitability of our business in California. The following appendices provide a brief summary of applicable research in the development, strategy, and positioning our business.

APPENDICES

THIS PAGE LEFT INTENTIONALLY BLANK

Appendix Contents

List of Figures

List of Tables

THIS PAGE LEFT INTENTIONALLY BLANK

Acronyms

AF	Acre-feet
AFY	Acre-feet per year
ASR	Aquifer storage and recharge
BAP	Base Annual Production
Cal-Am	California American Water
CBMWD	Central Basin Municipal Water District
CBWA	Central Basin Water Association
CBWRMS	Chino Basin Water Resources Management Study
CVWD	Cucamonga Valley Water District
CWBWRD	Central and West Basin Water Replenishment District
DWR	California Department of Water Resources
FPA	Free Production Allowance
GWD	Goleta Water District
LACDPW	Los Angeles County Department of Public Works
HDWD	Hi-Desert Water District
M&I	Municipal and industrial
MCL	Maximum Contaminant Level
MWA	Mojave Water Agency
MWD	Metropolitan Water District of Southern California
PWS	Progressive Water Solutions, LLC
PGB	Pajaro Groundwater Basin
PVPA	Pomona Valley Protective Association
PVWMA	Pajaro Valley Water Management Agency
RO	Reverse osmosis
SBVMWD	San Bernardino Valley Metropolitan Water District
SAWC	Santa Ana Water Company

SCAG	Southern California Association of Governments
SCWC	Southern California Water Company
STWMA	San Timoteo Watershed Management Authority
SWP	State Water Project
TCCWD	Tehachapi-Cummings County Water District
TDS	Total dissolved solids
USFS	United States Forest Service
USGS	United States Geological Survey
WBMWD	West Basin Municipal Water District
WRD	Water Replenishment District of Southern California

Appendix 1: The Problem of Groundwater

Water Scarcity in America

Water scarcity is one of the most critical challenges facing Americans. The future promises continued population growth, increased urbanization, and climate change. Water is arguably our most valuable natural resource because it has no substitutes, we consume it directly, and it is used in virtually every segment of the economy. In order to ensure a prosperous future, Americans must maintain reliable water supplies.

It can be difficult to appreciate that the nation is in the midst of a water crisis, especially when storms bring rains and even floods and a turn of the tap always brings a flow of water. However, the crisis is real and widespread, and it is caused by increases in demand for freshwater combined with reductions in water availability in many regions.[1] Climate change is affecting natural hydrologic cycles so that, as Robert Glennon describes it, "water may not be *where* we want it *when* we need it in the *form* that we need."[2] The U.S. Government Accountability Office conducted a survey of water managers in 50 states, to which managers from 36 states responded that they anticipate water shortages within the next decade even under normal conditions, let alone drought conditions.[3] Even seemingly water-rich regions are not immune. For example, water levels in Lake Superior—the largest freshwater body on the planet—have been below average since 1998 and cargo ships on the lake have to lighten their load of materials or risk running aground. [4,5]

Water in the Western United States

The problem of water scarcity is especially critical in Western states, where cities like Las Vegas are artificial oases built on piped-in water. Much of the landscape is arid to semi-arid, and precipitation occurs in winter, whereas the greatest

[1] Rogers 2008
[2] Glennon 2009
[3] United States General Accounting Office 2003
[4] National Oceanic and Atmospheric Administration 2009
[5] Santos 2007

demand for water occurs in summer.[6] The situation in Lake Mead illustrates the Western water crisis: it is a manmade reservoir on the Colorado River that supplies water to Los Angeles and Phoenix, and there is a 50% chance that the lake will go dry by 2021.[7] California is in its third year of drought, and in February of 2009 Governor Schwarzenegger proclaimed a statewide emergency due to the severity of the drought.[8,9] The crisis has negative impacts not just on people, but also on birds, fish, amphibians, plants, and other species that depend on aquatic habitats that are drying up in the drought.

California's Water Crisis

California is the most populous state in the nation and the eighth-largest economy in the world, and so a dependable water supply is highly consequential.[10,11] Adding to California's water crisis is the fact that about 75% of the state's rainfall occurs in northern California, but 80% of the agricultural and urban demand for water exists in central and southern California.[12] Water is distributed through the most complex water storage and transport system in the world in an attempt to satisfy demand all over California. The system's dams, reservoirs, pumping plants, and aqueducts transport roughly half the state's water, sometimes hundreds of miles. This redistribution causes intense rivalries between regions and interest groups, known as California's "water wars."[13]

Groundwater in California

The majority of the water distributed through California's conveyance infrastructure is surface water from rivers, streams, and snowmelt. Another source of water for Californians is groundwater. The groundwater stored in underground aquifers supplies 30% of the state's urban and agricultural water needs during average years and over 40% in drought years.[14] As important a resource as groundwater is, sustainable management is challenging because of hydrological factors, weak authority over the resource, and California's exceedingly complex water rights system.

---

[6] Bachman et al. 2005
[7] Barnett and Pierce 2008
[8] Jones 2009
[9] California Department of Water Resources
[10] Center for Continuing Study of the California Economy 2009
[11] U.S. Census Bureau 2009
[12] Water Education Foundation 2006
[13] Water Resources Center Archives 2010
[14] Osugi et al. 2003

Determining how aquifers are connected and evaluating how groundwater extraction is affecting the aquifer and overlying land requires subsurface drilling and sophisticated modeling, which are costly and time-intensive. California lacks a mandatory State groundwater management statute, so responsibility for groundwater management has been delegated to local agencies under the authority of the California Water Code. [15,16] The state also lacks a comprehensive monitoring network for evaluating the volume and quality of groundwater. In terms of rights to the resource, groundwater is an open access resource because, barring special restrictions, every landowner has the right to pump as much groundwater as they can put to beneficial use.[15] Thus, groundwater exploitation is a prime example of the tragedy of the commons, as individual landowners determine that the benefits of additional water outweigh the costs of a slightly lowered water table, and the aquifer is depleted for everyone.[17]

When more groundwater is extracted than can be naturally replaced over many years, overdraft ensues. Basin overdraft can result in a variety of negative consequences such as land subsidence, reduced surface flows, impaired water quality from seawater intrusion in coastal basins, and higher pumping costs. There is ample evidence of these effects in California; in the San Joaquin Valley, land surface elevation dropped nine meters from 1925 to 1977 as a result of intensive groundwater extraction. Groundwater extraction under Redwood Creek in northern California increased during the drought of 1988-1991 and the length of the stream habitat containing water decreased to 23% of its historical length, which decimated the native steelhead trout population.[18] In the agriculture-dominated Pajaro Valley groundwater basin, groundwater is the predominant source of water for irrigation, and overdraft has caused seawater to intrude over two miles inland.[19]

Effective groundwater management that prevents overdraft requires that special legal requirements be met, which is discussed in the next appendix.

References

Bachman, Steven, Carl Hauge, Russel McGlothlin, Kevin Neese, Timothy Parker, Anthony Saracino, and Scott Slater. *California Groundwater Management: A*

[15] California Department of Water Resources 2009
[16] California State Senate 2009
[17] Hardin 1968
[18] Zekster et al. 2005.
[19] Pajaro Valley Water Management Agency 2002

Resource for Future Generations. 2nd ed. Sacramento: Groundwater Resources Association of California, 2005.

Barnett, T.P. and D.W. Pierce. "When Will Lake Mead Go Dry?" *Water Resources Research* 44 (2008): W03201.

California Department of Water Resources. "Drought Timeline." California's Drought. 2009. http://www.water.ca.gov/drought/docs/timeline-present.pdf (accessed December 19, 2009).

Groundwater Information Center. "Groundwater Management." California Department of Water Resources. 2009. http://www.groundwater.water.ca.gov/ technical_assistance/ gw_management/#sadwithgw (accessed January 4, 2010).

California State Legislature. *California Water Code*. http://info.sen.ca.gov/cgibin/ calawquery?codesection=wat&codebody=&hits=20&site=sen (accessed November 11, 2009).

Center for Continuing Study of the California Economy. "2008 California Economy Rankings." 2009. http://www.ccsce.com/PDF/Numbers-Aug09_2008-California-Economy-Rankings.pdf (accessed January 20, 2010).

Glennon, Robert. *Unquenchable: American's Water Crisis and What to Do About It*. Washington, DC: Island Press, 2009.

Great Lakes Environmental Research Laboratory. "Lake Superior Hydrograph." National Oceanic and Atmospheric Administration. 2009. http://www.glerl.noaa.gov/data/ now/wlevels/lowlevels/plot/Superior.gif (accessed February 2, 2010).

Hardin, Garrett. "The Tragedy of the Commons." *Science* 162 (1968): 1243-1248.

Jones, Jeanine. "California Drought, An Update: December 2009." California Department of Water Resources. 2009. http://www.water.ca.gov/drought/docs/ dec09_drought_report.pdf (accessed January 20, 2010).

Osugi, Doug, Robert Swartz, and Carl Hauge. "California's Groundwater - Bulletin 118, Update 2003." Groundwater Information Center. Sacramento: California Department of Water Resources. 2003. http://www.water.ca.gov/ groundwater/bulletin118/ bulletin118update2003.cfm (accessed February 10, 2009).

Rogers, Peter. "Facing the Freshwater Crisis." *Scientific American* 299, no. 2 (2008.): 46-83.

Santos, Fernanda. "As Great Lakes Shrink, Cargo Carriers Worry." *New York Times,* October 23, 2007, World section.

United States Census Bureau. "United States—States, GCT-T1-R. Population Estimates (geographies ranked by estimate)." American FactFinder. 2009. http://factfinder.census.gov/ servlet/GCTTable?_bm=y&-geo_id=01000US&-_box_head_nbr=GCT-T1-R&-ds_name=PEP_2009_EST&-_lang=en&-redoLog=false&-mt_name=PEP_2009_EST_ GCTT1R_US40S&-format=US-40S&-_sse=on/drought/ (accessed February 2, 2010).

United States General Accounting Office. "Freshwater Supply: States' Views of How Federal Agencies Could Help Them Meet the Challenges of Expected Shortages." Report to Congressional Requesters GAO-03-514. Washington, DC: General Accounting Office, July 2003. http://www.gao.gov/new.items/d03514.pdf (accessed January 16, 2010).

Water Education Foundation. "California Water: The Basics." 2006. http://www.water-ed.org/watersources/subpage.asp?rid=9&page=18 (accessed January 12, 2010).

Water Resources Center Archives. "Liquid Gold: California's Water." 2010. http://www.lib.berkeley.edu/WRCA/exhibit.html (accessed January 14, 2010).

Zekster, S., H.A. Loáiciga and J.T. Wolf. "Environmental Impacts of Groundwater Overdraft: Selected Case Studies in the Southwestern United States." *Environmental Geology* 47 (2005): 396-404.

Appendix 2: Groundwater Law in California

Groundwater Law

Although groundwater and surface water are often hydraulically connected, groundwater and surface water considered legally separate entities in California. Since 1914, the State of California has regulated surface water use and defined rights through a permitting process. However, the State Legislature has consistently held that groundwater management is a local issue, and has not outlined a state management strategy.[20]

Treating groundwater as a common-pool resource worked until water users began over-extracting groundwater from basins. Classic tragedy of the commons situations occur when each groundwater user extracts as much as he can in order to utilize the resource while it is still available. Since there are no defined rights and no incentive to minimize groundwater use (because someone else will simply use it anyway), groundwater overdraft can result and the groundwater users, basin hydrologic system, and surrounding ecosystems suffer.

Groundwater Management Through Adjudication

At present, there is no limit to individual users' groundwater extractions as long as water use is "beneficial and reasonable", except through basin adjudication by way of a lawsuit. Adjudication is the process through which the total amount of groundwater extraction rights in a basin is limited to an amount that does not result in overdraft, and the groundwater rights of all the users in the basin are defined through a court Judgment. Rights are defined in terms of acre-feet (AF), which is the volume of one acre of surface area to a depth of one foot, or 325,851 gallons. The process of adjudication is as follows:

- One or more groundwater users within a basin sue for adjudication.
- The Court requires hydrologists and water managers to define the geologic limits of the groundwater basin, determine the safe yield, quantify any problems the basin is experiencing, and predict future basin supplies. Safe

[20] Osugi, Swartz and Hauge 2003

yield is the maximum volume of groundwater that can be extracted annually and is naturally replenished without detrimental effects.

- Subsequently, all groundwater users above a certain volume of AF extracted annually are identified and become party to the adjudication.
- The Court requires that all parties must negotiate a Stipulated Judgment (an agreement among users to curtail extractions) before trial, and all parties must stipulate to the judgment after trial.
- Overlying rights preempt appropriative rights. Overlying rights are the rights of landowners to extract groundwater from their property and use it anywhere on their parcel, and appropriative rights are rights to extract groundwater and transport it to other parcels. Appropriative rights are not linked to land ownership and are maintained through continuous beneficial use. Furthermore, the mutual prescription doctrine holds, which means that the available groundwater will be apportioned among all users in amounts proportional to their historical extraction.[21] Lastly, a 'physical solution' must be found. That is, there must be a means for maintaining water supply to appropriative rights holders or compensating them for lost water supply.

The outcomes of adjudication include: 1) determination of groundwater rights holders within the basin, 2) determination of the volume of groundwater each rights holder can extract, and 3) appointment of a Watermaster to ensure compliance and basin management. Adjudication has occurred in 22 of the approximately 515 groundwater basins in California, where groundwater users or management agencies sued other groundwater users in the basin, citing over-extraction of groundwater resulting in deteriorating basin conditions.

History of Groundwater Adjudication

Table 2.1 summarizes the chronology of the 22 groundwater basin adjudications that have occurred in California to date. The first adjudication case was filed in 1937 in Raymond Basin in Los Angeles County. Raymond Basin began experiencing groundwater overdraft in 1913 as a result of expanding agricultural production and increasing municipal population.[22] The judge ruled that the filing was not simply an action to quiet title, but adjudication of the rights of the entire

[21] Salvi 1994
[22] Raymond Basin Management Board 2008

basin.[23] The Judgment stipulated a safe yield and limited individual extraction. Furthermore, the court appointed a Watermaster to monitor groundwater users and manage groundwater resources in the basin. The case acknowledged the prescriptive rights doctrine established in 1903 with Katz v. Wilkinshaw. Further, the case set a precedent for prescriptive rights and allowed users in an overdrafted basin to craft an alternative capacity to resolve overdraft problems, work out their own settlement with some assurance that the judge would place public authority behind it, and constitute their own basin governance and management programs.[24] Groundwater overdraft ceased with the conclusion of the case.

Two subsequent adjudications were followed by the precedent-setting adjudication of Central Basin in Los Angeles County beginning in 1965. The seawater intrusion caused by overdraft was an immediate threat to groundwater supply, but a large number of defendants—700—promised protracted litigation. To speed up the process, the Central Basin Water Association (CBWA) drafted an interim agreement curtailing extractions from the basin. The majority of basin users approved of the interim agreement, and a Stipulated Judgment was filed with the court. The Central Basin case thus set the precedent that a Stipulated Judgment must be reached before a case can go to court. [25]

A total of 11 more groundwater basins underwent adjudication over the following two decades. Most of the basins took at least four years to get to trial, and adjudication gained a reputation for contentious legal battles and prohibitive expense for all parties involved.

With the adjudication of Goleta Basin in 1989, the Court set a precedent that simultaneously simplified and confused the process. As described by David Aladjem in the California Water Law and Policy Reporter, "[the case] involved an groundwater adjudication with both overlying users and appropriators where the main question was whether a court could subordinate unexercised overlying rights to appropriative rights to groundwater."[26] The Judgment held that,

> "[w]hile a court has the authority to determine the existence, extent, and character of a groundwater user's exercised rights, a court cannot determine the prospective rights of overlying landowners [and] that a judicial determination of

[23] Raymond Basin Management Board 2007
[24] Raymond Basin Management Board 2008
[25] California Department of Water Resources 2001
[26] Aladjem 1998

> basin rights is only binding on parties to the litigation because adjudication of groundwater rights is essentially a private lawsuit."[27]

Thus, the Goleta Basin adjudication case exempted large landowners from district rationing during drought.[28] Thereafter, the normal rule for surface water rights apportionment—'first in time, first in right'—became pertinent to groundwater rights and the Goleta Basin adjudication set the stage for the litigious and contentious Mojave Basin adjudication, the only adjudication case to go to the California Supreme Court.

The Mojave Water Agency originally began the process of adjudication in the late 1960s as a result of critical groundwater overdraft and decreasing availability of State Water Project (SWP) water. However, as a result of legal disputes and questions over relative benefits to users, the adjudication process was abandoned in the mid-1970s. The urban population in the area continued to grow rapidly and, even though SWP water was supplied to the basin, groundwater overdraft continued to be a problem. In 1990, the City of Barstow and the Southern California Water Company sued the City of Adelanto and other cities upstream that were pumping groundwater and affecting downstream withdrawals. They also sued for the "[Mojave Water Agency] to fulfill its statutory authority to obtain and provide supplemental water for use within the Mojave River Basin area."[29] In all, over 800 rights holders were party to the adjudication.

Due to the large number of parties holding water rights and the millions of dollars that would have been required to do a full adjudication, the court ordered that the litigation be placed on hold to give parties time to negotiate and reach a settlement. A committee of attorneys and engineers was established to gather data and draft a stipulated judgment and physical solution. The committee favored an equitable apportionment in which all major users would cut back their water use by an equally proportionate amount rather than a well-by-well determination of each party's water use and whose rights were paramount.[30]

The Superior Court Judge ordered all parties in the basin to stipulate to the equitable apportionment solution. Some parties objected to the stipulation (the City of Adelanto, the Jess Ranch Water Co., and a group of alfalfa and dairy

[27] Foley-Gannon 1999
[28] Sadler 2007
[29] McClurg 2000
[30] Kaiser 1996

farmers called the Cardozo Group), and the case eventually went to the California Supreme Court. The Supreme Court upheld previously determined "first in right, first in time" rights, stating that "case law simply does not support applying an equitable apportionment to water use claims unless all claimants have correlative rights." However, it did maintain that reasonable and beneficial use is limited if the basin is overdrafted. Thus, the Cardozo Group kept their water rights but could not increase their groundwater pumping. Consequently, the Mojave case strengthened water rights priorities and encouraged full adjudication of rights, especially quantification of individual rights, despite the high expense.[31]

To some degree, the Mojave ruling was a victory for senior water rights holders in the Mojave River Basin and throughout the state.[32] The case also solidified the requirement of a 'physical solution' in the Stipulated Judgment. That is, equitable apportionment must be achieved through a 'physical solution' as opposed to equal reduction in groundwater extraction. In practice, this means that there must be means for maintaining water supply to appropriative rights holders in formulating a Stipulated Judgment.[33]

Since the Mojave case, two basins without overdraft problems have filed for adjudication in order to ensure good management of groundwater resources into the future. The cases were very short. The last basin to adjudicate was Seaside Basin in 2006. The adjudication was the first so-called 'friendly adjudication', where all parties agreed to the Stipulated Judgment before trial.

In 2003, groundwater in Seaside Basin was overdrafted and continued to be over-extracted each year, even though there were few rights holders. Groundwater pumping at the time was estimated to be approximately twice the basin's safe yield.[34] This overdraft resulted in a significant threat of seawater intrusion.[35] The Seaside Basin is unique in its division of water rights with 'Standard Producers' holding appropriative rights and 'Alternative Producers' holding overlying rights.[36] Seaside Basin's unique rights structure and the pressure of groundwater

[31] McClurg 2000
[32] McClurg 2000
[33] Aladjem 2000
[34] Monterey Peninsula Water Management District 2008
[35] Saxton 2006
[36] Monterey Peninsula Water Management District 2008

shortages, seawater intrusion, and litigation likely caused the adjudication parties to ac rationally and craft a fully supported Stipulated Judgment.[37]

As of 2009, 22 groundwater basins in California have been adjudicated. Antelope Basin is currently in the process of adjudication and many more overdrafted basins are under threat of lawsuit.

Table 2.1 Timeline of Adjudicated Basins.

Basin	Filed	Adjudicated
Raymond Basin	1937	1944
Cucamonga Basin	1958	1959
West Coast Basin	1946	1961
San Gabriel Basin	1968/1972	1965/1973
Central Basin	1962	1965
Santa Margarita River Watershed	1951	1966
Western San Bernardino Basin	1963	1969
Brite Basin	1966	1970
Tehachapi Basin	1966	1971
Cummings Basin	1966	1972
Warren Valley Basin	1976	1977
Chino Basin	1975	1978
Upper Los Angeles River Area	1955	1979/1984
Scott River Valley Basin	1970	1980
Puente Basin	1985	1986
Goleta Basin	1973	1989
Mojave Basin Area	1990	1996
Santa Paula Basin	1991	1996
Six Basins	1998	1998
Beaumont Basin	2003	2004
Seaside Basin	2003	2006
Santa Maria Valley Basin	1997	2008

Current State of Adjudication

Groundwater adjudication has evolved into a way to provide an effective start to solving overdraft, seawater intrusion, and general water shortage problems. Adjudication cases are now relatively well-defined with a clear process for the resolution of the lawsuits.

[37] Saxton 2006

Although adjudication results in effective local management of a basin and allows more flexible and informed use of groundwater, the process is lengthy, contentious, and expensive. The legal fees and scientific research involved require substantial time and money. The outcome of most adjudications is that groundwater users are restricted in their right to pump groundwater from a basin, or this right is eliminate entirely. Such reductions in groundwater availability result in lost profits for agricultural and industrial interests and critical water shortages for municipal water suppliers or utilities. As groundwater users know that the costs and outcomes of adjudication can be economically detrimental many want to avoid adjudication, even when their groundwater basin is experiencing severe overdraft (e.g. Pajaro Valley Basin).[38]

With the most recent, more clear iteration of groundwater adjudication case law, the example of the Seaside 'friendly adjudication', and increasing groundwater shortages, adjudication will likely become a more frequent solution to groundwater management in the near future.

Current Adjudicated Basins

Table 2 lists the 22 adjudicated groundwater basins in California and Figure 2.1 shows their locations. The basins vary in number of parties, size, groundwater use, and safe yield. Note that there are seven basins that use groundwater predominantly for agricultural purposes, nine for urban purposes, and five for mixed purposes. A more detailed description of each of the 22 adjudicated basins and a general description of non-adjudicated basins can be found in Appendix 6.

[38] Khalsa and Mauriello 2009

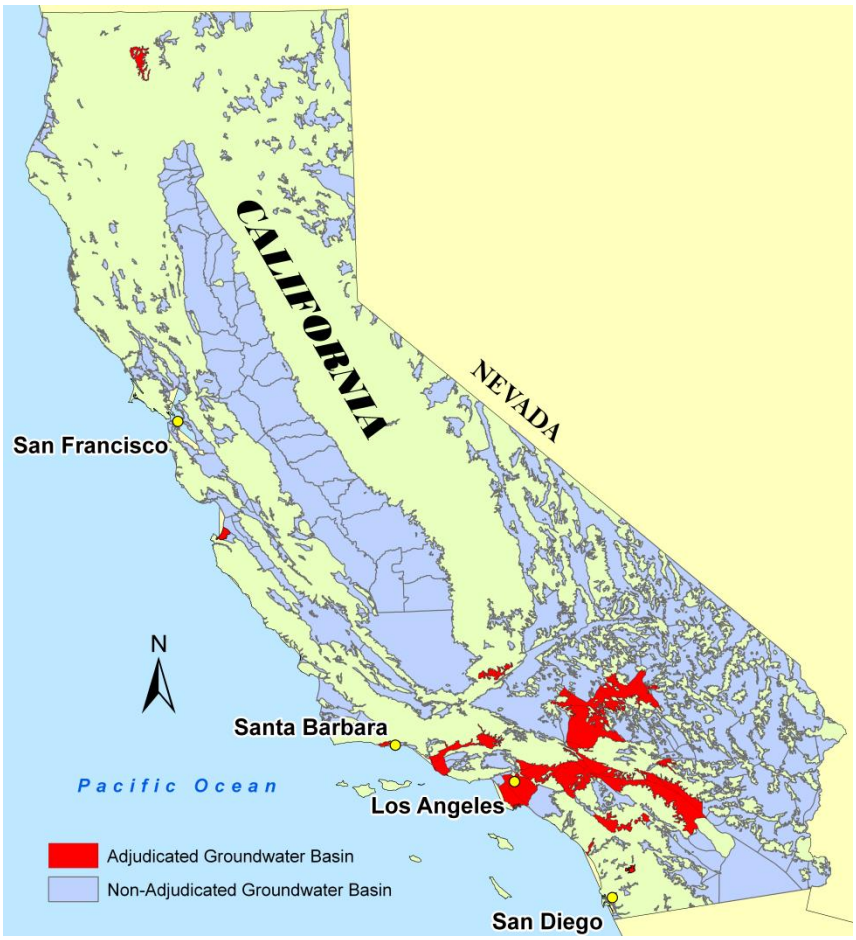


Figure 2.1 California's 22 adjudicated basins.[39]

[39] California Department of Water Resources 2010

Table 2.2 Adjudicated Basins in California.

Basin	Year Filed / Year Adjudicated	Number of Parties	Area (square miles)	Type of Water Use	Approximate Use (AF)	Safe Yield (AF)
Beaumont	2003/2004	35	26	Urban	8,650	Unknown
Brite	1966/1970	Not fully adjudicated	5	Agricultural	500	500
Central	1962/1965	140	277	Urban	217,367	Unknown
Chino	1975/1978	17	240	Mix	78,000	140,000
Cucamonga	1958/1959	3	15	Mix	22,721	Unknown
Cummings	1966/1972	Not fully adjudicated	16	Agricultural	Unknown	4,090
Goleta	1973/1989	45	14.5	n/a	2,350	2,350
Mojave	1990/1996	475	1,400	Mix	180,000	134,000
Puente	1985/1986	5	14	Agricultural	1,666	Unknown
Raymond	1937/1944	16	40	Urban	33,622	21,900
San Gabriel	1965/1972 1968/1973	190	255	Mix	152,700	Unknown
Santa Margarita	1951/1966	Unknown	12	Urban	Unknown	Unknown
Santa Maria Valley	1197/2008	1,000	170	Agricultural	Unknown	70,000
Santa Paula	1991/1996	74	35	Agricultural	33,500	33,500
Seaside	2003/2006	13	20	Urban	2,581	2,913
Scott River Valley	1970/1980	684	100	Agricultural	24,300	Unknown
Six Basins	1998/1998	Unknown	16	Urban	19,300	19,300
Tehachapi	1966/1971	65	37	Agricultural	5,500	5,500
Upper LA River Area	1955/1979/1984	5	226	Mix	97,820	97,820
Warren Valley	1976/1977	19	27	Urban	900	900
West Coast	1946/1961	67	142	Urban	64,468	Unknown
Western San Bernardino	1963/1969	4,000	Unknown	Urban	232,100	Unknown

References

Aladjem, David. "Affirming Secure Property Rights in Water: Barstow v. Mojave Water Agency." California Law and Policy Reporter. July 1998. http://www.downeybrand.com/publications/articles/980701_secureproprtyrights.php (accessed September 11, 2009).

Aladjem, David. "Property Rights Triumphant: Barstow v. Mojave Water Agency." California Law and Policy Reporter. October 2000. http://www.downeybrand.com/publications/articles/001001_propertyrights.php (accessed September 11, 2009).

California Department of Water Resources, Southern District. "Watermaster Service in the Central Basin." 2001. http://www.water.ca.gov/watermaster/sd_documents/central_basin_2001/centralbasinreport2001.pdf (accessed September 11, 2009).

Foley-Gannon, Ella. "Institutional Arrangements for Conjunctive Water Management in California and Analysis of Legal Reform Alternatives." UC Berkeley: University of California Water Resources Center, 1999. http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1175&context=wrc (accessed September 11, 2009).

Kaiser, Michael E. "City of Barstow vs City of Adelanto, Case No. 208568, Judgment After Trial." County of Riverside Superior Court. 10 January 1996. http://www.mojavewater.org/home/watermaster/documents/Judgment.pdf (accessed September 11, 2009).

Khalsa, Rama and Susan A. Mauriello. "Status of Groundwater Management Efforts in the Pajaro Basin." County of Santa Cruz Health Services Agency. 22 November 2009. http://sccounty01.co.santa-cruz.ca.us/bds/Govstream/BDSvData/non_legacy/agendas/2009/20091208/PDF/031.pdf (accessed March 1, 2010).

McClurg, Sue. "The Mojave River Basin Decision." *Western Water Magazine*, September/October 2000, http://www.watereducation.org/doc.asp?id=926 (accessed September 10, 2009).

Monterey Peninsula Water Management District. "Seaside Groundwater Basin Questions and Answers." September 2008. http://www.mpwmd.dst.ca.us/seasidebasin/ord135/QAOrd135091108.pdf (accessed September 11, 2009).

National Science & Technology Center. "California Water Rights Fact Sheet." Bureau of Land Management. 15 August 2001. http://www.blm.gov/nstc/ WaterLaws/ california.html (accessed March 1, 2010).

Osugi, Doug, Robert Swartz, and Carl Hauge. "Chapter 2: Groundwater Management in California" in California's Groundwater - Bulletin 118, Update 2003. Groundwater Information Center. Sacramento: California Department of Water Resources. 2003. http://www.water.ca.gov/pubs/ groundwater/bulletin_118/california%27s_groundwater__bulletin_118_-_update_2003_/bulletin118-chapter2.pdf (accessed February 10, 2009).

Raymond Basin Management Board. "Chronology of the Raymond Basin." 2008. http://www.raymondbasin.org/about-us/RBMB-Complete-Timeline.pdf (accessed June 7, 2009).

Raymond Basin Management Board. "Raymond Basin History at a Glance." 2007. http://www.raymondbasin.org/about-us/timeline.html (accessed September 11, 2009).

Sadler, Martha. "Steamed Over Goleta Water Law." *The Santa Barbara Independent*, November 8, 2007, http://www.independent.com/news/2007/ nov/08/steamed-over-goleta-water-law/ (accessed September 11, 2009).

Salvi, Kristen. "Mutual-Prescription Doctrine." Watershed Dynamics Hydrogeological Glossary. http://www.brown.edu/Courses/GE0158/ web2_revised/webglossary/mdef/ mutualprescriptiondoctrine.html (accessed March 1, 2010).

Saxton, Steve. "The Seaside Basin Case: Adjudication Grows Up." California Water Law and Policy Reporter. April 2006. http://www.argentco.com/htm/ f20060406.735418.htm (accessed September 11, 2009).

Appendix 3: Why Water Markets

As discussed in the Appendix 2, adjudication is currently the only way to limit total groundwater extraction in a basin and allocate pumping rights among individual users. Once these rights are defined, the conditions in the basin are correct for a groundwater rights market, which may be necessary to reallocate rights among users as their demands change over time. Markets can be an efficient means for reallocation that provides realistic management solutions as well as other benefits.

What is a Water Market?

One definition of a market is: "a set of institutions, expectations, and patterns of behavior that enables voluntary exchange."[40] The simplest function of markets is to allocate scarce resources among competing users and uses.[41] Groundwater in many California basins has become a scarce resource with competing uses and users. In the California Water Code, the state legislature has declared that "voluntary transfers between water users can result in a more efficient use of water, benefiting both the buyer and the seller…" and that "transfers of surplus water on an intermittent basis can help alleviate water shortages, save capital outlay development costs, and conserve water and energy.[42] As evidence of these benefits, voluntary transfers of groundwater have been occurring in some basins for many years (See Appendix 4). In various adjudicated basins, the frequency and number of these transactions have grown into what can be considered informal markets with proper market oversight provided by the terms of the adjudication. At a sufficient scale, these informal markets create general benefits that can be grouped in three categories: economic, social, and environmental.

Economic Gains

California water expert Brent Haddad holds that water markets are the "reallocation policy of choice," explaining that those who could derive the most value from water would pay the most for it, and they would buy it if available.[43] When water is reallocated in such a way, it ensures that each unit of water is producing the highest economic return. Sellers would benefit from a market

[40] Haddad 2000
[41] Mankiw 2004
[42] California State Legislature 2010
[43] Haddad 2000

because they would be compensated with a payment worth more than they could generate with each unit of water, while buyers would benefit because they could derive more value from a unit of water than what was paid for it. The value of this opportunity has been measured in Australia by Brooks and Harris, who found economic gains in producer and consumer surplus through water markets.[44] A common example of this occurs when a farmer sells water rights to a water purveyor, who then sells this water to a number of urban users at a much higher rate. The farmer is happy to receive more money from the sale of the water than could be generated through farming, and the water purveyor can provide water to meet its customers' needs.

Social Benefits

Water is a critical input for nearly every industrial and commercial sector of the economy and essential for residential areas. When a region's water supply is fixed through natural or legal impositions there should be a way for shifting use over time depending on the needs of the water users. Some sectors may wish to expand and will need additional water, while others will contract and use less water. Water markets provide this flexibility in supply over time because individuals or sectors can purchase more water when it is needed, sell it when they no longer need it, or find economic advantages for doing so.

Water markets can facilitate in the management of water resources. For instance, many water supply managers are practicing conjunctive management of water resources to take advantage of the benefits of groundwater storage. Aquifer storage and recovery (ASR) and banking agreements are potentially vulnerable to exploitation if water agencies are not sure that they will get their water back at a later time. In non-adjudicated basins any overlying land owner could pump groundwater that may have been purchased from another water purveyor and stored in the aquifer. That overlying land owner may not have to pay anything for the water because rights are undefined and pumping limits may not be enforceable. In an adjudicated basin, such as the Goleta Groundwater Basin, water injected into the aquifer for later use would be protected by pumping limits and fees imposed by the adjudication.

The price signal created through water markets will allow water allocation to remain efficient without the need for centralized planning. Markets will move

[44] Brooks and Harris 2008

water to those who need it the most and are willing to purchase it for what it is valued at that time and place. This access to additional water provides the opportunity for risk management that is absent from centralized control of water resources.[45] Furthermore, reallocation can occur in a politically neutral manner, avoiding conflicts between sectors. This flexibility, political neutrality, and ability to manage risk becomes increasingly important in the context of inter-annual variation in water supply, and even more so with the uncertainties associated with drought and climate change.

Environmental Benefits

In addition to social/political and economic benefits, the application of our online market to a groundwater basin will provide environmental benefits. An online market would provide a clear price signal for water users within a basin, creating a strong incentive for conservation of water.[46] If a user can use less water and sell it to another for a profit, he will reduce the amount of groundwater he extracts. By providing compensation for those best able to reduce their use, a financial incentive for conservation will be created. This on its own would shift water to its highest value use within a basin, but would not necessarily reduce total basin use.

Many heavy water users, such as municipal water purveyors, have portfolios of water supplies which include some combination of local groundwater, surface water, imported water, or recycled water. If groundwater trading becomes easier and more transparent, water users in adjudicated basins will be able to obtain the rights to pump local groundwater more easily. A real-time price for groundwater will allow for direct comparisons of the costs of various water sources. A local, reliable, and clearly priced supply of water will be extremely attractive to water users and should encourage shifting of portfolios. This could lead to a greater reliance on local, rather than imported sources, which can yield significant environmental and energy benefits.

Water imported from the State Water Project (SWP), Central Valley Project, and Colorado River Project is energy intensive. Figure 3.1 shows the energy intensity of selected water sources in Southern California, where the majority of adjudicated groundwater basins are located. Groundwater use is several times less energy intensive than many other sources, particularly water delivered through the SWP. Even saline or contaminated groundwater which requires reverse osmosis

[45] Provencher and Burt 1994
[46] Adler 2009

(RO) treatment uses less than half of the energy per acre-foot (AF) than any imported source or ocean desalination. Using this less energy-intensive local water will result in reduced associated greenhouse gas emissions and less strain on California's energy grid. The clear market price for groundwater will encourage the recharge of aquifers with recycled water. Water recycling is already underway in some groundwater basins, but a transparent market will provide strong financial incentive for large scale intrabasin water reuse. This too will reduce the demand for imported water.

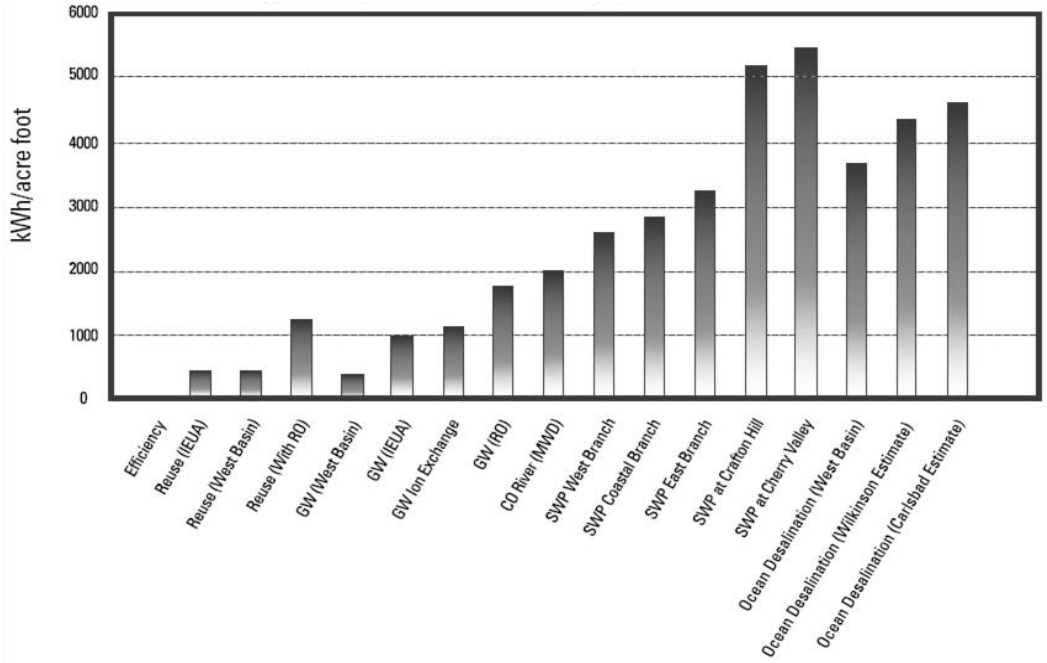


Figure 3. 1. Energy intensity of selected Southern California Water Sources. [47]

A large percentage of water exported to Southern California is pumped from the Sacramento-San Joaquin Delta. This important estuarine ecosystem has been endangered for years, with water exports playing a large role. If the volume of exports is reduced, it will yield significant ecosystem benefits. Water extracted from local groundwater basins within the sustainable yield is much less harmful to ecosystems than removing water from rivers and estuaries and exporting it over long distances.

Markets could provide another means for purchase of groundwater for environmental purposes. If the market becomes entrenched and accepted by the

[47] NRDC 2009

initial users within a basin, it may be expanded to include those without adjudicated rights. Conservation groups could then purchase groundwater, either for pumping and discharge to streams for in-stream flows or wetlands restoration, or for maintenance of water table levels for ecological purposes.

The right conditions need to exist in order for groundwater markets to work properly and maximize the environmental, economic, and socio-political benefits in a basin. The same economic principles apply to groundwater markets as other markets. There should be adequate buyers and sellers to create competition. Transaction costs need to be low. There needs to be enough information so that participants can make wise decisions and manage risk. The proper institutions need to be in place to ensure that externalities and unintended consequences are managed. Property rights need to be clearly defined. Water use must be limited (scarce). The lack of these conditions can be partially to blame for why groundwater markets have not yet thrived in California despite a growing need to reallocate water resources.

Where Will a Groundwater Market Thrive?

Most groundwater basins in California do not have the conditions necessary for a market to thrive. The largest obstacle for groundwater markets is clearly defined rights. Markets for goods with poorly defined rights are not stable and have a high risk of inefficiency or failure.[48] As discussed previously, groundwater rights are only defined in the 22 adjudicated basins. Some of these basins already have markets for groundwater, operating at various levels of efficiency. Many adjudicated basins could not support a competitive groundwater market because rights are consolidated among too few parties, or there is too small a volume of groundwater available to support a vibrant market. Groundwater scarcity is inherent in adjudicated basins by virtue of the fact that overdraft is required for adjudication to proceed.

Based on these factors we can conclude that groundwater markets will are best suited to adjudicated basins that have many rights holders and a large pool of groundwater resources dedicated to multiple sectors.

[48] Mankiw 2004

Barriers to Efficient Groundwater Markets

In those adjudicated basins that have the necessary conditions to support a market there are three barriers that can be prevent the development of stable and efficient markets. This first barrier is comprised by the institutions that provide the rules, oversight, and accounting to ensure that the markets function within the framework and constraints provided by the adjudication. Local and state water agencies provide most of the institutional support to ensure adequate water supply and quality, however they are ill suited for the emerging need to reallocate water resources. For instance, in the Mojave Groundwater Basin the terms of the adjudication dictate how transfers must be conducted and what restrictions apply to particular areas, but do nothing to promote transactions.[49] Rights holders conduct transactions individually and on an ad hoc basis, and file the requisite paper work with the Mojave Water Agency.[50] The negotiated price of these transactions has historically been extremely unpredictable. This is a direct result of the second barrier to efficient groundwater markets—lack of information.

Other than the Watermaster reports published annually there are seldom good sources of market information to inform buyers and sellers while they negotiate a transaction price. While parties can and do reach acceptable agreements, this system does not yield an aggregate price for water in the basin. The result is that rights holders do not know how much their water is worth and can waste time trying to broker a favorable transaction, or worse, not bother because of effort needed to make a transaction and uncertainty in the outcome.

Adding to the informational barrier is a location barrier. Most successful markets have a 'marketplace' where transactions are normally conducted. Water markets are no different. Without an actual location, physical or virtual, it is difficult for buyers and sellers to both locate each other and engage in negotiations. This lack of a central marketplace currently inhibits trading in many California groundwater basins.

These barriers to potentially viable markets result in high transaction costs and inefficient market performance. Groundwater allocation is not optimized or efficient, and the environmental, socio-political, and economic gains that could be achieved are never fully realized. Once a basin can overcome these barriers and

[49] Mojave Water Agency 2008
[50] Weigenstein 2009

establish a viable groundwater market there are still a number of potential externalities that can result without proper regulation and enforcement.

Potential Drawbacks to the Use of Markets

While it is generally recognized that voluntary transfers of groundwater can bring about multiple benefits, there are several reasons when such transfers can be harmful. These drawbacks are primarily associated with the potential for the geographic concentration of groundwater extraction. It is possible that, through voluntary market transactions, a significant portion of a groundwater basin's groundwater extraction could be locally concentrated in an economically powerful area, causing adverse effects.

Because a market will reallocate water from low value uses to higher valued uses, groundwater is most likely to be transferred from the agricultural sector (low value) to urban uses (high value) in many areas. This is a contentious trend in current California water transfers; however, in adjudicated basins farmers who are willing to sell are compensated by an amount that is presumably more than they could derive through crop production. Likewise, buyers would derive more value from the water than what they would pay for it. This is an element that must be addressed by local planning agencies and residents. Regional values and social interests must be taken into account by groundwater market managers.

Concentrated pumping can lead to land subsidence in certain types of aquifers, such as those comprised of fine-grained sediments.[51] Subsidence is a major problem throughout the United States, affecting approximately 17,000 square miles over forty five states, as shown in Figure 3.2. Within California, land subsidence due to intensive groundwater extraction is especially noticeable in the Central Valley and Inland Empire regions.

[51] USGS 1999

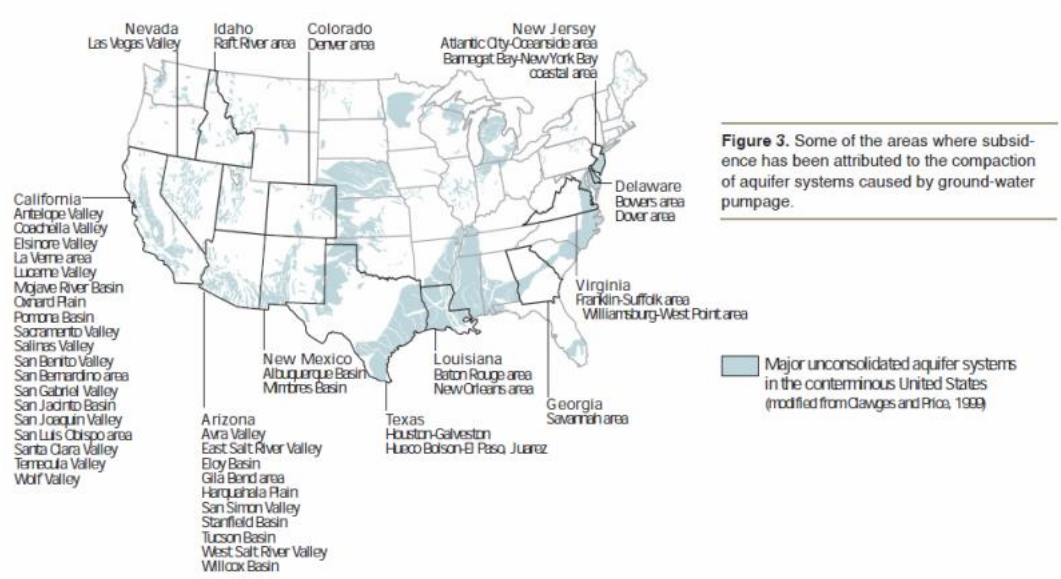


Figure 3. Some of the areas where subsidence has been attributed to the compaction of aquifer systems caused by ground-water pumpage.

Figure 3.2 Land Subsidence in the United States. [52]

When portions of aquifers are overdrafted, unconsolidated silts and clays in aquitards can consolidate and compact, resulting in subsidence of the Earth's surface. Subsidence can cause severe damage to buildings and infrastructure imposing costs on those not responsible for the overdraft.[53] If a market system allows a single area to dominate extraction within a basin, the risks of subsidence increase.

Another potential issue with concentrated extraction is localized drawdown and the reduction of in-stream flows. If an aquifer which is hydraulically connected to streams is pumped excessively, local cones of depression can streams reduce the amount of water available to feed streams. Reduced stream flow put pressure on fish, amphibians, riparian vegetation, and the animal which rely on riparian vegetation for habitat. Downstream surface water users will also see reduced flows as an infringement of their riparian rights, which can lead to lawsuits. Localized drawdown of an aquifer can also lead to increased pumping costs for water users.

One final potential drawback to concentrated pumping is seawater intrusion, which occurs when near-shore portions of coastal aquifers are over pumped. This

[52] USGS 2000
[53] USGS 1999

lowers the hydraulic head in coastal aquifers and triggers inland migration of saline water, resulting in contamination of freshwater supplies.[54]

Any groundwater market design must have a system of checks in place to ensure that trades do not increase existing or potential future risks due to concentration of pumping. In adjudicated basins, this role can be served by the Watermaster which generally has the authority to accept, reject, or place conditions on transactions. The structure of the online water market will need to be tailored to accommodate basin-specific conditions regarding subsidence, seawater intrusion, in-stream flow, and adjudication rules.

References

Adler, J.H. "Warming Up To Water Markets." *Regulation* Winter 2008-200944 (2008):14-17.

Brooks, Roberta and Harris, Edwyna. "Efficiency gains from water markets: Empirical analysis of Watermove in Australia." *Agricultural Water Management* 95 (2008): 391-399.

California State Legislature. *California Water Code*, Section 475. http://www.leginfo.ca.gov/cgi-bin/calawquery?codesection= wat&codebody=&hits=20 (accessed December 10, 2009).

Haddad, Brent M. *Rivers of gold: designing markets to allocate water in California*. Covelo, California: Island Press, 2000.

Mankiw.N.G. *Principles of Microeconomics*, 2nd Ed. Mason: Thomson Southwestern, 2004.

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.2008.

Provencher, Bill, and Burt, Oscar. 1994. "A Private Property Rights Regime for the Commons: The Case for Groundwater. *American Journal of Agricultural Economics* 76 (1994): 875-888.

United States Geological Survey (USGS). "Land Subsidence in the United States." USGS Circular 1182. 1999.

United States Geological Survey (USGS). "Land Subsidence in the United States." USGS Fact Sheet 165-00. 2000.

[54] Zeckster and Loáiciga 2005

Weigenstein, Valerie. Personal Communication. October 29, 2009.

Mankiw.N.G. *Principles of Microeconomics,* 2nd Ed. Mason: Thomson Southwestern, 2004.

National Resources Defense Council (NRDC). *A Clear Blue Future*. NRDC Issue Paper. 2009. August.

Zekster, S., H.A. Loáiciga and J.T. Wolf. "Environmental Impacts of Groundwater Overdraft: Selected Case Studies in the Southwestern United States." *Environmental Geology* 47 (2005): 396-404.

Appendix 4: Basin Case Studies

4.1 Mojave River Groundwater Basin

Introduction

The Mojave Groundwater Basin is located San Bernardino County, bordering both Los Angeles and Kern Counties, extending to the north just beyond Cuddleback Lake and to the south just beyond Lake Arrowhead. The eastern border is flanked by the Cady and Bullion mountain ranges. The Mojave River winds from the northeast to the middle of the basin and then turns south, ultimately draining into the Mojave River Forks Reservoir, created by Forrette Dam. The total area of the groundwater basin is approximately 1,400 square miles.[55] The basin was divided into five hydrologically connected subareas during adjudication. Principal cities include Barstow, Victorville, Adelanto, Apple Valley, and Hesperia (Figure 4.1.1). Naturally occurring groundwater and imported water from the State Water Project (SWP) are the only sources of water in the basin.

Current Basin Statistics

Number of users	368,000 (population)
Adjudication parties	475 (current)
Year of adjudication	2000 (Final rulings)
Duration of litigation	16 years
Watermaster	Mojave Water Agency
Court-allocated yield (Adjudicated Rights)	179,989 AF
Sustainable yield	134,000 acre-feet
Size	1,400 square miles

[55] United States Geological Survey 2001

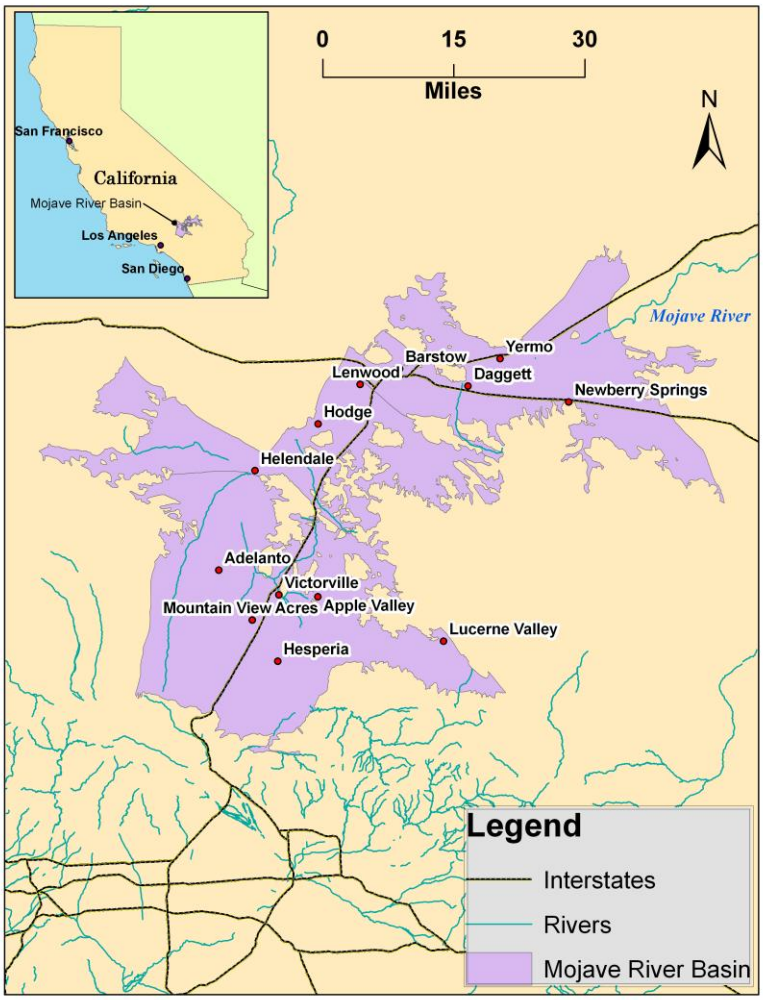


Figure 4.1.1. Location of the Mojave Groundwater Basin. [56]

Basin Demographics

The 2004 Mojave Water Agency (MWA) Regional Water Management Plan projects population to increase by nearly 60 percent from 2010 to 2030, with basin-wide population increasing from about 368,000 to 588,000. The Alto subarea has the most people, with a 2010 projected population of about 300,000 residents.[57]

[56] California Department of Water Resources 2010, US Department of Interior 2009
[57] Mojave Water Agency 2004

Basin Water Supply and Use

Annual water supply (i.e. sustainable yield) in the basin is limited to the natural recharge of groundwater (+/- annual water production surplus or deficit) and SWP imports. While the MWA has a SWP contract to receive up to 75,800 AF annually, it has only received an average of 18,000 AF for the water-years 2002/2003 – 2007/2008. The MWA recognizes that Delta export restrictions could increase management challenges, as lower and more unreliable imports will further stress local groundwater supplies. In November 2009 the California Legislature passed SBX7 1, a bill that lays the foundation for a massive ecological restoration of the Delta.[58] This effort, in addition to legal restrictions on water exports for the endangered Delta smelt, has likely already caused a downward shift the delivery probability exceedance curve in Figure 4.1.2 (below), and will probably cause it to lower more in the future. Periods of prolonged drought will likely result in cutbacks on SWP deliveries as well. As population rises there is opportunity to create a dependable supply of reclaimed wastewater. The basin has already been using this source, but it so far it only accounts for about 3 percent of total basin consumptive use. The MWA estimates the sustainable yield for naturally recharged groundwater at 63,400 AF/year. This number will fluctuate year to year, however long-term average recharge should be close to this estimate. The MWA estimates that total storage capacity in the basin is roughly 5 million AF.[59]

[58] California State Legislature 2009
[59] Mojave Water Agency 2004(b)

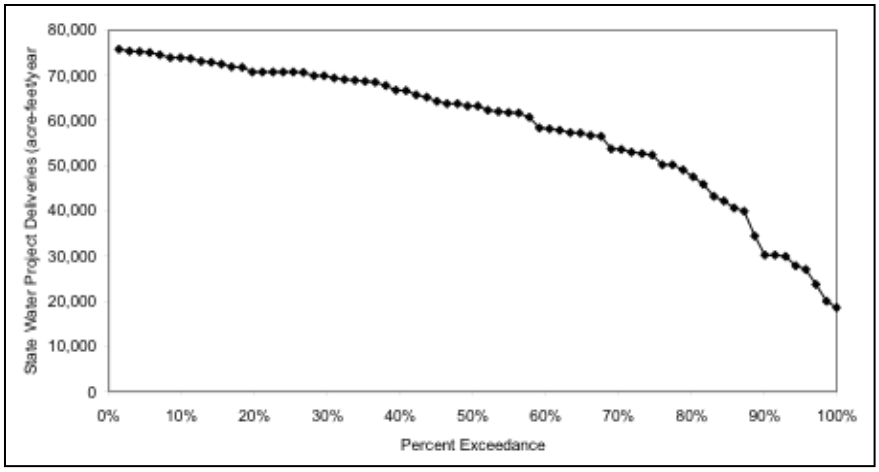


Figure 4.1.2. Percent exceedance of SWP Deliveries in 2020.[60]

To meet the demands of growing urban populations, water consumption has been shifting away from agricultural uses. Between 1995 and 2000 agricultural water consumption has declined by about 20,000 AF, or 36%. Only 12,800 AF of this water was actually converted to urban uses, meaning that total water use in the basin decreased.[61] Table 4.1.1 summarizes recent water supply and total consumptive use in the basin.

Table 4.1.1. Consumptive water use in the Mojave Basin.[62]

Water year	Delivered Reclaimed Wastewater	State Water Imports	Verified FPA (Groundwater)	Total Water Use
02-03	5,214	7,180	149,891	162,285
03-04	4,704	28,657	156,462	189,823
04-05	7,105	7,800	145,593	160,498
05-06	5,171	39,172	159,206	203,549
06-07	4,750	14,325	169,459	188,534
07-08	4,776	11,060	156,724	172,560
6-year Ave	**5,287**	**18,032**	**156,223**	**179,542**
Percentage	**3%**	**10%**	**87%**	**100%**

Despite the pumping limits imposed by the adjudication, reduced SWP imports have recently been resulting in consumptive use that exceeds local and imported

[60] Mojave Water Agency 2004(b)
[61] Mojave Water Agency 2004(b)
[62] Mojave Water Agency 2004-2009

supply.[63] In the short-term the deficit can only be overcome through additional SWP imports. Alto and Baja are most reliant on this imported water. As the future of SWP imports is looking more uncertain it is likely that the long-term water production in the basin will have to be further limited if new supplies and conservation cannot fill the deficit and meet growing urban demand. The trend of shifting water use from agriculture to urban uses is likely to continue given population growth estimates, and could even be accelerated by lower SWP imports.

As mandated by the adjudication, the MWA calculates a water balance for the basin to determine if flows are being met.[64] The data, provided in Chapter 5 of each annual Watermaster report, summarizes the annual status of hydrologic flows and balances. Safe yield production is determined analyzing the changes in water supply inputs to the basin and consumptive use and outflows out of the basin. The average safe yield for the past six years has been about 134,000 AF while average production has been around 164,000 AF for the same time period. As seen in Figure 4.1.3 below, annual production has recently exceeded safe yield by an average of about 30,000 AF per year despite the physical solution set forth by the adjudication.[65]

[63] Mojave Water Agency 2004(b)
[64] Mojave Water Agency 2008
[65] Mojave Water Agency 2004-2009

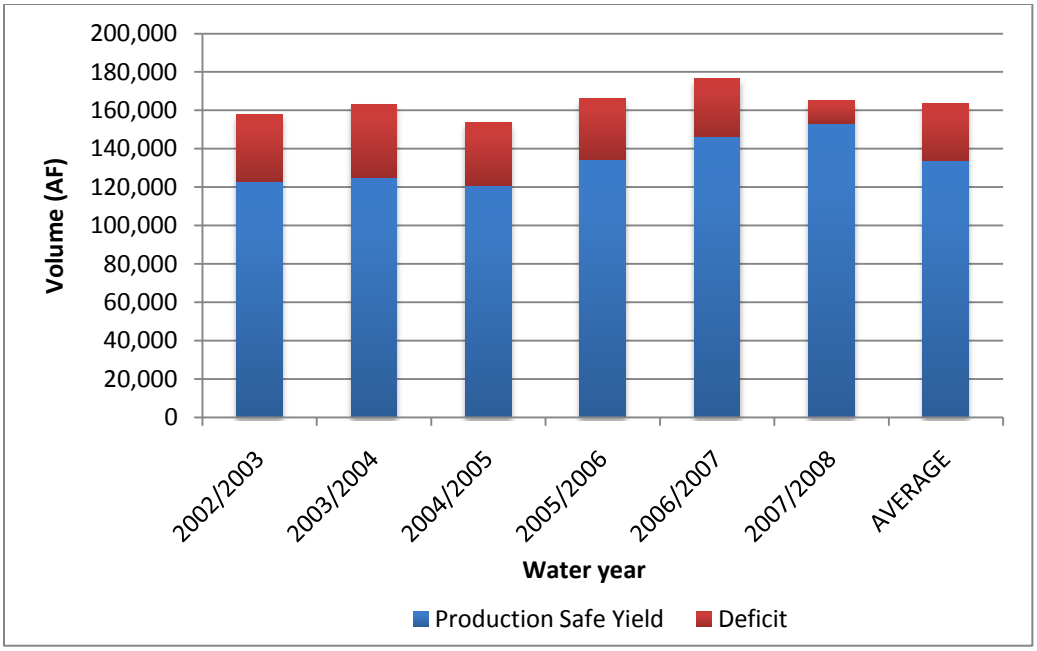


Figure 4.1.3. Total water production is the equivalent to the height of each bar, with the red portion showing the volume produced that exceeds the estimated safe yield for that year.

Figure 4.1.4 shows the consumptive use of the urban and agricultural sectors of the Mojave. These two sectors account for the majority of water use in the basin.

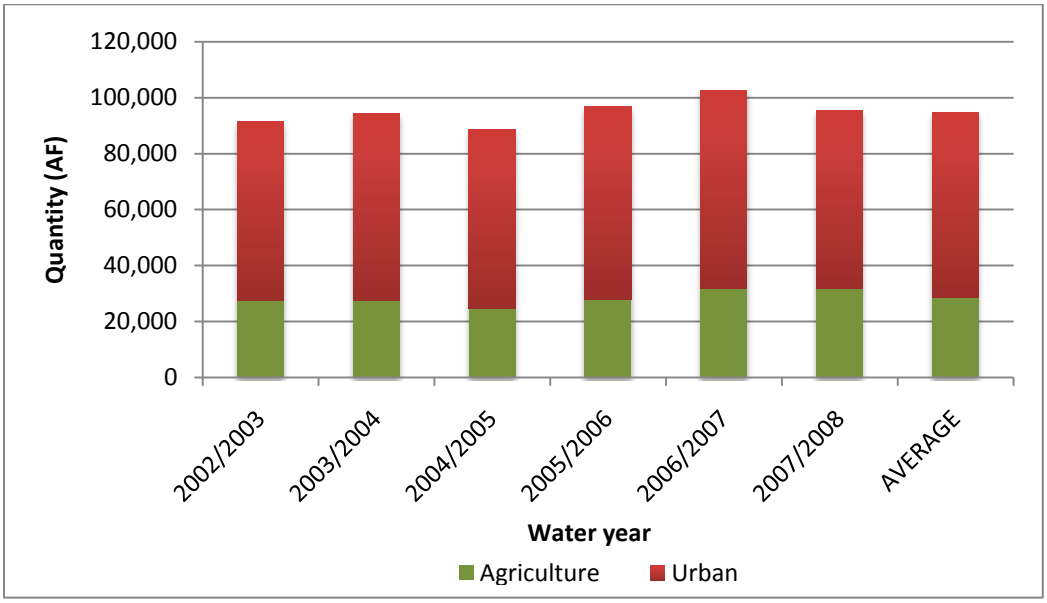


Figure 4.1.4. Recent agricultural and urban consumptive water use in the Mojave Groundwater Basin.

History

The primary source of surface water and groundwater recharge in this region is the Mojave River, which is often dry except for one reach that receives perennial runoff and after large storms. In the late1940's groundwater pumping increased dramatically to meet growing agricultural and urban water needs. The basin lost thousands of acre-feet of storage and groundwater tables declined. As explained by the USGS, the hydrologic connectivity between subareas is such that pumping in one will affect flow and supply in another. A groundwater flow model developed for the Mojave Groundwater Basin was developed by the USGS, which found that overdraft began in the early 1950's in the Centro and Baja subareas.[66] As shown in Figure 4.1.5 below, by 1960 overdraft was occurring in all subareas and as of 1999 the cumulative impact of this practice over the entire basin was a 2.5 million acre-foot reduction in stored groundwater.[67] Total estimated pumping peaked around 1990 at over 200,000 AF. The consequences of this prolonged overdraft have been loss of riparian habitat along the Mojave, declining water levels and increased pumping costs, and changes in volume and spatial distribution of recharge.[68]

The MWA has contracted water imports from the SWP since 1991, and has used this water to recharge the groundwater aquifers.[69]

[66] United States Geological Survey 2001
[67] United States Geological Survey 2001
[68] United States Geological Survey 2001
[69] Mojave Water Agency 2008

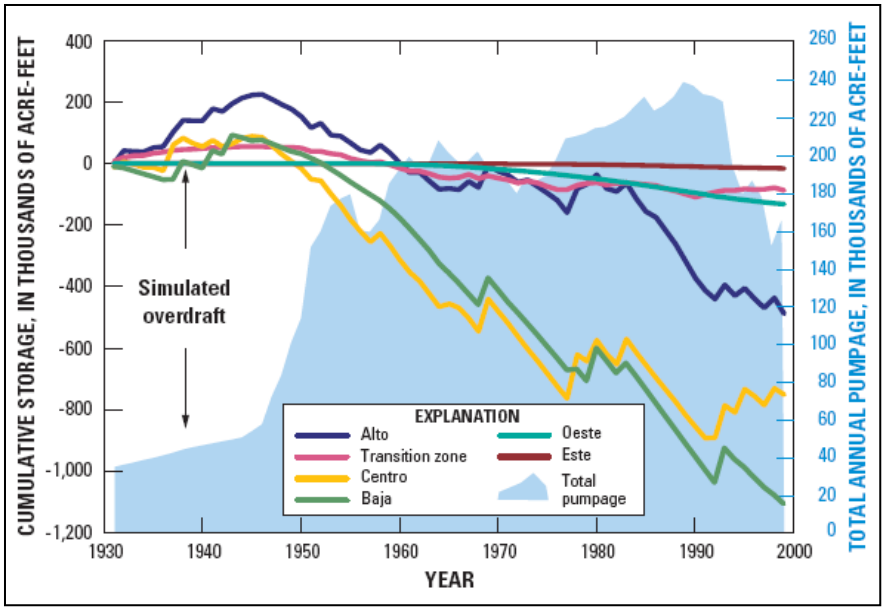


Figure 4.1.3. Cumulative simulated aquifer storage by subarea and total pumpage for all subareas, 1931-99.[70]

Mojave River Basin Adjudication

The Mojave River Basin was adjudicated in the San Bernardino County Superior Court in the case *City of Barstow, et al. vs. City of Adelanto, et al*. The case began on May 30, 1990 and the final judgment was issued on January 10, 1996, adopting the physical solution. Additional litigation and appeals followed that settled the claims of non-stipulating parties after Supreme Court review in 2000. "Minimal producers" were classified as producers who use less than 10 acre-feet of water per year and were excused from the case. More than 75 percent of the parties involved agreed to the terms of the stipulation, which represented more than 80 percent of the verified water production in the basin. About 475 producers are currently part of the judgment. They are required to report water production and pay administrative and biological assessments quarterly.[71]

The Judgment

The adjudicated area of the Mojave basin was divided into five hydrologically connected subareas. Upstream subareas have an obligation to uphold the average naturally occurring annual flows (excluding stormwater) to downstream subareas. The baseline for these estimates was a 60-year period between from 1930 and

[70] United States Geological Survey 2001
[71] Mojave Water Agency 2008

1990. For each subarea a Base Annual Production (BAP) level was calculated by averaging the maximum annual production for each water rights holder (producer) from 1986-1990. Each stipulating party was then given a percentage share of the BAP for their subarea based on their pumping during the same base period. In order to restore natural groundwater flows to each subarea pumping rights were reduced to only a portion of the subarea BAP. This volume is called the Free Production Allowance (FPA). Similarly, producers are allocated an equal priority FPA representing their share of the BAP. Starting in the1993/1994 water-year the FPA for each basin was ratcheted down, as specified by the Watermaster, to meet the flow requirements of the judgment. The MWA was and remains the court appointed Watermaster.[72]

The Physical Solution

In order to restore the natural flows between subareas the courts solution was to lower the FPA for all subareas and producers by 5 percent of BAP each year for the four water-years after the initial 93-94 water-year. Allocation, or FPA, in 93-94 was set at 100 percent of BAP, and the subsequent four years were to be allocated 5 percent less each year as shown below in Table 4.1.2.

Table 4.1.2. Mojave Water Agency FPA allocation reduction schedule

Subarea	1993/1994	1994/1995	1995/1996	1996/1997	1997/1998
%BAP	**100%**	**95%**	**90%**	**85%**	**80%**
Este	19,251	18,288	17,326	16,363	15,401
Oeste	6,857	6,514	6,171	5,828	5,486
Alto	114,308	108,593	102,877	97,162	91,446
Centro	54,716	51,980	49,244	46,509	43,773
Baja	63,929	60,733	57,536	54,340	51,143
Total	**259,061**	**246,108**	**233,155**	**220,202**	**207,249**

After 1998 the Watermaster could recommend to the Court decreases or increases to FPA in order to balance water flows in the Basin. Producers are allowed to use as much water as they need so long as the requirements of the Physical Solution are met. It was assumed that natural supply, water imports, conservation, water reuse, and transfers among parties will meet the water needs of all subareas. Producers who pump more than their share of the FPA may purchase another producer's FPA to make up the difference, or they will have to pay the MWA a Makeup Water Assessment. The Makeup Water assessment can be changed from

[72] Mojave Water Agency 2008

year to year depending on the cost of replacement water (imports). The MWA monitors water flows between subareas and accounts for surpluses and deficiencies, which will be credited or debited to the subarea. If a subarea does not meet its obligation down gradient, then the MWA is required to purchase and deliver Replacement Water to cover the deficit.[73]

Transfers

Alternatively, producers who do not use their full FPA may apply the difference to next year's FPA allocation as "carryover water" or sell that portion of FPA to another producer. Carryover must be used within the year. Both FPA and Carryover water can be transferred in a lease or permanent sale. The Judgment sets rules so that subareas do not increase water use through transfers. As Watermaster the MWA reviews and processes all transfers that are submitted[74].

Producers are required to report water production quarterly and pay various fees based on the number of acre-feet produced. The Administrative Assessment pays for the MWA to monitor flows, verify annual production, process transfers, collect assessments, and prepare their annual report for the Court. This fee can be changed as necessary and currently is set at $3.25 per AF. A Biological Resources assessment is collected to fund species protection and habitat restoration projects. The fund is capped at $1,000,000 the assessment began at $0.50 per AF production and is now at $0.70 per AF.[75]

Existing Water Markets

As previously mentioned, the Judgment allows for producers to transfer BAP in permanent sales or FPA and Carryover FPA in temporary leases. The market in the Mojave has had fairly consistent activity since the 1993/1994 water year. Figure 4.1.6 shows the most recent market activity. The number of temporary leases transfers for the past six years has been fairly stable, ranging from 202 to 217 in all water years except 2005/2006 when 134 transfers occurred. Permanent transfers of BAP have remained fairly steady over the same period, ranging from a low of 31 in 2007/2008 to a high of 43 in 2004/2005.[76]

[73] Mojave Water Agency 2008
[74] Mojave Water Agency 2008
[75] Mojave Water Agency 2002-2008
[76] Mojave Water Agency 2002-2008

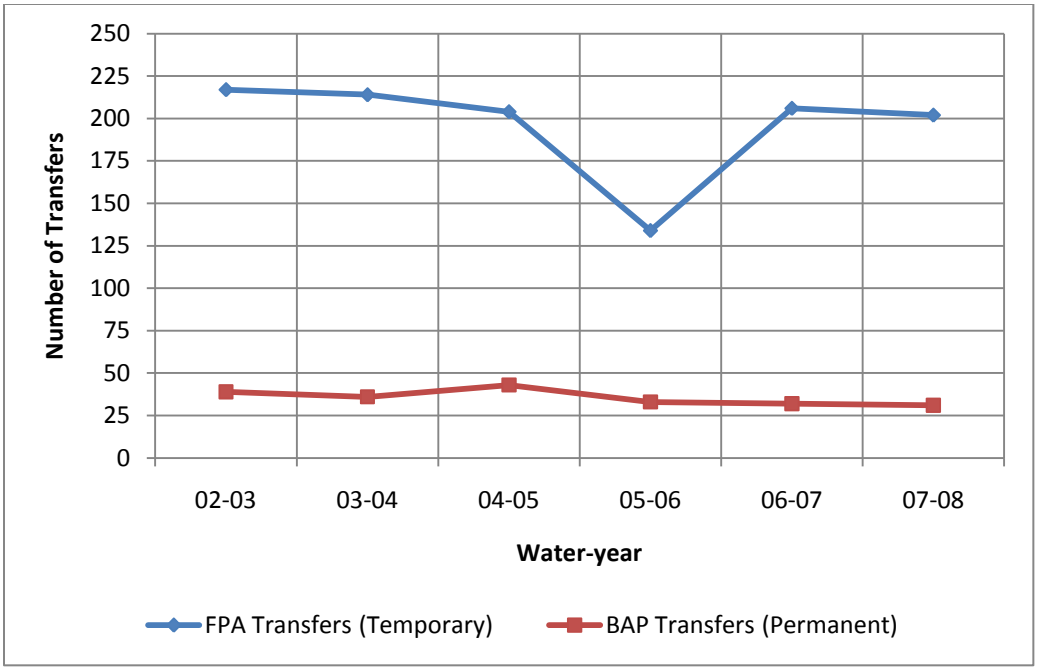


Figure 4.1.4. Permanent and temporary water transfers are shown for the previous six water years.

Table 4.1.3 summarizes how many producers may participate in the market by subarea and how much of the BAP they controlled for the 2008/2009 water year. Market activity by subarea reflects this composition of water producers. As seen in Figure 4.1.7 below, Alto, Baja, and the Centro/Alto transition zone have historically transferred the most acre-feet of water. Since 1997/1998 FPA has been reduced below 80% for Alto, Centro, and Baja subareas. Current FPA is now at 69% of the original BAP.

Table 4.1.3. Breakdown of water rights in the Mojave Basin by subarea in 2008/2009.

Subarea	BAP	Subarea % of Total Allocation	Base FPA	Percent of BAP	# Producers
ESTE	19,251	7%	15,422	80%	61
OESTE	6,857	3%	5,489	80%	13
ALTO	114,308	44%	71,598	63%	132
CENTRO	54,716	21%	39,520	72%	81
BAJA	63,929	25%	47,960	75%	188
GRAND TOTAL	**259,061**	**100%**	**179,989**	**69%**	**475**

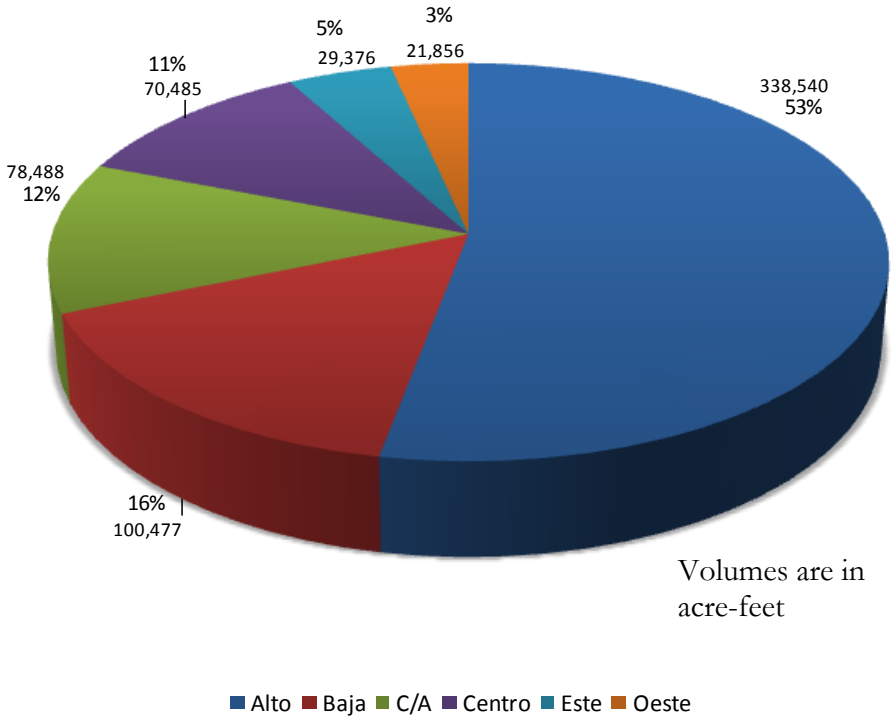


Figure 4.1.7. Cumulative lease transaction volume in the Mojave Basin by Subarea, 1994-2008.

Market Analysis

The following section offers an analysis of the existing groundwater market in the Mojave River Basin based on transaction information published by the MWA. The original data for this analysis was modified to correct for transactions that were representative of the actual water market. All transactions that occurred for

$1 or less per AF (non-monetary) were removed from the sales data because these transfers are not reflective of the use value of water, and in many cases took place within or between related or the same right holding party or organization. The end of this section elaborates on the extent of the non-monetary transactions taking place in the Basin.

Lease Transfers

While the number of temporary transfers of FPA has remained fairly steady over the past six years the total value of the transfers has been increasing, which is illustrated by Figure 4.1.8, and in Figure 4.1.9 by the trend of increasing sales price per acre-foot transferred. The peak volume of temporary transfers occurred in 2001 with over 45,000 AF of sales. However, the peak annual sales value occurred in the most recent year of this record, 2008/2009, approaching sales of almost $6 million. The points seen in Figure 4.1.8 show every temporary lease transaction between the 1994/1995 and 2008/2009 water years, illustrating the extreme market variability. While average price was near $160 per AF in 2008, transactions occurred below $25 and almost as high as $320 per AF.

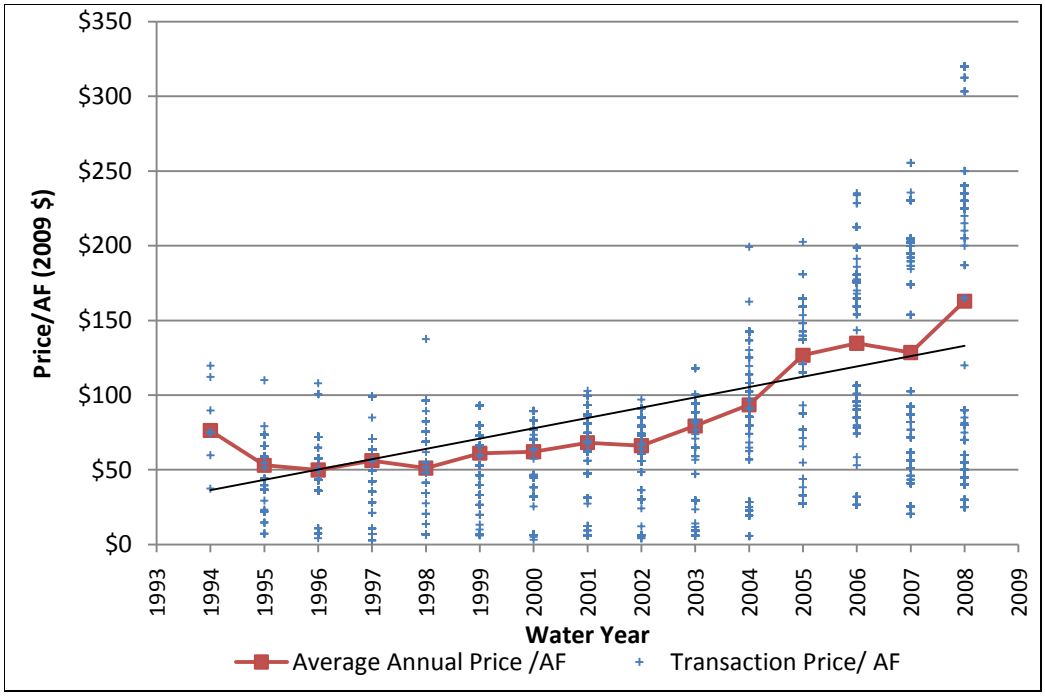


Figure 4.1.8. Transaction prices for individual lease sales from 1994/1995 to 2008/2009 are represented by the points. The red line tracks the average annual sales price for each water year, while the black line shows the overall trend.

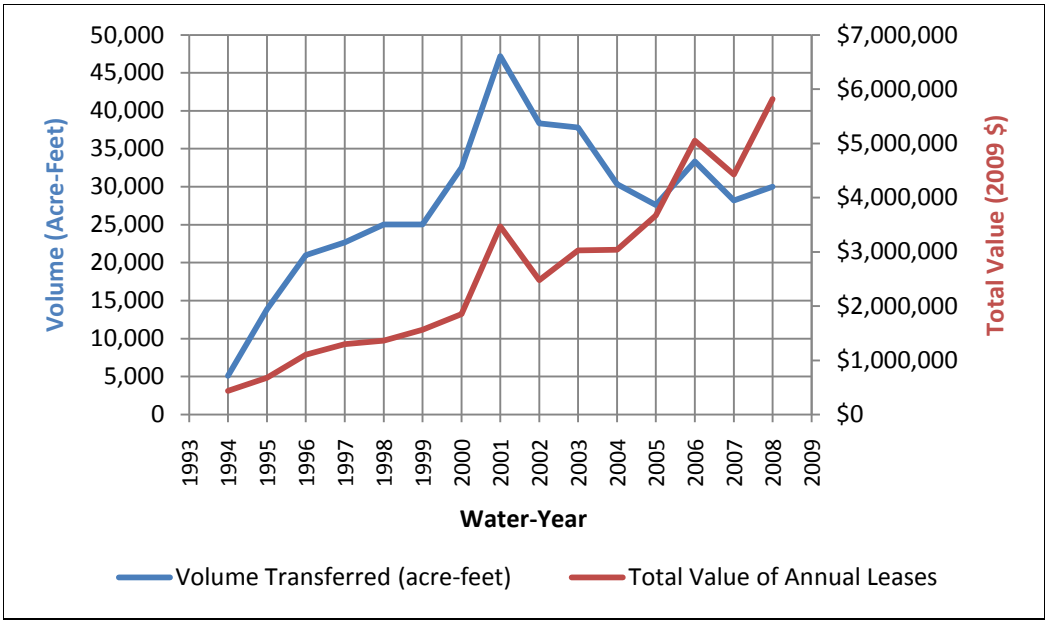


Figure 4.1.9. The total annual sales value and volume for annual leases is shown for water years 1994/1995 – 2008/2009.

Permanent Transfers

Permanent water sales are more erratic than temporary lease sales, however there are some visible trends within this side of the market. Many transfers have simply been the movement of water rights to a new person or entity, often with no money exchanged (explained later in this section). The highest price per unit transaction was $3,900/AF for 100 AF. The largest volume transferred was more than 18,000 AF (2006), but no money exchanged hands. Coincidentally, the highest valued transaction also occurred in 2006 for over $17 million, for 9,380 AF.

As seen in Figure 4.1.10, the total volume of permanent transfers has generally been below 5,000 AF annually, with the 2006/2007 water year as the only exception, when more than 10,000AF was transferred. Total value of sales closely followed the trend of volume transferred, with annual sales typically between $2 and $8 million. 2006/2007 sales of BAP exceeded $20 million.

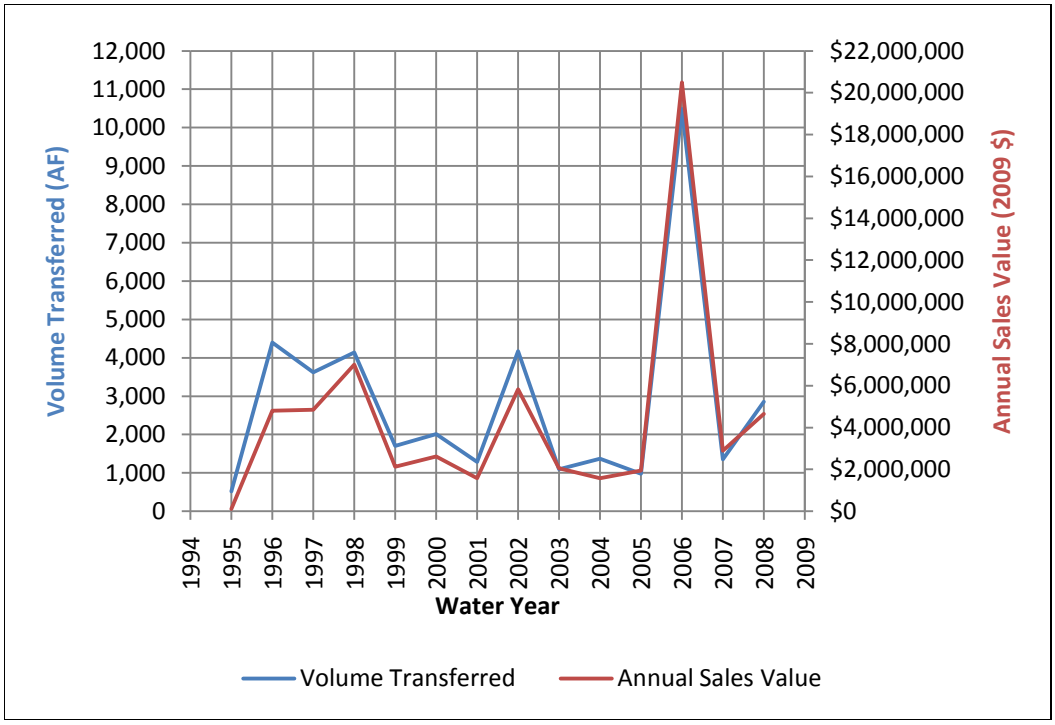


Figure 4.1.5. The total annual sales value and volume for permanent sales is shown for water years 1995/1996 – 2008/2009.

There has been an increasing trend in average per AF transaction price for permanent water sales since 1995 (Figure 4.4.11). The points in this figure show every permanent transaction since 1995, illustrating the extreme market variability in permanent sales. While average price was near $2,000 per AF in 2008, transactions occurred below $500 and almost as high as $4,000 per AF.

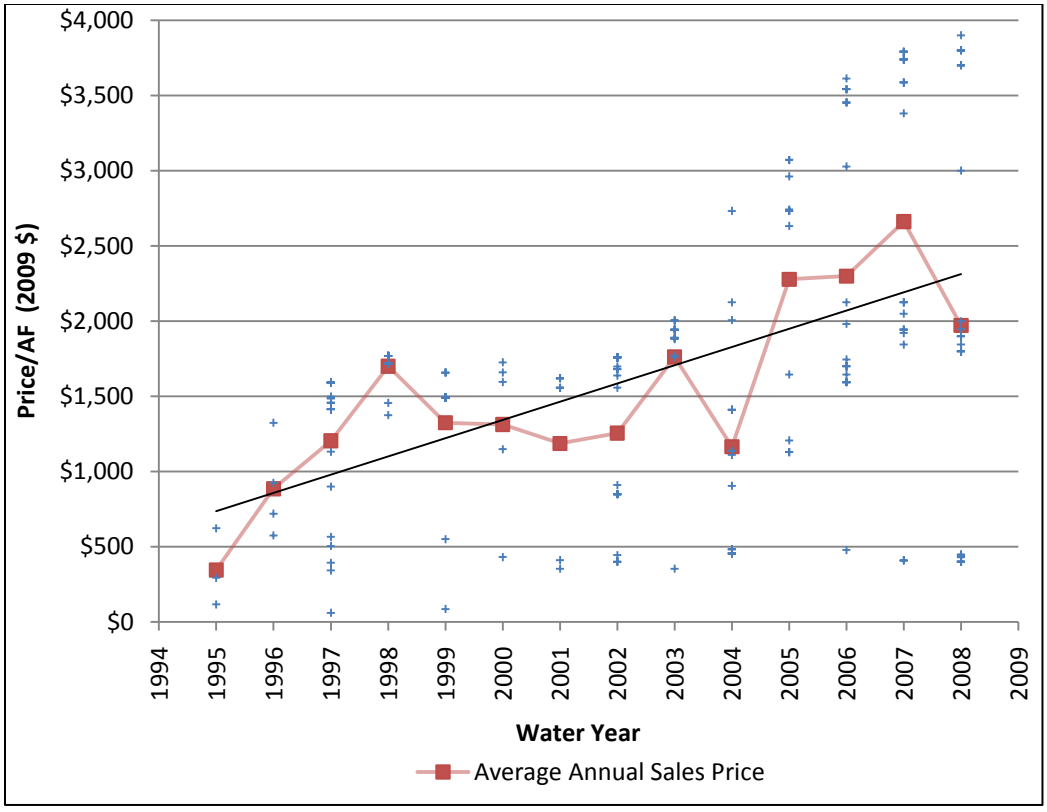


Figure 4.1.6. Transaction prices for individual permanent sales from 1995 to 2009 are represented by the points. The red line tracks the average annual sales price for each water year, while the black line shows the overall trend.

Non-monetary transactions

To date almost 140,000 AF (78 percent) of permanent transfers have been non-monetary, while only 40,000 AF have been monetary transfers. The annual totals of these types of transactions are shown in Figure 4.1.12. Just over 42,000 AF (9 percent) of lease transfers to date can be considered non-monetary in nature.

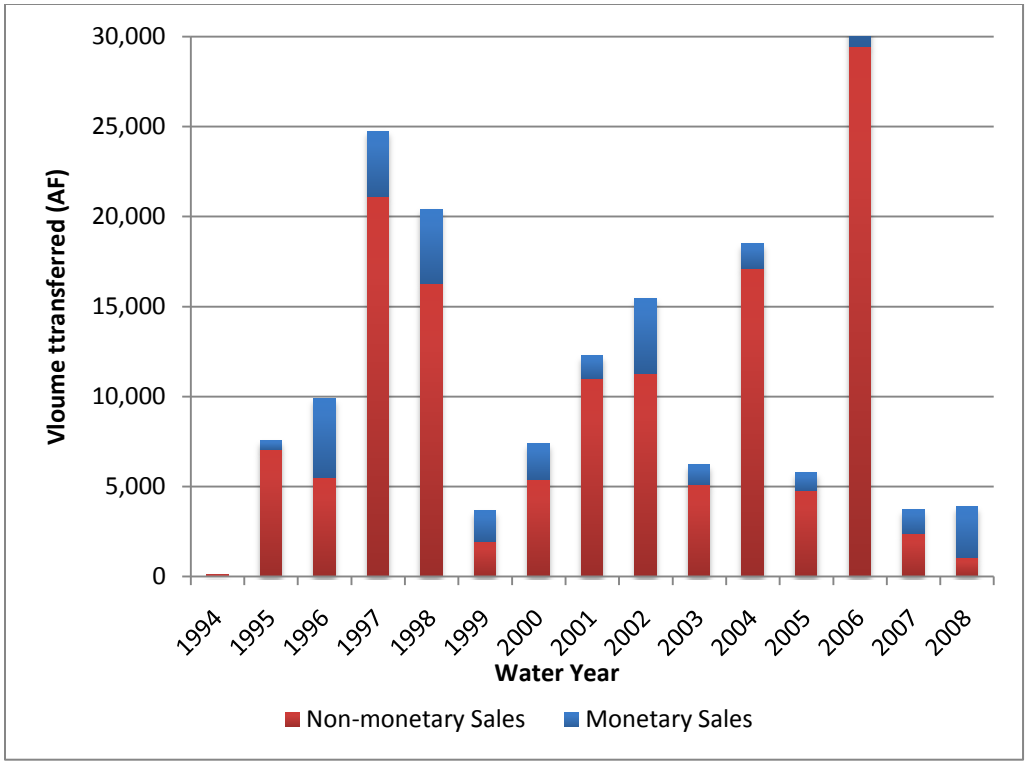


Figure 4.1.7. Non-monetary transactions and monetary transactions are compared for permanent sales in water years 1994/1995 - 2008/2009.

Threats to groundwater supplies

There are a number of sources of contamination that could potentially threaten groundwater supplies. Groundwater contamination would have an unpredictable impact on groundwater markets. If portions of the aquifer become unsuitable for use it could result in increased transfers or delivery from other producers or sources if available. Conversely, if the contaminated aquifer can no longer be used, that water may not be bought and sold in the market. Lastly, contaminated groundwater supplies can be pumped and treated or treated in situ, adding significant cost, which would result in a devaluation of the water in the event of a transfer. The MWA reports that there are sites in all subareas with contaminants that include: arsenic, nitrates, iron, manganese, chromium VI, total dissolved solids, total petroleum hydrocarbons, and volatile organic compounds. Salinity may become increasingly problematic, as the Mojave River Basin is a closed basin. Salts dissolved in imported SWP water and the 5,400 AF of annual wastewater returns therefore accumulate in places, rendering water unsuitable for

some uses and requiring costly treatment.[77] A 1993 USGS study concluded that "current on-site domestic –wastewater disposal practices pose little immediate threat to local groundwater resources" in the Mojave River Basin.[78] Considering the population growth that has occurred since 1993 this declaration is probably in need of reevaluation.

The Future of the Mojave Water Market

Analysis of past water market activity, usage data, and assessment fees charged by MWA demonstrate that in previous years the Mojave water market was operating below Kaldor-Hicks efficiency conditions. For example, in the 2006/2007 water year every subarea except Alto had sufficient unused FPA to satisfy the entire replacement water obligation in that subarea (the replacement water obligation is water produced in excess of FPA after carryover and transfers are accounted for). In the Alto subarea there was 8,586 AF of unused FPA, while producers pumped 27,542 AF beyond their allocated FPA. These producers paid $277/AF for exceeding their allocations, generating $7,629,134 for MWA. Alto producers could have captured part of this revenue had they sold their rights in either a permanent transfer or temporary lease. Table 4.1.4 shows the most recent market inefficiencies.

Table 4.1.4. Estimated market inefficiency is the volume of water over-produced for which producers paid assessments to MWA, shown in the right most column. This is for the entire Mojave Groundwater Basin.

Water Year	Market Inefficiency	Assessments paid to MWA*
2002/2003	229	$50,609
2003/2004	6,685	$1,484,070
2004/2005	8,217	$2,309,069
2005/2006	11,226	$3,987,788
2006/2007	9,219	$7,811,213
2007/2008	22,976	$10,969,013
Median	**8,718**	

[77] Mojave Water Agency 2004(b)
[78] United States Geological Survey 1993

In addition to future increases in market activity for purely economic reasons, a growing population will also necessitate water transfers in the future. Water purveyors will be looking for new sources of water to satisfy a growing demand. Since there are no new sources that can be developed it becomes necessary for this new demand to be satisfied through conservation and reallocation. There are many variables that make predicting future water demand difficult. For our analysis we will make a number of assumptions that will enable us to roughly estimate this future demand, and to some extent, future market activity.

Methodology for Projections

Volume

We assume that the information provided by PWS LLC to rights holders will correct the current market inefficiency over time. The median market inefficiency for the last five years was 8,718 AF/year. On average, about 90% of the transactions that take place in the Mojave Basin are one-year leases, while 10% are permanent. We assume that this median market inefficiency will be corrected by the market at a rate of 10% per year (split 90%/10% between lease sales and permanent transactions) if the H_2O Exchange were to be used in the basin. Permanent sales would correct the inefficiency for good, thus each year we project an additional 87 AF of permanent transactions. This volume is added to the historical sales volume trend extended to the year 2020, shown in Figure 4.1.13. The same method is applied to lease sales, Figure 4.1.14, except each year the percentage accrues. By the tenth year 100% of the median market inefficiency is corrected through implementation of the H_2O Exchange.

Price

Transaction prices in the Mojave show a clear rising trend in both lease sales and permanent sales. To estimate a lower bound for average lease sale price/AF we projected the historical trend of price in real dollars forward to 2020 (Figure 4.1.15). The price of replacement water (provided by the MWA) would act as the price ceiling for the lease sales market, as no producer would ever knowingly pay more than this price for additional water. The replacement water fee is set by the MWA and has been increasing every year. This trend is carried forward as the price ceiling in Figure 4.1.15. Permanent sales price is projected forward linearly in Figure 4.1.16, and is probably a conservative projection considering many permanent transactions have already been occurring above $3,000/AF.

Projections

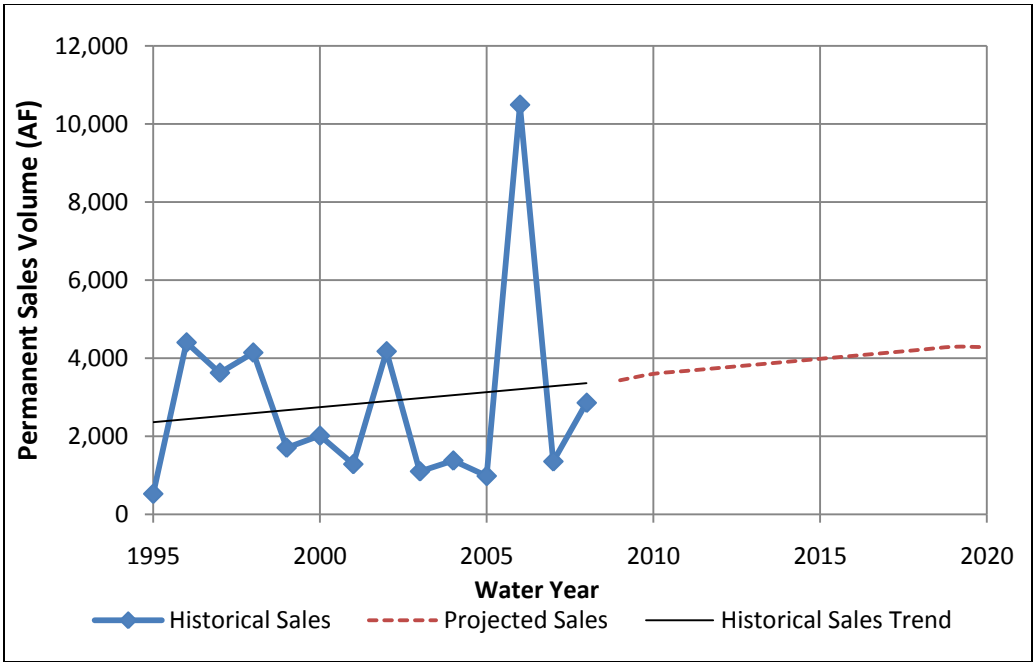


Figure 4.1.13. Historical and projected permanent sales volume in the Mojave Groundwater Basin.

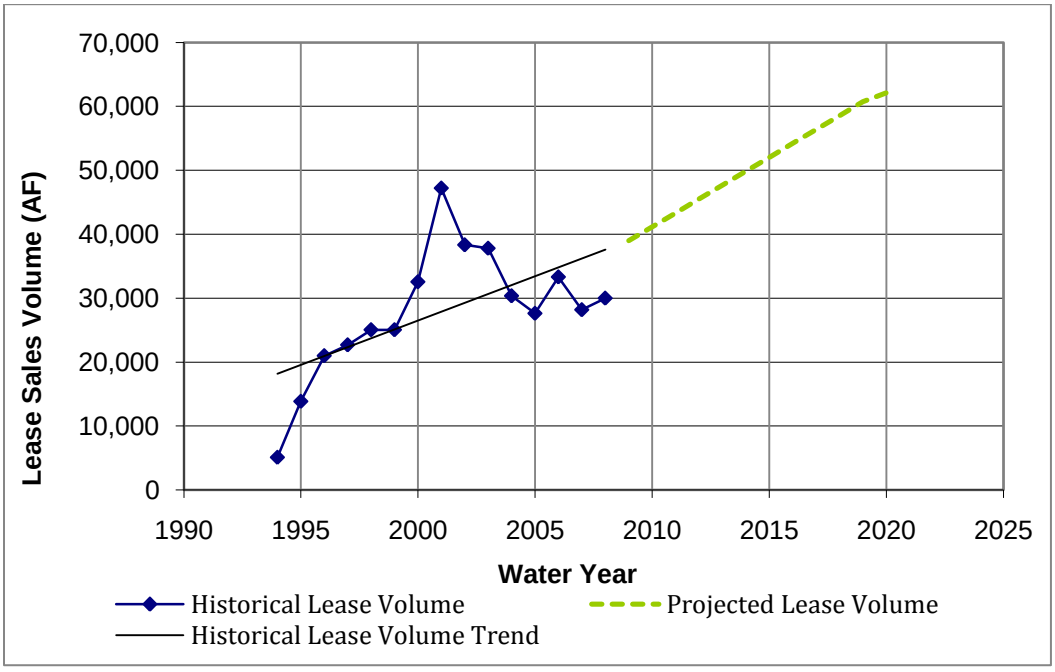


Figure 4.1.14. Historical and projected lease volumes in the Mojave Groundwater Basin.

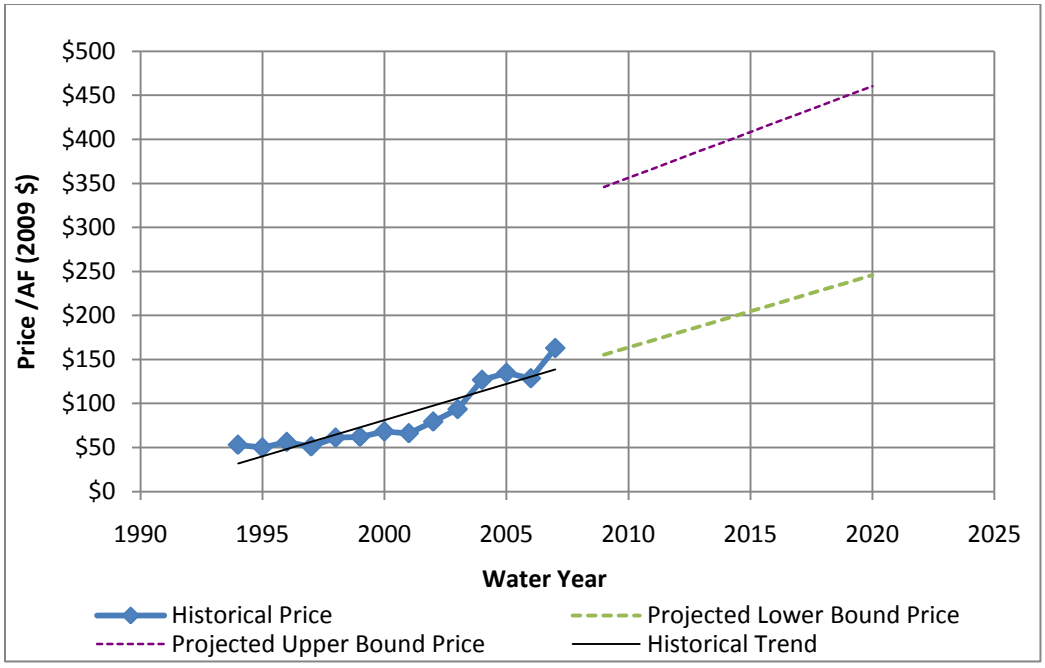


Figure 4.1.15. Historical and projected average price for leases in the Mojave Groundwater Basin.

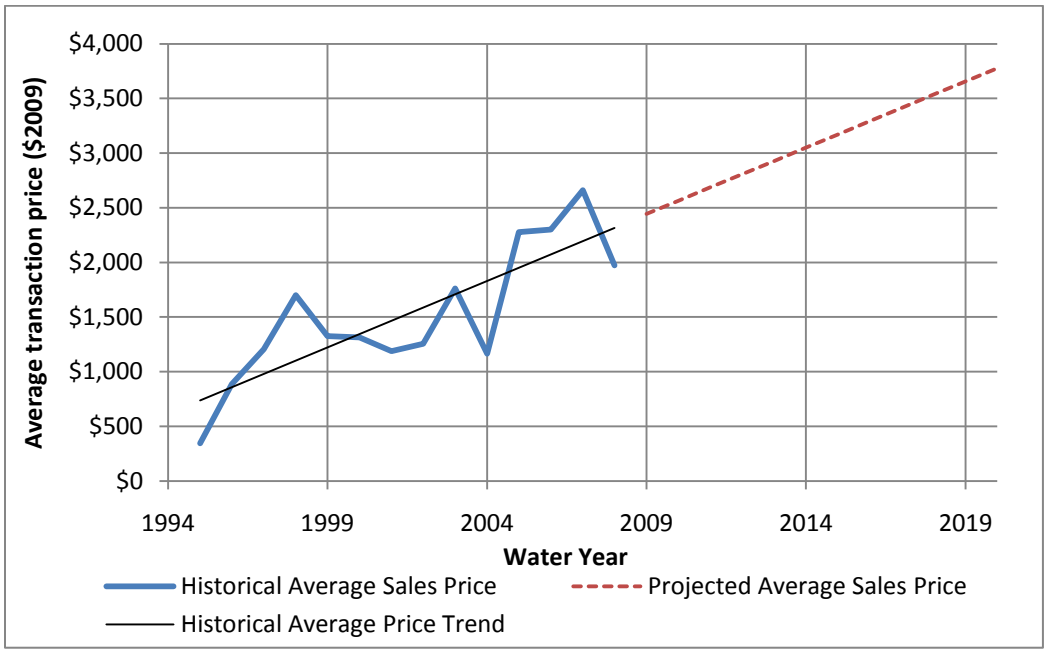


Figure 4.1.16. Historical and projected average sales price for permanent transactions in the Mojave Groundwater Basin.

Opportunity for PWS LLC

At present an informal market operates where buyers and sellers seek each other out individually and negotiate the price and volume of water they wish to transfer.[79] The adjudication provides the framework and rules for the transactions while the MWA approves and processes the transactions as they are requested. All of temporary and permanent transfers of water are accounted for in the water master Annual Reports.

A more transparent and formal groundwater rights market in the Mojave is likely to bring benefits to groundwater users, the environment, and the managing agency, MWA. As described before, the current water market has been historically operating at suboptimal levels and it is probable that water supply in the Mojave will continue to become less reliable through time. These two factors make it likely that water transfers will continue to be important means of water rights reallocation in the near future. Given these market inefficiencies and the opportunity for future market growth the Mojave Basin would be a suitable market for implementing the H_2O exchange. The market has no institutional oversight and will continue to operate at suboptimal levels until the market has institutional support.

The services provided by PWS LLC could yield a number of benefits to the Mojave Basin and generate revenue as a percentage of market activity. A formal online marketplace that is accessible to all producers and managed by PWS LLC would result in specific changes to the market. First, the PWS marketplace would provide statistical market information to producers so that they can better plan their water use to capture the highest value possible from each acre-foot. Water users will know whether they can derive more revenue using the water or selling it to another user. With this higher degree of transparency all sellers and buyers can be sure they are getting "market price" for their purchase or sale. This is likely to reduce transaction costs because markets participants can sell or buy without negotiation. Furthermore, an online interface will minimize the time necessary to fill out paperwork, as this process will be streamlined and automated based on information collected when users set up accounts.

PWS LLC would assume the accounting for transfers in water rights and work with the MWA to assure that all transactions are valid. This would remove

[79] Weigenstein 2009

uncertainty from the administrative obligations of the MWA and enable the agency to more accurately budget its resources. The agency covers the cost of processing transactions through its administrative fee, which is collected for every AF produced in the basin. There is no extra fee for processing transfers, which results in unexpected expense for the agency. Using the services of PWS LLC the MWA may be able to lower administrative fees or refrain from raising them in the future.

Optimizing the water transfer market in the Mojave would reduce dependence on imported SWP water, and will likely result in increased transfers from agricultural to urban uses. This will both increase water supply reliability and reduce the environmental impacts in the source watersheds for SWP imports. Furthermore, active and profitable groundwater markets in the Mojave will drive innovation in water use efficiency, increasing the resource productivity of water in the region.

Conclusions from the Mojave Groundwater Basin

The Mojave Basin has the largest and most active markets of the 22 adjudicated groundwater basins in California. There is considerable opportunity to expand and formalize the existing water market.

References

California Department of Water Resources. Shape file "B118v3NAD27UTM10". Division of Mines and Geology. 2010. http://www.water.ca.gov/groundwater/bulletin118/gwbasin_maps_descriptions.cfm (accessed January 10, 2010).

Mojave Water Agency (MWA). "State of the Basin, Watermaster." http://www.mojavewater.org/ (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster.*1994. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster.*1995. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster.*1996.

http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.1997. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.1998. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.1999. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.2000. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.2001. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009)

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.2002. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.2003. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster.2*004(a). http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). "Regional Water Management Plan." 2004(b). http://www.mojavewater.org/home/projects/projRegionContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.2005. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.2006. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.2007. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.2008. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

Mojave Water Agency (MWA). *Annual Report of the Mojave Basin Area Watermaster*.2009. http://www.mojavewater.org/home/waterMaster/watermasterDloadContent.aspx (accessed October 19, 2009).

United States Department of Interior. National Atlas Dataset. 2009. http://nationalatlas.gov/atlasftp.html (accessed January 12, 2010).

United States Geological Survey (USGS). "Water Supply in the Mojave River Ground-WaterBasin, 1931-99, and the Benefits of Artificial Recharge." 2001. http://pubs.usgs.gov/fs/fs-122-01/pdf/fs-122-01.pdf. (accessed November 13, 2009).

United States Geological Survey (USGS). "Potential for Groundwater Contamination from movement of wastewater through the unsaturated zone, upper Mojave River Basin, California." Water Resources Investigative Report 93-4137. 1993. http://www.mojavewater.org/Reports/RegionalandLocalizedStudies/Search.aspx (accessed October 19, 2009).

Weigenstein, Valerie. Personal communication. October 29, 2009.

4.2 West Coast Basin

Introduction

The West Coast Basin is located in Los Angeles County (Figure 4.2.1). The area overlying the basin has been heavily developed and includes twenty incorporated cities and several unincorporated areas. The predominant uses of water in the Basin are residential and industrial. In fiscal year 2008-2009, groundwater comprised approximately 18% of total water use (Figure 4.2.2).[80]

Figure 4.2.1. Location of the West Coast Basin in southern California.[81]

[80] California Department of Water Resources 2009(a)
[81] California Department of Water Resources 2010(a), United States Department of Interior 2009

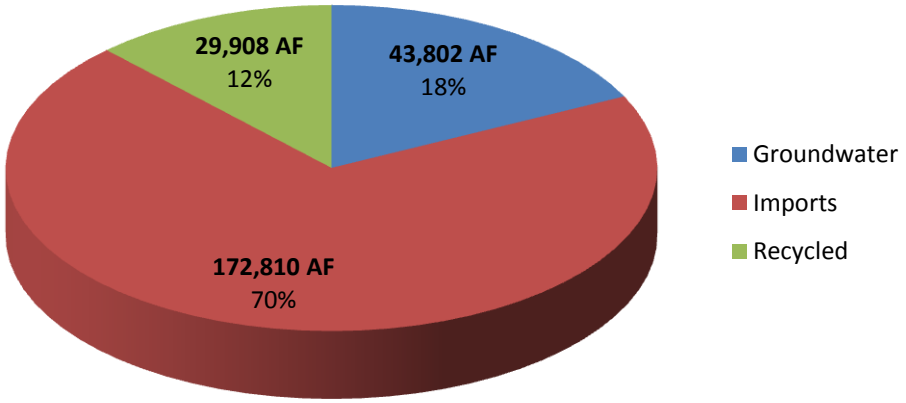


Figure 4.2.2. Total water use in West Coast Basin in acre-feet (AF) for fiscal year 2008-2009.

Current Basin Statistics

Number of users	Approximately 900,000[82]
Parties to Adjudication	67 parties, 1 non-party, 4 exempt parties
Year of adjudication	1955 Interim Agreement, 1961 Final Judgment
Duration of litigation	16 years
Watermaster	California Department of Water Resources (DWR)
Court-allocated yield (Adjudicated Rights)	42,566 acre-feet + allowable carryover
Sustainable yield	Approximately 38,309.4 acre-feet[83]
Size (acres)	91,300 (*142 square miles*)[84]
Overdraft	No
Seawater intrusion	No
Land subsidence	No
Water agencies in basin	West Coast Municipal Water District, California Water Service Company, Los Angeles County Sanitation District 2, Los Angeles County Waterworks District 29, Water Replenishment District, Western Water Service Company, various cities

[82] Metropolitan Water District of Southern California 2010
[83] Cernosek 2009
[84] Osugi et al. 2003

History of the Basin

Prior to 1870, settlers in the West Coast Basin obtained sufficient quantities of water from surface water sources. After 1870, shallow wells were required to supply enough water to sustain development and economic growth. Then in 1909, groundwater pumping was greatly enhanced by the deep-well turbine pump, which allowed nearly all water users to have efficient water wells and a dependable supply of water. This efficient, reliable water supply attracted industry and agriculture to the basin, and overdraft ensued. By 1932, the entire coast of the basin was experiencing seawater intrusion due to water levels dropping below sea level.

To halt overdraft and the deterioration of groundwater quality, two water companies and one city sued for adjudication in 1945. Shortly thereafter, the West Basin Association and the West Basin Municipal Water District (WBMWD) were formed. The West Basin Association created a water resources management plan to limit groundwater extractions, provide supplemental water supply for major producers, and create an exchange pool to provide pumping rights for users who lacked access to supplemental supplies. The WBMWD was created to distribute water from the Colorado River, and the District was annexed to the larger Metropolitan Water District of Southern California (MWD) one year after its inception.[85] Supplemental water from the Colorado River began flowing into the West Coast Basin in 1948, and State Water Project (SWP) water began flowing into the basin in 1974.[86]

Basin Activities

Replenishment - Natural replenishment of the West Coast Basin occurs from underflow from the Central Basin, which lies to the east of the West Coast Basin. Total replenishment occurs through local runoff and proactive spreading operations conducted by the Los Angeles County Department of Public Works (LACDPW) and the Water Replenishment District of Southern California (WRD).[87]

Seawater Intrusion Barriers - Seawater intrusion has been halted by the LACDPW-operated West Coast Basin Barrier Project and Dominguez Gap Barrier Project. The West Coast Basin Barrier Project consists of a line of 153

[85] California Department of Water Resources 2010(b)
[86] California Department of Water Resources 2009(a)
[87] California Department of Water Resources 2009(a)

injection wells that parallel the coastline along the Santa Monica Bay.[88] The Dominguez Gap Barrier Project consists of 41 injection wells[89] along the San Pedro Bay. Imported SWP water, Colorado River water, and recycled water is injected into the wells to create a pressure ridge that impedes the inland movement of seawater and maintains groundwater elevations. The WBMWD collaborates with LACDPW to perform injection well maintenance and monitoring, and also operates a tertiary treatment system to treat reclaimed water from the Hyperion wastewater treatment for injection. Recycled water from the treatment system is also used for industry and landscaping.[90]

Desalters – The basin has two desalters are in operation. The Brewer Desalter in the City of Torrance is operated by the California Water Service Company and treats 1.5 million gallons (4.6 AF) of brackish groundwater per day. The Goldsworthy Desalter, also in the City of Torrance, was initially operated by the WRD and is now operated by the City of Torrance. The Goldsworthy Desalter treats approximately 210 AF of brackish water per month, or 7 AF per day.[91]

Basin Adjudication

History of Adjudication

Adjudication was initiated in the West Coast Basin in 1945 because groundwater levels were declining due to overdraft and seawater intrusion threatened groundwater quality. The California Water Service Company, Palos Verdes Water Company, and City of Torrance were the first parties in the adjudication suit. As part of the Los Angeles County Superior Court's preliminary hearings, the DWR defined the boundaries and determined the geohydrologic characteristics of the basin with assistance from an Engineering Advisory Committee retained by the basin's major water extractors. The magnitude of the overdraft and groundwater quality problem became evident as a result of the geohydrologic investigation, and 340 parties were added to the adjudication suit in 1949.[92]

An Interim Agreement was reached in 1955 to halt overdraft and the Court appointed the DWR as the interim Watermaster. In 1956, a second adjudication suit was filed, resulting in an additional 76 parties being added to the Court's

[88] California Department of Water Resources 2009(a)
[89] Los Angeles County Department of Public Works 2010
[90] California Department of Water Resources 2009(a)
[91] California Department of Water Resources 2009(a)
[92] California Department of Water Resources 2009(a)

jurisdiction. When the Final West Coast Basin Judgment was reached in 1961, the Court retained the DWR as the Watermaster.[93]

The West Coast Basin Judgment was amended several times after 1961:[94]

- 1980 amendment – Provided for a transition in the administrative year from a water year to a fiscal year, thereby creating a 9-month transition year in 1980-1981.
- 1981 amendment – Established a non-consumptive water use right subordinate to adjudicated rights, permitted Hughes Aircraft Company to become a party with zero water rights, and authorized the production and disposal of water from wells to analyze and find a method of well operation for correction of increased salinity from seawater intrusion.
- 1984 amendment – Provided for non-consumptive additional water production to recover old refined oil, permitted the Atlantic Richfield Company to operate an oil recovery project for 5 years without a production charge because all water produced was returned to the basin.
- 1989 amendment – Revised the provisions for non-consumptive cleanup operations, including hydrocarbon cleanup.
- 1993 amendment – Modified carryover provisions for unextracted water to 2 AF or 20% of Adjudicated Right, whichever is greater.
- 2009 proposed amendment – Provides for groundwater storage.

Current Key Adjudication Provisions

The West Coast Basin Final Judgment and its subsequent amendments include several important provisions for groundwater management:

- Each groundwater user reports monthly extractions to the Watermaster, who computes the total amount extracted thus far in the fiscal year, the amount that can be legally extracted in the remainder of the fiscal year, and supplies each user with an updated monthly account.
- To maintain accurate measurements of groundwater extractions, the Watermaster strives to calibrate the water meter on each active water well at least biannually and inform users to replace inaccurate meters.
- The Watermaster measures the depth to the static groundwater level each fall and spring and prepares contour maps of groundwater elevations.

[93] California Department of Water Resources 2009(a)
[94] California Department of Water Resources 2009(a)

- If a user does not extract his full Adjudicated Right in a given year, he may carry over 20% of his Adjudicated Right or 2 AF, whichever is greater, to the following year.[95]
- In order to meet possible emergencies, each user may extract an amount exceeding his Adjudicated Right as long as the water is put to beneficial use. The excess amount should not exceed 10% of his Adjudicated Right or 2 AF, whichever is greater, unless a greater amount is approved by the Court. Users that extract an amount in excess of their Adjudicated Rights are required to reduce their extractions below their Adjudicated Right by an amount equivalent to the excess extraction in the following year.[96]
- To allow users to obtain additional pumping rights, the Final Judgment authorizes an Exchange Pool. Each July, parties to the Judgment may choose to participate in the Exchange Pool. Participants estimate their water supply and water use for the year. Participants with access to supplemental water (other than their Adjudicated Right) whose supply exceeds their estimated use must make a 'Mandatory Offer' to lease a portion of their Adjudicated Right to the Exchange Pool. The charge per AF for a Mandatory Offer cannot exceed the price of replacement water. Additionally, participants without supplemental supplies can make a 'Voluntary Offer' of a portion of their Adjudicated Right if their supply exceeds estimated use. The charge per AF for a Voluntary Offer cannot exceed the price of imported water supplied by the WBMWD. Participants whose estimated use exceeds their supply for the year may request additional Adjudicated Rights from the Exchange Pool.[97]
- Adjudicated Rights may be transferred between users through leases or sales, and records of the transfers are maintained by the Watermaster. The Watermaster provides samples of recommended lease and sale agreements in each annual Watermaster Report.[98] Only parties to the Judgment may lease water, but anyone may purchase water rights permanently.[99]

[95] California Department of Water Resources 2008
[96] California Department of Water Resources 2008
[97] California Department of Water Resources 2009(a)
[98] California Department of Water Resources 2009(a)
[99] California Department of Water Resources 2009(b)

Basin Demographics

The population of 142-square mile West Coast Basin is approximately 900,000.[100] Data from the South Bay Cities Council of Governments (the 21 cities and unincorporated areas represented by the Council closely match those of the West Coast Basin) shows that the South Bay population increased by roughly 25% between 1990 and 2000.[101] If this population growth trend continues, the population of the West Coast Basin will be approximately 1.5 million in 2020. Even though the WBMWD has crafted aggressive water conservation programs, this magnitude of population growth will most likely result in corresponding growth in water demand.

Water Use

As shown in Figure 4.2.3, total water use in West Coast Basin generally increased until the late 1980s, then began to decline slightly. Groundwater extractions have also been declining since about 2004. These recent declines in total water and groundwater use may be due to the use of recycled water starting in 1995 and the WBMWD's aggressive conservation programs. The conservation programs include incentives to reduce residential, commercial, and outdoor water use[102] and a goal to reduce dependence on imported water from 66% to 33% by 2020[103]; the WBMWD estimates that the conservation programs have saved over 4.5 billion gallons (approximately 13,800 AF) of imported water annually.[104]

[100] Metropolitan Water District of Southern California 2010
[101] South Bay Cities Council of Governments 2009
[102] West Basin Municipal Water District 2006
[103] West Basin Municipal Water District 2010
[104] West Basin Municipal Water District 2010

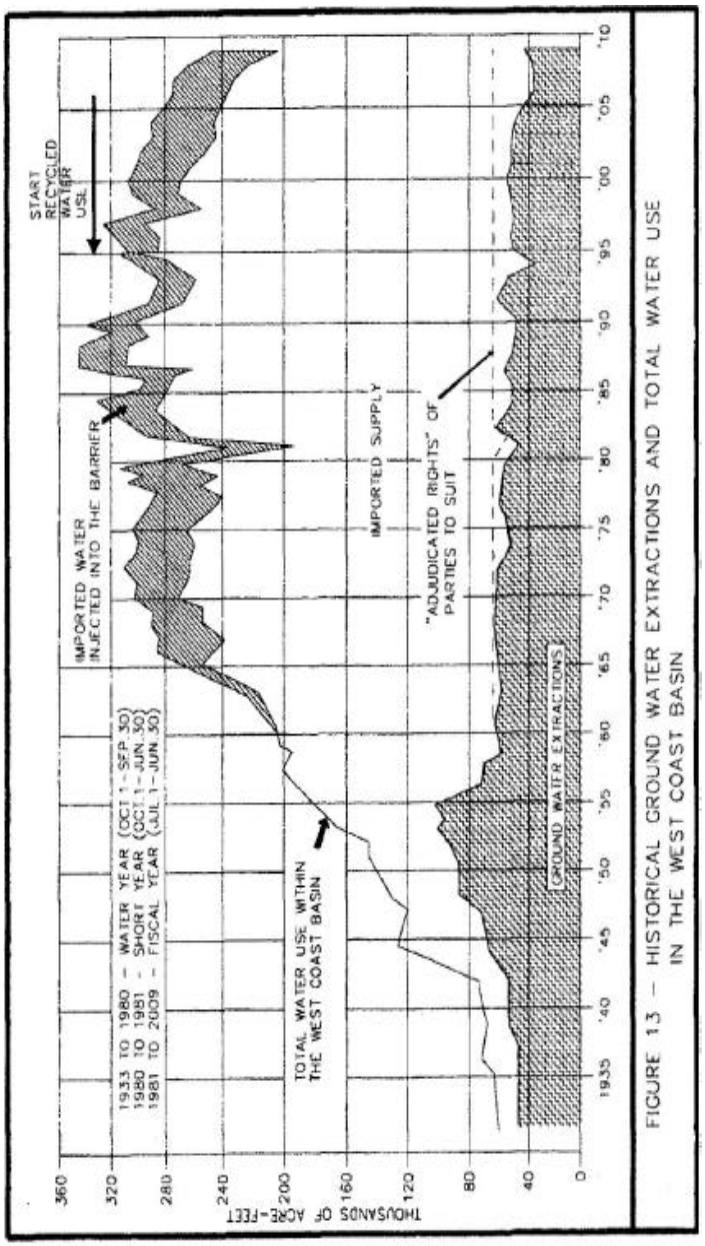


Figure 4.2.3. Historical water use in the West Coast Basin. [105]

[105] California Department of Water Resources 2009(a)

The WBMWD is the primary water purveyor in West Coast Basin, and 100% of its water distributed is used for municipal and industrial (M&I) purposes.[106] A small volume of groundwater is extracted for agricultural use[107]; there are three nurseries with Adjudicated Rights, only one of which extracted any groundwater in the 2008-2009 fiscal year (22.43 AF).[108] Oil recovery is conducted in the basin by Chevron USA and Mobil Oil Corporation and is classified as non-use of groundwater, although groundwater is extracted. This use of groundwater could be considered an environmental use.[109]

The majority of West Coast Basin's water supply is comprised of imported water, with smaller proportions of groundwater and recycled water. Table 4.2.1 summarizes groundwater use in the basin for the last six years.

Table 4.2.1. Groundwater use in West Coast Basin since fiscal year 2003-2004.

Fiscal Year	Total Adjudicated Rights (AF)	Total Actual Extractions (AF)	Total Unused Adjudicated Rights (AF)	Violation Over-extractions (AF)	Total Imported Water (AF)	Total Water Purchased Within Basin (AF)	Total Recycled Water (AF)
2003-2004	64,468	46,020	18,448	167	216,778	15,451	24,554
2004-2005	64,468	41,485	22,983	56	212,864	17,753	24,065
2005-2006	64,468	34,168	30,300	146	214,303	23,167	23,654
2006-2007	64,468	34,679	29,790	140	208,411	20,349	29,250
2007-2008	64,468	37,883	26,585	89	191,922	19,743	32,209
2008-2009	64,468	42,566	21,902	105	172,810	11,775	29,908

Water Quality

Since the area overlying the West Coast Basin is highly urbanized, there are many potential sources of groundwater contamination present in the basin, such as underground fuel storage tanks, chemical processing facilities, sewer lines, and landfills. These sources can contaminate groundwater with petroleum-based fuels, fuel additives, metals, and solvents.[110] Fortunately, the vast majority of groundwater monitored by the WRD in both the West Coast Basin and the adjacent Central Basin is of high quality due to geopurification—the purification process that occurs as groundwater moves slowly through gravel, sand, silt, and clay formations. As of 2008, less than 0.5% of samples from the WRD's groundwater quality database contained contaminants in amounts exceeding the

[106] Metropolitan Water District of Southern California 2010
[107] Osugi et al. 2003
[108] California Department of Water Resources 2009(a)
[109] California Department of Water Resources 2009(a)
[110] Matsumoto 2009

Maximum Contaminant Levels (MCL)[111]—the legal limit set by the US Environmental Protection Agency under the Safe Drinking Water Act.[112] The WRD has a Safe Drinking Water Program to assist users whose wells have MCL exceedances with treatment planning and funding.[113] Thus, groundwater quality should not be a barrier to trading groundwater extraction rights.

Groundwater Rights Market

Existing State of the Market

Despite the flexibility provided by the Exchange Pool to lease pumping rights on an annual basis, the Pool has not operated in over a decade because Exchange Pool rates often exceed lease market rates, so users turn to the informal lease and permanent sale market to purchase additional pumping rights and sell excess supply.[114] West Coast Basin groundwater users have two ways to participate in this informal transfer market: 1) users notify the Watermaster of their offer to buy, sell or lease water, and the Watermaster posts the offers and contact information on its website for viewing by potential transfer partners,[115] or 2) users find transfer partners without facilitation by the Watermaster. Once a trade is negotiated, the transfer paperwork is submitted to the Watermaster for verification of parties and Adjudicated Right quantities.

The lease market is especially important to users without access to MWD water who require additional supply. The market also benefits users who have access to MWD water because leased groundwater does not have the temporal restrictions of MWD water nor the high rates.[116]

Table 4.2.2 summarizes transfer market activity in West Coast Basin from the last six years. The greatest volume of water is usually transferred in long-term leases in which the exact length of the lease is agreed upon by both parties, then short-term annual leases, then permanent sales. The volume of water transferred annually ranges between approximately 7,600 AF and 11,900 AF, or roughly 15% of the total amount of Adjudicated Rights in the basin.

---

[111] Johnson 2008
[112] United States Environmental Protection Agency 2009
[113] Johnson 2008
[114] Stuart 2009
[115] California Department of Water Resources 2010
[116] Cernosek 2009

Table 4.2.2. Volume of water transferred in informal market in short-term leases, long-term leases, and permanent sales since fiscal year 2003-2004.[117,118,119,120]

Fiscal Year	Transfer Term	Quantity (AF)	Total Value (2009$)	Price / AF (2009$)	Replacement Water Price / AF (2009$)
2003-2004	Short-term	6,068.82	N/A [a]	$102.71 [a]	$612.71
2003-2004	Long-term	5,795.40	N/A [a]	$102.71 [a]	$612.71
2003-2004	Permanent	23.60	N/A [a]	N/A [a]	$612.71
2004-2005	Short-term	2,577.10	N/A [a]	$85.38 [a]	$586.26
2004-2005	Long-term	5,795.40	N/A [a]	$85.38 [a]	$586.26
2004-2005	Permanent	242.60 [b]	N/A [a]	N/A [a]	$586.26
2005-2006	Short-term	1,447.60	N/A [a]	$75.69 [a]	$579.18
2005-2006	Long-term	9,434.60	N/A [a]	$75.69 [a]	$579.18
2005-2006	Permanent	282.00 [c]	N/A [a]	N/A [a]	$579.18
2006-2007	Short-term	766.00	N/A [a]	$73.32 [a]	$574.85
2006-2007	Long-term	6,814.90	N/A [a]	$73.32 [a]	$574.85
2006-2007	Permanent	3,442.00 [d]	N/A [a]	N/A [a]	$574.85
2007-2008	Short-term	1,318.00	N/A [a]	$76.58 [a]	$620.92
2007-2008	Long-term	6,814.90	N/A [a]	$76.58 [a]	$620.92
2007-2008	Permanent	0.00	N/A [a]	N/A [a]	$620.92
2008-2009	Short-term	4,153.00	N/A [a]	$95.00 [e]	$689.00
2008-2009	Long-term	6,814.90	N/A [a]	$95.00 [e]	$689.00
2008-2009	Permanent	23.60	N/A [a]	N/A [a]	$689.00

[a] = Most transfer prices are undisclosed to Watermaster. Lease price average reported in The Water Strategist.

[b] = An additional 363.70 AF were permanently transferred due to a merger between Los Angeles County Alondra Park and Los Angeles County Chester L. Washington Golf Course under the new name Los Angeles County Recreation Facilities. Due to the non-monetary nature of this transfer, the transfer quantity is not included in this summary.

[c] = An additional 7,502.24 AF were permanently transferred due to a company name change. Due to the non-monetary nature of this transfer, the transfer quantity is not included in this summary.

[d] = 3,432 AF were permanently transferred from Shell Oil Products US to Tesoro Refining and Marketing Co. This outlying quantity was excluded from projections for future transfers.

[e] = Calculated from approximate range of lease prices paid in FY 2008-2009 given by Watermaster.

The general demographics of the parties that participate in transfers are water purveyors, cities, industries, petroleum companies, and occasionally individual users. The number of transfers ranges between 10 and 18 transfers per year.

[117] California Department of Water Resources 2009(a)
[118] Smith 2005
[119] Smith 2008
[120] Smith 2009

Barriers to Trading

While the informal pumping rights transfer market that exists in West Coast Basin is relatively stable, the current market is not operating at maximum efficiency. Many parties extract 0% of their Adjudicated Rights while a few parties extract more than their adjudicated rights allow, resulting in a violation of the Judgment, and other parties (water service companies and cities) must import water from the State Water Project, Colorado River, and Owens River-Mono Basin. In short, some parties are needlessly violating the Judgment and paying for imported water when they could purchasing or leasing water at a lower price from parties who are not using their allotted groundwater. The barriers that prevent more efficient trading are:

- Lack of information – Most prices for transactions that have occurred are unpublished so potential buyers may not be aware of the savings they could incur by participating in the market, and potential buyers may not be aware of the revenue they could receive by selling their unused rights.

- High transaction costs – Since neither the Watermaster nor any other body mediates transfers, market participants must identify trading partners, negotiate prices, and complete the appropriate paperwork. These complicated tasks may prohibit more users from participating in the market.

Current market operations may also present difficulties for the Watermaster. While the Watermaster does not mediate transfers in any way, the staff does review the transfer paperwork, record transactions in a database, and publish the transfers in annual reports. If a party's name in the Watermaster's records does not match the name on the transfer paperwork, the Watermaster must investigate, and multiple transfers may be necessary when parties change names. Investigation is also required if a party is selling 100% of his Adjudicated Right, but the transfer paperwork does not specify whether the party's allotted carryover volume is being transferred as well. The time necessary to approve such complicated transfers is not necessarily included in the Watermaster's budget.[121]

[121] Cernosek 2009

Implementation of PWS H_2O Exchange

H_2O Exchange Effects Over Time

PWS' H_2O Exchange can correct the inefficiency in the existing West Coast Basin transfer market by providing a central marketplace for all buyers and sellers, facilitating transfers that are easy and convenient for market participants, revealing the value of groundwater relative to other water sources, and revealing the value of participation in the market. Over time, the H_2O Exchange will correct the current market inefficiency through increased groundwater rights sales, long-term leases, and short-term leases, resulting in a redistribution of groundwater rights so that most parties have enough rights to supply their annual needs and must rely less on imported water.

Projections

Transfer Volume Projections

We used the median volume of unextracted groundwater rights in the basin for the last six years as the amount of inefficiency in the current market. Since 2003, permanent sales have comprised approximately 1% of all transfer quantities, long-term leases have comprised approximately 77% of all transfer quantities, and short-term leases have comprised approximately 22% of all transfer quantities. We used these proportions for our projections of future transfer quantities of adjudicated rights following implementation of the H_2O Exchange until 2020.

Projection assumptions:

- Permanent sales will permanently correct 1% of the market inefficiency by 2020, thereby reducing the volume of unextracted groundwater rights by 1% by 2020. The total correction will be achieved through equal quantities of permanent sales each year until 2020 such that the total volume of future permanent sales is equal to 1% of the market inefficiency (Figure 4.2.4).
- Long-term leases will permanently correct 77% of the market inefficiency by 2020, thereby reducing the volume of unextracted groundwater rights by 77% by 2020. The total correction will be achieved through equal quantities of long-term leases each year until 2020 such that the total volume of future long-term leases is equal to 77% of the market inefficiency. We treated long-term leases the same as permanent sales

because the majority of long-term leases in West Coast Basin have 14-year terms—longer than the time span of our projections. These long-term leases would remove their quantities of adjudicated rights from the "supply pool" (the volume of unextracted groundwater rights) for 14 years (Figure 4.2.5).

- Short-term leases will correct the remaining 22% of the market inefficiency by 2020, thereby reducing the volume of unextracted groundwater rights by 22% by 2020. The total volume of adjudicated rights transferred in short-term leases will not be equal every year, but rather will increase over time as parties see the demonstrated value of the H_2O Exchange. In the first year of market implementation, the volume of adjudicated rights transferred in short-term leases will equal the median volume of historical short-term leases. This volume will increase by an equal increment each year until 22% of the market inefficiency is being transferred in short-term leases in 2020 (Figure 4.2.6).
- By 2020, 100% of the market inefficiency will have been corrected through permanent sales, long-term leases, and short-term leases (Figure 4.2.7).

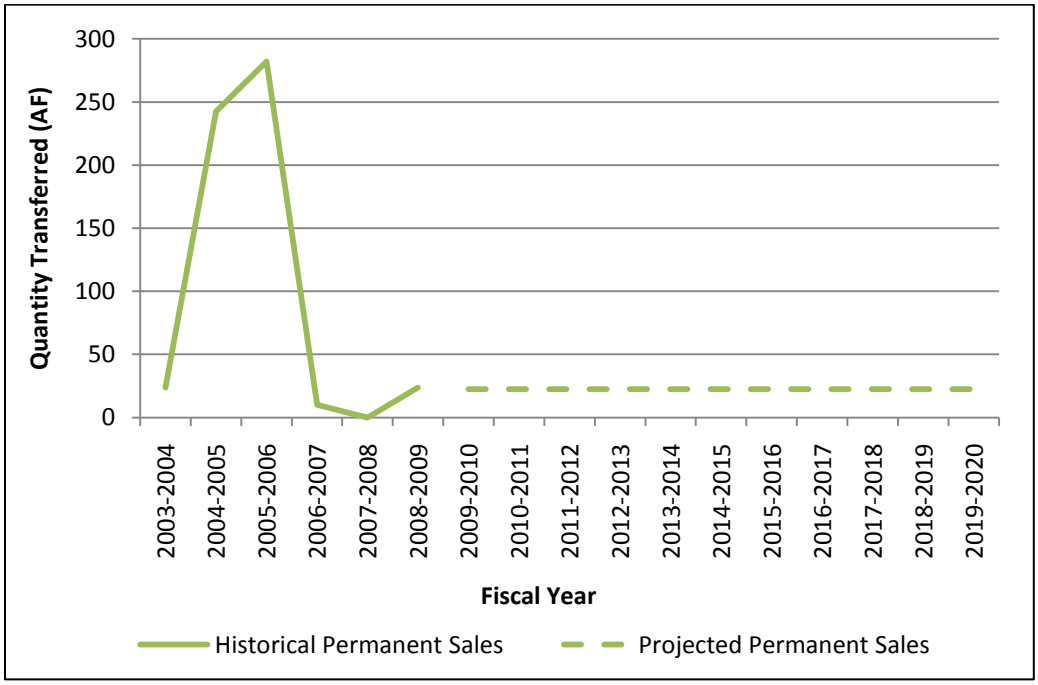


Figure 4.2.4. Historical and projected quantities of groundwater rights transferred in permanent sales.

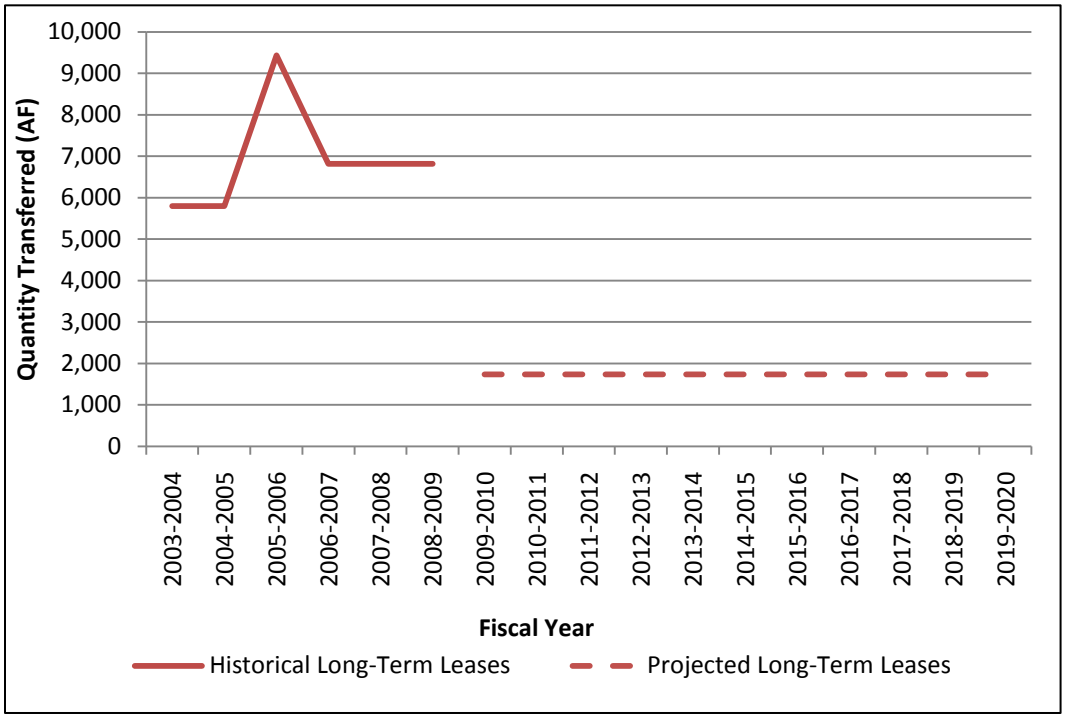


Figure 4.2.5. Historical and projected quantities of groundwater rights transferred in long-term leases.

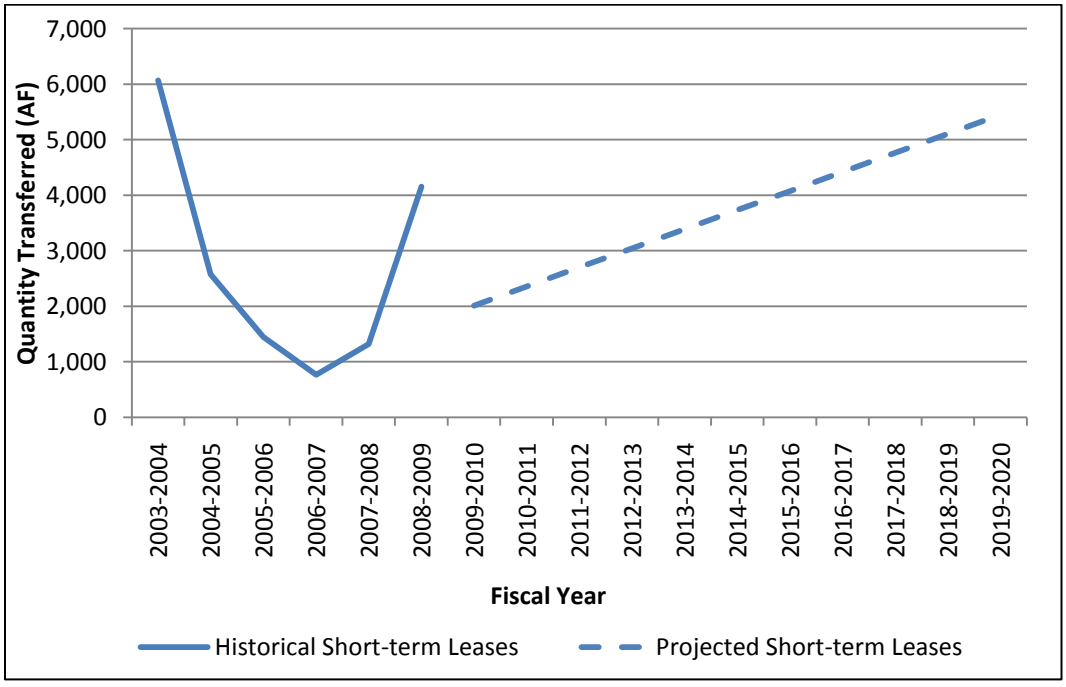


Figure 4.2.6. Historical and projected quantities of groundwater rights transferred in short-term leases.

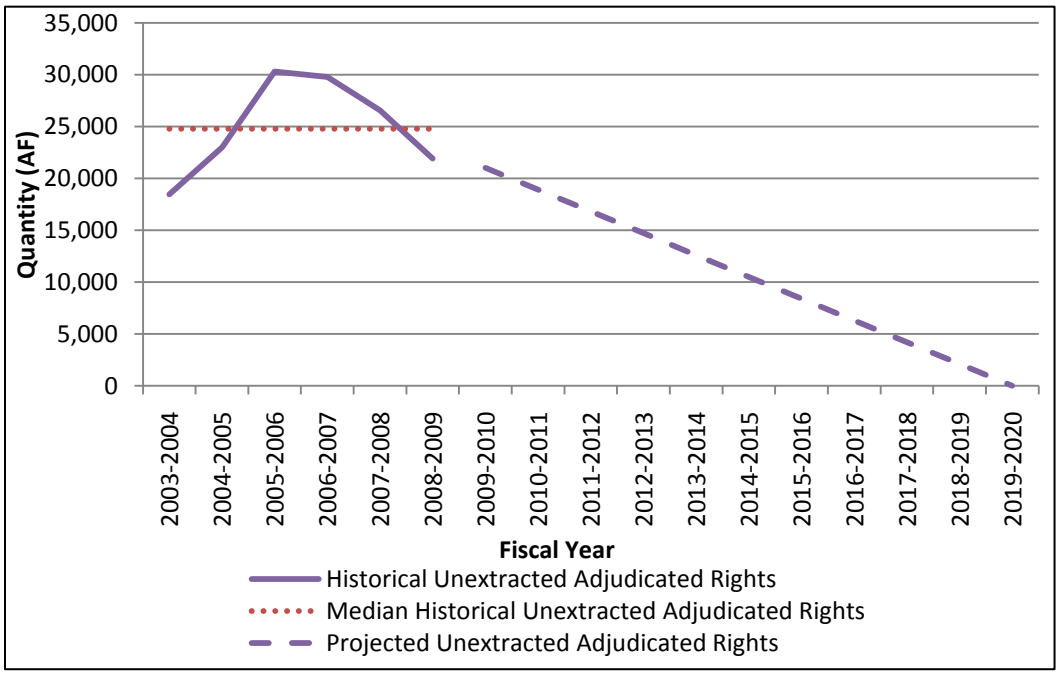


Figure 4.2.7. Projected decrease in market inefficiency over time, as measured by the volume of unextracted groundwater rights.

The projections used for West Coast Basin are conservative, as we assumed that the H_2O Exchange would only correct the current market inefficiency. In all likelihood, the H_2O Exchange would result not only in a redistribution of groundwater rights so that parties need not resort to over-extractions in violation of the Adjudication Judgment and need not import as much water from outside the basin, but also would prompt parties who do extract a portion of their groundwater rights to extract less so they could sell their rights in the market. Thus, the quantities of transfers would be even greater than those we have projected here.

Transfer Price Projections

We used price trends in historical groundwater rights transfers, trends in replacement water rates, trends in electricity rates, and proxy permanent sales prices from other basins to calculate projections for transfer prices in West Coast Basin. Historical transfer prices for individual transactions were unavailable as most transfer prices are not disclosed to the Watermaster. Average historical lease prices were reported in various issues of *The Water Strategist*, however, and so these average prices were used for both historical short-term and long-term leases. Neither individual nor average permanent sale prices were not found in

Watermaster records or *The Water Strategist*, so the Water Transfer Level Dataset was searched for proxy sale prices. The Dataset did not contain sales from West Coast Basin, but did contain records of sales in other basins by a water purveyor that is a party in West Coast Basin's Adjudication Judgment. The median value of these sales prices was calculated and used as the proxy permanent sale price in West Coast Basin.

We projected an upper bound and a lower bound for lease prices to provide a realistic range of future lease prices (Figure 4.2.8). All nominal prices were converted to real dollars (2009 dollars) using the California Department of Finance's Consumer Price Index.

Projection Assumptions:

- The upper bound is the projected future price of replacement water, which is distributed by the West Basin Municipal Water District and supplied by the Metropolitan Water District of Southern California.
- The lower bound increases as the same rate as the annual increase in electricity rates (electricity is needed to pump groundwater to the surface), according to the Department of Energy's Energy Information Administration.

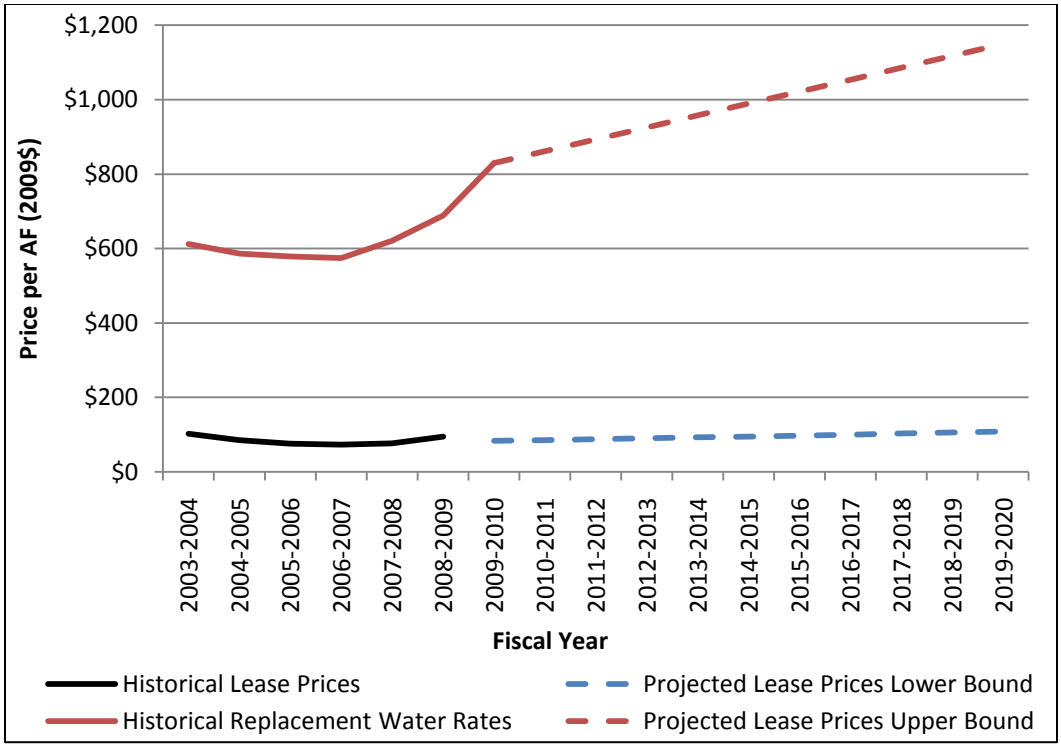


Figure 4.2.8. Historical average lease prices and replacement water rates and projected groundwater rights lease prices. The lower bound projection was calculated using the equation: $\boldsymbol{Price_t = (Median\ historical\ lease\ price) \times 1.027^t}$, where t is a future year and 1.027 reflects the 2.7% annual increase in electricity rates. The upper bound projection was calculated by regressing historical replacement water rates to determine the rate of increase in the future.

We show only the lower bound for permanent sale prices because the lower bound values are actually greater than the projected upper bound values until 2016 (Figure 4.2.9). This phenomenon demonstrates that permanent sale prices are already much higher than lease prices. As in the lower bound lease price projection, sale prices increase at the same rate as the annual increase in electricity rates.

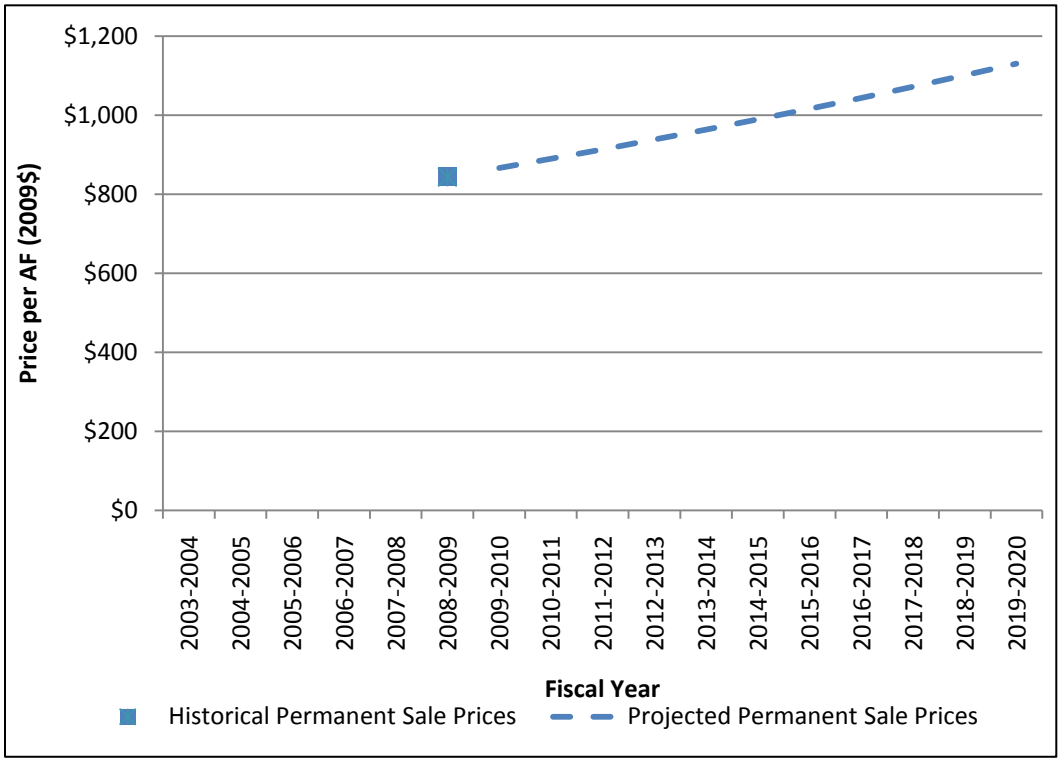


Figure 4.2.9. Proxy value for historical groundwater rights permanent sale prices and projected sale prices. The projection was calculated using the equation: $\boldsymbol{Price_t = (Historical\ sale\ price) \times 1.027^t}$, where t is a future year and 1.027 reflects the 2.7% annual increase in electricity rates.

Benefits of the H_2O Exchange

Given the probable increases in water demand, continual need for reallocation of extraction rights, and opportunity for improving the existing groundwater rights transfer market in West Coast Basin, we expect that implementation of the H_2O Exchange in the basin would be successful and beneficial for basin users. The H_2O Exchange and PWS' management of the market would increase information for users and reduce transaction costs. Due to the reduction of these present barriers to trading, we anticipate that more users would participate in transfers through the H_2O Exchange than are currently trading.

Economic Benefits

Increased transfers through the H_2O Exchange would result in a decrease in the existing market inefficiency, increase in revenue for under-extractors who would sell their rights, and increase in savings for users who require additional extraction rights and would purchase them through the Exchange. When this high

potential for mutually beneficial exchange is clearly demonstrated, we expect some groundwater users to implement water-conserving measures and technologies so as to capture the highest possible value from each AF and maximize revenue from the sale of unextracted groundwater, and other water users to increase their use of groundwater by purchasing the rights through the H_2O Exchange and reducing their use of costly imported water. Implementing the H_2O Exchange would reveal the market value of groundwater rights and result in more efficient use of groundwater and increased resource productivity. Furthermore, the H_2O Exchange and PWS' management of the market would reduce administrative costs for the Watermaster, as PWS would ensure that all transfer paperwork is complete and accurate. Finally, increasing reliance on groundwater as a local, sustainable resource instead of imported water improves water resource security.

Social Benefits

H_2O Exchange operations are transparent and participation is voluntary, so participants can be confident in using the Exchange. Also, the H_2O Exchange yields a single market price for groundwater rights for each transfer term during each market period. This characteristic eliminates the tension that arises through price negotiations and the uncertainty that a market participant did not pay or receive a fair price that results from the existing market. Lastly, participants in the H_2O Exchange are assured that they are taking an active role in shaping their water future when supply is uncertain due to climate change and regulation.

Environmental Benefits

The reallocation of groundwater rights, more efficient use of groundwater, and sale of currently unextracted groundwater rights would eventually result in maximum use of groundwater and reduced use of imported water. Maximum use of groundwater would be a sustainable use of the resource because the total amount of Adjudicated Rights in West Coast Basin is 10% less than the safe yield of the basin[122]—the amount of groundwater that can be extracted without impairing groundwater quality or inducing other negative environmental effects.[123] The most significant environmental benefit of the H_2O exchange would result from the reduced use of imported water. Transferring water from the

[122] Cernosek 2009
[123] Fetter 2001

Sacramento-San Joaquin Delta, Colorado River, and Owens River-Mono Basin causes ecological harm to those sensitive ecosystems.

Conclusions

There is considerable opportunity for PWS to implement the H_2O Exchange in the West Coast Basin and for groundwater users and the Watermaster to benefit from PWS' presence in the basin.

References

California Department of Water Resources. "Southern District, Offers to Buy or Sell Water Rights." 2009b. http://www.water.ca.gov/watermaster/aboutwatermaster/buy_sell.cfm (accessed February 21, 2010).

California Department of Water Resources. Shape file "B118v3NAD27UTM10". Division of Mines and Geology. 2010(a). http://www.water.ca.gov/groundwater/bulletin118/gwbasin_maps_descriptions.cfm (accessed January 10, 2010).

California Department of Water Resources. "Southern District, Background." 2010(b). http://www.water.ca.gov/watermaster/aboutwatermaster/index.cfm (accessed February 21, 2010).

California Department of Water Resources. "Southern District, West Coast Basin Judgment, V. Physical Solution – Carry-over, Excess Production and Drought Carry-over." 2008. http://www.water.ca.gov/watermaster/westbasin_judgment/carry-over.cfm (accessed February 21, 2010).

California Department of Water Resources. "Watermaster Service in the West Coast Basin, Los Angeles County, July 1, 2008-June 30, 2009a." 2009. http://www.water.ca.gov/watermaster/sd_documents/west_basin_2009/westcoastbasinwatermasterreport2009.pdf (accessed November 5, 2009).

Cernosek, Milan. Personal communication. November 4, 2009.

Fetter, C W. "The Concept of Safe Groundwater Yield in Coastal Aquifers." *Journal of the American Water Resources Association*. Vol. 8 No. 6. pp. 1173-1176.

Johnson, Ted. "Groundwater Quality in the Central and West Coast Basins." Water Replenishment District of Southern California Technical Bulletin Volume 15. 2008.http://www.wrd.org/engineering/groundwater-quality-west-central-basin.php (accessed January 12, 2010).

Los Angeles County Department of Public Works. "Seawater Barrier Historical Perspective." 2010. http://dpw.lacounty.gov/wrd/Barriers/Historical.cfm (accessed December 12, 2009).

Matsumoto, Nancy. "Groundwater Contamination Prevention and Cleanup in the Central and West Coast Basins." Water Replenishment District of Southern California Technical Bulletin Volume 18. 2009.http://www.wrd.org/engineering/groundwater-contamination.php (accessed January 12, 2010).

Metropolitan Water District of Southern California. "West Basin Municipal Water District." 2010. http://www.mwdh2o.com/mwdh2o/pages/memberag/agencies/westbasin.htm (accessed January 3, 2010).

Osugi, Doug, Robert Swartz, and Carl Hauge. "California's Groundwater - Bulletin 118, Update 2003." Groundwater Information Center. Sacramento: California Department of Water Resources. 2003. http://www.water.ca.gov/groundwater/bulletin118/bulletin118update2003.cfm (accessed February 10, 2009).

South Bay Cities Council of Governments. "South Bay Population Data." 2009. http://www.southbaycities.org/node/258 (accessed February 2, 2010).

Smith, Rodney, ed. *Water Strategist*. Claremont: Stratecom, Inc., February 2005.

Smith, Rodney, ed. *Water Strategist*. Claremont: Stratecom, Inc., February 2008.

Smith, Rodney, ed. *Water Strategist*. Claremont: Stratecom, Inc., February 2009.

Stuart, Mark. E-mail message to author. October 30, 2009.

United States Environmental Protection Agency. "Frequently Asked Questions." Ground Water & Drinking Water. 2009. http://www.epa.gov/safewater/faq/faq.html#mcl (accessed January 12, 2010).

US Department of Interior. National Atlas Dataset. 2009. http://nationalatlas.gov/atlasftp.html (accessed January 12, 2010).

West Basin Municipal Water District. "Conservation Mater Plan Highlights." 2006. http://www.westbasin.org/files/pdf/Conservation_masterplanHighlights.pdf (accessed February 3, 2010).

West Basin Municipal Water District. "Water Reliability 2020." 2010. http://www.westbasin.org/water-reliability-2020 (accessed February 3, 2010).

4.3 Chino Groundwater Basin

Introduction

The Chino Basin is a 240 square mile groundwater basin in the Santa Ana River Watershed in parts of San Bernardino County, Riverside, and Los Angeles Counties, California. The Chino Basin is the one of the largest groundwater basins in Southern California and "provides much of the water used by area cities, dairies, farms, industry, and businesses."[124] The boundaries of the Chino Basin are shown in Figure 4.3.1. San Antonio Creek and Cucamonga Creek drain the surface of the subbasin southward to join Santa Ana River.

The Basin is managed by the Chino Basin Watermaster. Before adjudication it was managed by various water agencies, including the Chino Basin Municipal Water District. The Basin storage capacity is between 5 and 7 million acre-feet (AF), and the safe yield from over 800 active wells is more than 140,000 AF per year (AFY).

[124] Chino Basin Watermaster 2009.

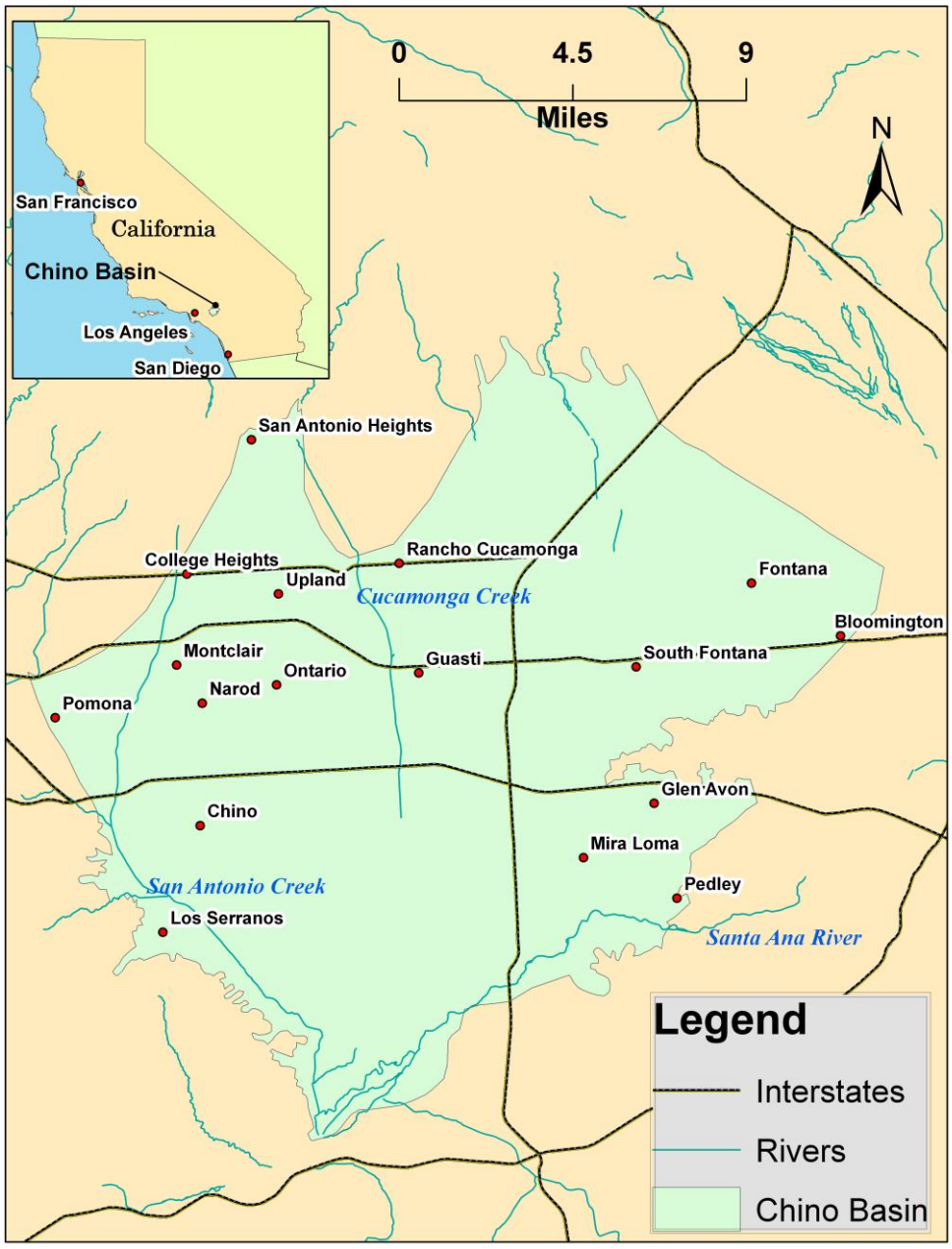


Figure 4.3.1. Chino Basin Boundary. [125]

[125] California Department of Water Resources 2009, United States Department of Interior 2010.

History of the Basin

Groundwater in the Chino Basin was used in the early and mid 20th century by urban water purveyors, dairy farmers, and irrigated agriculture. However, by the early 1970's, users in the basin were confronted with several water issues—a falling groundwater table, land subsidence (see Figure 4.3.2), and degraded groundwater quality due to high concentrations of dissolved solids and nitrate-nitrogen[126]. Use of the groundwater by agriculture, industry, business, and cities continued to increase with growing populations. Water extractors conducted studies in the early 1970s that led to a Memorandum of Agreement for the Chino Basin. The State Legislature then dedicated $2 per each AF pumped from the Basin to finance development of a Basin management plan and an agreement on the allocation of water rights among extractors. To complete the framework, Chino Basin Watermaster was established in 1977 under a Judgment by the Superior Court in San Bernardino County. Watermaster was charged with administering adjudicated water rights and managing groundwater resources within the Chino Groundwater Basin. According to the California Department of Water Resources (DWR), "[g]roundwater levels declined about 80 feet from historical high marks in the 1920s by 1980. By 2000, water levels had recovered about 20 feet."[127]

[126] California Department of Water Resources 2003
[127] CA Department of Water Resources 2003

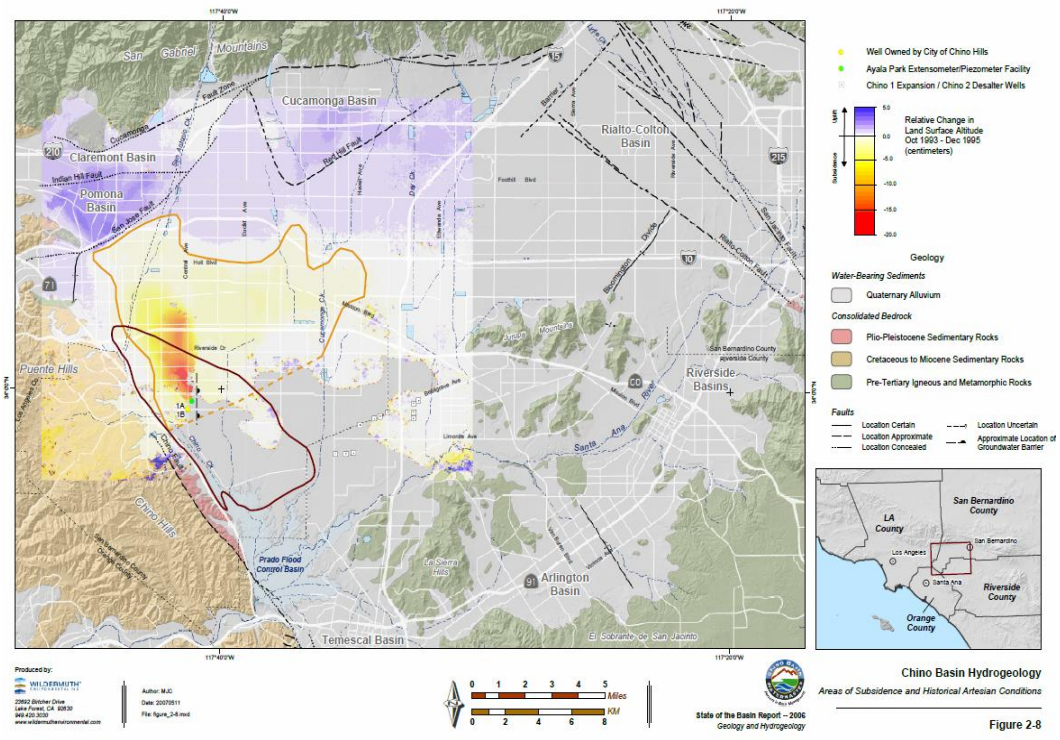


Figure 4.3.2. Land Subsidence in the Chino Basin. [128]

Adjudication

In 1974, parties "recognized the need for a cooperative solution [and] adopted a Memorandum of Agreement."[129] In 1975, Chino Basin Municipal Water District filed suit for adjudication against the City of Chino and others. The case of Chino Basin Municipal Water District v. City of Chino et al. (case no. SCV 16327/now RCV 51010) was extensive, but resulted in a fairly quick judgment in 1978.[130]

The 1978 Judgment limited groundwater extraction to the safe yield (estimated to be 140,000 AF per year). It divided stakeholders and water rights into three representative Pool Committees: overlying agriculture, overlying non-agriculture, and appropriators. Each of the Pool Committees then recommends actions to the Watermaster and oversees its activities. Any action that a Pool Committee disagrees with can be appealed to the trial Judge. The Watermaster is funded by assessments collected from the Pool Committees. It assesses the Operating Safe Yield, enforces water rights, and monitors groundwater levels, storage, and

[128] Wildermuth Environmental 2008
[129] Chino Basin Watermaster 2009
[130] Chino Basin Watermaster 2009

quality. Under the Judgment, members of the appropriative pool, consisting primarily of public water agencies, agreed to pay for all the costs associated with the overlying agricultural pool's extraction. In return, any unextracted water from the agricultural pool is directly transferred and allocated among the appropriators. All other inter-pool water transfers are prohibited.

A fundamental premise of the Judgment is that all Chino Basin water users are allowed to pump enough water from the Basin to meet their needs. Where pumping exceeds the share of the safe yield, the Watermaster assesses fees to replace the over-extraction. The Judgment recognizes that the Chino Basin contains significant groundwater storage capacity that can be utilized for storage and conjunctive use of supplemental water and basin waters; makes utilization of this storage subject to Watermaster control and regulation; and provides that any person or public entity, whether or not a party to the Judgment, may make reasonable beneficial use of the available storage, provided that no such use shall be made except pursuant to a written storage agreement with the Watermaster.[131]

After the adjudication, the actions of the Watermaster were controversial and often challenged by the separate interest groups. In 2000, interested parties drafted, and the Court approved, a 'Peace Agreement', creating the Optimum Basin Management Plan. An amendment to the Peace Agreement was entered in 2004.[132]

Basin Demographics

The Chino Basin covers over 235 square miles and provides water for over 700,000 residents. The Basin is located amid one of the fastest growing areas of Southern California. The area has undergone steady urbanization and population growth.[133]

Table 4.3.1 summarizes the population projections from the Southern California Association of Governments (SCAG) for the Chino Basin area by water purveyor. These projections indicate population in the Basin will increase by 2.6 percent per year, to 1,631,000 in 2020. The population in water service areas in the San Bernardino County portion of the basin are projected to increase the most rapidly.

[131] Wildermuth Environmental 2008
[132] Chino Basin Watermaster 2009
[133] Chino Basin Watermaster 2009

Table 4.3.1. Chino Basin Population Projections by water purveyor.[134]

Water Purveyor	1994	2000	2005	2010	2015	2020
Chino	57,491	67,072	78,170	90,744	103,244	113,874
Chino Hills	40,947	52,646	61,513	69,396	82,693	93,351
Chino Institution for Men	7,358	7,745	8,138	8,548	8,990	9,435
Cucamonga County WD	120,292	137,574	154,865	172,072	190,953	210,258
Fontana Water Co	109,483	131,681	153,909	176,967	197,703	224,058
Jurupa CSD	52,151	57,502	62,324	67,133	71,833	76,151
Marygold Mutual Water Co	9,888	11,114	11,888	12,868	14,168	15,712
Monte Vista WD	42,610	47,647	52,118	57,225	62,540	68,668
Norco	24,705	26,735	28,765	30,794	32,586	34,456
Not Served	179	443	785	1,107	1,365	1,612
Ontario	146,898	160,188	175,176	192,089	209,274	223,838
Pomona	136,418	153,616	165,356	175,362	186,532	202,133
Rialto	65,202	73,262	81,290	89,732	99,231	108,620
San Antonio Water Co	3,159	3,491	3,866	4,223	4,919	5,292
Santa Ana River Water Co	7,088	7,367	7,656	7,944	8,321	8,539
Southern California Water Co	34,020	35,206	36,031	36,734	37,514	38,600
Upland	67,558	71,121	74,793	78,636	82,828	86,942
West San Bernardino Co WD	45,967	57,820	70,162	82,534	94,548	109,091
Total	971,414	1,102,230	1,226,805	1,354,107	1,489,242	1,630,630
Percent Growth since 1994	0%	13%	26%	39%	53%	68%

The SCAG data project increases in total housing in the basin from 284,000 units in 1994 to 496,000 in 2020, a growth rate of 75 percent. However, average occupancy is projected to decrease slightly from 3.4 to 3.3 persons per dwelling unit. Employment is projected to increase from 316,000 jobs in 1994 to 702,000 jobs in 2020, a growth rate of 122 percent.[135]

Water Quality

Chino Basin groundwater is not only a critical resource to overlying extractors of water; it is a critical resource to the entire Santa Ana Watershed. From a regulatory perspective, the use of Chino Basin groundwater to serve potable demands is limited by drinking water standards, groundwater basin water quality objectives, and Santa Ana River water quality objectives.[136]

[134] Wildermuth Environmental 1999
[135] Wildermuth Environmental 2008
[136] Wildermuth Environmental 2006

Current Water Use

Total water use in the Chino Basin has risen over time from 225,000 AF in 1974-1975 to 299,883 AF in 2007-2008, as is shown in Table 4.3.2.

Table 4.3.2 Groundwater Extraction and Imports in the Chino Basin[137]

TOTAL WATER CONSUMPTION WITHIN THE CHINO BASIN[1]
(ACRE-FEET)

Fiscal Year	Chino Basin Extractions[2]	Other Imported Supplies[3]	Total
74-75	175,757	49,383	225,140
75-76	181,017	57,686	238,703
76-77	173,355	55,765	229,120
77-78	154,675	61,567	216,242
78-79	142,412 [4]	75,864	218,276
79-80	140,566	70,727	211,293
80-81	144,416	77,765	222,181
81-82	137,532	67,491	205,023
82-83	122,635	76,000	198,635
83-84	132,799	99,257	232,056
84-85	134,870	92,952	227,822
85-86	136,113	114,624	250,737
86-87	147,068	126,493	273,561
87-88	152,402	116,175	268,577
88-89	143,998	128,167	272,165
89-90	154,620	139,004	293,624
90-91	140,151	116,493	256,644
91-92	141,904	104,480	246,384
92-93	135,923	117,205	253,128
93-94	129,682	136,038	265,720
94-95	152,768	116,797	269,565
95-96	150,669 [4]	130,494	281,163
96-97	161,281 [4]	115,031	276,312
97-98	145,735	106,360	252,095
98-99	162,267	113,040	275,307
99-00	178,820	129,208	308,028
00-01	161,475 [4]	128,596	290,071
01-02	165,898	140,907	306,805
02-03	163,897	134,154 [4]	298,051
03-04	181,727	143,989	325,716
04-05	164,588	145,644	310,232
05-06	161,241	171,896	333,137
06-07	171,491	176,807 [4]	348,297
07-08	137,427	162,465	299,893

Agricultural Pool pumping has declined continually, as urbanization encroaches on agricultural land. In 2007/08, total extraction for the Agricultural Pool fell to 30,910 AF, the lowest extraction on record for the pool. Appropriative Pool extraction has tended to increase at approximately the same rate that Agricultural Pool extraction decreases (Figure 4.3.3).

[137] Chino Basin Watermaster 2009

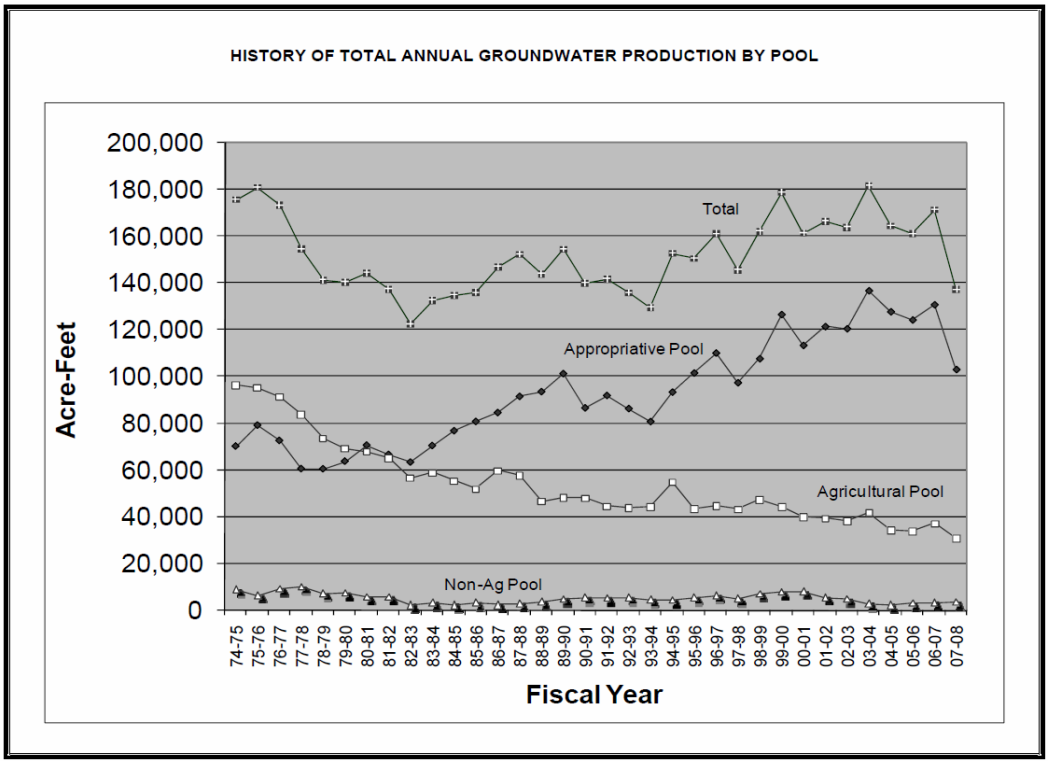


Figure 4.3.3. Groundwater Extraction in the Chino Basin. [138]

Supplemental Supplies

Appropriators supplement Chino Basin Groundwater with groundwater from other basins, surface diversions, imports from the San Bernardino Valley Metropolitan Water District (SBVMWD) and the Metropolitan Water District of Southern California (MWD), and with reclaimed water. These other sources are described below. Table 4.3.3 shows the quantities of other supplies used by members of the appropriative pool.

[138] Chino Basin Watermaster 2009

Table 4.3.3 Supplemental Supplies[139]

SUMMARY OF SUPPLEMENTAL SUPPLIES
FISCAL YEAR 2007-2008
(ACRE-FEET)

Member Agency	Other Basins	Surface Diversions	SBVMWD & MWDSC Imported Deliveries	Reclaimed Water	Total
Chino, City of	-	-	-	3,139.0	3,139.0
Chino Hills, City of	-	-	-	1,694.8	1,694.8
Cucamonga Valley Water District[1]	3,040.7	4,846.8	-	1,100.6	8,988.1
Inland Empire Utilities Agency[2]	-	-	-	1,174.1	1,174.1
Fontana Water Company[3]	22,903.9	6,419.4	-	-	29,323.3
Jurupa Community Services District[4]	891.6	-	-	31.4	923.0
Marygold Mutual Water Company[5]	821.1	-	-	-	821.1
MWDSC[6]	-	-	68,675.8	-	68,675.8
Monte Vista Water District	-	-	-	105.3	105.3
Ontario, City of	-	-	-	3,971.9	3,971.9
Pomona, City of[7]	4,366.1	2,292.4	2,530.4	-	9,188.9
San Antonio Water Company[8]	7,272.7	1,470.1	-	-	8,742.8
San Bernardino, County of	-	-	-	1,288.4	1,288.4
State of California, CIM[9]	-	-	-	1,166.0	1,166.0
Upland, City of[10]	9,926.0	2,095.0	-	239.9	12,260.9
West End Consolidated Water Company[11]	2,813.0	-	-	-	2,813.0
West Valley Water District[12]	8,188.8	-	-	-	8,188.8
Total	60,223.8	17,123.7	71,206.2	13,911.4	162,465.1

A number of the appropriators which extract groundwater from the Chino Basin obtain a portion of their water supplies from local surface water sources. These agencies include the: City of Pomona, City of Upland, Cucamonga County Water District, Fontana Water Company, San Antonio Water Company, West End Consolidated Water Company, and West San Bernardino County Water District. The principal surface water sources include San Antonio Canyon, Cucamonga Canyon, Day Creek, Deer Creek, Lytle Creek and several smaller surface sources. For the most part, these surface water sources are fully developed and usage is expected to remain at 16,000-17,000 AFY.[140]

Other local groundwater supplies represent a significant supplemental source of water for Chino Basin water agencies. Other groundwater supplies in the study area include the Claremont Heights, Live Oak, Pomona and Spadra Basins in Los Angeles County, the Riverside South and Temescal Basins in Riverside County,

[139] Chino Basin Watermaster 2009
[140] Wildermuth Environmental 2008

and the Colton-Rialto, Cucamonga, Lytle Creek Bunker Hill, and Riverside North Basins in San Bernardino County. These supplies may increase slightly in the future as additional wells are constructed. However, most of these sources are essentially fully developed. Descriptions of these groundwater basins were presented in the CBWRMS Final Report (1995). The aggregate supply from these basins is currently 63,000 AFT and is projected to be 76,000 AFY in 2020.[141]

Two regional agencies are responsible for imported water deliveries within the Chino Basin: MWD and SBVMWD. MWD obtains imported supplies from the Colorado River and the State Water Project (SWP). The demand for imported water purchased from Metropolitan for the Chino Basin is projected to increase from about 68,000 AFY in 1997 to 129,000 AFY by 2020, an increase of about 90% percent. The demand for replenishment water in the Chino Basin could reach 40,000 AFY by 2020 if reclaimed water is not used for replenishment or direct uses and water in local storage accounts is not available for use as replenishment.[142] SBVMWD is a wholesale water agency in the eastern part of the Chino Basin. SBVMWD is a SWP Contractor with a 102,600 AFY entitlement. The City of Rialto and West San Bernardino County Water District obtain water from SBVMWD through its Baseline Feeder that supplies Bunker Hill groundwater (included in other groundwater above).

There are several existing sources of recycled water in use within the Chino Basin study area. Current recycled water use in the basin is 13,911.4 AF.

Projections of future water demand indicate that approximately 40,000 to 50,000 AFY of Chino Basin groundwater extraction will incur a replenishment obligation. The replenishment obligation can be met by the recharge of imported and reclaimed water, in-lieu replenishment involving imported water, and from water in local storage accounts. In the long run, it is believed that the replenishment obligation of about 40,000 to 50,000 AFY will need to be met with imported and recycled water. However, trading of extraction could reduce the amount if imported water required. Tables 4.3.4 and 4.3.5 show the projected water demands by purveyor and projected water demand by source.

[141] Wildermuth Environmental 2008
[142] Wildermuth Environmental 1999

Table 4.3.4 Chino Basin Water Demand Projections by Purveyor[143]

Summary of Projected Water Demands by Purveyor
(acre-ft/yr)

Purveyor	2000	2005	2010	2015	2020
Ameron	9	9	9	9	9
City of Chino	14,800	17,250	20,000	22,800	25,150
City of Chino Hills	17,640	19,100	20,670	22,350	23,240
City of Norco	6,360	7,020	7,680	8,340	9,000
City of Ontario(a)	44,980	52,100	60,360	69,050	72,040
City of Pomona(a)	30,200	31,440	32,580	33,900	35,104
City of Upland	22,000	23,000	24,000	24,000	24,000
Cucamonga County Water District	49,910	54,440	58,960	63,480	68,000
Fontana Water Company	36,800	41,200	45,600	49,900	54,300
Jurupa Community Services District	14,550	17,550	19,550	22,820	25,820
Kaiser Ventures	670	0	0	0	0
Marygold Mutual Water Company	1,450	1,580	1,620	1,660	1,700
Mira Loma Space Center	25	25	25	25	25
Monte Vista Irrigation Company	270	230	0	0	0
Monte Vista Water District	14,160	14,160	14,160	14,160	14,160
San Antonio Water Company - Domestic	1,590	1,720	1,740	1,760	1,780
San Antonio Water Company - Non-Potable	2,510	2,630	2,740	2,870	2,750
San Bern. County Parks Dept.	75	75	75	75	75
San Bernardino Co Division of Airports - Domestic	300	300	300	300	300
Santa Ana River Water Company	2,000	2,090	2,120	2,140	2,170
Southern California Edison Company	3,300	3,300	3,300	3,300	3,300
Southern California Water Company	14,200	14,950	15,680	15,680	15,680
Sunkist	1,470	1,470	1,470	1,470	1,470
Swan Lake	350	350	350	350	350
West San Bernardino County WD	6,130	7,835	10,900	10,900	10,900
Others (Non-Ag)	2,682	2,682	2,682	2,682	2,682
Total Purveyor Demand	288,431	316,507	346,571	374,021	394,005
· Agricultural Producers	46,490	39,120	28,580	18,270	7,950
·(a) Recycled Water	8,300	8,300	8,300	8,300	8,300
Total Demand	343,221	363,927	383,451	400,592	410,255

Notes:
1 - SB County ag, CIM,and CIW included in the agricultural producers demand
2 - Mira Loma Space Center to be served by Jurupa Community Services District.
3 - Data from Chino Basin Water Resources Management Study Final Report, 1995
4 - Total Ag production from CBWCD and Watermaster Phase 1 Recharge Master Plan by Mark J. Wildermuth, Water Resources Engineers

Table 4.3.5 Projected Demand by Source[144]

Source	2000	2005	2010	2015	2020
Imported Water	62,090	77,720	103,170	117,510	125,224
Chino Basin Production Pools 2 and 3	148,630	157,891	156,511	168,502	180,191
Chino Basin Production Pool 1	46,490	39,120	28,580	18,270	7,950
Other Local Supplies	77,711	80,895	86,890	88,010	88,590
Recycled Water	8,300	8,300	8,300	8,300	8,300
Total	343,221	363,926	383,451	400,592	410,255

[143] Wildermuth Environmental 1999
[144] Wildermuth Environmental 2008

Existing Groundwater Market

The existing groundwater market in the Chino Basin is limited. Since only appropriators may trade, and unused agricultural overlying extraction is transferred directly to the appropriators, the market is fairly small, with only 5-10 trades occurring in any given year.

Trades occur for two reasons: to offset over-extraction, and to purchase water for storage and future use. Trades are conducted on an ad hoc basis. Potential traders wishing to purchase water have but to call around to the other water purveyors to find out who has extraction rights to transfer. With only 22 members of the appropriative pool, most of the purveyors have standing relationships, and are often in communication with trading partners for other purposes throughout the year. The Watermaster tracks transactions, but does not release the terms of any trades until the end of the year when the annual report for the basin is published. This withholding of transfer terms is at the request of the agencies, who, according to the Watermaster, do not desire transparency in the market.

The Watermaster has veto power over transactions. Trades are approved or denied after an analysis of physical or material injury resulting from the trade, and an assessment of negative effects on the basin or other parties. The Watermaster will usually not deny a transfer, but will place rules on the transfer to mitigate any harm to third parties. The Watermaster charges a nominal fee to cover its administrative costs, but this is extremely small relative to the value of the trades.

Hypothetical Market Implementation

Implementation of the PWS market would be extremely difficult given the existing legal structure within the basin. The trading pool would be limited to the appropriators, many of whom already have standing trading relationships. In addition, the appropriators do not desire transparency in the price of water transfers and would likely choose not to participate in the market.[145] The price of leasing water is currently less than the cost of replenishing water. In addition, low cost replenishment water from the MWD is projected to only be available in three out of every ten years in the future. Water purveyors in the basin will have to purchase water from MWD each year to make up any shortfalls based on their Tier 1 or Tier 2 contract rate. To simulate what the basin groundwater market for one-year leases might look like if basin users were amenable to the online market,

[145] Chino Watermaster 2009

two end-member price paths for basin groundwater were modeled. The true price path would likely fall within this range.

The upper bound was determined by finding the average rate of increase in MWD Tier 1 untreated full service water. Most of the purveyors in the basin have Tier 1 contacts with MWD and would be able to make up any shortfall by purchasing this water. However, to avoid this highest cost water, each purveyor would be willing to pay up to this amount, less pumping costs, to reduce the cost of marginal water. For this sake of this hypothetical exercise, pumping costs are excluded. A rough estimate of pumping costs is approximately $13/AF, with electric rates of $0.07/kWh. This amount is negligible relative to the high value of MWD water. To estimate the lower bound, the median value of groundwater transactions in the basin since 2000 was assumed to increase at the real rate of energy costs each year, approximately 2.7 percent.[146] The prices shown in Figure 4.3.4 are normalized to 2009 dollars.

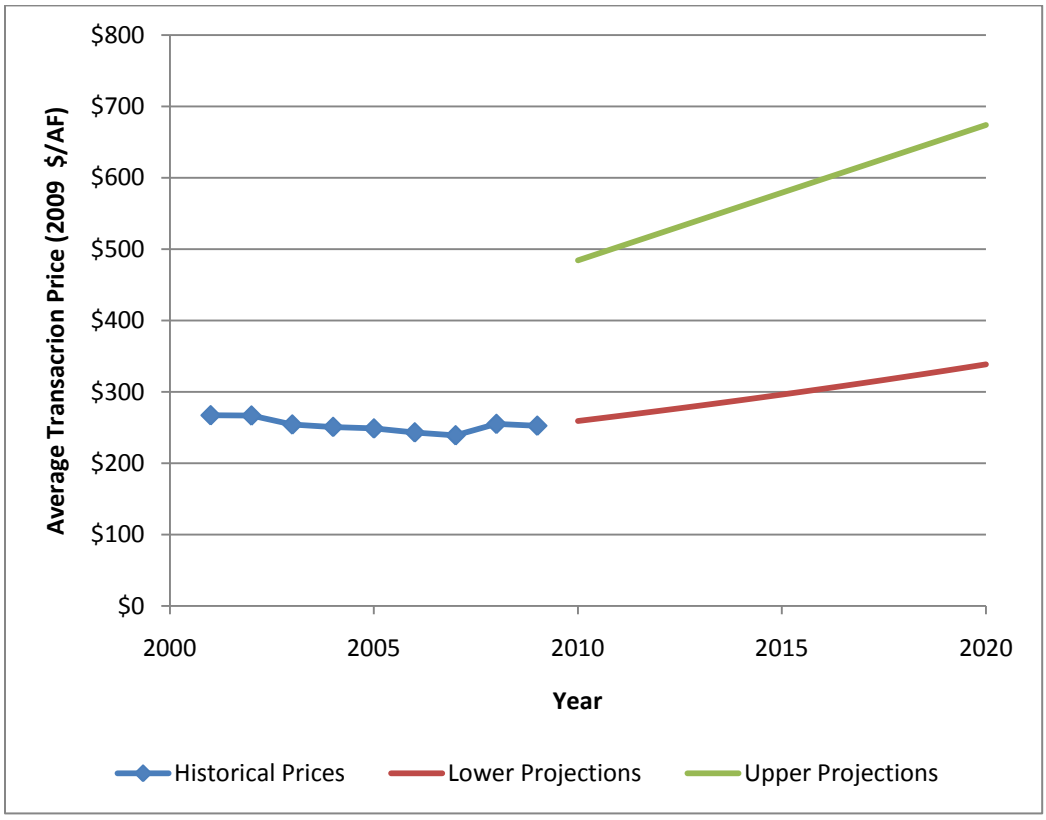


Figure 4.3.4. Historical and Projected Average Transaction Price for One-Year Leases

[146] United States Energy Information Administration 2010

The volume of water transferred would also likely increase over time, as the market becomes established and trusted as a resource for increasing the groundwater portion of a supply portfolio. The market in Chino is currently inefficient, with not all potentially beneficial transfers taking place. To project future volume traded we assumed that the H_2O Exchange would correct the inefficiency in the existing Chino Basin transfer market within ten years. It would do this by providing a central marketplace for all buyers and sellers, facilitating transfers that are easy and convenient for market participants, revealing the value of groundwater relative to other water sources, and revealing the value of participation in the market. Projected volume is shown in Figure 4.3.5.

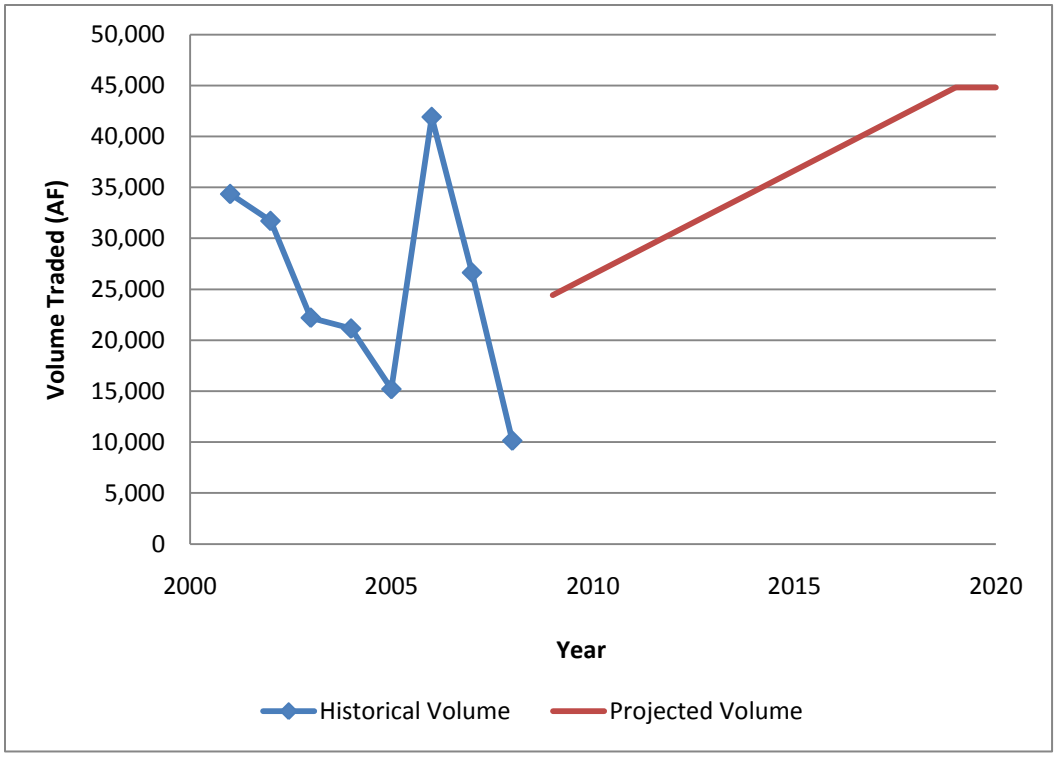


Figure 4.3.5. Historical and projected average annual volume traded.

Conclusion

As stated previously, these estimates are a hypothetical scenario of what the market might look like if implementation was possible. While it is unlikely that the H_2O Exchange would work in the Chino Groundwater Basin, this case study does yield some important lessons. It demonstrates that the structure of the adjudication, the volume of adjudicated rights, and the number of rights holders

who are able to trade are key factors which will impact the success of the H_2O exchange in California groundwater basin.

References

California Department of Water Resources. Shape file "B118v3NAD27UTM10". Division of Mines and Geology. 2010. http://www.water.ca.gov/groundwater/bulletin118/gwbasin_maps_descriptions.cfm (accessed January 10, 2010).

CA Department of Water Resources. "Chino Groundwater Basin." Retrieved from, http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/8-2.01.pdf.

Chino Basin Watermaster. Thirty First Annual Report. 2009.

Osugi, Doug, Robert Swartz, and Carl Hauge. "California's Groundwater - Bulletin 118, Update 2003." Groundwater Information Center. Sacramento: California Department of Water Resources. 2003. http://www.water.ca.gov/groundwater/bulletin118/bulletin118update2003.cfm (accessed February 10, 2009).

United States Department of Interior. National Atlas Dataset. 2009. http://nationalatlas.gov/atlasftp.html (accessed January 12, 2010).

United States Energy Information Administration. "Average Retail Prices of Electricity: 1960-2008." January 2010. <http://www.eia.doe.gov/emeu/aer/txt/ptb0810.html>.

Wildermuth Environmental. Optimum Basin Management Program Phase I Report. 2008. August.

Wildermuth Environmental. "Chino Basin Optimum Basin Management Program, 2006 State of the Basin Report." 2006. June.

Wildermuth Environmental. "Chino Basin Optimum Basin Management Program, Final 2008 State of the Basin Report." 2008. December.

4.4 Santa Paula Basin

Introduction

The Santa Paula Groundwater Basin is located in Ventura County in southern California (Figure 4.4.1). The basin is bordered on the West by the Pacific Ocean, and encompasses the cities of Santa Paula and Saticoy. The groundwater in the basin is mostly used for agriculture, but there is a rapidly expanding urban population.

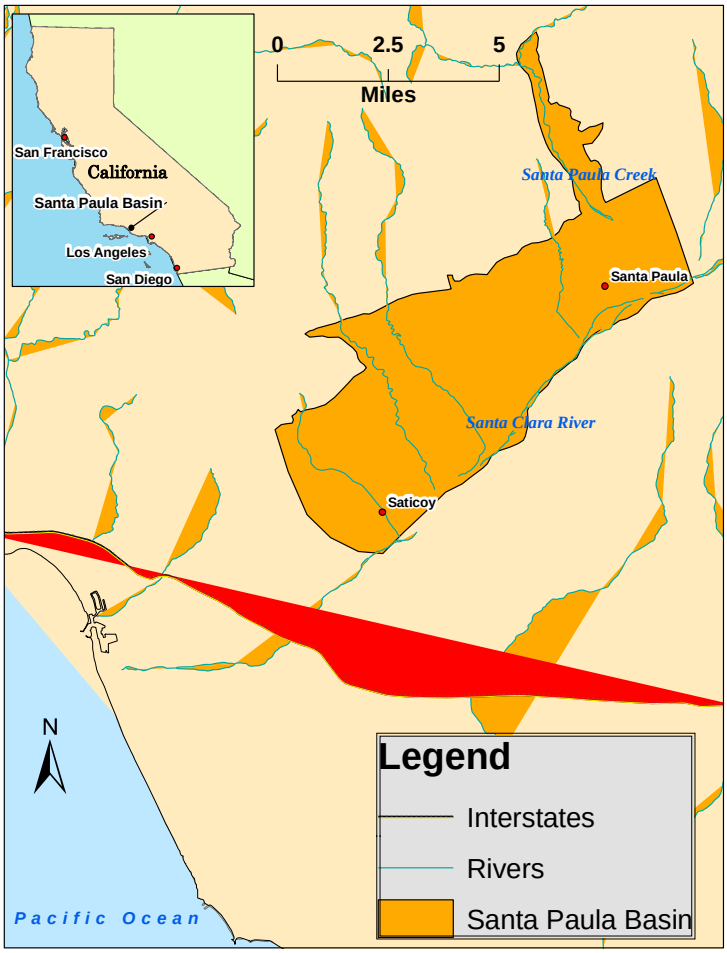


Figure 4.4.1. Santa Paula Basin Boundaries.[147]

[147] California Department of Water Resources 2010, United States Department of Interior 2009

Current Basin Statistics

Number of users	Originally 75 users were party to the adjudication; now 74[148]
Parties to Adjudication	Originally 75 users were party to the adjudication; now 74[149]
Year of adjudication	1996[150]
Watermaster	Technical Advisory Committee consisting of representatives from the Santa Paula Basin Pumpers Association, United Water Conservation District, and the City of Buenaventura. The Santa Paula Basin Pumpers Association handles transfers, extraction monitoring, and other administrative duties. The United Water Conservation District handles monitoring and water replenishment.
Court-allocated yield (Adjudicated Rights)	Initially 33,500 acre-feet per year (AFY), adjusted annually by the Watermaster[151]
Sustainable yield	Unknown
Size (acres)	22,800 acres[152]
Demographics	Mostly agricultural, except for the town of Saticoy and the City of Santa Paula
Overdraft	Not currently believed to be in critical overdraft, but the United Water Conservation District predicts problems in the future
Seawater intrusion	No
Land subsidence	No
Water agencies in basin	United Water Conservation District, Santa Paula Pumpers Association, Santa Paula Groundwater Basin Watermaster, Ventura County Department of Public Works

History of the Basin

The Santa Paula Basin encompasses the City of Santa Paula and the unincorporated town of Saticoy. The remainder of the basin has been used for

[148] Santa Paula Pumpers Association 2008
[149] Santa Paula Pumpers Association 2008
[150] California Department of Water Resources 2003
[151] California Department of Water Resources 2004
[152] California Department of Water Resources 2003

irrigated agricultural for many years.[153] Historically, groundwater supplied most of the water for agricultural, industrial, and municipal uses.

The Basin experienced drawdown of the aquifer in the 1990s.[154] Overall, however, groundwater extraction has remained fairly constant (Figure 4.4.2).

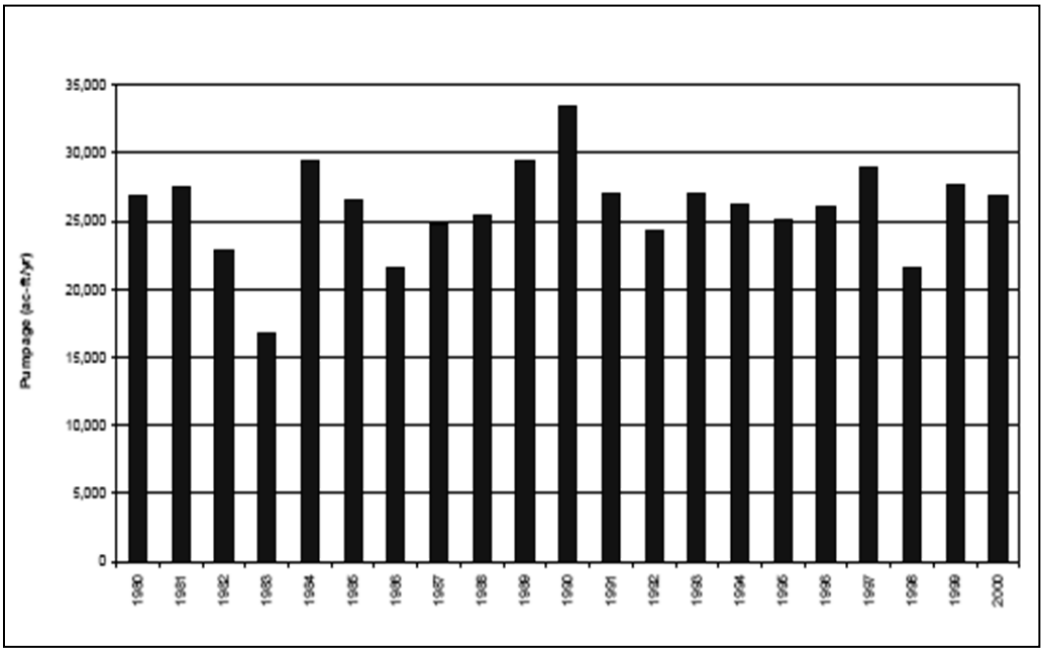


Figure 4.4.1. Santa Paula Basin Experts Group. Average groundwater extraction is slightly less than 26,000 acre-feet per year.[155]

In recent years, groundwater use has begun to increase and experts predict further utilization in the future. Nevertheless, the basin has not experienced critical overdraft, saline intrusion, or land subsidence. The basin is managed very closely because of the region's economic dependence on groundwater supply.

Adjudication

In the early 1990s, the City of Ventura expressed an intention to increase groundwater pumping in the Santa Paula Basin. The Basin was already experiencing drawdown of the aquifer and the United Water Conservation District was concerned about the impact of increased groundwater extraction on local

[153] Santa Paula Pumpers Association 2008
[154] California Department of Water Resources 2003
[155] Santa Paula Pumpers Association 2008

agriculture.[156] Consequently, they filed for adjudication in 1991, and the Stipulated Judgment was entered at the Ventura County Superior Court in 1996.[157]

The Judgment appointed a Watermaster comprising a Technical Advisory Committee. The committee consists of representatives from the United Water Conservation District, the City of Buenaventura, and the Santa Paula Basin Pumpers Association (an association of agricultural water users in the Santa Paula Basin).[158] The Judgment also specifies the application of the 'Modified Hill Method' and comparison of the change in groundwater levels over a base period for determining the yield of the basin and thus each rights holder's yearly groundwater allowance. The Santa Paula Technical Advisory Committee uses both methods for monitoring the groundwater levels in the basin. In the Santa Paula Basin Experts Group's 2003 report, they report that better monitoring is needed to fully understand the groundwater level dynamics of the basin.[159]

The Santa Paula Basin Pumpers Association handles groundwater transfers, extraction monitoring, and other administrative duties. In the case of extraction over a rights holder's allowance, the Santa Paula Basin Pumpers Association collects fines per acre-feet illegally extracted. The United Water Conservation District handles groundwater monitoring and water replenishment. They also manage surface water supply. Well owners pay pump charges to United Water.

The Judgment set a safe yield of 33,500 AFY. The Santa Paula Basin Experts Group estimates the safe yield to be approximately 26,000 AFY. Total current pumping rates do not generally exceed 26,000 AFY. However, extraction rates are predicted to increase significantly in the near future as agricultural demand increases and urban populations continue to grow.[160]

Existing Water Use

As discussed above, average extraction remains at approximately 26,000 AFY. However, the amount of over-extraction has been increasing in recent years, and the amount of under-extraction has been decreasing. Not only is this indicative of increased water use, it suggests water use changes that will result in continued

[156] California Deparment of Water Resources
[157] Santa Paula Pumpers Association 2008
[158] California Department of Water Resources 2004
[159] Santa Paula Pumpers Association 2008
[160] Frank Brommenschenkel 2009

future demand for increased water supply.[161] Groundwater remains the largest source of water in the basin.

In general, the groundwater is high quality. The Total Dissolved Solids (TDS) and sulfate concentrations sometimes exceed the secondary drinking water standards, although they do meet agricultural standards. These concentrations do not preclude groundwater from future urban use, but would necessitate increased treatment before use. The TDS and sulfate concentrations vary geographically—they are both lower in deeper portions of the aquifer.[162]

Rights utilization varies among groundwater users. There has been both over-extraction and under-utilization each year since the adjudication (Figure 4.4.3).

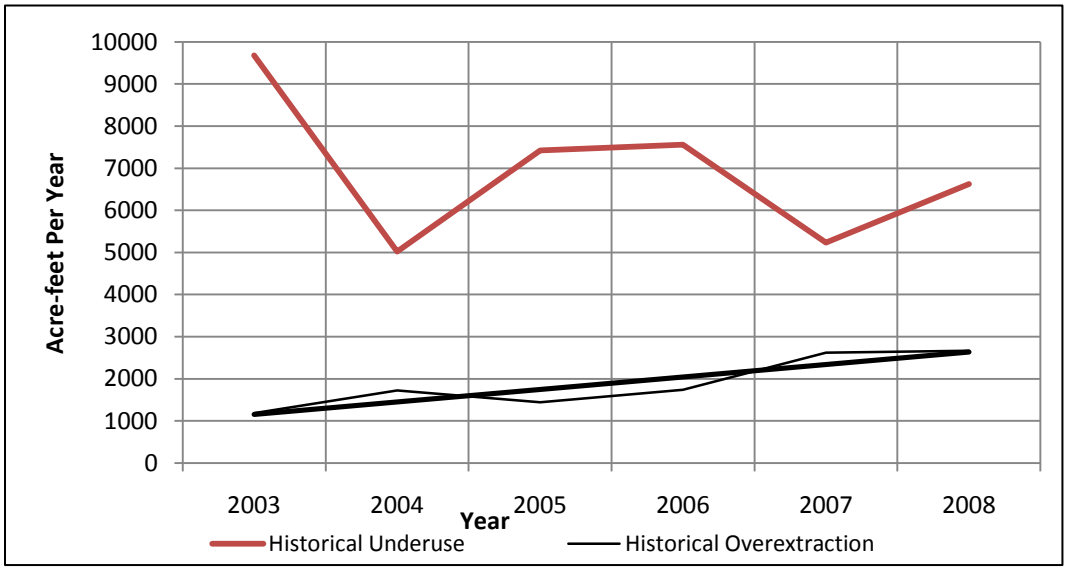


Figure 4.4.2. Groundwater rights usage in the Santa Paula Basin from 2002 to 2008. [163]

Groundwater use in the Santa Paula Basin is not efficient; there are currently 74 rights holders party to the Judgment. Of those rights holders, 39 regularly extract more than their yearly allowance and 35 regularly extract less.[164] Furthermore, there is no management structure for reallocation of groundwater rights as demand increases. Most studies focus on the importation of State Water Project

[161] United Water Conservation District 2007
[162] Santa Paula Pumpers Association 2008
[163] Santa Paula Pumpers Association 2008
[164] Santa Paula Pumpers Association 2008

(SWP) water or changes in surface water use to meet higher demand in the future.[165,166]

Existing State of the Market

The Santa Paula Basin groundwater market is very nascent. There have only been three rights transfers since adjudication, all of them permanent transfers. Despite a significant portion of rights holders that over-extract and pay fines each year, short-term transfers have not taken place.[167] Tensions run high in the basin; a third party could help facilitate the formation of an active market.

Initial Implementation of the H_2O Exchange

In 2008, each party to the Judgment either over-extracted groundwater or under-utilized their groundwater right. The total volume of over-extraction was 2,664.32 AF. The total volume of under-utilization was 6,622.81 AF. In the initial implementation of the H_2O Exchange, 2,664 AF could be transferred per year. All of the users currently over-extracting would have incentive to trade. Approximately 40% of the users currently under-utilizing would have incentive to trade.

Projections

Price

To project future groundwater prices, we calculated upper and lower price bounds (Figure 4.4.4). For the upper bound, we determined the trend in Metropolitan Water District of Southern California (MWD) agricultural replacement water prices, normalized the prices to 2009 dollars, and projected the prices forward at the historical linear price increase trend. For the lower bound, we took the average annual percent increase in US electricity price to be 2.7%. We then took the median short-term groundwater transfer price of Mojave Basin, Chino Basin, and West Coast Basin as a proxy for short-term transfer prices in the Santa Paula Basin and projected it forward at the rate of increase in electricity prices. Thus, our equation was: $Lower\ Bound\ Price = Median\ Water\ Price \times 1.027^t$, where *t* is nth future year

[165] United Water Conservation District 2007
[166] United Water Conservation District 2007
[167] Frank Brommenschenkel 2009

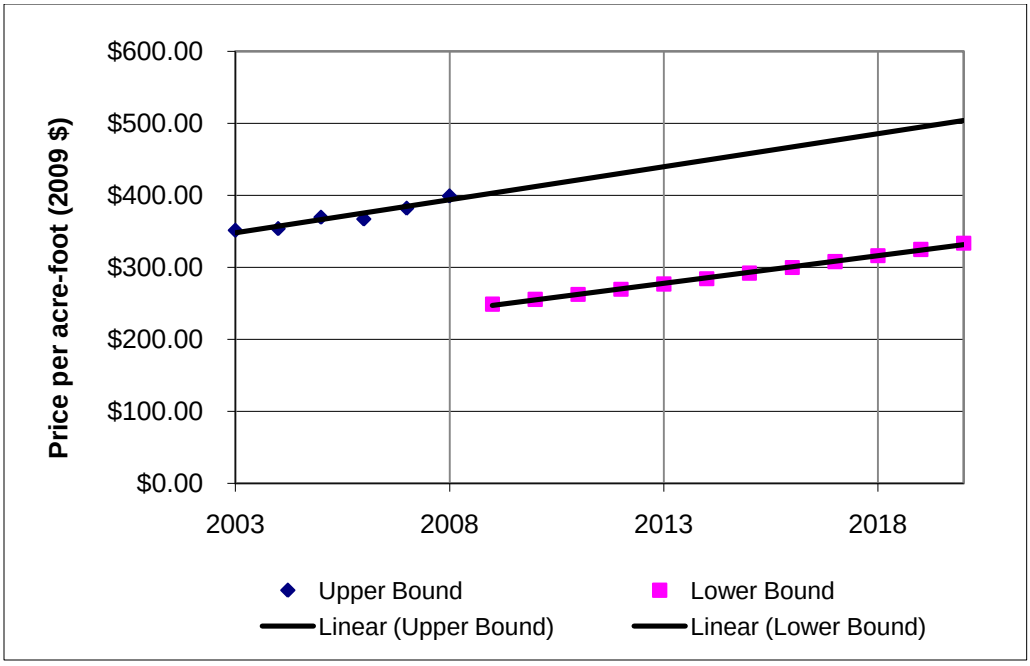


Figure 4.4.3. Santa Paula Basin Groundwater Price Projections.

Volume

To project the volume that will likely be traded, we graphed historical over-extraction and calculated the historical trend. We then projected the over-extraction of groundwater in the basin forward through time. We assumed that the amount of over-extraction is the total excess demand for groundwater. We assumed that by year 12 of operation of the H_2O Exchange, we would capture 100% of the demand for groundwater. For a lower bound, we assumed that we would capture 80% of the demand. We assumed linear increases in participation (increments of $1/12^{th}$ of the total demand) over 12 years. We also assumed that there would be no increase in demand for groundwater due to the availability of the H_2O Exchange or decreased available volume of surface water, so we determined that both projections are conservative. Therefore, we used the upper bound volume projection (Figure 4.4.5).

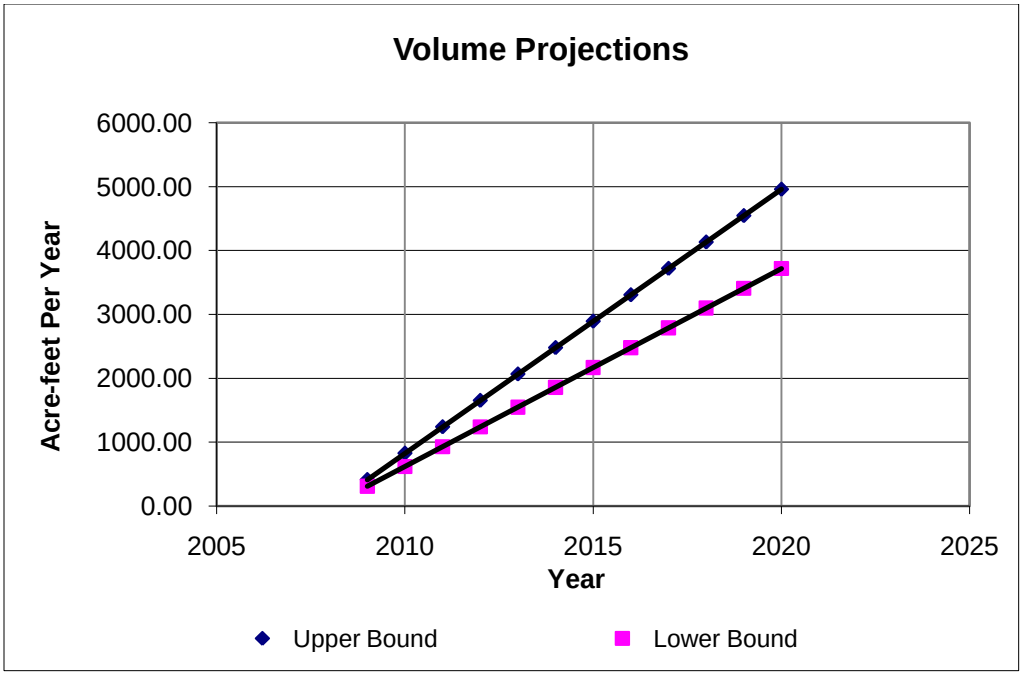


Figure 4.4.4. Santa Paula Basin Volume Traded Projections.

Evolution of the Market

The Santa Paula Groundwater Basin shows promise in evolving into a long-term market. Changing agricultural demands and increasing urban population will increase demand for groundwater and increase demand for ways to access and obtain groundwater rights. Permanent transfers might reduce the total amount of groundwater available for trade, but Santa Paula Basin has many agricultural users that show no sign of selling their land. Thus, a strong market will likely continue to exist into the foreseeable future.

References

California Department of Water Resources. Shape file "B118v3NAD27UTM10". Division of Mines and Geology. 2010(a). http://www.water.ca.gov/groundwater/bulletin118/gwbasin_maps_descriptions.cfm (accessed January 10, 2010).

California Department of Water Resources. "Santa Paula Valley Groundwater Basin." Retrieved from, http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/4-4.04.pdf.

California Department of Water Resources. "Water Facts No. 3." 2004. Retrieved from, http://www.dpla2.water.ca.gov/publications/waterfacts/water_facts_3.pdf. 9-11-2009.

US Department of Interior. National Atlas Dataset. 2009. http://nationalatlas.gov/atlasftp.html (accessed January 12, 2010).

. Brommenschenkel Frank. Personal Communication. Santa Paula Pumpers Association. 11-5-2009.

Santa Paula Pumpers Association. "Appendix D Table 1: Pumpage and Allocations 2008." 2008.

United Water Conservation District. "Water Management Plan." 2007. Retrieved from, http://www.unitedwater.org/index.cfm?go2=waterplan. 3-19-2010.

4.5 Pajaro Groundwater Basin

Introduction

The Pajaro Groundwater Basin is an unadjudicated 120-square mile basin on the central California coast (Figure 4.5.1). The Pajaro Basin is listed by the DWR Bulletin 118-80 as one of 11 critically overdrafted basins in California.[168] Water demand by agricultural users and growing urban populations in the basin is continually increasing. Groundwater provides over 95% of water used in the Pajaro basin, and about 85% of groundwater goes to agricultural uses. The land overlying the basin is predominantly used to grow crops such as lettuce, strawberries, other berries, apples, and nursery plants.[169] Chronic overdraft through excessive groundwater pumping has resulted in aquifer depletion and seawater intrusion along the coast. Since 1964, the basin has lost approximately 100,000 acre-feet (AF) of groundwater supply to overdraft and approximately 200,000 AF to seawater intrusion.[170] The magnitude of groundwater lost to overdraft and seawater intrusion is significant, as groundwater pumping currently provides approximately 69,000 acre-feet per year (AFY) (Figure 4.5.2).[171]

[168] PVWMA 2009
[169] Bannister 2009
[170] Osugi et al. 2003
[171] PVWMA 2002

Figure 4.5.1. Location of the Pajaro Groundwater Basin in California. [172]

[172] California Department of Water Resources 2010, United States Department of Interior 2009

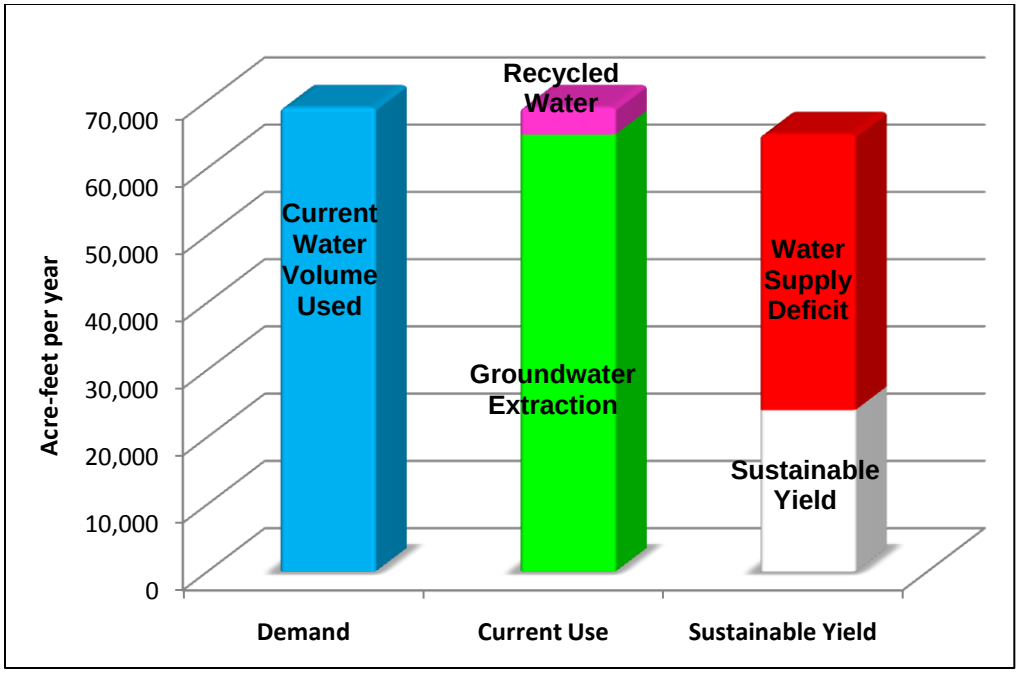


Figure 4.5.2 Current water use statistics in the Pajaro Groundwater Basin.

Groundwater Management in the Pajaro Basin

Water resources in the basin are managed by the Pajaro Valley Water Management Agency (PVWMA). PVWMA was created in 1984 through a special act of the California Legislature and was granted authority to limit groundwater extraction in the basin. PVWMA was mandated by the state to "efficiently and economically manage existing and supplemental water supplies in order to prevent further increase in, and to accomplish continuing reduction of, long-term overdraft and to provide and insure sufficient water supplies for present and anticipated needs within the boundaries of the agency."[173] PVWMA is also directed by the state to prioritize agricultural water use in the basin. Though PVWMA has the legal authority to limit groundwater extraction, restricting pumping rights is politically unfavorable, and PVWMA has thus far focused on augmenting groundwater supply with external water sources.

In its 2002 Revised Basin Management Plan (BMP), PVWMA used the Pajaro Valley Integrated Ground and Surface Water Model to estimate the sustainable yield of the groundwater basin. The estimated sustainable volume of water that could be pumped from the basin is 24,000 AFY. To provide the additional water

[173] California Water Code Appendix 2006

demanded by PGB users, PVWMA adopted several water supply augmentation projects. A Coastal Distribution System (CDS) was constructed to deliver water to coastal farmers impacted by seawater intrusion. The Recycled Water Project, which recycles water from the local wastewater treatment plant for crop irrigation, was completed in March of 2009 and will provide 4,000 AFY to coastal farmers through the CDS. The Harkins Slough Project was intended to supply 1,200 AFY, but that augmentation has not occurred due to a leak in the storage basin. The Central Valley Project was intended to supply 13,400 AFY of imported water through the CDS, but the project was scrapped due to insufficient funds and the strain on the Sacramento-San Joaquin Delta that this project would create.[174,175] Since many of the supply augmentation projects have been unsuccessful, excessive groundwater pumping continues to occur.

Legal Constraints on Effective Groundwater Management

In order to pay for the projects completed, PVWMA levied an augmentation fee on agricultural users in the PGB. PVWMA was sued over the fee because the manner in which it was levied did not satisfy the requirements of the Assessment and Property-Related Fee Reform amendment of the California Constitution, Proposition 218 (Prop. 218). According to this amendment, all property owners who would be subject to the fee must be notified of the proposed fee by mail, a public hearing must be held, and the fee must be approved by a majority vote of the affected property owners.[176] As a result of the litigation, PVWMA must refund users who paid the augmentation fee. Already operating under a very tight budget, the court-ordered refund further limits PVWMA's funds available for water projects and general operations.

Due to its budgetary constraints, PVWMA has approximately one year to develop a revenue-generating mechanism and begin to halt overdraft before bankruptcy becomes an imminent threat. PVWMA is currently developing a tiered pricing structure for groundwater extraction to generate revenue. Under the tiered pricing structure, light users who pump little groundwater would pay a low extraction rate per AF and heavier users would pay increasingly higher extraction rates at each successive increment of extraction volume and price tier. This management strategy would provide funds for PVWMA to continue operations as well as create an incentive for heavy users to reduce their volume of extraction. At this

[174] Bannister 2009
[175] PVWMA 2002
[176] California Constitution 2009

time, PVWMA is holding meetings with stakeholders to incorporate their feedback into the pricing structure. Ultimately, the pricing structure must have enough stakeholder support to satisfy a Proposition 218 vote.[177]

PVWMA faces a challenge in passing the tiered pricing structure under Proposition 218, and if the tiered structure does not pass, the basin may undergo adjudication. Almost all constituents in the Pajaro Basin want to avoid adjudication because they expect the adjudication process to be extremely expensive and lengthy, and they fear unfair reductions in groundwater pumping rights.[178] At public meetings to discuss possible rate scenarios, a common phrase concerning adjudication was, "we don't want to give all our money to the lawyers."[179] Many of the agricultural water users would resent having their groundwater pumping rights limited by a court. Finding ways to manage groundwater use in the Pajaro Basin has been very contentious thus far, and the adjudication process would likely be even more divisive. [180]

An additional difficulty in undergoing adjudication in the Pajaro Basin is the lack of alternative water sources. The basin cannot receive imported water from the State Water Project or any other outside source.[181] Thus, it would be very difficult to satisfy the 'physical solution' requirement for adjudication and ensure that all users receive sufficient water resources once groundwater pumping is limited. As things stand now, the PGB cannot adjudicate without redefinition of adjudication case law—a difficulty that many central and northern groundwater basins without access to imported water face (see Appendix 2).

Opportunity for PWS

The complex conditions in the Pajaro Basin (and other similar basins) provide an excellent opportunity for PWS' consulting services. PWS could present PVWMA and/or other interested stakeholders in the basin with a plan for implementing the H_2O Exchange upon adjudication to satisfy the 'physical solution' requirement and enable adjudication. The use of the H_2O Exchange as the 'physical solution' would provide flexibility and reliability for farmers and other water users, and diffuse tension among stakeholders with a politically-neutral market solution.

[177] PVWMA Ad Hoc Funding Committee 2009
[178] Lyons 2010
[179] PVWMA Public Information Meeting No. 2 2009
[180] PVWMA Board Meeting Minutes 2009
[181] Lyons 2010

PWS would demonstrate to stakeholders that the definition of their rights via adjudication would not necessarily lock them into a particular quantity of rights because they could trade rights through the H_2O Exchange. An initial allocation of groundwater rights that may be perceived unfair by some rights holders could easily be changed. Thus, by garnering stakeholder support, PWS could contribute to a less expensive, less time-intensive adjudication in the Pajaro Basin.

PWS would obtain a consulting fee of $50/hour from PVWMA and any other stakeholders interested in our consulting services. PWS would also receive the brokerage fees from transfers through the H_2O Exchange once adjudication is complete and market activity can commence (see Appendix 5).

References

Bannister, Mary. Personal communication. April 27, 2009.

California Constitution. "Assessment and Property-Related Fee Reform." Article 13D.

California Department of Water Resources. Shape file "B118v3NAD27UTM10". Division of Mines and Geology. 2010. http://www.water.ca.gov/groundwater/bulletin118/gwbasin_maps_descriptions.cfm (accessed January 10, 2010).

California Water Code Appendix. "Chapter 124 Pajaro Valley Water Management Agency Act." 124-102(f). 2006. http://www.pvwma.dst.ca.us/about_pvwma/assets/ Agency%20Act2006.pdf (accessed Apr 27, 2009).

Lyons, Jessica. "Supervisors the Hold Pajaro Basin Water Study Session." *The Post* 12, no. 3 (2010).

Osugi, Doug, Robert Swartz, and Carl Hauge. "California's Groundwater - Bulletin 118, Update 2003." Groundwater Information Center. Sacramento: California Department of Water Resources. 2003. http://www.water.ca.gov/groundwater/bulletin118/ bulletin118update2003.cfm (accessed February 10, 2009).

Pajaro Valley Water Management Agency. "Revised Basin Management Plan." 2002. http://www.pvwma.dst.ca.us/basin_management_plan/ bmp_documents.shtml#bmpdocuments (accessed Mar 15, 2009).

Pajaro Valley Water Management Agency Ad Hoc Funding Committee. "Alternative C." May 11, 2009. Ad Hoc Funding Committee Meeting. Watsonville, CA.

PVWMA Board Meeting Minutes. November 4, 2009. Watsonville, CA.

PVWMA Public Information Meeting No. 2. June 10, 2009. Watsonville, CA.

United States Department of Interior. National Atlas Dataset. 2009. http://nationalatlas.gov/atlasftp.html (accessed January 12, 2010).

Appendix 5: Financial Analysis

To conduct our financial analysis, we calculated revenue projections from each of case studies to generate our statements. We also assumed that we would expand into other adjudicated markets, and categorized other adjudicated basins as similar to each of our case study basins. Please see the sections below for our categorization methods and financial statements.

Revenue Projections

To calculate the revenue projections for PWS, we multiplied the upper bound volume projections by the lower and upper bound price projections to calculate total projected market value for each case study basin. We then calculated our revenue by taking a 2% brokerage fee of the market value.

Adjudicated Basin Categorization

In order to project PWS' financial statements, we assumed that PWS would initiate markets in the three case study basins that could support a market (Mojave, West Coast, and Santa Paula Basins), and then begin to expand into the other nine adjudicated California groundwater basins that will support the H_2O Exchange.

First, we characterized all adjudicated basins (including our case study basins) by the number of parties in the basin who are eligible to trade groundwater rights, the total volume of Adjudicated Rights in the basin available to be traded, and whether an informal market currently exists in the basin (Table 5.1). We then categorized each basin as capable of supporting a small market, medium market, large market, or no market (Table 5.2). We characterized small markets such as Santa Paula Basin as having less than 35,000 acre-feet per year (AFY) of Adjudicated Rights and no existing groundwater market. We characterized medium markets such as West Coast Basin as having less than 65,000 AFY of Adjudicated Rights, fewer than 100 rights holders, and/or an existing groundwater market. We characterized large markets such as Mojave Basin as having more than 70,000 AFY of Adjudicated Rights, over 100 rights holders, and/or an existing groundwater market. Finally, we characterized 'no market' basins such as Chino Basin as having fewer than 50 rights holders, very few Adjudicated Rights, or legal structures incompatible with the H_2O Exchange.

We assumed that each basin would have the same revenue projections as the case study basin in the same category.

Table 5.1 Basin characterization for implementation of H2O Exchange.

Basin Number	Basin	Number of parties	Adjudicated Rights (AF)
1	Cucamonga	3	22,721
2	Puente	5	1,666
3	Upper LA River Area	5	97,820
4	Seaside	13	2,581
5	Raymond	16	33,622
6	Chino	17	78,000
7	Warren Valley	19	900
8	West Coast	26	30,000
9	Beaumont	35	8,650
10	Goleta	45	2,350
11	Tehachapi	65	5,500
12	Santa Paula	74	33,500
13	Central	140	217,367
14	San Gabriel	190	152,700
15	Mojave	475	180,000
16	Scott River Valley	684	24,300
17	Santa Maria Valley	1,000	70,000
18	Western San Bernardino	4,000	232,100
19	Brite	not adjudicated	500
20	Cummings	not adjudicated	4,090
21	Santa Margarita	unknown	unknown
22	Six Basins	unknown	19,300

Table 5.2 Basin characterization by expected market size.

Large Market	**Small Market**	**Medium Market**	**No Market**
Mojave	Santa Paula	West Coast	Chino
San Gabriel (M_1)	Scott River Valley (SP_1)	Raymond (WC_1)	Upper LA River Area (C_1)
Santa Maria Valley (M_2)	Tehachapi (SP_2)	Seaside (WC_2)	Cucamonga (C_2)
Western San Bernardino (M_3)	Beaumont (SP_3)		Puente (C_3)
Central (M_4)			Goleta (C_4)
			Warren Valley (C_5)

The following five tables summarize PWS' financial projections to year 2020.

Financial Projections

Table 5.3 Water Market Division and Revenue Projections

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Market # 1	*Mojave*	*Mojave*	*Mojave*	*Mojave*	*Mojave*	*Mojave*	*Mojave*	*Mojave*	*Mojave*	*Mojave*	*Mojave*
PWS Fee	$477,710	$515,079	$553,727	$593,653	$634,858	$677,341	$721,103	$766,144	$812,463	$860,061	$895,135
Market # 2		*Santa Paula*	*Santa Paula*	*Santa Paula*	*Santa Paula*	*Santa Paula*	*Santa Paula*	*Santa Paula*	*Santa Paula*	*Santa Paula*	*Santa Paula*
PWS Fee		$8,529	$13,077	$17,816	$22,744	$27,861	$33,169	$38,666	$44,352	$50,229	$56,295
Market # 3		*West Coast*	*West Coast*	*West Coast*	*West Coast*	*West Coast*	*West Coast*	*West Coast*	*West Coast*	*West Coast*	*West Coast*
PWS Fee		$62,550	$70,890	$79,670	$88,892	$98,556	$108,661	$119,207	$130,194	$141,623	$153,493
Market # 4			*WC_2*	*WC_2*	*WC_2*	*WC_2*	*WC_2*	*WC_2*	*WC_2*	*WC_2*	*WC_2*
PWS Fee			$62,550	$70,890	$79,670	$88,892	$98,556	$108,661	$119,207	$130,194	$141,623
Market # 5			*M_1*	*M_1*	*M_1*	*M_1*	*M_1*	*M_1*	*M_1*	*M_1*	*M_1*
PWS Fee			$477,710	$515,079	$553,727	$593,653	$634,858	$677,341	$721,103	$766,144	$812,463
Market # 6				*M_2*	*M_2*	*M_2*	*M_2*	*M_2*	*M_2*	*M_2*	*M_2*
PWS Fee				$477,710	$515,079	$553,727	$593,653	$634,858	$677,341	$721,103	$766,144
Market # 7				*M_3*	*M_3*	*M_3*	*M_3*	*M_3*	*M_3*	*M_3*	*M_3*
PWS Fee				$477,710	$515,079	$553,727	$593,653	$634,858	$677,341	$721,103	$766,144
Market # 8					*M_4*	*M_4*	*M_4*	*M_4*	*M_4*	*M_4*	*M_4*
PWS Fee					$477,710	$515,079	$553,727	$593,653	$634,858	$677,341	$721,103
Market # 9					*WC_1*	*WC_1*	*WC_1*	*WC_1*	*WC_1*	*WC_1*	*WC_1*
PWS Fee					$62,550	$70,890	$79,670	$88,892	$98,556	$108,661	$119,207
Market # 10						*SP_2*	*SP_2*	*SP_2*	*SP_2*	*SP_2*	*SP_2*
PWS Fee						$8,529	$13,077	$17,816	$22,744	$27,861	$33,169
Market # 11							*SP_3*	*SP_3*	*SP_3*	*SP_3*	*SP_3*
PWS Fee							$8,529	$13,077	$17,816	$22,744	$27,861
Market # 12								*SP_1*	*SP_1*	*SP_1*	*SP_1*
PWS Fee								$8,529	$13,077	$17,816	$22,744
Market # 13									*FA_1*	*FA_1*	*FA_1*
PWS Fee									$8,529	$13,077	$17,816
Market # 14										*FA_2*	*FA_2*
PWS Fee										$8,529	$13,077
Total	$477,710	$586,158	$1,177,953	$2,232,527	$2,950,309	$3,188,253	$3,438,654	$3,701,699	$3,977,579	$4,266,483	$4,546,271

Types of Markets: Adjudicated - Mojave (M_), Santa Paula (SP_), Chino (C_), West Coast (WC_)
Non-adjudicated - Pajaro/Antelope, Santa Paula-like, Future Adjudication (FA_)

Table 5.4 Income Statement

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Revenues											
Consulting											
Base Fee	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Number of Clients				1		1					1
Total	$0	$0	$0	$100,000	$0	$100,000	$0	$0	$0	$0	$100,000
Water Market Total	$477,710	$586,158	$1,177,953	$2,232,527	$2,950,309	$3,188,253	$3,438,654	$3,701,699	$3,977,579	$4,266,483	$4,546,271
Total	$477,710	$586,158	$1,177,953	$2,332,527	$2,950,309	$3,288,253	$3,438,654	$3,701,699	$3,977,579	$4,266,483	$4,646,271
Cost of Goods Sold											
Materials	$10,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000
Web Hosting	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Travel	$6,000	$14,400	$19,200	$24,000	$28,800	$27,600	$30,000	$32,400	$34,800	$37,200	$33,600
Rent	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000
Total	$44,000	$47,400	$52,200	$57,000	$61,800	$60,600	$63,000	$65,400	$67,800	$70,200	$66,600
Gross Profit	$433,710	$538,758	$1,125,753	$2,275,527	$2,888,509	$3,227,653	$3,375,654	$3,636,299	$3,909,779	$4,196,283	$4,579,671
Operating Expenses											
Salaries and Wages											
Number of Employees	3	3	3	5	5	5	5	5	5	5	5
Base Salaries	$30,000	$40,000	$40,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Salaries	$90,000	$120,000	$120,000	$250,000	$250,000	$250,000	$250,000	$250,000	$250,000	$250,000	$250,000
Comission	$14,331	$17,585	$35,339	$111,626	$147,515	$159,413	$171,933	$185,085	$198,879	$213,324	$227,314
Total	$104,331	$137,585	$155,339	$361,626	$397,515	$409,413	$421,933	$435,085	$448,879	$463,324	$477,314
Sales and Marketing	$12,000	$27,600	$34,800	$42,000	$49,200	$44,400	$48,000	$51,600	$55,200	$58,800	$50,400
Legal Expenses	$60,000	$132,000	$156,000	$180,000	$204,000	$168,000	$180,000	$192,000	$204,000	$216,000	$168,000
Other Expenses											
Total	$176,331	$297,185	$346,139	$583,626	$650,715	$621,813	$649,933	$678,685	$708,079	$738,124	$695,714
Operating Profit	$257,379	$241,573	$779,615	$1,691,901	$2,237,793	$2,605,841	$2,725,721	$2,957,614	$3,201,700	$3,458,159	$3,883,958
Other Revenues or Gains											
Other Expenses or Losses				($50,000)	($476,000)	($50,000)	($50,000)	($50,000)	($50,000)	($50,000)	($50,000)
EBITDA Income	$257,379	$241,573	$779,615	$1,641,901	$1,761,793	$2,555,841	$2,675,721	$2,907,614	$3,151,700	$3,408,159	$3,833,958

Note: Fiscal year ends 12/31.
EBITDA = Earnings before interest, taxes, depreciation, and amortization

Table 5.5 Cash Statement

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cash Flow from Operating Activities											
Water Market	$477,710	$586,158	$1,177,953	$2,232,527	$2,950,309	$3,188,253	$3,438,654	$3,701,699	$3,977,579	$4,266,483	$4,546,271
Consulting	$0	$0	$0	$100,000	$0	$100,000	$0	$0	$0	$0	$100,000
Cash Paid for Operating Expenses	($176,331)	($297,185)	($346,139)	($583,626)	($650,715)	($621,813)	($649,933)	($678,685)	($708,079)	($738,124)	($695,714)
Other											
Net Cash Provided by Operating Activities	$301,379	$288,973	$831,815	$1,748,901	$2,299,593	$2,666,441	$2,788,721	$3,023,014	$3,269,500	$3,528,359	$3,950,558
Cash Flow from Investing Activities											
Cash Received from Collection of Notes Payable											
Cash Paid to Acquire Businesses											
Cash Paid for Purchase of Capital Assets (Land)				$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Net Cash Used in Investing Activities	$0	$0	$0	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Cash Flow from Financing Activities											
Repayment of Debts					($426,000)						
Payment of Cash Dividends									($1,600,850)	($1,729,080)	($1,941,979)
Issuance of Common Stock								$2,139,964			
Repurchase of Common Stock										($100,000)	($100,000)
Net Cash Used in Financing Activities	$0	$0	$0	$0	($426,000)	$0	$0	$2,139,964	($1,600,850)	($1,829,080)	($2,041,979)
Net Increase/Decrease	$301,379	$288,973	$831,815	$1,798,901	$1,923,593	$2,716,441	$2,838,721	$5,212,978	$1,718,650	$1,749,280	$1,958,579
Cash and Equivalents, Beginning of Year	$0	$301,379	$590,352	$1,422,166	$3,221,067	$5,144,661	$7,861,101	$10,699,822	$15,912,801	$17,631,451	$19,380,730
Cash and Equivalents, End of Year	$301,379	$590,352	$1,422,166	$3,221,067	$5,144,661	$7,861,101	$10,699,822	$15,912,801	$17,631,451	$19,380,730	$21,339,309

Note: Fiscal year ends 12/31.

Table 5.6 Balance Statement Assets

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Current Assets											
Cash											
Water Market	$477,710	$586,158	$1,177,953	$2,232,527	$2,950,309	$3,188,253	$3,438,654	$3,701,699	$3,977,579	$4,266,483	$4,546,271
Consulting	$0	$0	$0	$100,000	$0	$100,000	$0	$0	$0	$0	$100,000
Accounts Receivable	$477,710	$586,158	$1,177,953	$2,332,527	$2,950,309	$3,288,253	$3,438,654	$3,701,699	$3,977,579	$4,266,483	$4,646,271
Other Current Assets											
Total Current Assets	$477,710	$586,158	$1,177,953	$2,332,527	$2,950,309	$3,288,253	$3,438,654	$3,701,699	$3,977,579	$4,266,483	$4,646,271
Fixed Assets											
Land				$50,000	$100,000	$150,000	$200,000	$250,000	$300,000	$350,000	$400,000
Buildings											
Accumulated Depreciation											
Total Net Fixed Assets	$0	$0	$0	$50,000	$100,000	$150,000	$200,000	$250,000	$300,000	$350,000	$400,000
Total Assets	$477,710	$586,158	$1,177,953	$2,382,527	$3,050,309	$3,438,253	$3,638,654	$3,951,699	$4,277,579	$4,616,483	$5,046,271

Note: Fiscal year ends 12/31.

Table 5.7 Balance Sheet Liabilities and Shareholders' Equity

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Current Liabilities											
Accounts Payable	$104,000	$179,400	$208,200	$237,000	$265,800	$228,600	$243,000	$257,400	$271,800	$286,200	$234,600
Short Term Notes											
Current Portion of Long Term Notes	$426,000	$426,000	$426,000	$426,000	$426,000						
Interest Payable	$106,500										
Dividends Payable	$0	$0	$0	$0	$0	$0	$0	$0	$1,600,850	$1,729,080	$1,941,979
Accrued Payroll	$104,331	$137,585	$155,339	$361,626	$397,515	$409,413	$421,933	$435,085	$448,879	$463,324	$477,314
Other Current Liabilities											
Total Liabilities	$740,831	$742,985	$789,539	$1,024,626	$1,089,315	$638,013	$664,933	$692,485	$2,321,529	$2,478,604	$2,653,892
Total Long Term Liabilities											
Shareholder's Equity											
Capital Stock								$2,139,964	$2,139,964	$2,039,964	$1,939,964
Retained Earnings										$100,000	$100,000
Total Shareholder's Equity	$0	$0	$0	$0	$0	$0	$0	$2,139,964	$2,139,964	$2,139,964	$2,039,964
Total Liabilities and Equity	$740,831	$742,985	$789,539	$1,024,626	$1,089,315	$638,013	$664,933	$2,832,449	$4,461,493	$4,618,568	$4,693,857

Note: Fiscal year ends 12/31.

Appendix 6: Adjudicated Basins in California

Adjudicated Basins

BEAUMONT BASIN

Filed/Adjudicated: 2003/2004
Number of Parties: 35
Square Miles: 26
Ag/Urban/Mix: Urban
Safe Yield: 8,650 AFY

BACKGROUND

The Beaumont Basin is a 26 square mile groundwater basin in Riverside and San Bernardino Counties, southern California.[182] It underlies the cities of Beaumont and Yucaipa, among others. Most groundwater extraction is for municipal use although there is at least one agricultural user.[183]

The Basin is managed by the Beaumont Watermaster.

REASONS FOR ADJUDICATION

In 2001 the Beaumont-Cherry Valley Water District, the City of Beaumont, the South Mesa Water Company, and the City of Yucaipa formed the San Timoteo Watershed Management Authority (STWMA) to "enhance water supplies and optimize management of the STWMA area groundwater basins," among other goals.[184] The STWMA found that adjudication was necessary to optimally manage groundwater resources and subsequently filed for adjudication of the Beaumont Basin in 2003.

OUTCOME

The Court determined the safe yield to be 8,650 AFY. Water rights are divided into overlying and appropriative rights. Only appropriators may lease or sell their

[182] Beaumont Basin Watermaster
[183] Beaumont Basin Watermaster 2005
[184] Beaumont Basin Watermaster 2005

rights.[185] It further ordered that any pumping in excess of groundwater rights must be replaced to recharge the groundwater basin. It appointed a Watermaster committee comprised of representatives from the City of Banning, the City of Beaumont, the Beaumont-Cherry Valley Water District, South Mesa Mutual Water Company, and the Yucaipa Valley Water District.[186]

As of 2005, the Beaumont Basin was in overdraft, but reductions in use were planned over a 10-year period with increases in imported water. Furthermore, they were concerned about potential land subsidence, and were planning monitoring.[187] The Court ordered a 'physical solution', and thus groundwater use will not be significantly reduced until the San Gorgonio Water Agency can import adequate replacement water.[188] They use a combination of imported water, recycled water, and recharge ponds.[189] There are currently a total of 35 parties.[190]

BRITE BASIN

Filed/Adjudicated: 1966/1970
Number of Parties: not fully adjudicated
Square Miles: 5
Ag/Urban/Mix: Ag
Safe Yield: 500 AFY

BACKGROUND

The Brite Basin is a 5 square mile groundwater basin in Kern County, central-inland California.[191] The Basin primarily underlies rural-agricultural land and the groundwater is used for agricultural purposes. However, the urban population is rapidly expanding.[192]

The Basin is managed by the Tehachapi-Cummings County Water District, which also serves as the court-appointed Watermaster.[193]

REASONS FOR ADJUDICATION

[185] Beaumont Cherry Valley Water District 2009
[186] Beaumont Basin Watermaster
[187] Beaumont Basin Watermaster 2005
[188] Beaumont Cherry Valley Water District 2009
[189] Beaumont Cherry Valley Water District
[190] Beaumont Basin Watermaster 2005
[191] California Department of Water Resources 2003
[192] Integrated Resource Management, LLC 2008
[193] Integrated Resource Management, LLC 2008

According to Anderson and Snyder in their book Water Markets: priming the invisible pump, "groundwater overdraft began in the Tehachapi Basin in the 1930's following a steady increase in irrigation [and in the 1960's] pumping costs increased dramatically and some wells ran dry. Fears that continued overdraft would seriously affect the agriculturally based economy brought about the formation of the Tehachapi-Cummings County Water District."[194] In 1965, a citizen advisory committee decided to start importing water and to adjudicate the basin in order to initiate better management.[195] The Tehachapi-Cummings County Water District has jurisdiction over Tehachapi Basin, Brite Basin, and Cummings Basin. While Brite Basin did not experience the same groundwater management problems as the Tehachapi Basin, the Tehachapi-Cummings County Water District filed for adjudication in all three basins under their jurisdiction.

OUTCOME

The Court determined the safe yield to be 500 AFY. According to the Tehachapi-Cummings County Water District, "current groundwater extraction is approximately 229 AF for agriculture and 99 AF for municipal and domestic purposes [...] The Basin water levels continue to increase and there are no restrictions on extraction within the Basin."[196] Thus, "[t]he basin was and is not in overdraft and there is no injunction against pumping."[197] The Court also appointed the Tehachapi-Cummings County Water District Watermaster. The Basin is under continuing jurisdiction of the Court.[198] The Basin is not fully adjudicated and the rights holders are not defined.

Central Basin

Filed/Adjudicated: 1962/1965
Number of Parties: 140
Square Miles: 277
Ag/Urban/Mix: Urban
Safe Yield: less than 217,367 AFY

BACKGROUND

[194] Anderson 1997
[195] Anderson 1997
[196] Integrated Resource Management, LLC 2008
[197] California Department of Water Resources 2003
[198] Tehachapi-Cummings Water District

The Central Basin is a 277 square mile groundwater basin in southeastern Los Angeles County, California. According to Dorothy Green in Managing Water, Central Basin lies "under the cities of Montebello, Cerritos, and Compton, among others, south of the Whittier Narrows Dam." Central Basin thus underlies a highly urbanized area, and the groundwater is mainly extracted from 344 active wells for "urban-suburban" use.[199] Furthermore, "little of the basin's groundwater is replenished by the percolation of local rainfall. Most of the basin's natural replenishment occurs from surface inflow […] and groundwater flowing […] from the Main San Gabriel Basin."[200] The Basin also obtains water from the State Water Project.[201]

The Basin is managed by the court-appointed Central Basin Watermaster (part of the California Department of Water Resources). Before adjudication, the area was managed by the Central and West Basin Water Replenishment District (CWBWRD).

REASONS FOR ADJUDICATION

According to the CA Department of Water Resources, in the late 1950's "overdraft of the groundwater basin and declining water levels caused seawater intrusion and threatened the groundwater supply."[202] Consequently, in 1962, the CWBWRD filed for adjudication against approximately 700 defendants. There are 140 parties to the adjudication.[203]

OUTCOME

The judgment reduced extractions to 217,367 AFY. Users may sell or lease their adjudicated rights. Users may carryover their water allowance from one year to the next (not exceeding 20% of their allowance). Furthermore, users may over-extract by 20% but "the over-extraction must be made up the following fiscal year unless Watermaster grants a relief due to an unreasonable hardship; such relief shall be prorated over a 5-year period."[204]

[199] California Department of Water Resources 2003
[200] Dorothy 2007
[201] California Department of Water Resources 2003
[202] California Department of Water Resources 2003
[203] Central Basin Watermaster 2009
[204] California Department of Water Resources 2003

The Central Basin Judgment is unique in its use of an 'Exchange Pool'. Every summer "the Watermaster mails an Exchange Pool form [that] provides for making: mandatory offers of water rights to the pool, referred to as "Required Subscription" in the Judgment; "Voluntary Subscription"; and requests for water rights from the pool. In completing the form, the member must estimate his water needs and supply for the ensuing fiscal year."[205]

Nevertheless, the basin cap is not set at the level necessary to prevent overdraft. The Water Replenishment District of Southern California is charged with purchasing water to inject back into the ground to maintain groundwater levels.[206] Despite the Exchange Pool and conservation efforts, Central Basin continues to struggle with supplying enough water to meet the demand. Also, Central Basin has established an ongoing project combating seawater intrusion with West Coast Basin.

Chino Basin

Filed/Adjudicated: 1975/1978
Number of Parties:
Square Miles: 240
Ag/Urban/Mix: Mix
Safe Yield: 140,000 AFY

BACKGROUND

The Chino Basin is a 240 square mile groundwater basin in the Santa Ana River Watershed in parts of San Bernardino County, Riverside, and Los Angeles Counties, California.[207] According to the Chino Watermaster, the Basin is the one of the largest groundwater basins in Southern California and "provides much of the water used by area cities, dairies, farms, industry, and businesses."[208]

The Basin is managed by the Chino Basin Watermaster. Before adjudication it was managed by various water agencies including the Chino Basin Municipal Water District.

REASONS FOR ADJUDICATION

[205] California Department of Water Resources 2003
[206] Johnson 2005
[207] Chino Basin Watermaster 2008
[208] Chino Basin Watermaster 2008

By the early 1970's, the Basin was overdrafted and experienced land subsidence. Use of the groundwater by agriculture, industry, business, and cities continued to increase with growing populations.[209]

OUTCOME

The 1978 Judgment limited groundwater extraction to the safe yield (estimated to be 140,000 AFY). It divided stakeholders and water rights into three representative Pool Committees: overlying agriculture, overlying non-agriculture, and appropriators. Each of the Pool Committees then recommends actions to the Watermaster and oversees its activities. Any action that a Pool Committee disagrees with can be appealed to the trial Judge. The Watermaster is funded by assessments collected from the Pool Committees. It assesses the Operating Safe Yield, enforces water rights, and monitors groundwater levels, storage, and quality.[210]

After the adjudication, the actions of the Watermaster were controversial and often challenged by the separate interest groups. In 2000, interested parties drafted, and the Court approved, a 'Peace Agreement', creating the Optimum Basin Management Plan. An amendment to the Peace Agreement was entered in 2004.

According to the Bulletin 118 Update 2003, "[g]roundwater levels declined about 80 feet from historical high marks in the 1920s by 1980. By 2000, water levels had recovered about 20 feet."[211]

Cucamonga Basin

Filed/Adjudicated: 1958/1959
Number of Parties: 3
Square Miles: 15
Ag/Urban/Mix: Urban
Safe Yield: 22,721 AFY

BACKGROUND

The Cucamonga Basin is a 15 square mile groundwater basin in the upper Santa Ana Valley in San Bernardino County, southern California. It underlies the Cities

[209] Chino Basin Watermaster 2008
[210] Chino Basin Watermaster 2008
[211] California Department of Water Resources 2003

of Cucamonga and Upland, among others. The area is urbanized, and water use is mostly municipal. The area's population is rapidly growing. The Cucamonga Valley Water District obtains approximately 30% of its water from groundwater. However, the area was primarily agricultural when the Basin was adjudicated.[212] Now, the "Santa Ana Water Company (SAWC), Cucamonga Valley Water District (CVWD) and the City of Upland (through agreements with SAWC and West End Consolidated Water Company) are the primary extractors in the Cucamonga Basin."[213]

The Cucamonga Valley Water District, a special district under Division 12 of the State Water Code, manages the Basin.[214]

REASONS FOR ADJUDICATION

In the 1950's, wells in Cucamonga Basin were running dry and "drought conditions were plaguing the various water companies [supplying water to agricultural users in the Basin and]. A complaint was filed in the Superior Court by San Antonio Water Company to determine the water rights of all Cucamonga Basin water users."[215]

OUTCOME

The Court adjudicated the groundwater rights in 1959 and determined Safe Yield to be 22,721 AFY.[216] The Court did not limit pumping but ordered that extraction of groundwater beyond the Safe Yield must be replenished. Furthermore, "[u]nder the Cucamonga Basin Judgment, SAWC is allowed to export 100 percent of their 6,500 AFY allocation while CVWD is allowed to export 8,177 AFY (43 percent of their total allocation of 19,071)."[217] According to the CA Department of Water Resources, although Cucamonga Basin was "adjudicated separately; [a] Watermaster has not been appointed. The basin is operated as part of Chino Basin."[218] The Basin is not currently overdrafted.[219]

[212] Cucamonga Valley Water District 2004
[213] Metropolitan Water District of Southern California 2007
[214] Cucamonga Valley Water District
[215] Cucamonga Valley Water District
[216] Metropolitan Water District of Southern California 2007
[217] Metropolitan Water District of Southern California 2007
[218] California Department of Water Resources 2009
[219] Metropolitan Water District of Southern California 2007

Cummings Basin

Filed/Adjudicated: 1966/1972
Number of Parties: not fully adjudicated
Square Miles: 16
Ag/Urban/Mix: Ag
Safe Yield: 4,090 AFY

BACKGROUND

The Cummings Basin is a 16 square mile groundwater basin in Kern County, central-inland California.[220] The Basin primarily underlies rural-agricultural land and the groundwater is used for agricultural purposes. However, the urban population is rapidly expanding.[221]

The Basin is managed by the Tehachapi-Cummings County Water District, which also serves as the court-appointed Watermaster.[222]

REASONS FOR ADJUDICATION

According to Anderson and Snyder in their book Water Markets: priming the invisible pump, "groundwater overdraft began in the Tehachapi Basin in the 1930's following a steady increase in irrigation [and in the 1960's] pumping costs increased dramatically and some wells ran dry. Fears that continued overdraft would seriously affect the agriculturally based economy brought about the formation of the Tehachapi-Cummings County Water District."[223] In 1965, a citizen advisory committee decided to start importing water and to adjudicate the basin in order to initiate better management.[224] The Tehachapi-Cummings County Water District has jurisdiction over Tehachapi Basin, Brite Basin, and Cummings Basin. While Cummings Basin did not experience the same problems as the Tehachapi Basin, it did experience groundwater overdraft.[225] The Tehachapi-Cummings County Water District filed for adjudication in all three basins under their jurisdiction.

[220] California Department of Water Resources 2003
[221] Integrated Resource Management, LLC 2008

[222] Integrated Resource Management, LLC 2008
[223] Anderson 1997
[224] Anderson 1997
[225] California Department of Water Resources 2003

OUTCOME

The Court determined the Safe Yield to be 4,090 AFY and limited groundwater extraction to the Safe Yield. The Court adjudicated overlying rights and enjoined from exporting water.[226] Approximately 3,900 AF is extracted annually, 2,989 for agricultural use and 911 for municipal and industrial use.[227] According to the CA Department of Water Resources, "[s]ince the start of basin adjudication in the early 1970s, groundwater levels have increased to those present during the late 1940s when the valley's groundwater overdraft problem became apparent. The importation of SWP water to supplement groundwater supplies starting in 1973 has also had a significant effect on reducing basin overdraft."[228] The Court also appointed the Tehachapi-Cummings County Water District Watermaster. The Basin is under continuing jurisdiction of the Court.[229] The Basin is not fully adjudicated and the rights holders are not defined.

Goleta Basin

Filed/Adjudicated: 1973/1989
Number of Parties: 45
Square Miles: 14.5
Ag/Urban/Mix: n/a
Safe Yield: 2,350 AFY

BACKGROUND

The Goleta Basin is a 14.5 square-mile groundwater basin on the central coast of California in Santa Barbara County. It underlies the City of Goleta and the City of Santa Barbara. The Basin provided water to municipal users in Goleta and Santa Barbara from 1963 to 1991. It is not in active use.

The Goleta Basin is managed by the Goleta Water District (GWD). The GWD was formed in 1944.[230]

REASONS FOR ADJUDICATION

[226] Tehachapi-Cummings Water District
[227] Integrated Resource Management, LLC 2008
[228] California Department of Water Resources 2003
[229] Tehachapi-Cummings Water District
[230] Goleta Water District 2006

The Goleta Basin began experiencing groundwater overdraft and the threat of seawater intrusion as a result of the GWD's groundwater extraction. According to an end of the year report for the GWD, "the District began pumping groundwater from the basin in 1963. By 1974, the District had installed five new wells and ramped its groundwater extraction up to 3,700 AF. District pumpage peaked in 1985 when it pumped slightly more than 6,000 AF of groundwater from the basin. District pumping declined sharply in 1991 and has been essentially zero since 1993."[231]

[231] Goleta Water District 2005

OUTCOME

The Goleta Water District was appointed Watermaster.[232] Furthermore, the Court limited the District's pumping rights to pump 2,350 AFY. Aside from the Court's judgment, a 1991 ordinance requires that the District commit at least 2,000 AFY to groundwater basin recharge. In 1991 pumping declined sharply.[233] However, the Court also "provides the GWD with the right to defer extracting its annual groundwater entitlement, and consider that water as additional stored water for later use during droughts."[234] According to a 2005 report by CH2M Hill, "in the near future, the District plans to bring all its primary extraction wells back on line. Since 1992, the District has met all its demand with water from the Cachuma and State Water projects. The District has also injected surplus Cachuma spill water on several occasions. These collective actions have resulted in the District banking nearly 40,000 AF of water in the basin," which is near historical groundwater storage levels.[235]

Mojave Basin

Filed/Adjudicated: 1991/1996
Number of Parties: 475
Square Miles: 1,400
Ag/Urban/Mix: Mix
Safe Yield: 121,800 AFY

BACKGROUND

The Mojave River Basin encompasses approximately fourteen hundred square miles of western San Bernardino County.[236] The Mojave River Groundwater Basin is recharged by the Mojave River, known as "the Inconstant River." It underlies the rapidly growing High Desert region east of Los Angeles, and provides water for both residential and agricultural users—there are 475 rights holders. According to the September/October 2000 issue of Western Water, it "serves as the only local water source for residents," supplemented only by water

[232] Association of Groundwater Agencies 2004
[233] Goleta Water District 2007
[234] County of Santa Barbara
[235] CH2M Hill 2005
[236] California Department of Water Resources 2003

from the State Water Project.[237] Thus, the number of water users is large, and the use of the groundwater is varied.

The Mojave River Basin was identified as being in overdraft in the late 1950s; the Mojave Water Agency (MWA) was formed in 1960 after the state allocated State Water Project (SWP) water to the area. The Mojave Water Agency currently manages the basin and serves as Watermaster to the partially-adjudicated sections of the River Basin.

REASONS FOR ADJUDICATION

The Mojave River Basin has been in critical overdraft since the 1960s. With SWP water arriving in the late 1960s, the MWA began the process of adjudication. However, as a result of legal battles and questions over relative benefits to users, the adjudication process was abandoned in the mid-1970s.[238] The urban population in the area continued to rapidly grow and, even though SWP water was supplied to the Basin, groundwater overdraft continued to be a problem. According to one attorney, "agricultural pumping alone in the lower subarea would consume the safe yield of the Mojave Basin," and "for those of us who had to serve water to [the people in the small towns and cities], you don't have a choice […] You have to find a way to serve water to the people."[239]

Finally, in 1990, Barstow and the Southern California Water Co. sued the City of Adelanto and other cities upstream that were withdrawing groundwater and affecting downstream withdrawals. They also sued for the "MWA to fulfill its statutory authority to obtain and provide supplemental water for use within the Mojave River Basin area."[240]

OUTCOME

According to an article in the Western Water Magazine, the adjudication of the Mojave Basin "was the state Supreme Court's first major water rights decision since the 1983 landmark ruling on the public trust doctrine. Some view the Mojave ruling as a victory for senior water rights holders in not only the Mojave

[237] McClurg 2000
[238] McClurg 2000
[239] McClurg 2000
[240] McClurg 2000

River Basin, but throughout the state."[241] The Supreme Court upheld previously determined "first in right, first in time" rights, stating that "case law simply does not support applying an equitable apportionment to water use claims unless all claimants have correlative rights."[242] However, it did maintain that reasonable and beneficial use is limited if the basin is overdrafted. Thus, the Cardozo Group kept their water rights but could not increase their groundwater pumping. Consequently, the Mojave case strengthened water rights priorities and encouraged full adjudication of rights, especially quantification of individual rights, despite the prodigious expense.

After the ruling, the Mojave Water Agency became the Mojave Basin Area Watermaster Board[243] and formed a basin management plan on order of Superior Court Judge Kaiser. The Mojave Basin currently supplies most of their water through the State Water Project, and groundwater *appears* not to be over-drafted. However, the Mojave Water Agency projects that its water supplies will be stretched given projected growth to 2020. The safe yield is 121,800 AFY.[244]

Puente Basin

Filed/Adjudicated: 1985/1986
Number of Parties: 5
Square Miles: 14
Ag/Urban/Mix: Ag
Safe Yield: 4,400 AFY

BACKGROUND

The Puente Basin is a fourteen square mile groundwater basin that lies on the western end of the San Jose Valley in Los Angeles County, California. [245] Puente Basin is hydraulically connected to the San Gabriel Basin with no impediments to flow. However, it is adjudicated separately. The Basin partially supplies water to the San Gabriel Groundwater Basin. It also provides water to five pumpers. However, "the only source of water is natural recharge, and the water quality of the basin is not potable […] it is used for [agricultural] irrigation only."[246]

[241] McClurg 2000
[242] McClurg 2000
[243] Mojave Water Agency
[244] Mojave Water Agency
[245] Metropolitan Water District of Southern California 2007
[246] Green 2007

The Puente Basin is now managed by the Puente Basin Watermaster and Puente Narrows Watermaster. The Three Valleys Municipal Water District is charged with importing water to the Basin.

REASONS FOR ADJUDICATION

The groundwater was overdrafted each year, limiting both the in-basin pumping and groundwater supply to the San Gabriel Basin.

OUTCOME

The Court determined that a management plan would be implemented by a Puente Basin Watermaster, two court-appointed individuals. The Watermaster would determine the annual Operating Safe Yield and allocate water rights accordingly.[247] Furthermore, according to the CA Department of Water Resources, the judgment requires "a minimum underflow from Puente Basin to Main San Gabriel Basin of 588 AFY."[248] A separately appointed Puente Narrows Watermaster ensures that the required amount of groundwater flows the San Gabriel Basin each year.[249]

The Metropolitan Water District of Southern California states that, "[a]ccording to the Puente Basin Judgment […] the declared safe yield of the Puente Basin is 4,400 AFY (Puente Basin Judgment, 1986). However, the basin is managed on the basis of Operating Safe Yield determined annually by the Watermaster and has averaged 1,666 AFY since 1988."[250]

The Basin is not currently overdrafted.

Raymond Basin

Filed/Adjudicated: 1937/1944
Number of Parties: 16
Square Miles: 40
Ag/Urban/Mix: Urban
Safe Yield: 21,900 AFY

BACKGROUND

[247] Metropolitan Water District of Southern California 2007
[248] California Department of Water Resources 2003
[249] Metropolitan Water District of Southern California 2007
[250] Metropolitan Water District of Southern California 2007

The Raymond Basin is a 40 square mile groundwater basin that lies in Los Angeles County, California.[251] Raymond Basin provides groundwater for multiple municipal cities, most notably Alhambra and Pasadena. Water use is primarily urban.

The Raymond Basin is managed by the Raymond Basin Management Board, which has Watermaster responsibilities.

REASONS FOR ADJUDICATION

Groundwater overdraft in Raymond Basin began in 1913 as a result of expanding agricultural extraction and increasing municipal population. It continued until adjudication.[252]

OUTCOME

In all, there were 30 defendants.[253] In 1944, the Court determined individual user rights. Furthermore, it decreed that an individual user cannot exceed their rights by more than 10% in a single year. If they exceed their rights, the excess water use will be subtracted from their use the following year. The judgment stipulated a Safe Yield of 21,900 AFY. The City of Pasadena asked the Court to re-determine the Safe Yield in 1950. The Court subsequently increased the Safe Yield. Lastly, it gave management of the Basin to the Raymond Basin Advisory Board. The Advisory Board later became the Raymond Basin Management Board, which was given Watermaster responsibilities in 1984.[254]

With the judgment in this case, the Court laid the foundation for all following California groundwater adjudications. The Raymond Basin is not currently in overdraft.

San Gabriel Basin

Filed/Adjudicated: 1965/1968/1972/1973
Number of Parties: 190
Square Miles: 255
Ag/Urban/Mix: Mix

[251] California Department of Water Resources 2003
[252] Raymond Basin Management Board
[253] Raymond Basin Management Board
[254] Raymond Basin Management Board

Safe Yield: 152,700 AFY

BACKGROUND

The San Gabriel Basin is a 255 square mile[255] groundwater basin that lies in eastern Los Angeles County, California.[256] The San Gabriel Basin underlies "most of the San Gabriel Valley," and is bounded by "the San Gabriel Mountains to the north, San Jose Hills to the east, Puente Hills to the south, and […] the Raymond Fault to the west."[257] The Basin natural safe yield is approximately 152,700 AFY. The basin's groundwater provides approximately 85 percent of the domestic water supply for more than 1,000,000 people who live in the Valley.[258] There are 305 wells tapping the Basin, of which 250 supply municipal users, approximately 25 serve agricultural users, and approximately 25 serve industrial users.[259] There are 190 groundwater rights holders.[260] The supply demanded is unlikely to vary significantly over short periods of time. The area is highly urbanized and has a rapidly growing population.

The San Gabriel Basin falls under the jurisdiction of the Upper San Gabriel Valley Municipal Water District, Three Valleys Municipal Water District, and the San Gabriel Valley Municipal Water District. It is now managed by the Main San Gabriel Basin Watermaster. The Water Districts are charged with delivering supplemental water beyond the annual safe yield.[261]

REASONS FOR ADJUDICATION

The San Gabriel Groundwater Basin was significantly overdrafted each year by the water users.[262]

OUTCOME

"The Board of Water Commissioners of the City of Long Beach, the Central Basin Municipal Water District (CBMWD), and the City of Compton […] filed an action against the San Gabriel Valley Water Company and 24 other extractors

[255] San Gabriel Basin Watermaster
[256] Metropolitan Water District of Southern California 2007
[257] Metropolitan Water District of Southern California 2007
[258] U.S. Environmental Protection Agency
[259] Metropolitan Water District of Southern California 2007
[260] San Gabriel Watermaster
[261] Metropolitan Water District of Southern California 2007
[262] Metropolitan Water District of Southern California 2007

of groundwater from the San Gabriel Valley [seeking] a determination of the rights […] to the waters of the San Gabriel River system."[263] The Long Beach Judgment resulted in the creation of a three-member River Watermaster that calculates the yearly allocation of water to the area adjudicated in the judgment.

The Main Basin Judgment required the creation of the Main San Gabriel Basin Watermaster. It further stipulated the portion of the yearly-established Operating Safe Yield each groundwater user is entitled to and then requires that users pay for imported water should they extract more than their allocation. The Watermaster determines the Operating Safe Yield each year and monitors users' groundwater extraction rates. The Municipal Water Districts are charged with importing water using the fees collected from users who exceed their allocation of the naturally occurring groundwater.

Lastly, "Water rights under the Main Basin Judgment are transferable by lease or purchase so long as such transfers meet the requirements of the Judgment. There is also provision for Cyclic Storage Agreements by which Parties and non-parties may store imported supplemental water in the Main Basin under such agreements with the Main San Gabriel Basin Watermaster pursuant to uniform rules and conditions and Court approval."[264]

The San Gabriel Basin is not currently in overdraft.[265] According to Bulletin 118 Update 2003, "[t]he water level in [one] well has fluctuated over 95 feet in elevation over the last 20 years from a high in 1983 to a low in 1991 (MSGBW 1999). Since 1993, the water level in this well has only varied over a range of about 30 feet and in 1999 was within about 10 feet of its 200-year mean (MSGBW 1999)."[266]

Santa Margarita Basin

Filed/Adjudicated: 1951/1966
Number of Parties: Unknown
Square Miles: 12
Ag/Urban/Mix: Urban
Safe Yield: Unknown

[263] Stetson Engineers Inc. 2005
[264] Stetson Engineers Inc. 2005
[265] Stetson Engineers Inc. 2005
[266] California Department of Water Resources 2003

BACKGROUND

The Santa Margarita River Watershed is a 12 square mile[267] groundwater basin in San Diego County, California. The groundwater basin underlies a mostly urbanized area and supplies about half of the area's water.[268] The safe yield has not been definitively quantified.

A U.S. Court-appointed Watermaster ensures that court orders are followed. The main water agencies are the Fallbrook Public Utility District, the Santa Margarita Water District, and the Marine Corps Base Camp Pendleton.

REASONS FOR ADJUDICATION

The Basin has a long history of "struggle for water rights between local farmers and the federal government."[269] Litigation over both the surface and groundwater dates to the 1920's.

The Basin has historically experienced groundwater overdraft, which has posed a problem for agricultural users and for urban users. According to a report of the 108th U.S. Congress, "[t]he lack of adequate water supply [still] poses a serious problem for water users in the Santa Margarita River Basin. Urbanization, especially since about 1970, has transformed this area in San Diego County from large ranches to tract homes. In the lower basin, the modest agricultural use of land and water […] has stayed relatively constant. The creation of Camp Pendleton Marine Base, which covers most of the lower basin, added a relatively small, constant demand for water for base operations."[270]

In the late 1940's and early 1950's, agriculture grew rapidly in the area. The introduction of Camp Pendleton added tension. When the Fallbrook Utility District (upstream of Camp Pendleton) began to make plans to dam the river, the United States tried to quiet their title to both surface and groundwater rights.

OUTCOME

The "[j]udgment does not quantify water rights, but specifies certain operational requirements and facts, defines the scope of the watershed and lands and current

[267] California Department of Water Resources 2003
[268] Santa Margarita Water District
[269] Fetbrandt 2009
[270] U.S. 108th Congress

owners within the jurisdiction of the court, and retains continuing jurisdiction for the court to quantify the water rights at a future time."[271] True adjudication of the groundwater rights is still pending. Consequently, there are many pending lawsuits concerning water rights in the Santa Margarita River Watershed.

According to a 2008 Santa Cruz Sentinel article, the groundwater basin is in overdraft,[272] even though the basin receives water from the State Water Project. The case generated copious bad publicity for the federal government, particularly for Camp Pendleton.

Santa Maria Valley Basin

Filed/Adjudicated: 1997/2008
Number of Parties: 1,000
Square Miles: 170
Ag/Urban/Mix: Ag
Safe Yield:

[271] Metropolitan Water District of Southern California 2007
[272] Alexander 2008

BACKGROUND

The Santa Maria Valley Basin is a 170 square mile groundwater basin in Santa Barbara and San Luis Obispo County, California along the Californian coast.[273] According to the County of Santa Barbara, the basin is "one of the largest agricultural and historically important oil producing coastal valleys of California."[274] Most of the groundwater is used for agricultural purposes.

REASONS FOR ADJUDICATION

Until 1997, all of Santa Maria Valley's water came from groundwater. The basin has long experienced overdraft of groundwater resources. Despite and influx of SWP starting in 1997, the basin continued to be overdrafted. The Santa Maria Valley Water Conservation District filed for adjudication.

OUTCOME

The Judgment appointed a Watermaster. The Watermaster is in charge of monitoring extraction rates and adjusting the safe yield with the fluctuations in naturally occurring recharge.

There are roughly 1,000 parties to the judgment. Approximately 70 landowners fought the settlement, are not party to the Judgment, and have no groundwater rights.[275] The safe yield is estimated to be 70,000 AFY.[276]

Santa Paula Basin

Filed/Adjudicated: 1991/1996
Number of Parties: 74
Square Miles: 35
Ag/Urban/Mix: Ag
Safe Yield: 33,500 AFY

[273] County of Santa Barbara 2007
[274] County of Santa Barbara 2007
[275] Nossaman 2008
[276] County of Santa Barbara 2007

BACKGROUND

The Santa Paula Basin is a 35 square mile groundwater basin in Ventura County, California.[277] According to the United Water Conservation District, "[w]ith the exception of these urban areas, the remainder of the basin has been essentially fully developed to irrigated agricultural uses for many years. Historically, water uses within the basin have relied on pumped groundwater, with relatively minor exceptions."[278] Thus, most of the groundwater is used for agricultural purposes.

The Basin has been managed by the United Water Conservation District (formerly known as the Santa Clara Water Conservation District) since its formation in 1927.[279] It is now overseen by a Watermaster and Technical Advisory Committee.

REASONS FOR ADJUDICATION

In the early 1990's the City of Ventura indicated that they intended to increase groundwater pumping in the western portion of the basin. Concerns about groundwater overdraft prompted the United Water Conservation District to file for adjudication.

OUTCOME

The Judgment appointed a Watermaster and formed a Technical Advisory Committee consisting of representatives from the United Water Conservation District, the City of Ventura, and the Santa Paula Basin Pumpers Association.[280] Initial safe yield was estimated to be 33,500 AFY, and rights were divided accordingly. The Watermaster and Technical Advisory Committee are in charge of monitoring extraction rates and adjusting the safe yield with the fluctuations in naturally occurring recharge.

The basin is not reported to be in overdraft—they import State Water Project Water.[281] There are currently 74 parties to the judgment.[282]

[277] California Department of Water Resources 2003
[278] Santa Paula Basin Experts Group 2003
[279] United Water Conservation District
[280] California Department of Water Resources 2003
[281] California Department of Water Resources 2003
[282] Santa Paula Pumpers Association 2008

Seaside Basin

Filed/Adjudicated: 2003/2006
Number of Parties: 13
Square Miles: 20
Ag/Urban/Mix: Urban
Safe Yield: 2,581 to 2,913 AFY

BACKGROUND

The Seaside Basin is a twenty square mile[283] groundwater basin that lies on the central coast of California in Monterrey County.[284] According to the Monterey Peninsula Water Management District, "Seaside Basin underlies the cities of Seaside and Sand City; and parts of the cities of Del Rey Oakes and Monterey, former Fort Ord and the Highway 68 corridor to Laguna Seca. The Basin provides water supply for about 25% of the California American Water (Cal-Am) distribution system, the City of Seaside municipal system, two golf courses in the Seaside area, and several industrial users[285]—a total of 13 rights holders.[286] Thus, the number of groundwater users in the Seaside Basin is relatively small and the use of the groundwater is specialized compared to the large number of users and varied groundwater use (generally agricultural) in other California groundwater basins.

The Seaside Basin was defined as a groundwater basin in 1982 by the U.S. Geological Survey.[287] It originally fell under the management of the Monterey Peninsula Water Management District and the Monterey County Water Resources Agency and is now regulated by the Seaside Basin Watermaster.

REASONS FOR ADJUDICATION

By 2003, groundwater in the Basin was overdrafted and continued to be overdrawn each year. Groundwater pumping at the time was estimated to be

[283] California Department of Water Resources 2003
[284] California Department of Water Resources 2003
[285] Monterey Peninsula Water Management District 2005
[286] Seaside Basin Watermaster 2009
[287] Monterey Peninsula Water Management District 2008

approximately twice the basin's safe yield. [288] Furthermore, the groundwater overdraft resulted in a significant threat of seawater intrusion.[289]

According to Steve Saxton in an article in the California Water Law and Policy Reporter, "[g]roundwater extraction near the coast increased markedly in 1995, principally the result of increased pumping by the plaintiff [California American Water (Cal-Am)]."[290] Cal-Am became the principal user and supplier of groundwater in the area. In some cases, it exported groundwater to surrounding areas not overlying the Seaside Groundwater Basin.

In 2003, municipal demand for groundwater had increased and industrial demand remained strong. Declining water quality and predicted future shortages led Cal-Am to sue the City of Seaside "for declaratory and injunctive relief seeking a general adjudication of groundwater rights."[291]

OUTCOME

Safe yield was determined to be between 2,581 and 2,913 AFY.[292] The court decided that the Watermaster Board would consist of 13 voting positions, three to Cal Am, three to Seaside, two to the Monterey Peninsula Water Management District, two to the Monterey County Water Resources Agency, and three to the other cities and landowners. Furthermore, the court allocated rights only up to the natural safe yield, though it allowed pumping in excess of the safe yield for three years following the verdict in 2006.[293]

The Seaside Basin is also unique in its division of water rights. "Standard Producers" have appropriative rights—they are required to reduce their groundwater extraction over a period of years to a sustainable level. However, they may store groundwater. "Alternative Producers" have overlying rights—they are required to reduce their groundwater extraction only when the Standard Producers have reached 0 AFY extraction and further reductions are necessary. However, they may not store groundwater. They may convert to become a Standard Producer if they so desire. Seaside Basin is currently in overdraft and is

[288] Monterey Peninsula Water Management District 2008
[289] Saxton 2006
[290] Saxton 2006
[291] Saxton 2006
[292] Saxton 2006
[293] Saxton 2006

experiencing seawater intrusion. The Watermaster is developing a plan to halt overdraft and reverse seawater intrusion.[294]

Scott River Valley Basin

Filed/Adjudicated: 1970/1980
Number of Parties: 684
Square Miles: 100
Ag/Urban/Mix: Ag
Safe Yield: unknown Extracted: 24,300

BACKGROUND

The Scott River Valley Basin is a 100 square mile groundwater basin underlying Siskiyou County in inland northern California.[295] The overlying land is approximately one third federal land, including parts of the Klamath National Forest, one third industrial timber, and one third privately owned agriculture. According to the Forest Service, "[a]griculture is the primary industry in the Scott Valley, mostly cattle ranching, alfalfa grazing, and timber harvest."[296] The groundwater is mostly used by agriculture, but the Forest Service also has claim to some groundwater rights. However, "groundwater levels in the valley aquifer reflect drawdown during the irrigation season and recharge during the wet season."[297] American Indian tribes also have some claim to the water.

The Scott River Stream System Watermaster (part of the Department of Water Resources) oversees and enforces adjudicated rights. The Scott River Watershed Council manages the watershed.

REASONS FOR ADJUDICATION

The valley has long experienced water shortages.

[294] Monterey Peninsula Water Management District 2008

[295] CA Department of Water Resources 2003

[296] U.S. Forest Service 1997

[297] National Research Council 2004

OUTCOME

In 1970 the Scott Valley Irrigation District filed for adjudication. Subsequent investigations revealed "hydraulic connections between shallow groundwater and surface flows, indicating that adjudication should include both surface-flow rights and pumping rights adjacent to the river."[298] However, at that time, such adjudication was not legally possible in California. Thus, special legislation was passed to allow for the adjudication.

In 1980, the Court decreed the adjudication and recognized 684 (mostly agricultural) diversions from the water supply. It also appointed the Department of Water Resources as Watermaster. As a result of the adjudication, "[g]round water was determined to be interconnected with surface water through a large section of the valley and, as a result, many water users changed from direct surface diversion to well use as it is a more reliable source. The effects of this sustained pumping on the water table, ground water recharge rate and the surface flow after irrigation season are not known,"[299] but, according to a study by the U.S. Forest Service, they likely result in groundwater overdraft and reduced surface flows.[300]

The adjudication has not solved groundwater rights disputes. The U.S. Forest Service (USFS) was not awarded adjudicated rights upstream of the USGS gage in Fort Jones, and allotted only limited flows downstream of the gage. Consequently, the "USFS, a junior appropriator, commonly does not receive its adjudicated flows during late summer and fall."[301] This has resulted in reduced habitat for endangered fish in the area.[302] Also, according to the Klamath Riverkeeper, "[t]he evidence is strong that the Superior Court erred greatly in its narrow delineation of the line of interconnected groundwater."[303]

The Scott River Watershed Council, representing all interest groups in the area, is currently implementing a Strategic Action Plan to better manage groundwater resources.[304] Current groundwater extraction is approximately 24,300 AFY.[305]

---

[298] National Research Council 2004
[299] Siskiyou Resource Conservation District 1995
[300] Robert and Seth 2008
[301] Siskiyou Resource Conservation District 1995
[302] Pace 2009
[303] Klamath Riverkeeper 2009
[304] Scott River Watershed Council

Six Basins

Filed/Adjudicated: 1998/1998
Number of Parties: Unknown
Square Miles: 16
Ag/Urban/Mix: Urban
Safe Yield: 19,300

BACKGROUND

Six Basins is a 16 square mile network of six groundwater subbasins in the northwest upper Santa Ana Valley in parts of Los Angeles County and San Bernardino County, California.[306] The Six Basins consist of Canyon, Upper Claremont Heights, Lower Claremont Heights, Pomona, Live Oak, and Ganesha subbasins. The Basins underlie the cities of Claremont, La Verne, and northern Upland. The Basins underlie a heavily populated area and groundwater extraction is for municipal use.[307]

Six Basins is managed by the Six Basins Watermaster Board of Directors and the Three Valleys Municipal Water District by a contract with the Watermaster.[308]

REASONS FOR ADJUDICATION

Although the Six Basins area has not experienced significant overdraft,[309] an expanding population led to concerns over future extraction. Various conservation groups also expressed concerns. Lastly, the Southern California Water Company was expanding the amount of water they supplied throughout southern California. According to the Three Valleys Municipal Water District, the adjudication was "initiated by a 'friendly' lawsuit filed by the Southern California Water Company against the other major groundwater producers in the area" and "resulted in a clarification and protection of groundwater rights."[310]

OUTCOME

---

[305] California Department of Water Resources 2003

[306] California Department of Water Resources 2004
[307] Metropolitan Water District of Southern California 2007
[308] Metropolitan Water District of Southern California 2007
[309] Metropolitan Water District of Southern California 2007
[310] Three Valleys Municipal Water District

The Court adjudicated the Basins in 1999 by a stipulated judgment. The Court appointed a Watermaster, consisting of a nine-member Board of Directors. Each of the nine members represents a producer or interest in the Basins as follow: the City of La Verne, the City of Pomona, the City of Claremont, the San Antonio Water Co., Pomona College, the Pomona Valley Protective Association (PVPA), the Southern California Water Co. (SCWC), the Three Valleys Municipal Water District, and the City of Upland.[311] The Watermaster Board of Directors and the Three Valleys Municipal Water District determine the Operating Safe Yield and enforce water rights. The Judgment limited groundwater extraction to the Operating Safe Yield within Canyon, Upper Claremont Heights, Lower Claremont Heights, and Pomona subbasins (known as the Four Basins Area). Live Oak and Ganesha are not regulated due to insufficient information. The Court determined the Natural Safe Yield to be to be 19,300 AFY. The Operating Safe Yield varies annually.

According to the Metropolitan Water District of Southern California, the adjudication judgment, "[established] procedure for setting annual operating safe yield for 4 of the 6 basins (Canyon, Upper and Lower Claremont Heights, and Pomona basins), [allowed] over-extraction but with obligation for replacement water, [and established] annual surface water and groundwater extraction rights."[312] Furthermore, the Judgment "allocated [pumping rights] to each extractor in the Four Basins Area based on the percentages in the Judgment."[313] Any extractor that uses groundwater beyond their allowance must replace the groundwater.

Since adjudication, the groundwater has not been overdrafted and, according to the Six Basins Watermaster in 2008, the "[e]xpectation is that water levels will remain stable for the foreseeable future."[314]

Tehachapi Basin

Filed/Adjudicated: 1966/1971
Number of Parties: 65
Square Miles: 37
Ag/Urban/Mix: Ag
Safe Yield: 5,500 AFY

311 Three Valleys Municipal Water District
312 Metropolitan Water District of Southern California 2007
313 Metropolitan Water District of Southern California 2007
314 Six Basins Watermaster 2008

BACKGROUND

The Tehachapi Basin is a 37 square mile groundwater basin in Kern County, central-inland California.[315] The overlying land is mostly rural-agricultural, but with a rapidly growing population. Forty-six percent of the groundwater extraction is for agricultural use. Industrial and municipal use comprises the other 54%.[316] There are currently 65 parties.[317]

The Tehachapi-Cummings County Water District (TCCWD) manages the Basin and is the court-appointed Watermaster.

REASONS FOR ADJUDICATION

According to Anderson and Snyder in their book Water Markets: priming the invisible pump, "groundwater overdraft began in the Tehachapi Basin in the 1930's following a steady increase in irrigation [and in the 1960's] pumping costs increased dramatically and some wells ran dry. Fears that continued overdraft would seriously affect the agriculturally based economy brought about the formation of the Tehachapi-Cummings County Water District."[318] In 1965, a citizen advisory committee decided to start importing water and to adjudicate the basin in order to initiate better management.[319]

OUTCOME

The Court determined that safe yield is 5,500 AFY. It determined base water rights (prescriptive rights) and reduced each by 1/3 to reduce total rights to the safe yield. It further provided for additional domestic users to pump up to three AFY and allowed stockpiling of water for future use. It appointed the Tehachapi-Cummings County Water District as Watermaster and established an Exchange Pool. Lastly, it issued an injunction against exporting water.[320] Anderson and Snyder estimated that the adjudication cost a total of $300,000 for 100 users.[321]

[315] California Department of Water Resources 2003
[316] Integrated Resource Management, LLC 2008
[317] Tehachapi-Cummings Watermaster 2008
[318] Anderson 1997
[319] Anderson 1997
[320] Tehachapi-Cummings Water District
[321] Anderson 1997

The Basin users now import most of their water, and the Basin is not in overdraft. Of the approximately 63 water users in the Basin, only 14 pumped water in 2006. According to the Tehachapi-Cummings County Water District, many "agricultural holders […] have elected to take in lieu [of groundwater] surface water deliveries, employ conservation measures or dry farm, or discontinue farming."[322]

Upper Los Angeles River Area

Filed/Adjudicated: 1955/1979/1984
Number of Parties: 5
Square Miles: 226
Ag/Urban/Mix: Mix
Safe Yield: 97,820 AFY

BACKGROUND

The Upper Los Angeles River Area, otherwise known as the San Fernando Valley Basin, consists of four groundwater basins (San Fernando, Sylmar, Verdugo, and Eagle Rock) covering 226 square miles in Los Angeles County, California.[323] The Basin underlies part of the highly urbanized area of Los Angeles County. It supplies water to municipal users and agricultural users. The San Fernando Valley Basin is the largest with 122 wells, then Verdugo with 17 wells, then Sylmar with 6 wells, and finally Eagle Rock with 3 wells.[324] In 2001, approximately 10 to 15% of Los Angeles city water was pumped from the San Fernando groundwater basins.[325]

The Basins are managed by the Upper Los Angeles River Area Watermaster. Before the adjudication, the basins were managed by the individual water agencies in each basin.

REASONS FOR ADJUDICATION

The Upper Los Angeles River Area experienced overdraft and the threat of seawater intrusion.

[322] Integrated Resource Management, LLC. 2008

[323] California Department of Water Resources 2003
[324] Metropolitan Water District of Southern California 2007
[325] Gumprecht 2001

OUTCOME

Safe yield was found to be 90,680 in San Fernando, 7,150 in Verdugo, 6.8 in Sylmar, and negligible in Eagle Rock. The main adjudication in 1979 defined rights in San Fernando, Verdugo, and Eagle Rock. A stipulation in 1984 defined rights in Sylmar.[326]

The judgment limited extraction to the safe yield plus recharge. Furthermore, the judgment distinguished each of the four groundwater basins and found them to be separate basin. Thus, distinct rights were set out in each basin. Los Angeles was awarded a Pueblo water right (the right is the highest form of right), but all groundwater extraction was reduced.[327] The Court also appointed a Watermaster and Administrative Committee (consisting of one representative from each of the five public agencies overlying the Upper Los Angeles River Area) to carry out the Court's orders.[328] Lastly, the Court set an upper and lower regulatory limit on the amount of groundwater that must be stored in the basins.

Groundwater storage has historically not met the regulatory limits. Furthermore, groundwater pumping regularly exceeds the safe yield.[329] However, the groundwater is usually replenished to the level required to prevent overdraft. According to the Metropolitan Water District of Southern California, "[d]espite a positive balance in stored water credits in the San Fernando Basin, groundwater levels and storage continued to decline. This imbalance is being addressed by the pumping parties and the Watermaster." All other areas have steady groundwater levels.[330]

Warren Valley Basin

Filed/Adjudicated: 1976/177
Number of Parties: 19
Square Miles: 27
Ag/Urban/Mix: Urban
Safe Yield: 900 AFY

BACKGROUND

[326] Metropolitan Water District of Southern California 2007
[327] City of Los Angeles 2001
[328] Metropolitan Water District of Southern California 2007
[329] Metropolitan Water District of Southern California 2007
[330] Metropolitan Water District of Southern California 2007

The Warren Valley Basin is a 27 square mile groundwater basin in San Bernardino County, inland-southern California.[331] According to the Warren Valley Basin Watermaster, "[t]he Warren Valley Basin provides a groundwater supply for the community of Yucca Valley in San Bernardino County, California."[332] The water use is mostly municipal. Users include "the Hi-Desert Water District (HDWD), Blue Skies Country Club, Institute of Mentalphysics, and 16 individuals for small domestic uses."[333]

The Warren Valley Basin is managed by the Warren Valley Basin Watermaster. The Hi-Desert Water District is appointed Watermaster.

REASONS FOR ADJUDICATION

In the 1970's, the Basin experienced critical overdraft and water supply began to be reduced. "Concerned about the prospect of not only continuing but even significantly increasing overdraft, HDWD filed a complaint for adjudication of the groundwater in 1976."[334]

[331] California Department of Water Resources 2003
[332] Warren Valley Basin Watermaster
[333] Hi-Desert Water District
[334] Warren Valley Basin Watermaster

OUTCOME

The Court determined the Safe Yield of the Basin to be 900 AFY and appointed the Hi-Desert Water District Watermaster.[335] The Court also ordered the Watermaster to find a physical solution. The adjudication gave the Blue Skies Country Club and 16 minimal extractors overlying rights and three users (Hi-Desert Water District, Yucca Water Company, and Institute of Mental Physics in the Zone of Transmission) appropriative rights. The rights exceed the Safe Yield but require pumping in excess of Safe Yield to be recharged.[336] The Hi-Desert Water District now owns the Yucca Water Company.

The Warren Valley Basin is not currently in overdraft as a result of the Morongo Basin Pipeline.[337]

West Coast Basin

Filed/Adjudicated: 1946/1961
Number of Parties: 67
Square Miles: 142
Ag/Urban/Mix: Urban
Safe Yield: 64,468 AFY

BACKGROUND

The West Coast Basin is a 142 square mile groundwater basin in southwestern Los Angeles County, California. The Basin "provides groundwater to approximately eleven cities and unincorporated areas of Los Angeles County."[338] This is a highly urbanized area. As such, most of the groundwater goes to municipal uses. There are 67 parties and the adjudicated yield of the Basin is 64,468 AFY.[339]

The Basin is managed by the court-appointed West Coast Basin Watermaster (part of the California Department of Water Resources). Before adjudication, the area was managed by the West Basin Municipal Water District.

REASONS FOR ADJUDICATION

[335] Hi-Desert Water District 2005
[336] Warren Valley Basin Watermaster
[337] Hi-Desert Water District 2008
[338] West Coast Basin Watermaster
[339] Ostrom and Ostrom 1972

Before adjudication in the late 1950's the West Coast Basin experienced groundwater overdraft and the threat of seawater intrusion.[340] Furthermore, groundwater pumping continued to increase with increased demand, and a Tragedy of the Commons situation led to ever-increasing incentives to maximize groundwater extraction.[341]

OUTCOME

The final adjudication was tried in court in 1961. In the interim, the West Basin Water Association negotiated a settlement in which 75% of groundwater users agreed to reduce their pumping by 25%. The court appointed a Watermaster to oversee the agreement. Furthermore, "an integral part of the agreement was an exchange pool which allowed those who had physical or economic difficulties in complying with the interim agreement to purchase annual rights to withdraw groundwater in excess of their assigned quota from others more able to gain supplemental supplies from alternative sources."[342]

The final judgment was very similar to the stipulated agreement. Only one major extractor challenged the judgment, but a Court of Appeals upheld the ruling. The Court appointed Department of Water Resources as the West Coast Basin Watermaster. However, "total adjudicated pumping rights in the West Coast Groundwater Basin remain at approximately 55,000 AFY."[343] Thus, annual groundwater extraction is significantly higher than recharge. The Water Replenishment District of Southern California (WRD) is charged with purchasing and injecting water to maintain groundwater levels and prevent seawater intrusion.[344] Also, West Coast Basin has established an ongoing project combating seawater intrusion with Central Basin.

The Basin experiences ongoing water demand challenges and threat of seawater intrusion.

Western San Bernardino Basin

Filed/Adjudicated: 1963/1969
Number of Parties: ~4,000

[340] Ostrom and Ostrom 1972
[341] Ostrom and Ostrom 1972
[342] Ostrom and Ostrom 1972
[343] West Basin Municipal Water District 2009
[344] West Basin Municipal Water District 2009

Square Miles:
Ag/Urban/Mix: Urban
Safe Yield: 232,100 AFY

BACKGROUND

The Western San Bernardino is a groundwater basin in San Bernardino and Riverside Counties, southern-inland California.[345] The area is highly urbanized and groundwater use is mostly municipal.[346]

The Basin is managed by the two-person Court-appointed Western San Bernardino Watermaster and the Western Municipal Water District.

REASONS FOR ADJUDICATION

As a result of decreasing water supplies and increasing demand, in 1963, the Orange County Water District filed against the City of Chino, the San Bernardino Valley Municipal Water District, and others for adjudication of surface water rights in Orange, Riverside, and San Bernardino Counties. Including cross-complaints, approximately 4,000 were party to the suit. According to the Western Municipal Water District, "[a]s a result of the Orange County settlement, it became apparent that a second settlement would be necessary between Riverside and San Bernardino entities who diverted water from the Santa Ana River surface and groundwater sources."[347] Additionally, "increasing withdrawals from groundwater resources, […] which supplied in large part the water requirements of San Bernardino and Redlands as well as the Riverside exporters, had been the cause of concern to the exporters in Riverside County."[348] Consequently, the Western Municipal Water District filed for adjudication of groundwater rights in the Western San Bernardino Basin in 1963.

[345] California Department of Water Resources 2004
[346] Western San Bernardino Watermaster 2006
[347] Western San Bernardino Watermaster 2006
[348] Western San Bernardino Watermaster 2006

OUTCOME

The Court required a physical solution and determined the safe yield to be 232,100 AFY. It adjudicated the rights of groundwater users in the Basin and required that groundwater extraction in excess of Safe Yield be recharged. The Judgment continued to allow exportation of groundwater. Several plaintiffs were awarded rights to groundwater flow from the Basin. It further appointed a two-person Watermaster to manage the Basin and enforce the Court's Judgment.[349]

According to the San Bernardino Watermaster, base rights (established at adjudication) were not exceeded in 2001-2005 and so they do not need to provide groundwater replenishment. Thus, the basin is not in overdraft.[350] The Basin imports State Water Project water to meet demand.

Non-Adjudicated Basins

There are 487 non-adjudicated groundwater basins in California. Most of those experience some extent of groundwater shortage. Many also battle land subsidence and saline intrusion resulting from extreme overdraft. California has had on average 3 groundwater adjudications per year. However, water shortages are worsening and the rate of adjudications will likely increase as the process becomes easier and in-basin politics deteriorate.

Of those basins, those mostly supplying groundwater for agricultural purposes are more likely to adjudicate (see the Pajaro Basin case study). According to Sue McClurg, no that most large southern California urban basins have adjudicated, "[a]gricultural interests may have more reason to adjudicate than the municipal purveyors […] Ag has two specters hanging over it […] One is that if there is an overdraft of the basin, the agricultural user can be prescribed against. Second, new agriculture can come along and dilute his portion of safe yield, or throw the basin into overdraft. People need to be quantified."[351]

References

Aladjem, David. "Affirming Secure Property Rights in Water: Barstow v. Mojave Water Agency." California Law and Policy Reporter. 1998. Retrieved from,

[349] Western San Bernardino Watermaster 2006
[350] Western San Bernardino Watermaster 2006
[351] McClurg 2000

http://www.downeybrand.com/publications/articles/980701_secureproprtyrights.php. 9-11-2009.

Alexander, Curtis. "Water officials eye old quarries to solve North County's supply problems." Santa Cruz Sentinel. 7-26-2008. Retrieved from, http://www.santacruzsentinel.com/localnews/ci_9999578. 6-7-2009.

CA Department of Water Resources. "Santa Clara River Valley Watershed, Santa Paula Subbasin." Retrieved from, http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs_desc/4-4.04.pdf. 6-7-2009.

Anderson, Terry. Water Markets: priming the invisible pump. Cato Institute: 1997.

Association of Groundwater Agencies. "Adjudicated Basins and Watermasters in California." 2004. Retrieved from, http://www.agwa.org/adjud_basins.html. 9-11-2009.

Beaumont Basin Watermaster. "About Us." Retrieved from, http://www.beaumontwatermaster.org/. 9-11-2009.

Beaumont Basin Watermaster. "Figure 1." Retrieved from, http://www.beaumontwatermaster.org/pdf%20files/Figure_1.pdf. 9-11-2009.

Beaumont Basin Watermaster. "Second Annual Report." 2005. Retrieved from, http://www.beaumontwatermaster.org/pdf/BBWM%202nd%20Annual%20Report.pdf. 6-7-2009.

Beaumont Cherry Valley Water District. "Memorandum." 2009. Retrieved from, http://www.cherryvalleyca.org/images/Reichenberger%20Report.pdf. 9-11-2009.

Beaumont Cherry Valley Water District. "Recharge and Recreation." Retrieved from, http://www.bcvwd.org/recharge.asp. 5-31-2009.

California Department of Water Resources. "Adjudicated Groundwater Basin Contacts." 2009. Retrieved from, http://www.groundwater.water.ca.gov/technical_assistance/gw_management/adjudicatedcontacts.cfm. 6-7-2009.

California Department of Water Resources. "Brite Valley Groundwater Basin." Retrieved from, http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs_desc/5-80.pdf. 6-1-2009.

California Department of Water Resources. "Court Adjudications." Retrieved from, http://www.water.ca.gov/groundwater/gwmanagement/court_adjudications.cfm. 9-11-2009.

California Department of Water Resources. "Cummings Valley Groundwater Basin." Retrieved from, http://www.groundwater.water.ca.gov/bulletin118/basin_desc/index.cfm. 6-1-2009.

California Department of Water Resources. "Cummings Valley Groundwater Basin." Retrieved from, http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/5-27.pdf. 9-11-2009.

California Department of Water Resources. "Groundwater Basin Map." 2003. Retrieved from, http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/maps/correct_statewide_basin_map_V3.pdf. 7-16-2009.

California Department of Water Resources. "Goleta Groundwater Basin." Retrieved from, http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs_desc/3-16.pdf. 6-1-2009.

California Department of Water Resources. "Groundwater Management." Retrieved from, http://www.groundwater.water.ca.gov/technical_assistance/gw_management/. 5-31-2009.

California Department of Water Resources. "Middle Mojave River Groundwater Basin," "Upper Mojave River Groundwater Basin." Retrieved from, http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/6-42.pdf. 9-11-2009.

California Department of Water Resources. "Salinas Valley Groundwater Basin: Seaside Area Subbasin." Retrieved from, http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs_desc/3-4.08.pdf. 6-7-2009.

California Department of Water Resources. "San Fernando Valley Groundwater Basin." Retrieved from, http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/4-12.pdf. 9-11-2009.

California Department of Water Resources. "San Gabriel Valley Groundwater Basin." Retrieved from, http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs_desc/4-13.pdf. 6-1-2009.

California Department of Water Resources. "Scott River Valley." Retrieved from, http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs_desc/1-5.pdf. 6-7-2009.

California Department of Water Resources. "Santa Margarita River Watershed." Retrieved from, http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs_desc/9-4.pdf. 6-7-2009.

California Department of Water Resources. "Southern District, Central Basin Judgment." Retrieved from, http://www.water.ca.gov/watermaster/centralbasin_judgment/introduction.cfm. 5-31-2009.

California Department of Water Resources. "Tehachapi Valley East Groundwater Basin." Retrieved from, http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/6-45.pdf. 9-11-2009.

California Department of Water Resources. "Upper Santa Ana Valley Groundwater Basin, Chino Subbasin." Retrieved from, http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs_desc/8-2.01.pdf. 6-1-2009.

California Department of Water Resources. "Warren Valley Groundwater Basin." Retrieved from, http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/7-12.pdf. 9-11-2009.

California Department of Water Resources. "Water Facts No. 3." 2004. Retrieved from, http://www.dpla2.water.ca.gov/publications/waterfacts/water_facts_3.pdf. 9-11-2009.

California Department of Water Resources. "Watermaster Service in the Central Basin." 2001. Retrieved from, http://www.water.ca.gov/watermaster/sd_documents/central_basin_2001/centralbasinreport2001.pdf.

Central Basin Watermaster. "Watermaster Report 2009." Retrieved from, http://www.water.ca.gov/watermaster/sd_reports/centralbasin.cfm. 3-19-2010.

CH2M Hill. "Basin Status Report for the Goleta Groundwater Basin." 2005. Retrieved from, http://www.goletawater.com/Basin_status_report.pdf. 6-7-2009.

Chino Basin Watermaster. "Chino Basin Watermaster." 2008. Retrieved from, http://www.cbwm.org/CBWM_Presentation.html. 9-11-2009.

City of Los Angeles. "Integrated Plan for the Wastewater Program: Stakeholder Workshop Number 5." 2001.

City of Seaside. "Action Minutes." 10-16-2008. Retrieved from, http://www.ci.seaside.ca.us/Modules/ShowDocument.aspx?documentid=1533. 9-11-2009.

County of Santa Barbara. "Public Services and Utilities." Retrieved from, http://www.countyofsb.org/ceo/rda//docs/masterplan/FEIR/FEIR_3.12%20Public%20Services.pdf. 9-11-2009.

County of Santa Barbara. "Santa Maria Groundwater Basin." 2007. Retrieved from, http://www.countyofsb.org/pwd/water/downloads/Santa%20Maria%20Groundwater%20Basin05.pdf.

Cucamonga Valley Water District. "2004 Annual Report." 2004. Retrieved from, http://www.ccwdwater.com/modules/ShowDocument.aspx?documentid=247. 9-11-2009.

Cucamonga Valley Water District. "About Us." 2007. Retrieved from, http://www.cvwdwater.com/index.aspx?page=5. 9-11-2009.

Cucamonga Valley Water District. "Our History." 2007. Retrieved from, http://www.cvwdwater.com/index.aspx?page=5. 9-11-2009.

Fetbrandt, Steve. "Officials in local water districts expect appeal in decades-old legal battle." San Diego News Network. 8-31-2009. Retrieved from, http://www.sdnn.com/sandiego/2009-08-31/news/officials-for-local-water-districts-expect-appeal-in-decades-old-legal-battle. 9-11-2009.

Foley-Gannon, Ella. "Institutional Arrangements for Conjunctive Water Management in California and Analysis of Legal Reform Alternatives." 1999. Retrieved from, http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1175&context=wrc. 9-11-2009.

Goleta Water District. "Agenda Memorandum: SAFE Ordinance." 2007. Retrieved from, http://www.goletawater.com/html/content/meeting_docs/AGENDA_3_safeordinance.pdf. 9-11-2009.

Goleta Water District. "About the District." 2006. Retrieved from, http://www.goletawater.com/about/history.htm. 9-11-2009.

Goleta Water District. "Basin Status Report for the Goleta Groundwater Basin. 2005. Retrieved from, http://www.goletawater.com/Basin_status_report.pdf. 9-11-2009.

Green, Dorothy. Managing Water: Avoiding Crisis in California. University of California Press: 2007.

Gumprecht, Blake. The Los Angeles River: Its Life, Death, and Possible Rebirth. John Hopkins University Press: 2001.

Harter, Thomas. Watersheds, Groundwater, and Drinking Water: A Practical Guide. University of California: 2008.

Hi-Desert Water District. "2005 Urban Water Management Plan." 2005. Retrieved from, http://www.hdwd.com/LinkClick.aspx?fileticket= fP392HNxy7U%3D&tabid=111&mid=592. 9-11-2009.

Hi-Desert Water District. "2007-2008 Annual Report." 2008. Retrieved from, http://www.hdwd.com/Watermaster/AnnualReports.aspx. 3-19-2010.

Hi-Desert Water District. "History." Retrieved from, http://www.hdwd.com/AboutUs/History.aspx. 9-11-2009.

Integrated Resource Management, LLC. "Draft Existing Conditions Report Greater Tehachapi Area Specific Plan Water Supply and Sewer Availability." 2008. Retrieved from, http://www.co.kern.ca.us/planning/pdfs/GTASP/ DraftExistingConditionsReports/DraftWaterSupply&SewerAvailabilityExistingConditionsReport.pdf. 9-11-2009.

Johnson, Chong. "A Century of Groundwater Changes in the Central and West Coast Basins." WRD Techincal Bulletin, Volume 4, 2005. Retrieved from, http://www.wrd.org/engineering/historic-groundwater-los-angeles.php. 6-7-2009.

Kirk, Robert; Naman, Seth. "Relative Effects of Climate and Water Use on Base-Flow Trends in the Lower Klamath Basin." *Journal of the American Water Resources Association*. Vol. 44 No. 4 pp. 1035-1052. 2008.

Klamath Riverkeeper. Letter to the State Water Resources Control Board. 5-9-2009. Retrieved from, http://www.northcoastwaternetwork.org/doc/2006-05Scott-KRK-fixes.html. 9-11-2009.

McClurg, Sue. "The Mojave River Basin Decision." Western Water. September/October 2000.

Metropolitan Water District of Southern California. "Groundwater Basin Reports: Inland Empire Basins." 2007. Retrieved from, http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/PDFs/InlandEmpireBasins/ChinoandCucamongaBasins.pdf. 9-11-2009.

Metropolitan Water District of Southern California. "Groundwater Basin Reports: Main San Gabriel and Puente Basins." 2007. Retrieved from, http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/PDFs/SanGabrielValleyBasins/SanGabrielandPuenteBasins.pdf. 6-7-2009.

Metropolitan Water District of Southern California. "Groundwater Basin Reports: Six Basins." 2007. Retrieved from, http://www.mwdh2o.org/mwdh2o/pages/yourwater/supply/groundwater/PDFs/SanGabrielValleyBasins/SixBasins.pdf. 9-11-2009.

Metropolitan Water District of Southern California. "Groundwater Basin Reports: Upper LA River Area." 2007. Retrieved from, http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/PDFs/SanFernandoValleyBasins/UpperLARiverAreaBasins.pdf. 6-7-2009.

Metropolitan Water District of Southern California. "Table B-1: Groundwater Basin Management." 2007. Retrieved from, http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/PDFs/FINALAppendixB.pdf. 9-11-2009.

Mojave Water Agency. "Post 2020 Water Supply Options." Retrieved from, http://www.mojavewater.org/home/projects/documents/MWAPost-2020Supplyaccptd051805.pdf. 6-1-2009.

Mojave Water Agency. "Watermaster." Retrieved from, http://www.mojavewater.org/home/watermasterContent.aspx. 9-11-2009.

Monterey Peninsula Water Management District. "MPWMD Releases Update on Seaside Basin Water Resource Conditions." 4-25-2005. Retrieved from, http://www.mpwmd.dst.ca.us/seasidebasin/SSbasinReportV3_042505%20dab%20final.htm. 6-7-2009.

Monterey Peninsula Water Management District. "Seaside Groundwater Basin Questions and Answers." 2008. Retrieved from, http://www.mpwmd.dst.ca.us/seasidebasin/ord135/QAOrd135091108.pdf. 9-11-2009.

National Research Council. Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery. National Academies Press: 2004.

Nossaman LLP. "Victory in Santa Maria Groundwater Adjudication." 2008. Retrieved from, http://www.nossaman.com/showAnnouncement.aspx?Show=4370. 3-19-2010

Ostrom, Vincent; Ostrom, Elinor. "Legal and Political Conditions of Water Resource Development." Land Economics. Vol 48., No. 1. 1972.

Pace, Felice. "The Shasta and Scott Are Going Dry." 8-15-2009. Retrieved from, http://klamblog.blogspot.com/2009/08/shasta-and-scott-are-going-dry-will.html. 9-11-2009.

Raymond Basin Management Board. "Chronology of the Raymond Basin." Retrieved from, http://www.raymondbasin.org/about-us/RBMB-Complete-Timeline.pdf. 6-7-2009.

Raymond Basin Management Board. "Raymond Basin History At A Glance." Retrieved from, http://www.raymondbasin.org/about-us/timeline.html. 9-11-2009.

Riverside County Superior Court. Case No. 208568. "Judgment After Trial." 1996. Retrieved from, http://www.mojavewater.org/home/watermaster/documents/Judgment.pdf. 9-11-2009.

Sadler, Martha. "Steamed Over Goleta Water Law." The Santa Barbara Independent. 11-8-2007. Retrieved from, http://www.independent.com/news/2007/nov/08/steamed-over-goleta-water-law/. 9-11-2009.

San Gabriel Basin Watermaster. Retrieved from, http://www.watermaster.org/geninfo.html. 6-1-2009.

Santa Margarita Water District. "Operations." Retrieved from, http://www.smwd.com/operations.htm. 9-11-2009.

Santa Paula Basin Experts Group. "Investigation of Santa Paula Basin Yield." 2003. Retrieved from, http://www.unitedwater.org/groundwater/67687177_20070828_050255.pdf. 9-11-2009.

Santa Paula Pumpers Association. "Appendix D Table 1: Pumpage and Allocations 2008." 2008.

Saxton, Steve. "The Seaside Basin Case: Adjudication Grows Up." California Water Law and Policy Reporter. April 2006.

Scott River Watershed Council. "History of the Council." Retrieved from, http://www.scottriver.org/SRWmain.html. 9-11-2009.

Seaside Basin Water. "Watermaster Report 2009." 2009. Retrieved from, http://www.seasidebasinwatermaster.org/Other/Final%20Annual%20Report%202009.pdf

Siskiyou Resource Conservation District. "Proposal for a Water Budget of the Scott River Watershed." 1995. Retrieved from, http://www.krisweb.com/biblio/scott_xxxx_siskrcd_xxxx_waterbudget/205.htm. 9-11-2009.

Stetson Engineers Inc. "City of Alhambra: Urban Water Management Plan Draft." 2005.

Tehachapi-Cummings Water District. Retrieved from, http://www.tccwd.com/gwm.htm. 5-31-2009.

Tehachapi-Cummings Watermaster. "Report of the Tehachapi-Cummings County Water District as Watermaster for Calendar Year 2008." 2008. Retrieved from, http://www.tccwd.com/Tehachapi%20Basin%202008.pdf. 3-19-2010.

Three Valleys Municipal Water District. "Six Basins History." Retrieved from, http://www.threevalleys.com/History.aspx?CompanyID=2. 9-11-2009.

Three Valleys Municipal Water District. "Six Basins Watermaster." Retrieved from, http://www.threevalleys.com/SixBasins.aspx. 9-11-2009.

United Water Conservation District. "Frequently Asked Questions." Retrieved from, http://www.unitedwater.org/index.cfm?go2=faq/conservation. 9-11-2009.

U.S. 108th Congress. Rept. 108-718. Retrieved from, http://ecip.loc.gov/cgi-bin/cpquery/T?&report=hr718p1&dbname=108&. 9-11-2009.

U.S. Environmental Protection Agency. "Superfund: Region 9." Retrieved from, http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/db29676ab46e80818825742600743734/131d9cd16e41ebf888257007005e944d!OpenDocument. 9-11-2009.

U.S. Forest Service. "Callahan Ecosystem Analysis." 1997. Retrieved from, http://www.fs.fed.us/r5/klamath/publications/pdfs/watershed/callahan/step1.pdf. 9-11-2009.

Warren Valley Basin Watermaster. "History." Retrieved from, http://www.wvbwatermaster.com/. 9-11-2009.

West Basin Municipal Water District. "West Coast Groundwater Basin." Retrieved from, http://d34527.u26.fmhosting.com/WaterReliability2020/Groundwater/WestCoastGroundwaterBasin/tabid/177/Default.aspx. 6-7-2009.

West Basin Municipal Water District. "West Coast Groundwater Basin." 2009. Retrieved from, http://www.westbasin.org/water-reliability-2020/groundwater/west-coast-groundwater-basin. 9-11-2009.

Western San Bernardino Watermaster. "Annual Report of the Western San Bernardino Watermaster for 2006." 2006. Retrieved from, http://www.wmwd.com/pdfs/WaterMasterReportII.pdf. 9-11-2009.

Wildermuth Environmental. "Declining Rainwater Recharge in the Chino Basin." 2009. Retrieved from, santaanawatershed.com/Portals/0/presentations/2009/Wildermuth.pps. 6-7-2009.