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Improving Water Management through Groundwater Banking: Kern County and the Rosedale-Rio Bravo Water Storage District

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Introduction

"Conjunctive use" refers to coordinating the use of surface water and groundwater to improve the overall reliability of water supply. In general, when surface water supplies are plentiful, they are either used by water customers in lieu of groundwater or diverted to recharge groundwater reserves. Groundwater is then used during dry periods when surface water is less available. Surface water can recharge groundwater basins through both natural and artificial means. Natural or incidental recharge results from percolation into the basin from natural waterways, fed by rainfall or snowmelt, and from excess water applied for crop irrigation. Artificial recharge replicates and promotes natural processes by capturing and retaining water in surface impoundments (dams, dikes, and infiltration areas) to allow water to percolate into the underlying basin. Another form of artificial recharge is direct injection of water into groundwater basins through injection wells. An additional form of recharge is "in-lieu," which refers to the groundwater that remains in basin when groundwater users switch to surface water instead of pumping from aquifers. Whether physical or in-lieu recharge methods are used, groundwater is stored in the basin for later use.

In the past decade, "groundwater banking" has come to refer to the practice of recharging specific amounts of water in a groundwater basin that can later be withdrawn and used by the entity that deposited the water. It differs from the more general description of conjunctive use because the water deposited in the bank is attributed to a specific entity and may be imported from non-local sources. Likewise, withdrawals must be in amounts specific to the amount deposited and available and can be used outside of the basin in which the deposits were made. In effect, groundwater banking uses aquifers for storage purposes and offers other water users, including those who do not overlie a groundwater basin, the opportunity to store water there. It also allows flexibility to respond to seasonal and inter-annual variability, as water can be stored in wet periods for use in dry ones. This will be increasingly important as climate change is projected to increase the frequency and intensity of extreme weather events, including floods and droughts.

As a storage alternative, water banking has several advantages over surface reservoirs. Groundwater storage is generally considered less environmentally damaging than dam or reservoir construction, and significantly reduces evaporative losses. Rising temperatures associated with climate change will increase this unproductive evaporation. Water stored underground does not evaporate, though losses can still occur as the water is being transferred to underground storage. In general, water banking has lower capital costs than dam and reservoir construction, though banking projects can require extensive distribution networks, infiltration areas, and injection wells. Infiltration areas require specific soil types and sometimes changes in land use. Annual operation and maintenance costs may also be higher than conventional surface storage, particularly when considering the recovery costs, e.g., pumping water for withdrawal during dry years. This case study reviews water banking programs in the Central Valley that have led to better coordination and use of limited water supplies.

Background

Water banking requires certain physical characteristics in terms of the groundwater basin, surface water availability, and access to transport, as well as the institutional factors related to the management and use of the basin. Ideal natural characteristics for conjunctive use and water banking include:

- Aquifers with accessible storage— unconfined, with adequate de-watered storage space at relatively shallow depth (decreased pumping costs);
- Aquifers that are easy to fill—overlying area has soils with high permeability;
- Aquifers that are easy to pump—high yielding wells with minimal pumping drawdown; and
- Areas that minimize negative impacts—no risk of land subsidence, liquefaction, or water-quality degradation as water levels change, lack of direct hydraulic connectivity with perennial streams that would induce recharge from other sources (Brown 1993).

Additionally, sources of surface water and transportation and distribution facilities to both receive and distribute banked water are needed. Banking requires that participants have access to surface water when it is available and the ability to transport it to the banking facility. Banking projects must also provide for a method of transporting recovered water to banking participants. Projects utilizing in-lieu recharge must have sufficient distribution systems to support conjunctive use. Beyond the physical infrastructure, these exchanges require institutional infrastructure including agreements, monitoring, and accounting methods to guarantee a secure right to the banked water.

There are several concerns related to groundwater banking. Overlying landowners, for instance, have concerns about local impacts on groundwater in terms of both quality and quantity. While recharge may have positive benefits, e.g., temporarily raising the water table, withdrawals have the opposite effect, drawing down the water table and possibly resulting in subsidence and water-quality degradation. In addition, residents within the boundaries of the groundwater basin may object to using stored water outside of the basin; in some cases there are county ordinances prohibiting out-of-basin use. Participants in groundwater banks may also be concerned about the security of their deposits since in some cases stored groundwater may not be 100% recoverable, or may not be recoverable at particular times.

Groundwater in the Central Valley

The groundwater basin that underlies the Central Valley contains one-fifth of all groundwater pumped in the nation—and thus is, in effect, California's largest reservoir. In 2009, the United States Geological Service released the first comprehensive, long-term analysis of groundwater levels in California's Central Valley. Among the major findings of the study was that groundwater levels have been rapidly declining in the southern, Tulare Basin portion of the San Joaquin Valley as more water is pumped out than recharges naturally (Figure 1). But the southern valley also shows the most promise for large-scale groundwater recharge, particularly along the eastern side with its coarse-grained soils from river and alluvial-fan sediments.

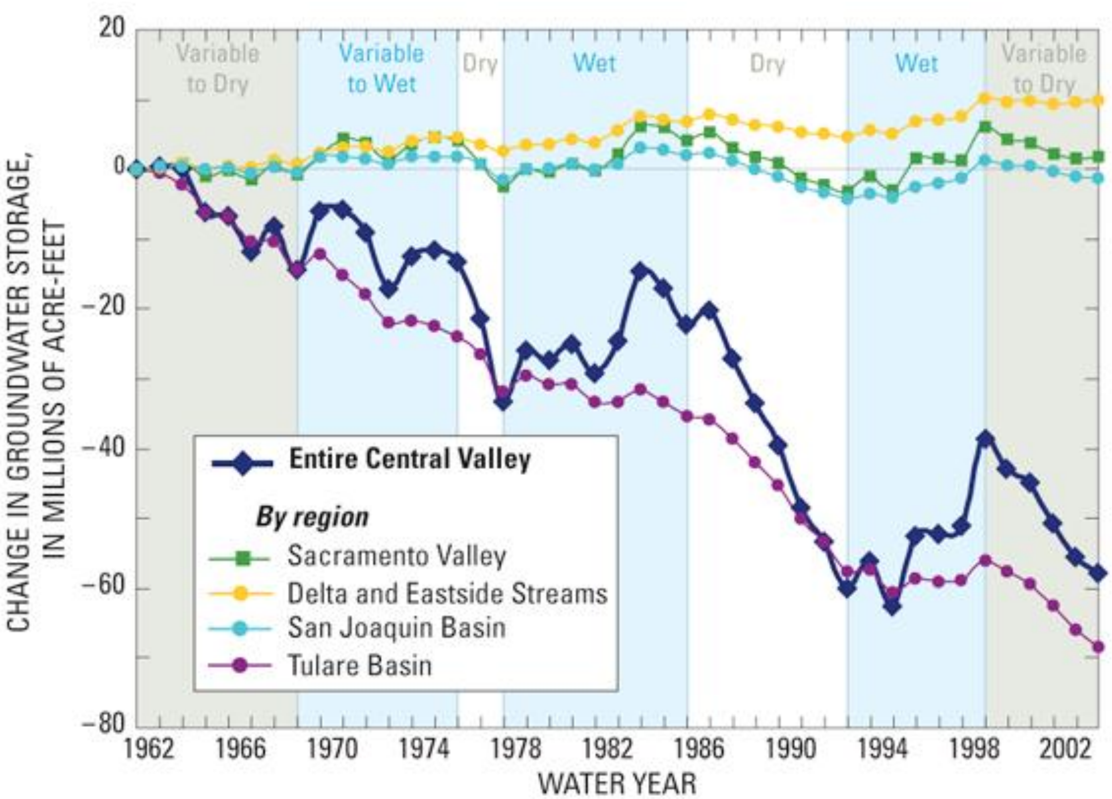

Figure 1. Changes in groundwater storage in the entire Central Valley and by region in millions of acre-feet, 1962-2003

Source: Faunt, C.C., ed., 2009

The report found severe aquifer overdraft between 1962 and 2003, when an average 9.1 million acre-feet of water went into storage annually, yet an average of 10.5 million acre-feet were removed annually (Faunt et al. 2009). Thus, in typical years the net loss in groundwater storage is about 1.4 million acre-feet. Over the last four decades the entire Central Valley has lost about 60 million acre-feet of groundwater, driven by the declines in the Tulare Basin, which lost almost 70 million acre-feet over the time period. This drawdown has had numerous negative effects, including localized subsidence and increased well-drilling and groundwater pumping costs. However, it also provides an opportunity as there is a vast amount of groundwater storage potential in the dewatered portions of the aquifer.

Water Banking in the Central Valley

Water banking in the Central Valley is primarily done through surface water impoundments in the southern part of the valley. Located at the southern end of the San Joaquin Valley, Kern County is the one of the most productive agricultural counties in the nation. With over 800,000 acres of irrigated farmland, the county relies on surface and groundwater sources to meet its water demand. Kern County offers an example of an area that has implemented water banking programs as an important water supply management tool to increase water supply reliability for both local and non-local actors (Figure 2).

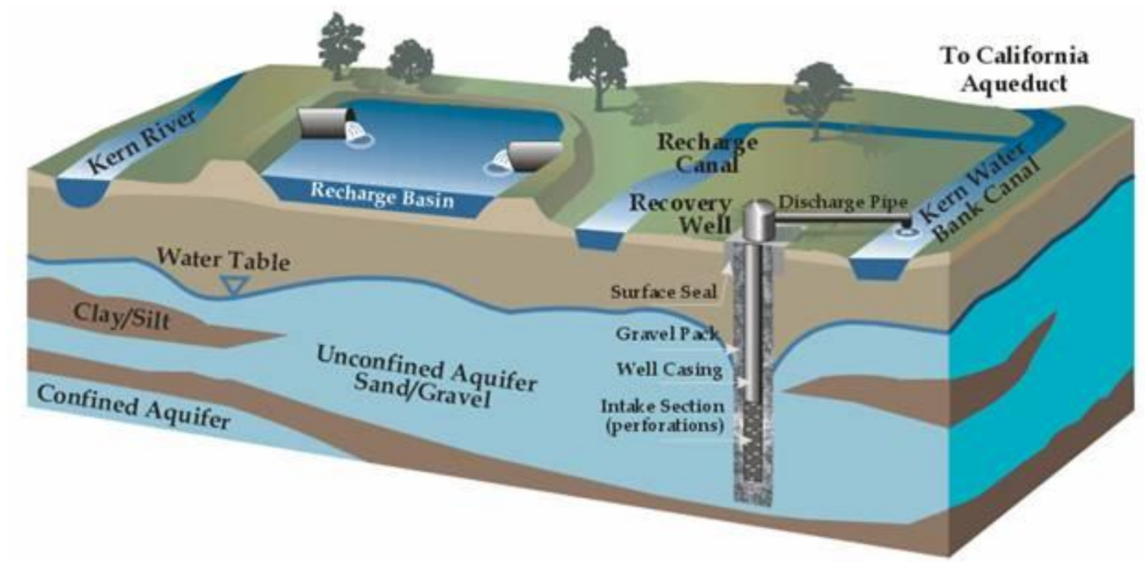

Figure 2. Cross-section of the Kern Water Bank in Kern County
Source: Kern Water Bank 2010

A number of factors make Kern County a prime area for water banking. The area is conveniently situated, in terms of geology and proximity, to water-supply and delivery systems. Kern County banks water from local rivers, the State Water Project (SWP), and the Central Valley Project (CVP). Most of the water banks are located on alluvial fans, consisting of sandy sediments on the valley floor, which are highly permeable and, therefore, well-suited for recharging underlying aquifers (Faunt et al. 2009). The heavy reliance on groundwater pumping over the last several decades has resulted in substantial dewatered storage. The county also has several options for moving water around via the Kern River, the Friant-Kern Canal (CVP), the California Aqueduct (SWP), and the Cross Valley Canal. In addition, a distribution network of canals and pipelines serves much of the irrigated acreage.

The earliest groundwater programs began in this area in the late 1970s and early 1980s. The city of Bakersfield developed a series of recharge ponds within its 2800 Acre Recharge Facility, and Kern County Water Agency developed 240 acres of recharge ponds on lands along the Kern River for the Berrenda Mesa Water District, as well as recharge operations in a portion of the Kern River channel. The early 1990s saw the development of still more water banks, including the Kern Water Bank, Kern County Water Agency's "Pioneer Property," and programs in the Arvin- Edison and Semitropic Water Districts. These programs were motivated by the ability to provide greater water supply reliability through conjunctive use, particularly in drought years when the CVP and SWP are not able to meet contracted water deliveries.

Today, the three major water banks (Arvin–Edison, Kern, and Semitropic) have a combined storage capacity of about 3 million acre-feet. That is more than five times the amount of water in Millerton Lake, one of the larger reservoirs feeding the Central Valley surface-water system. In addition, several smaller banking programs have been launched by the Buena Vista Water Storage District, Rosedale-Rio Bravo Water Storage District, and Kern Delta Water District. Altogether, groundwater banks in Kern County can currently store over 800,000 acre-feet a year and return 700,000 acre-feet annually (Table 1). And several new water banks are being proposed.

Table 1. Updated information about various groundwater banking projects in Kern County, California

Source: Originally published in KCWA n.d.

Water Bank	Acres	Maximum Annual Recharge (acre-feet/year)	Maximum Annual Recovery (acre-feet/year)
Berrenda Mesa	369	58,000	46,000
Bakersfield 2,800 Acres	2,760	168,000	46,000
Kern Water Bank	19,900	450,000	314,000
Pioneer Property	2,273	146,000	98,000
West Kern/Buena Vista	2,000	77,000	45,000
Arvin-Edison	130,000	150,000	150,000
Semitropic	221,000	430,000	423,000
Rosedale-Rio Bravo	40,000	234,000	45,000
Kern Delta	125,000	50,000	50,000
Buena Vista	50,000	110,00	32,000
Total	*566,000*	*864,000*	*700,000*

Rosedale-Rio Bravo Water Storage District's Conjunctive Use Program

Rosedale-Rio Bravo Water Storage District encompasses 44,150 acres in Kern County, with 28,500 acres developed as irrigated agriculture and about 6,000 acres developed for urban uses. The District was established in 1959 to develop a groundwater recharge program to offset overdraft conditions in the regional Kern County aquifer. To meet the long-term needs of its landowners, Rosedale developed the Groundwater Storage, Banking, Exchange, Extraction & Conjunctive Use Program (Conjunctive Use Program) in the late 1990s.

From the beginning, Rosedale took a unique approach to groundwater banking. Typically, the first step of a groundwater banking project is to secure partners that will provide capital for the development of infrastructure, and then to divide the banking capacity between those partners.

Most of the banks in Kern County are actually banking water for wealthier out-of-basin interests, most notably the Metropolitan Water District, a large urban supplier. Rosedale decided to finance the construction of banking infrastructure themselves through a variety of local financing mechanisms, including revenue bonds. Then, they set a 2:1 banking requirement, which means that for every 2 AF of water banked, only 1 AF is available for return.

Essentially, the contribution from the banking partner comes to Rosedale in the form of water rather than initial capital. Rosedale General Manager Eric Averett explains, “We thought that there was a greater value in the water than the capital…This year is a great example, you could have $5 million in the bank but if there is no water available that money does no good. Early on the board recognized that water is the more valuable of the two commodities and have invested considerably to ensure we have an adequate supply of water to meet the district’s needs.”

The Conjunctive Use Program currently manages over 200,000 acre feet (AF) of stored groundwater in the underlying aquifer, which has an estimated total storage capacity in excess of 1.7 Million AF (ESA 2008). Water supplies for the Conjunctive Use Program are supplied by the participating water agencies and include high-flow Kern River water and water from the Central Valley Project (CVP) and State Water Project (SWP). Currently, the infrastructure for the Conjunctive Use Program includes over 1,000 acres of recharge basins and ten recovery wells**.** There are several participants in its Conjunctive Use Program: Arvin-Edison Water Storage District, Delano-Earlimart Irrigation District, Kern-Tulare Water District, Castaic Lake Water Agency, Irvine Ranch Water District, and Buena Vista Water Storage District (Averett, personal communication). The Program provides for maximum annual recharge of approximately 250,000 acre-feet/year and a maximum annual recovery of 45,000 acre-feet/year (E. Averett, General Manager of the Rosedale-Rio Bravo Water Storage District, personal communication, February 16, 2010).

Conclusions

In the last decade, the number of water banks has grown as districts seek to take advantage of groundwater storage options and improve the management and reliability of often-scarce surface water supplies. Groundwater banking offers a valuable supply-side tool, particularly as a response to climate change impacts on water resources in California. As surface runoff is concentrated in the winter and early spring due to earlier snowmelt, supply will be increasingly out of phase with demand. In addition, rising temperatures will also lead to rising evaporation rates. Given that the annual yield of all proposed surface storage projects in the state is less than 4 million acre-feet and that many of these projects have been declared unfeasible by the Bureau of Reclamation, the approximately 10 million acre-feet of storage available in just Central Valley aquifers represents a large additional storage capacity.

Yet, there are still some concerns around groundwater banking programs. A program’s ability to transport water out of a basin raises issues related to water transfers and water rights. Two-to-one banking is one way to decrease local impacts and to ensure that water remains within the basin. In addition, appropriate monitoring of groundwater levels and accurate accounting of traded water are critical to maintain good relations with overlying and surrounding landowners, as well as the credibility of groundwater banking strategies. Finally, the lack of regulation of groundwater use in most areas of the state means that overlying landowners may pump from a groundwater bank without permission or monitoring. This could become a problem for banking efforts in the future.

Groundwater banking, like any conjunctive use strategy, cuts to the heart of links between surface and groundwater and basin impacts such as water quality, recharge, and groundwater levels. Thus, banking programs are best implemented as part of a larger, integrated planning effort. The state's recent focus on Integrated Regional Watershed Management Planning should include groundwater management, particularly in areas considering groundwater banking. Specifically, plans should require consistent monitoring of groundwater levels and quality and coordinate banking programs with other surface and groundwater uses. Groundwater banking programs can provide a valuable management tool to help better coordinate groundwater and surface water management to improve basin conditions.

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