Managing Aquifer Recharge in Southern California: the Orange County Groundwater Replenishment system (GWRS)

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Introduction

Two-thirds of California's population lives in Southern California, a water-scarce area, with a rather narrow, heavily populated coastal zone along the Pacific Ocean, a chain of medium to rather high mountains covering a great part of the region and desert conditions in the rest. Less than one-third of the State's precipitation falls in Southern California. Groundwater represents one of the major water resources of the region – along with diverted surface waters from the Colorado River and the Bay-Delta in Northern California.

A feature of water resources management in California is that most of the recycling done in the US is in California, i.e. about 60%.

This paper will present managed aquifer recharge in Orange County, between Los Angeles and San Diego, and its strong connection to reclaimed wastewater. While other Southern California counties rely mostly on imported water supplies to meet their water needs, Orange County does not. A large percentage of its water supply is derived from a large groundwater basin. This groundwater basin underlies north and central Orange County and holds over 40 million acre-feet (AF) (49 billion m^3) of water with an annual yield of nearly 300,000 AF (370 million m^3) of water and an operational capacity of roughly 700,000 AF (860 million m^3). In central Orange County, a sizable portion of public water supplies is derived from reclaimed wastewater that is used to recharge the aquifer. In effect, reclaimed wastewater and groundwater are treated as an integrated, conjunctively connected (through engineered-intervention) set of resources. (1)

Short history

The institution involved in aquifer recharge is the Orange County Water District, which was formed in 1933 on a background of water shortage, as groundwater levels were dropping and artesian wells disappearing. The blame was put on low rainfalls but also on the upstream interests (e.g. upstream

storage and spreading operations). The Water District was empowered to protect the water supply and the rights of those who depended upon it, i.e. about 60 000 people whose water use was 86% agricultural.

The first years of Orange County Water District were rather good in terms of groundwater availability but from 1945 to 1969, due to a heavy drought, groundwater levels dropped to almost 5m under sea level and ocean water moved into the aquifers. Besides, the explosion of population involved a significant increase of demand, and natural recharge could not offset groundwater extraction, which meant that massive importation and storage facilities would have to be constructed at an exorbitant cost. Therefore an important program of artificial recharge began, from 1948 on, based on water bought from the Metropolitan Water District of Southern California (MWD), formed five years before OCWD. The high cost of this water resulted in the State Legislature authorizing a pump tax, called Replenishment Assessment (RA), to be charged to all groundwater pumpers on the quantities they extracted from the basin. The replenishment was rather successful but, after 1969, it appeared that seawater intrusion could not be controlled and recharge had to be increased. After the Federal government's abandonment of a seawater desalination plant project in the 70's, OCWD introduced a 5 M gallons/day (18 925 m^3/d) demineralization plant based on reverse osmosis, which was dedicated in 1977 as Water Factory 21. It was the world's largest operating reverse osmosis plant. Its successes were rewarded when, in 1991, the California Department of Health Services granted OCWD a permit to inject 100% recycled wastewater without blending.

In the mid 1990s OCWD needed to expand Water Factory 21 and address continued problems with seawater intrusion. At the same time, Orange County Sanitation District (OCSD) faced the challenge of having to build a second ocean outfall. The Ground Water Replenishment System (GWRS), as a result of a collaborative effort between OCWD and OCSD, resolved these issues. Both districts shared the cost of constructing the GWRS ($481 million US dollars). OCSD supplied OCWD with stringently controlled, secondary treated wastewater at no charge. OCWD in turn agreed to manage and fund the GWRS operations. From a social point of view, it proved to be an interesting cooperation between two public agencies. The GWRS has become an essential component in the provision of reliable water for Orange County. (2)

OCWD general institutional information

A Board of Directors comprised of 10 members, 7 directly elected by the public and 3 appointed, governs OCWD. The groundwater basin is non-adjudicated, which means that the Board of Directors sets the amount of groundwater to be pumped annually, depending on the groundwater conditions. Actually it sets the Basin Production Percentage (BPP), which is the percentage of groundwater production out of the total water demand for the Orange County

Basin: e.g. in 2013 this amount is 70% of the total water demand. Each year the Board also sets the Replenishment Assessment (RA), a fee charged on pumping up to the BPP, and the Basin Equity Assessment (BEA), a fee set so that the cost of groundwater production above the BPP is similar to the cost of purchasing alternative supplies. Groundwater production above the BPP is charged the RA plus the BEA. (3) (4)

Orange County water supplies

The water supply sources of OCWD produce a total of 311,00 afy (383,612,280m^3/y)

- About 1/3rd of the total supplies come from the Santa Ana river
- About 1/3rd of the total supplies come from natural recharge from rainfall and storm capture, with a dam for storm water, rubber dams close to the Santa Ana river and discharge basins
- 20to 25% of total supplies come from the GWRS (72,000 afy=88,810,560m^3/y)
- About 10% of total supplies are purchased of imported water from the Metropolitan Water District.

A brief technical description of GWRS

The GWRS is comprised of three components:

- An advanced purification facility at the OCWD headquarters, which receives treated wastewater from OCSD and purifies it through microfiltration, reverse osmosis and ultraviolet light with hydrogen peroxide. The product water is of near distilled quality. These processes are briefly described in the GWRS Technical Brochure.
- A seawater intrusion barrier along the Pacific: approximately 35 M gallons per day (132,500 m^3/d) of the final product water are pumped into injection wells to create the seawater intrusion barrier.
- Percolation recharge basins in Anaheim: another 35 M gallons per day (132,500 m^3/d) are pumped to the basins, where the water naturally filters through sand and gravel to the deep aquifers of the groundwater basin. (1)

Regulatory oversight

The Federal government does not issue any regulation; each state has to set its own regulations. The State Water Resources Control Board is the agency that issues permits to discharge wastewater into any water body. Its nine Regional Water Quality Control Boards issue permits for recycling. The California Department of Public Health sets regulations for recharge of recycled wastewater and issues approvals for the type of treatment, depending on whether recharge is by direct injection or by percolation.

An Independent Advisory Panel (IAP), appointed and administered by the National Water Research Institute, analyzes data in OCWD's Annual GWRS Report on plant operations as well as water quality data collected throughout the groundwater basin. Scientific and engineering experts from around the world are members of IAP. The IAP also offers suggestions for enhanced monitoring of water quality and for improving the efficiency of current GWRS technologies and for evaluation of future projects associated with the GWRS.

The institutional actors that play a role in California groundwater are:

- California Department of Water Resources
- State Water Resources Control Board (SWRCB)

The State Water Resources Control Board (the State Water Board) was created by the Legislature in 1967. The mission of the Water Board is to ensure the highest reasonable quality for waters of the State, while allocating those waters to achieve the optimum balance of beneficial uses. The joint authority of water allocation and water quality protection enables the Water Board to provide comprehensive protection for California's waters.

The Water Board consists of five full-time salaried Members, each filling a different specialty position. Each board member is appointed to a four-year term by the Governor and confirmed by the Senate.

There are nine Regional Water Quality Control Boards (Regional Boards). The mission of the Regional Boards is to develop and enforce water quality objectives and implementation plans that will best protect the beneficial uses of the State's waters, recognizing local differences in climate, topography, geology and hydrology.

Each Regional Board has seven part-time Members also appointed by the Governor and confirmed by the Senate. Regional Boards develop "basin plans" for their hydrologic areas, govern requirements/issue waste discharge permits, take enforcement action against violators, and monitor water quality. The task of protecting and enforcing the many uses of water, including the needs of industry, agriculture, municipal districts, and the environment is an ongoing challenge for the Water Board and Regional Boards.

The State Water Resources Control Board has jurisdiction throughout California. The Board protects water quality by setting statewide policy, coordinating and supporting the nine Regional Water Board efforts, and reviewing petitions that contest Regional Board actions. This organization is a result of the landmark Porter-Cologne Act. (5) (6)

- Water Districts and Agencies including 157 irrigation districts
- Pollution Regulators (California EPA, USEPA, Department of Health Services)
- Land Use Regulators (e.g. County Zoning and Planning agencies and commissions)

More generally, the following institutions are involved in groundwater governance in California:
1-special groundwater management districts
2-adjudicated groundwater basins (through state courts)
3-AB3030 plan i.e. a legislatively authorized institutional arrangement that can coordinate fund raising powers across multiple existing political jurisdictions (AB means Assembly Bill)
4-counties through county ordinances

Besides, a variety of legislatively authorized districts have authority on groundwater: e.g. irrigation districts, county water districts, water storage districts, community service water districts, and flood control districts. And, of course, the groundwater users are involved.

Public information

When wastewater recycling and reuse is concerned, strong opposition is often occurring for various health-related reasons, even if the treatments are efficient and these concerns are not justified. OCWD did not experience such opposition by the public and its political representatives because it is reaching out to the public and the politicians through tours, lectures, on-line Internet. It organizes tours of the facilities for high school and university students and their professors, and, in general, aims at educating the public and its political representatives.

GWRS and Sustainable Development

The GWRS is an interesting example of a successful sustainable development project, as it satisfies the three usual components of sustainable development, economic, environmental and social.

- Economic: it provides an uninterruptible source of water for groundwater recharge and seawater intrusion protection. It uses less than half the energy required to transport water from Northern California to Southern California. It uses one-third of the energy required to desalinate seawater. And it is designed to increase production capacity to help meet future water needs.
- Environmental: it decreases Southern California's dependency on water from the Sacramento-San Joaquin River Delta and the Colorado River. It creates a locally controlled, reliable supply of high-quality water that is drought-resistant. It produces high quality water to replenish the groundwater basin. It protects Orange County's groundwater basin from seawater intrusion. It reduces the amount of wastewater discharged to the Pacific Ocean. It diversifies water supplies in Southern California, minimizing negative impacts resulting from limitations on imported water supplies, natural disasters, climate change, and/or droughts. It improves

groundwater quality by reducing the amount of dissolved solids, i.e. salt, in the groundwater basin.

- Social: by contributing to reducing the vulnerability of the region to drought and variations in precipitation, it has provided the public assurance of sufficient water supplies for its economic development and its health. It also has created jobs from its development, construction and operation, as, for instance, OCWD had to increase its staff but without involving administrative and organizational changes.

Conclusion

From the example of the Orange County Groundwater Replenishment System, we see that the major issues in Managing Aquifer Recharge are not scientific, administrative or regulatory but social. As it involves water and public health, the recharge of recycled wastewater into aquifers is a very sensitive subject and the experience shows that people, and especially older people, are quite reluctant to drink tap water when they know that part of it comes from wastewater even treated. And, of course, their political representatives usually support them. Therefore a major effort has to be made on the education of both the public and the policy-makers, including, of course, the media. In that respect, the example of Orange County GWRS, considered as the largest planned indirect potable water reuse project worldwide, is quite instructive and can be taken as a good example of the management of aquifer recharge.

References

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