THE GROUNDWATER REPLENISHMENT SYSTEM

PROVIDING WATER FOR THE FUTURE

2003-2004 ORANGE COUNTY GRAND JURY REPORT

THE GROUNDWATER REPLENISHMENT SYSTEM

SUMMARY

Orange County is an arid area that receives little rainfall. Local sources of water are woefully inadequate to serve the current needs, and water suppliers anticipate that water demand will increase to more than 600,000 acre-feet per year by 2020. The Orange County Water District hopes to increase the current rate of 324,000 acre-feet per year of groundwater withdrawals to help satisfy the future water needs. Changes in groundwater management strategies will be required to substantially increase the current rate of groundwater withdrawals.

The Orange County Water District and the Orange County Sanitation District are developing a project that will convert 100 million gallons per day of wastewater into an annual supply of 72,000 acre-feet of desalted and purified water. The project will postpone or eliminate the need for a second ocean outfall for wastewater and provide a new local source of fresh water, which will be used to replenish the County's underground water supplies.

The Orange County Water District intends to pump about 42,000 acre-feet per year of the purified wastewater to Kraemer Basin in Anaheim, where it will seep into the ground and replenish (recharge) the underground aquifer. Kraemer Basin is currently used to replenish the aquifer using Santa Ana River floodwaters and imported water purchased from the Metropolitan Water District. However, using the Basin to recharge purified wastewater will hinder the Orange County Water District's ability to capture floodwater during abnormally wet years and will undoubtedly result in the loss of some of the "free" floodwater that might otherwise have been captured.

The Orange County Water District intends to use the other 30,000 acre-feet per year of the purified wastewater to bolster an existing seawater-intrusion barrier in Talbert Gap. Under current plans, the barrier will be terminated on the west side of the Santa Ana River. The barrier should be extended to the east side of the Santa Ana River to protect municipal well fields in that area. Enhanced protection from seawater intrusion would enable continued use of coastal well fields.

Excessive groundwater withdrawals have caused water levels near the coast to fall to more than 80 feet below sea level. Efforts to relocate groundwater withdrawals to inland areas should stabilize, but not eliminate, this pumping depression. The Orange County Water District pumps groundwater from

deep wells in Fountain Valley for use in the Talbert Gap seawater-intrusion barrier. This deep-well pumping should be curtailed and other water sources should be used for the Talbert Gap seawater-intrusion barrier.

Initiating a mid-basin injection program would allow the Orange County Water District to disperse recharge over a larger area. Dispersing recharge could help alleviate the coastal pumping depression and enable water producers to increase the rate of groundwater withdrawals to meet future water demands.

INTRODUCTION

The Orange County Water District (Water District) and the Orange County Sanitation District (Sanitation District) have joined forces to develop a new local source of water while reducing the amount of wastewater that would have been discharged to the ocean. The Water District will convert 100 million gallons per day of wastewater from the Sanitation District's sewer collection system into 72,000 acre-feet per year of desalted and purified wastewater. Treated wastewater from the Sanitation District wastewater-treatment facilities will be filtered through a state-of-the-art micro-filtration system to remove particulate matter, passed through reverse-osmosis membranes to remove dissolved salts, and purified with ultraviolet and hydrogen-peroxide disinfection to produce "ultra pure" water that exceeds all drinking water standards. The purified water will be used to protect and replenish Orange County's underground water supplies. The project will substantially reduce Orange County's reliance on imported water and postpone or eliminate the need for a second submarine wastewater outfall. Adding desalted and purified water to the underground water supply will dilute the concentration of dissolved salts in groundwater and may reverse the trend of salt buildup in groundwater that has been occurring in recent years.

The Water District envisions that 30,000 acre-feet per year of the purified wastewater will be used to extend the Talbert Gap seawater-intrusion barrier, which protects the County's underground water supplies from encroaching salt water from the ocean. The remaining purified wastewater (42,000 acre-feet per year) will be piped to Kraemer Basin in the Water District's recharge facilities in Anaheim, where it will be used to replenish the groundwater supply. Future expansion of the purification plant could double the production of purified wastewater. The Water District anticipates that adding the purified wastewater to the underground water supply will enable local water producers to increase groundwater withdrawals to help satisfy future water needs.

PURPOSE OF STUDY

The purpose of this study was to conduct a thorough review of the Water District's Groundwater Replenishment System to assess potential benefits and identify potential problems. The first objective was to determine if continuous delivery of 42,000 acre-feet per year of purified wastewater to Kraemer Basin would hinder the Water District's ability to capture and recharge Santa Ana River floodwater. The second objective was to evaluate whether the aquifer-replenishment plan and the enhanced Talbert Gap seawater-intrusion barrier would alleviate depressed groundwater levels near the coast and retard the advance of seawater that has occurred in recent years. The third objective was to determine if the aquifer-replenishment plan would enable an increase in groundwater withdrawals to help satisfy future water needs. Finally, the study explored state requirements regarding the utilization of wastewater to replenish aquifers to determine if better uses might be made of the purified wastewater.

METHOD OF STUDY

Field tours of the Water District groundwater-replenishment (recharge) facilities were conducted to evaluate recharge capacity and to become acquainted with operational practices. Interviews were conducted with field personnel to identify potential problems and review opportunities for solutions. Interviews were conducted with Water District hydrologists and groundwater-modeling experts to assess current groundwater conditions and to review the Water District's groundwater-modeling efforts. An interview was also conducted with Water District planning personnel to review other options that have been considered to utilize purified wastewater.

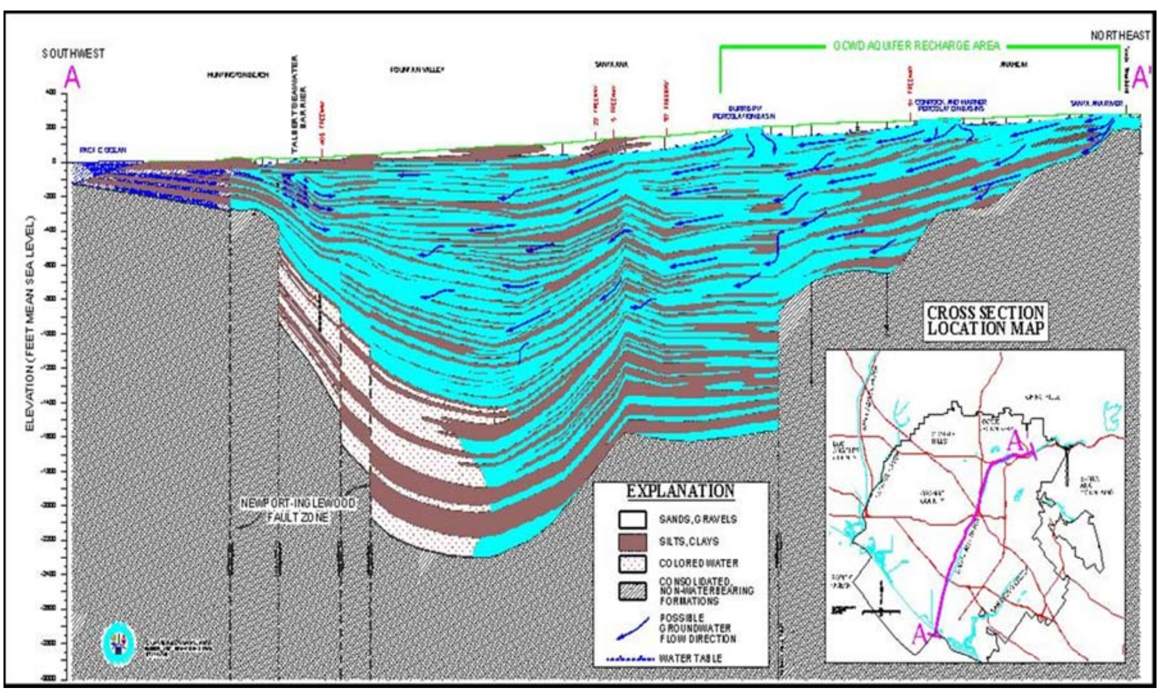
Numerous Water District reports describing groundwater resources, groundwater management, and planning activities were reviewed to gain insight on groundwater problems and planned solutions. U. S. Geological Survey stream flow records were reviewed to document changes in the pattern of stream flow in the Santa Ana River basin and to evaluate the Water District's ability to capture floodwater. Personnel of the California State Department of Health Services were interviewed to determine how regulations on the utilization of reclaimed wastewater might impact the Water District's efforts to make effective use of the new water source.

BACKGROUND

Northern Orange County is an arid area that enjoys abundant sunshine but sparse rainfall. Local sources of water (infrequent rainfall and intermittent stream flow in the Santa Ana River and tributary streams) are woefully inadequate to meet the needs of the area's 2.3 million residents. However, northern Orange County overlies a vast reservoir of underground water that is contained in an aquifer comprised of layers of sand and gravel. Water wells tapping this aquifer fueled Orange County's early agricultural development and sustained orange groves, row crops and dairy herds. Until the first imported water arrived from the Colorado River in 1949, the aquifer also served as the sole source of municipal and domestic water supplies for northern Orange County.

Geologic Setting

The aquifer beneath northern Orange County is comprised of interconnected layers of coarse-grained sand and gravel, which are interspersed with finer-grained layers of silt and clay (Figure 1). The layers of sand and gravel were deposited by floods as the Santa Ana River and other minor streams meandered across the landscape over millions of years. Finer-grained layers of silt and clay accumulated in ponds and marshy areas, which developed during wet periods. The complex assemblage of deposits is as much as 2,000 feet thick in the central part of the basin but thins to less than 200 feet along the coast.



From Orange County Water District

Figure 1. Layers of Sand and Gravel Contain Vast Amounts of Groundwater

Where the Santa Ana River flows out of the Santa Ana Canyon, the underlying deposits are primarily sands and gravels. Water seeps easily through the sandy bed of the river and sinks into the coarse sand and gravel layers, where it becomes part of the underground water supply. A considerable volume of water can enter the underground aquifer system during flood periods. This area is where most of the recharge to the aquifer occurs.

In the central part of the County, thick layers of silt and clay cap the underlying aquifer and retard the downward movement of water. Although this phenomenon limits recharge to the aquifer, it also serves to protect it from contamination. Chemicals and pollutants from man's activities (fertilizers applied to crops and lawns, chemicals dumped or spilled on the ground, sewage leaking from sewer lines, petroleum products leaking from storage tanks, etc.) that would otherwise seep downward into the main aquifer are intercepted by the fine-grained deposits and held above the underlying sand and gravel layers that are tapped by municipal water wells.

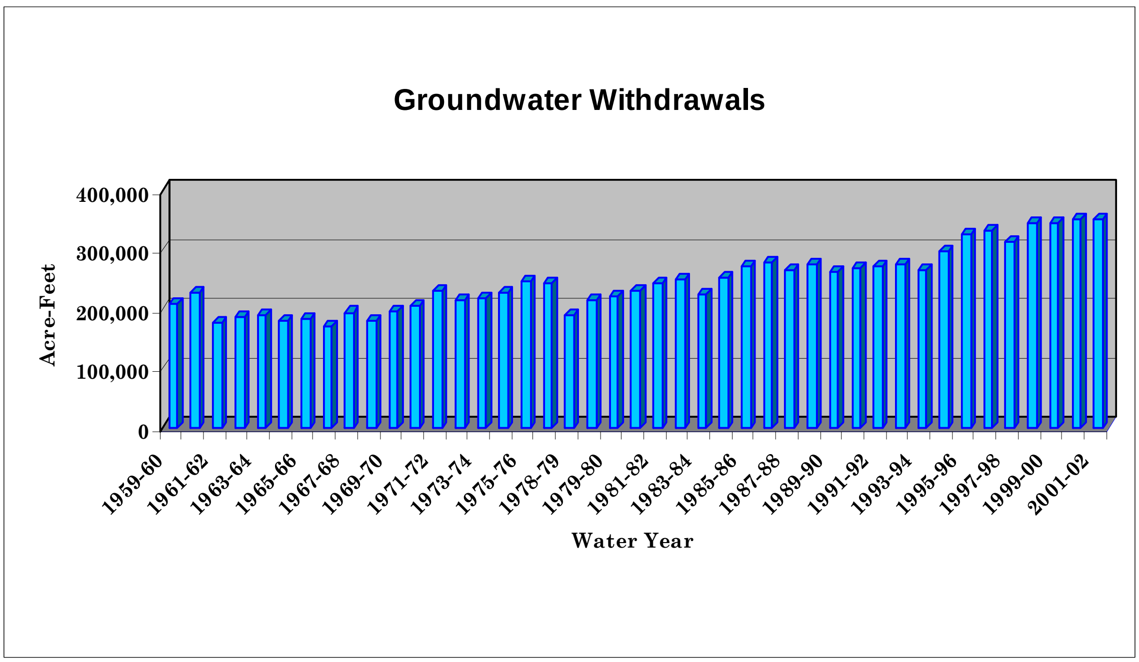
Groundwater Management

The earliest water wells drilled in Orange County encountered groundwater under considerable pressure and many wells flowed freely at land surface (hence the name Fountain Valley). However, drought conditions and heavy groundwater withdrawals during the 1920s caused water levels in wells to fall 70 feet or more, and many artesian wells ceased to flow by the early 1930s. Concerns about declining water levels, drought conditions and increased water use in the upper Santa Ana River basin prompted the California Legislature to establish the Orange County Water District in 1933 to manage the groundwater basin and represent local water users in litigation with upper Santa Ana River basin water users.

Above-normal rainfall during the late 1930s provided ample recharge to the aquifer, and water levels in wells began to recover until another drought began in 1945. In 1949, the Water District began an artificial-recharge program using Colorado River water purchased from the Metropolitan Water District to replenish the aquifer. Despite the addition of imported water to the aquifer, water levels in wells continued to decline. In 1956, water levels in wells averaged 20 feet below sea level, and the underground water supply had been depleted by 700,000 acre-feet. With groundwater levels falling below sea level along the coastline, salt water from the ocean began to migrate into the aquifer, and water wells as far as 3 ½ miles from the coast became contaminated.

The Water District increased efforts to replenish the aquifer, purchasing as much as 200,000 acre-feet of Colorado River water per year in the early 1960s to refill the aquifer. In 1965, the Water District installed injection wells along the coast in Talbert Gap near the mouth of the Santa Ana River to pump water into the shallow aquifers. Injecting water into the shallow aquifers produced a groundwater mound that stood higher than sea level. The artificial mound reversed the direction of groundwater flow and flushed the invading salty water back toward the ocean.

With a barrier in place to retard seawater intrusion, the Water District gained considerable flexibility in how groundwater could be managed. Instead of simply keeping the basin as full as possible to prevent seawater intrusion, it became feasible to draw water levels down during dry periods when local surface water and imported water sources were in short supply. During wetter periods, the depleted aquifer could be replenished with storm runoff and excess imported water. Utilizing this more flexible method of groundwater management, the Water District allowed the amount of depleted groundwater supply (basin overdraft) to fluctuate between "full" in 1969 to an overdraft of nearly 500,000 acre-feet in 1977 without causing irreparable damage to the resource. Consequently, groundwater withdrawals have increased from less than 200,000 acre-feet per year in the early 1960s to more than 350,000 acre-feet per year in 2002 (Figure 2).

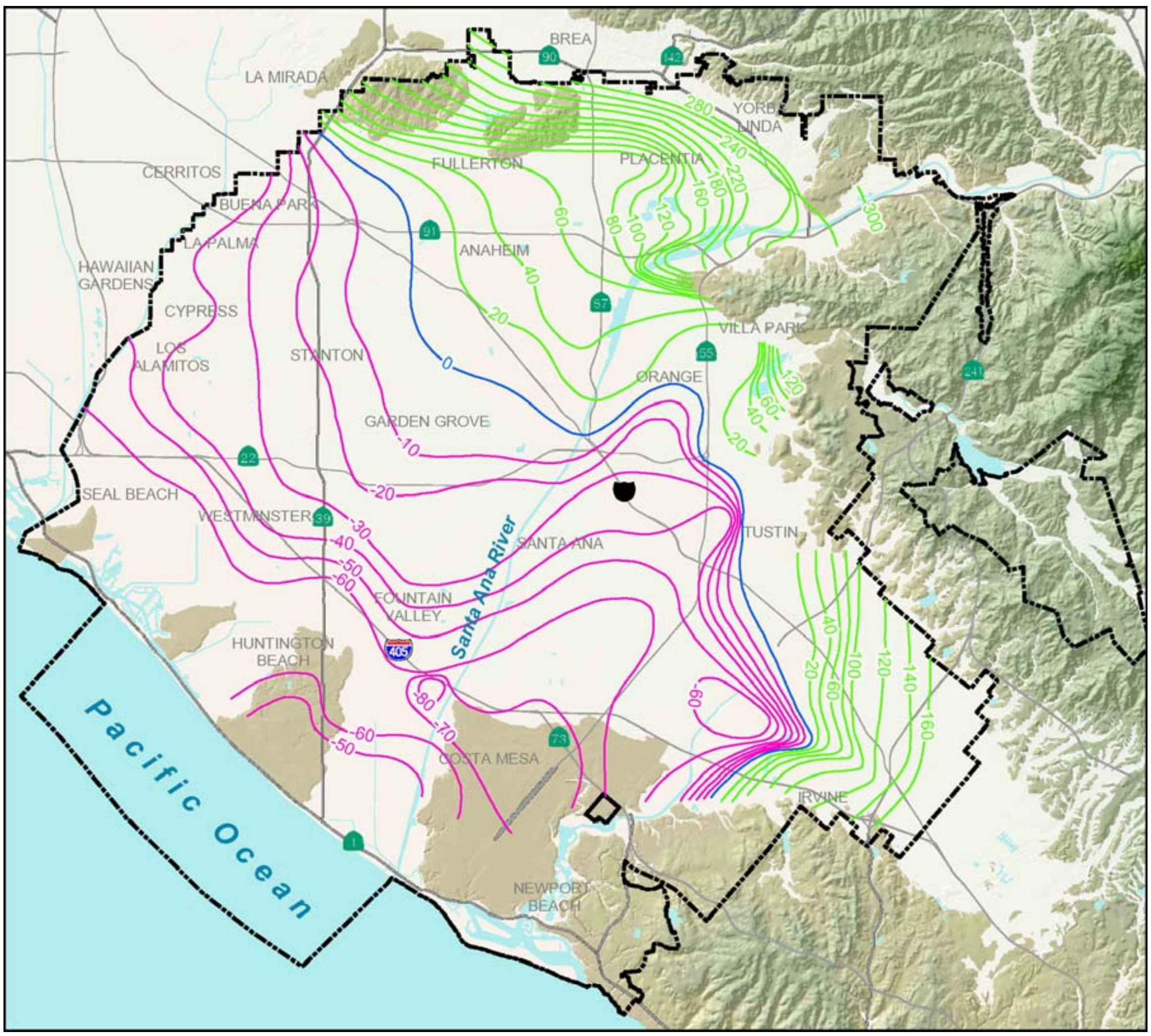


From Orange County Water District

Figure 2. The Rate of Groundwater Withdrawals Has Doubled Since the 1960s

The Water District has established a goal of maintaining an accumulated overdraft of about 200,000 acre-feet to allow storage space for replenishment when excess water is available during wet years. If the accumulated overdraft becomes excessive, the Water District uses complex financial disincentives to discourage groundwater withdrawals.

Since the 1997-98 water year (a wet year), the County has experienced dry conditions, resulting in overdrafts in excess of 30,000 acre-feet per year. Groundwater levels have declined more than 20 feet throughout the basin since 1998, and water levels near the coast are currently as much as 80 feet below sea level (Figure 3). In November 2002, the accumulated overdraft was estimated to be more than 400,000 acre-feet, which prompted the Water District to take actions to limit groundwater production rates and reduce the rate of withdrawal to about 324,000 acre-feet per year in 2003.



From Orange County Water District

Figure 3. Groundwater Levels Near the Coast Were More Than 80 Feet Below Sea Level in November 2002

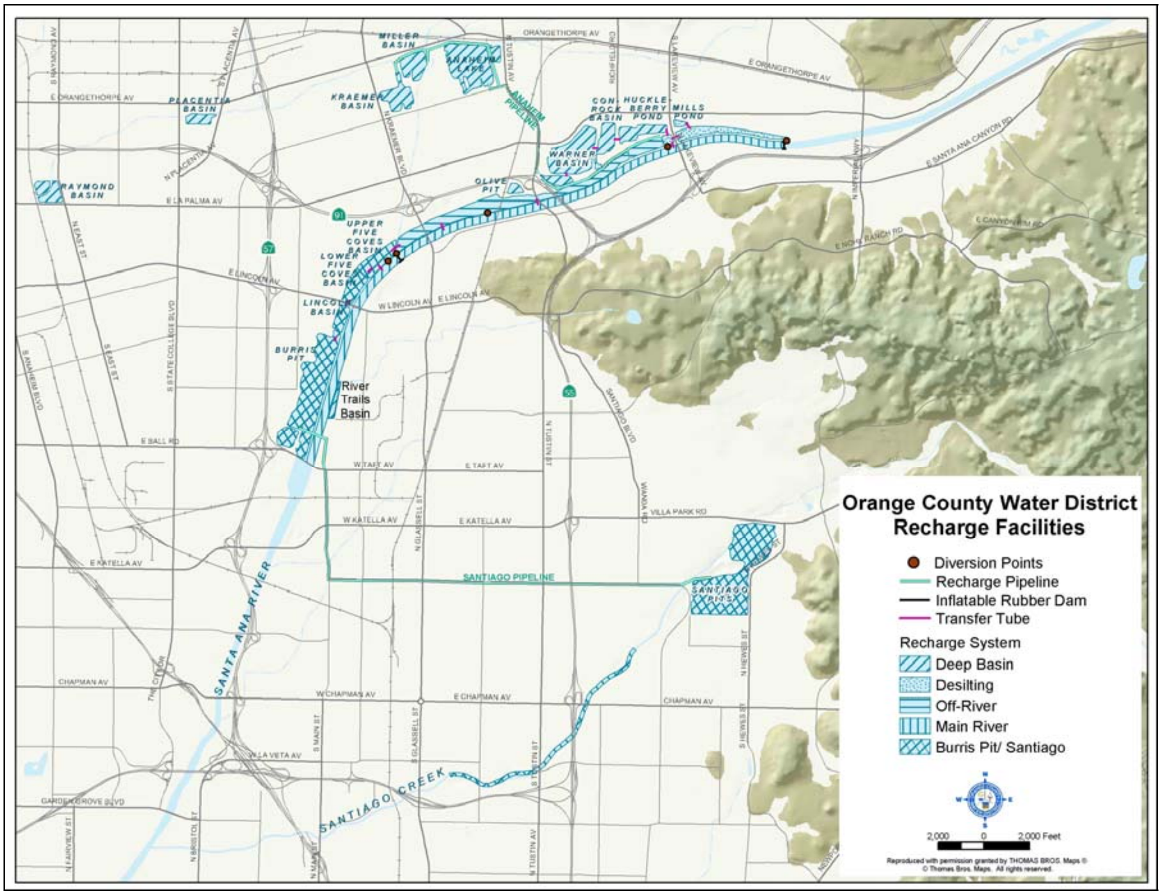
Aquifer Replenishment

Although the aquifer beneath northern Orange County holds hundreds of thousands of acre-feet of drinkable groundwater, there are practical limits to how much water can be withdrawn without causing excessive water-level declines in wells. As water levels in wells fall, the cost of pumping water increases, shallow wells can go dry, and poor-quality water may be drawn into the aquifer. Consequently, the Water District has been zealous in its efforts to maintain an overall balance between recharge and groundwater withdrawals.

In comparison to the 350,000 acre-feet of annual withdrawals from the basin during the period 1998-2002, the natural amount of incidental recharge (direct infiltration of rainfall, deep infiltration of excess irrigation water applied to crops and landscaping, leaks from sewer and water lines, and subsurface inflow from surrounding areas) is small (estimated by the Water District to be about 70,000 acre-feet per year). The majority of replenishment water is artificially recharged in the Water District's recharge facilities along the Santa Ana River in Anaheim. Base flow in the river (which currently averages about 150,000 acre-feet per year) is captured by the Water District and recharged through the Santa Ana River bed and deep recharge basins (abandoned sand and gravel pits) near the river. The Water District also captures an average of about 70,000 acre-feet of storm flows each year. To make up for the imbalance between the 290,000 acre-feet of recharge from local sources and the 350,000 acre-feet of withdrawals, the Water District has purchased an average of 60,000 acre-feet of imported water each year for supplementary recharge.

Recharge Facilities

The Water District recharges water in four distinct, but interconnected, systems: the main Santa Ana River system, an off-river shallow system, a deep-basin system and the Burris Pit/Santiago Creek system (Figure 4). Total surface area of the facilities is about 1,000 acres, and storage capacity is about 26,750 acre-feet. The total system can theoretically recharge about 1,300 acre-feet per day when basins are operating at full capacity. In Table 1, which summarized the characteristics of the four systems, seepage rates are expressed in cubic feet per second (cfs), a commonly used measure of water flow. A cubic foot per second of flow can be visualized by imagining one basketball (about one cubic foot) floating downstream each second. A one-cfs stream of water constitutes about two acre-feet per day.



From Orange County Water District

Figure 4. Water is Diverted to Recharge Facilities, Where it Seeps into the Ground to Replenish the Aquifer

Maximum seepage rates listed in Table 1 for the various systems are rarely attained. After only a few days of operation using silt-laden Santa Ana River water, a layer of fine-grained material accumulates on the bottoms of basins and clogs the porous surface, which dramatically retards seepage rates. Other factors (biological growth, chemical precipitation and compaction) also contribute to reductions in seepage rates.

The Water District can divert a maximum of 550 cfs into the off-river and deep-basin systems at an upstream diversion structure near Imperial Highway. A second diversion structure near Kraemer Boulevard can divert as much as 500 cfs into the Burris Pit/Santiago Creek system. Those rates of diversion can only be maintained during times that basins are filling. After basins are full, diversion rates must be reduced to match the constantly changing seepage rates from the recharge facilities.

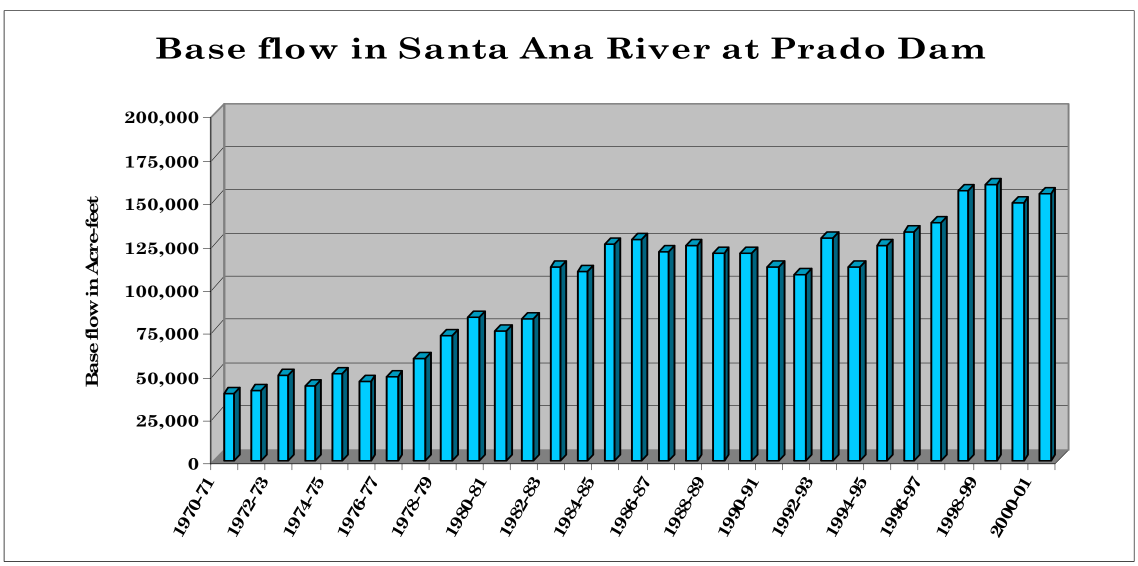
Table 1. Summary of Recharge Facilities

System	Area (Acres)	Storage Capacity (Acre-Feet)	Seepage Rate (cfs)	
			Maximum	Clogged
Main River	245	480	115	87
Off-River	126	394	40	15
Deep-Basin	280	8,484	300	89
Burris Pit/Santiago Creek	373	17,500	210	106
Total	1,024	26,758	665	297

From Orange County Water District

Santa Ana River Flows

Base flow in the Santa Ana River is maintained largely by discharge of treated wastewater from upstream communities. As population has grown in the upper basin, base flow in the river has increased from about 40,000 acre-feet per year in the early 1970s to more than 150,000 acre-feet per year in 2001 (Figure 5). The Santa Ana Watershed Project Authority predicts that wastewater discharges from upper basin communities will exceed 240,000 acre-feet per year in 2025.

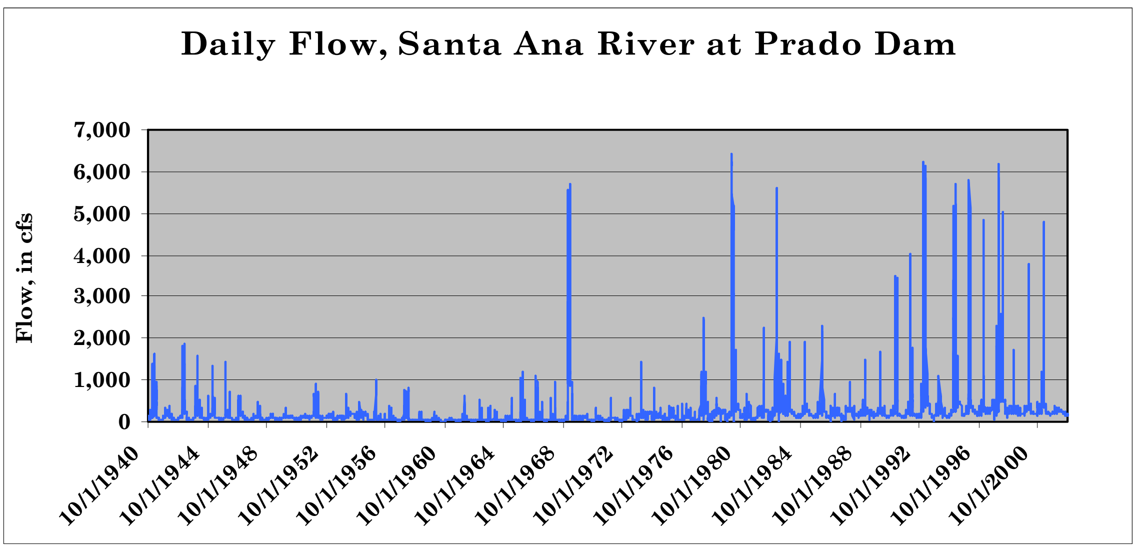


From Santa Ana River Water Master

Figure 5. Upper Basin Communities Are Discharging More Treated Wastewater Into the Santa Ana River, Causing an Increase in Flow

The rate of flow in the river during the non-flood season ranges from less than 150 cfs to as much as 300 cfs. Occasionally, off-season storms may increase stream flow to several hundred cfs, but the duration of high flows is usually only a few days. Except on rare occasions, the Water District has no problem capturing all of the Santa Ana River flow in its recharge facilities during the non-flood season.

Flood flow in the Santa Ana River has also changed dramatically as a result of urban growth in the upper basin. When impervious parking lots, streets and sidewalks replace naturally pervious soil, runoff from rainfall increases. Figure 6, which shows average daily stream flow in the Santa Ana River at Prado Dam from 1940-2002, clearly illustrates how urbanization has altered runoff in the basin. As urban growth in the upper basin continues, more flood runoff can be expected. In addition, the wildfires of 2003, which denuded thousands of acres in the upper Santa Ana River watershed, will undoubtedly cause increased runoff for a few years until the watershed recovers.



From U.S. Geological Survey

Figure 6. The Magnitude and Frequency of Floods in the Santa Ana River Basin Has Increased as a Result of Urban Development

During the flood season, operation of the recharge facilities is complicated by large releases from Prado Dam. Built by the U.S. Army Corps of Engineers (Corps) in 1941, the dam is, first and foremost, a flood-control structure. The reservoir behind the dam has sufficient storage capacity to provide flood protection from a 70-year storm event. To provide maximum protection, the Corps attempts to drain the reservoir as quickly as possible after a flood to allow space for the next storm that may occur. Historically, the Corps has released floodwaters at rates of as much as 6,000 cfs, which vastly exceeds the Water District's capacity to capture the water for recharge. However, owing to the Water District's steadfast efforts, the Corps has modified operation of the dam in recent years and now allows retention of 8,600 acre-feet in the reservoir during the flood season for water-conservation purposes. When reservoir storage is reduced to the conservation pool, the Corps allows the Water District to reduce the flow rate from Prado Dam to 500 cfs to facilitate capture in the recharge facilities. During the non-flood season, the Corps allows a conservation pool of 26,000 acre-feet.

The Corps is currently increasing the flood-retention capacity of Prado Dam to provide protection from a 190-year flood event. The increased storage capacity could allow more flexibility in release rates from the dam and, perhaps, lead to an increase in the size of the conservation pool. If the Water District is successful in its efforts to reserve part of the new reservoir capacity for water-conservation purposes, a greater percentage of flood-season runoff could be captured for aquifer replenishment.

WILL DELIVERING PURIFIED WASTEWATER TO KRAEMER BASIN IMPACT CAPTURE OF SANTA ANA RIVER FLOODWATER?

The Water District plans to begin delivery of nearly 60 cfs of purified wastewater to Kraemer Basin in 2007. If recharging purified wastewater, which costs $520 per acre-foot to produce, reduces the amount of "free" Santa Ana River water that can be captured, water users will pay the difference.

During the non-flood season, flow in the river is generally less than the recharge capacity of the Water District recharge facilities. Consequently, the Water District should have no problem manipulating diversions to various recharge sites during base-flow conditions to avoid any interference between the 60 cfs of purified wastewater and water diverted from the river.

However, during the flood season, river flow can exceed the Water District's capacity to divert and capture flow. Flows in excess of the capacity are lost to the ocean. Determining accurately how much additional flow might be lost as a consequence of dedicating Kraemer Basin for use in recharging purified wastewater would be extremely difficult. Seepage rates in the recharge facilities change constantly during the flood season as silt accumulates. In addition, the amount of water contained in each of the basins varies daily. During the early part of the flood season, when basins are dry and clean, capture rates can exceed 1,000 cfs. However, later in the season, when basins may be full and seepage rates have declined due to clogging, capture rates could be limited to less than 300 cfs.

A rudimentary approach to analyzing the potential loss of floodwaters that might occur as a result of dedicating Kraemer Basin to recharging purified wastewater is to consider how often a significant amount of river water has been lost in the past. Figure 7 shows the number of days when more than 10 cfs passed the U.S. Geological Survey stream gaging station in Santa Ana (located about 5 miles downstream from the recharge facilities) for each water year from 1980 to 2002. Because the Water District is unable to divert water when flows exceed 2,000 cfs, days when releases from Prado Dam were in excess of that amount were not included.

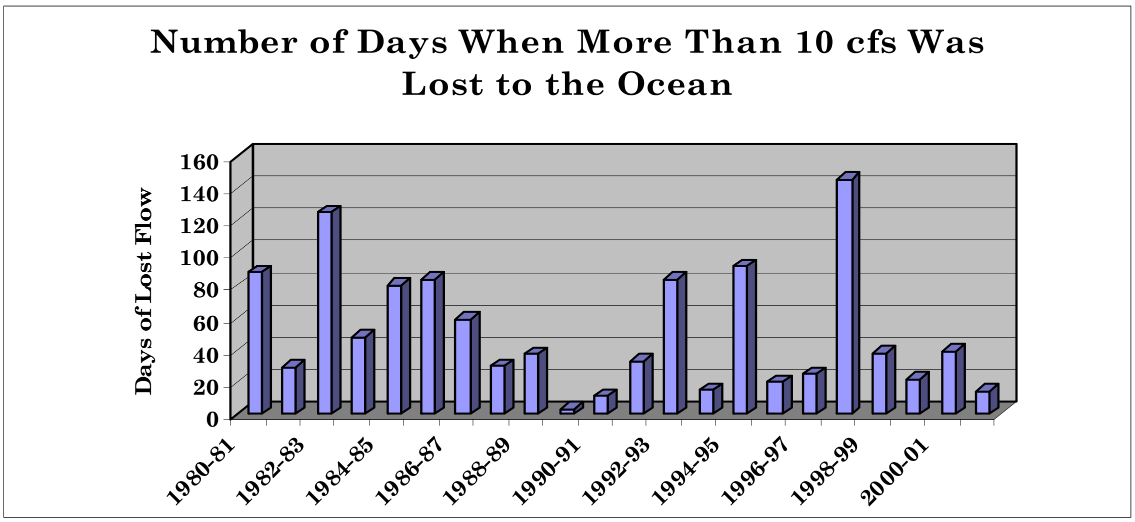


Figure 7. Some Floodwater Escapes to the Ocean Every Year

As shown in Figure 7, water flowed past the recharge facilities for 80 days or more in seven of the past 22 years. In water year 1997-98 (an unusually wet year), a significant amount of water flowed past the recharge facilities on 146 days. During the 1980s, before operation of Prado Dam was modified to facilitate water conservation, lost-flow days exceeded 30 days per year in eight out of 10 years.

Although there may have been extenuating circumstances which hindered the Water District's ability to capture river flow (mechanical problems with diversion structures, unexpected releases from Prado Dam, blockages in conveyance systems, etc.), the information shown in Figure 7 provides a reasonable indication of how often river flow exceeded the capacity of the recharge facilities during the last 22 years.

If one assumes that days when river water flowed to the ocean represent days that the recharge facilities were operating at full capacity, then it can be assumed that adding 60 cfs of purified wastewater to Kraemer Basin on those days would have resulted in an additional loss of 60 cfs of river water. Using this approach, losing an additional 60 cfs for 146 days would have totaled more than 17,000 acre-feet in the abnormally wet 1997-98 water year. If valued at the cost of purchasing untreated imported water (currently $248 per acre-foot), the value of water that would have been hypothetically lost would have been more than $4 million for that water year.

This simplified approach ignores an important aspect of the recharge facilities that precludes optimal use of Kraemer Basin for recharging river water. As currently configured, the pipeline from Warner Basin to the other deep basins can only convey about 180 cfs. When Mini-Anaheim and Anaheim Lakes and Miller Basin are operating at full recharge capacity (not clogged), they can recharge almost all of the river water that can be delivered through the pipeline, leaving Kraemer Basin underutilized. However, when seepage rates decline due to clogging, Kraemer Basin's role in floodwater capture increases. Determining Kraemer Basin's overall contribution to the capture of floodwaters would be a complex exercise, given the variations in seepage rates in the deep basins, but it is safe to assume that limitations in delivery capacity do, in fact, result in some underutilization of the basin.

The Water District has devoted considerable time and expertise to the issue of recharge capacity and has nearly completed an in-depth study of the facilities. The study has produced a number of important recommendations, which (if implemented) would substantially increase recharge capacity in the system. In October 2003, River Trails Basin was placed in service to add capacity to the Burris Pit/Santiago Creek system. The Water District also took delivery of four innovative Basin Cleaning Vehicles, which were scheduled to begin operation in December 2003. When fully operational, the new machinery is expected to increase recharge capacity by as much as 80 cfs by constantly vacuuming fine-grained sediments from basin bottoms. Other proposals include purchase of small plots of land for new basins, reshaping Burris Pit to facilitate cleaning and utilizing deep trenches to enhance recharge rates in areas underlain by fine-grained material.

The recommended improvements could have significantly reduced the number of days that river water was lost to the ocean in prior years. However, the anticipated increase in base flow and storm runoff resulting from urban development in the upper basin and potential changes in operation of Prado Dam could easily outstrip the planned increase in recharge capacity. If increases in river flow were in the range of the planned increases in recharge capacity, the issue of conflicting uses of the recharge facilities would remain.

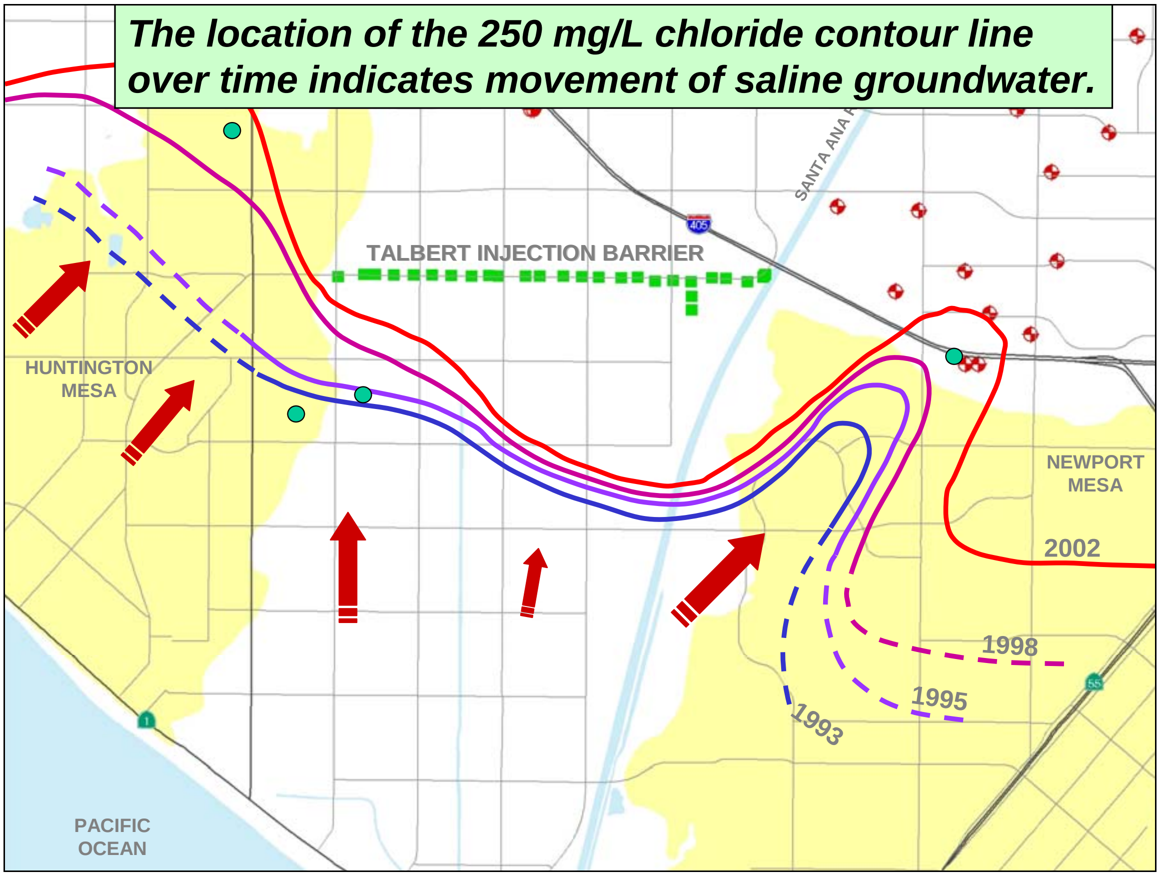
In the final analysis, it is very probable that delivery of purified wastewater to the recharge facilities will, in fact, reduce the Water District's ability to capture river water during wet years when river flows exceed the capacity of the recharge system. There is little doubt that abnormally wet years will occur, which could result in the loss of a significant amount of "free" water. However, during normal years and in non-flood periods, loss of river water will be negligible, and recharge of purified wastewater will add substantially to the local water supply.

WILL RECHARGING PURIFIED WASTEWATER IN THE RECHARGE FACILITIES ALLEVIATE CURRENT GROUNDWATER PROBLEMS?

A serious groundwater problem now confronting the County is declining water levels near the coastline. Water levels have fallen to more than 100 feet below sea level during the summer months as a result of large groundwater withdrawals from municipal well fields (and from deep Water District wells used to supply blending water for the Talbert Gap seawater-intrusion barrier). A decline in water levels increases pumping costs, causes upwelling of poor-quality water from deeper aquifers, and encourages seawater intrusion. Figure 8 shows that saline water has advanced more than five miles inland due to the depressed water levels. If the rate of saline water advance is not arrested in the near future, numerous water-supply wells will become contaminated.

The Water District used their groundwater-flow model to simulate the current plan to inject 30,000 acre-feet per year of purified wastewater into the Talbert Gap seawater-intrusion barrier and to recharge 42,000 acre-feet per year in Kraemer Basin. Groundwater levels simulated by the model suggest that water levels would increase in the recharge area but that the pumping depression along the coast would remain. The results clearly illustrate that simply increasing recharge in the Water District recharge facilities and extending the seawater-intrusion barrier will stabilize, but not alleviate, the coastal pumping depression.

Water District efforts to reduce groundwater withdrawals in the coastal area by encouraging more withdrawals from inland wells and more use of imported water in coastal communities can substantially reduce stress on the aquifer near the pumping depression. The Water District should explore incentives to minimize seasonal increases in withdrawal rates that exacerbate the problem. The Water District should also consider reducing withdrawals from deep wells used as a source of blending water for the seawater-intrusion barrier to minimize stress on the aquifer. If all these steps are taken, the pumping depression might be stabilized but would probably continue to be a problem.



From Orange County Water District

Figure 8. Salty Water Continues to Advance Inland

The plan to increase the rate of injection into the Talbert Gap seawater-intrusion barrier on the west side of the Santa Ana River will retard the landward advance of saline water in that area but will leave a significant gap in protection on the east side of the river. To design an adequate barrier on the east side of the river, detailed geologic information must be collected to determine the lateral and vertical extent of permeable zones that serve as conduits for groundwater flow. Adding appropriately designed injection wells on the east side of the river would retard the inland advance of saline water in that area and reduce the need to totally eliminate the coastal pumping depression. Because the shallow aquifer is interconnected with the deeper aquifer in the Talbert Gap area, it is likely that some of the purified wastewater that will be injected into the seawater-intrusion barrier will migrate into the deeper aquifer and help to remedy the coastal pumping depression.

Can the Rate of Groundwater Withdrawals be Increased if Purified Wastewater is Recharged in Kraemer Basin?

Water producers within the Water District have estimated that total annual water demand for northern Orange County will increase to more than 600,000 acre-feet by 2020. The Water District has conducted exhaustive studies to determine how much of the increased demand can be supplied by groundwater to minimize dependence on imported water.

Although it is obvious that groundwater withdrawals must be balanced with an equivalent amount of recharge to avoid depletion of the underground water supply, the issue is considerably more complex than simply ensuring volumetric balance. Groundwater moves very slowly through the aquifer (the rate of flow is on the order of feet per day) and may take decades to travel only a few miles. Consequently, if the rate of groundwater withdrawal is increased in areas several miles from the recharge area, declines in water levels could occur regardless of how much water is replenished. This is clearly illustrated by the coastal pumping depression that has developed in recent years despite the average rate of recharge being only slightly less than the overall rate of withdrawals.

Two management options that could lead to increased groundwater withdrawals, while taking into account the limited capacity of the aquifer to transport water, are inland well fields and mid-basin injection wells. Developing inland well fields near the recharge facilities could offset elevated water levels that would occur in the area if the rate of recharge is substantially increased. Mid-basin injection of purified wastewater would distribute recharge over a broader area rather than concentrating it all in the current recharge facilities.

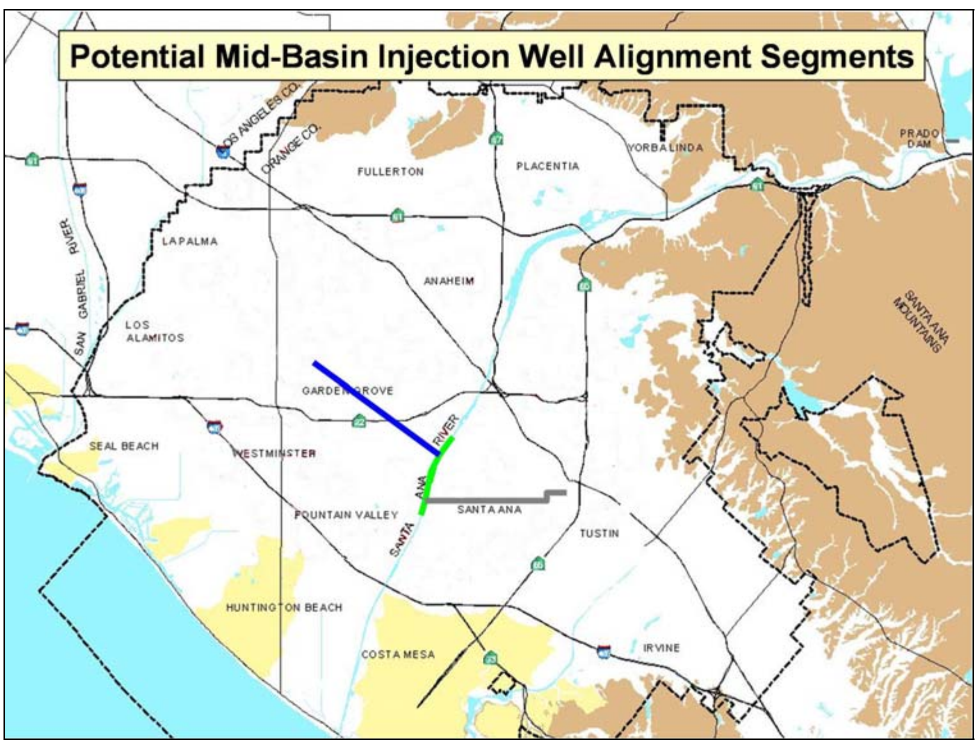
Inland Well Fields

Boyle Engineering Corporation (2001) conducted a study to determine the cost of pumping 43,500 acre-feet per year from well fields near the recharge area and piping it to the coastal communities — almost exactly the amount of purified wastewater that will be piped inland from the Fountain Valley wastewater-purification facility to Kraemer Basin. The Water District estimates that water users will pay more than $1 million per year in energy costs to pump purified wastewater to Kraemer Basin. To return water back to the coastal communities to reduce groundwater withdrawals in that area will require the expenditure of an additional $22.4 million to install inland wells and connect them to the East Orange County Feeder #2 water line.

Pumping groundwater near the recharge facilities would help control mounding of the water table that will undoubtedly occur when recharge rates increase in the future. Simulation studies have shown that water levels could rise more than 40 feet in the recharge area when recharges rates are increased to balance anticipated future rates of groundwater withdrawals. If groundwater levels beneath the recharge facilities rise to near land surface, seepage rates could decline. Installing new wells near the recharge facilities would mitigate that potential problem.

Mid-Basin Injection

A second management option involves installation of injection wells near the coastal pumping depression. Water ideally suited for injection could be obtained from the Groundwater Replenishment System purification process and piped a short distance inland to lines of injection wells located near the middle of the basin (Figure 9). A preliminary investigation by Camp Dresser & McKee (2000) shows that it would be feasible to inject more than 50,000 acre-feet per year in suitably designed wells. Water-level rises could exceed 30 feet near the injection wells, substantially alleviating the coastal pumping depression. The consulting company estimated that the capital cost of installing transmission lines and injection wells would be about $40 million.



From Orange County Water District

Figure 9. Mid-Basin Injection Wells Could Distribute Recharge Over Larger Areas

The primary advantage of this plan is that recharge would be distributed over a relatively large area. Distributing recharge would, in effect, compensate for the aquifer's limited capacity to transport water, thereby allowing water producers to increase groundwater withdrawals over a much larger area of the County.

CAN THE WATER DISTRICT OBTAIN A STATE PERMIT WHICH WOULD ALLOW FOR MID-BASIN INJECTION?

The Water District's decision to pipe water from the purification plant to Kraemer Basin was driven to a large extent by state regulations regarding the use of reclaimed wastewater. California Department of Health Services draft regulations outline very specific requirements when wastewater is to be introduced into aquifers used for domestic water supplies. If wastewater is introduced through surface recharge facilities, the water must travel a distance of at least 500 feet and remain in the aquifer for a period of at least six months prior to extraction. If wastewater is introduced through injection wells, the distance of travel must be 2,000 feet, and retention time is extended to 12 months. Rigorous monitoring requirements must be met and extensive analysis is required to predict retention times and to estimate the proportions of native and injected water that would be withdrawn by wells.

Information acquired from years of operating the Talbert Gap seawater-intrusion barrier and the Anaheim recharge facilities provided much of the data required by the regulatory agencies for permit approval, which expedited the permitting process. In October 2003, the Department of Health Services announced that all requirements for a wastewater-utilization permit for the Water District to proceed with the Groundwater Replenishment System had been met.

In order to acquire the necessary clearances to initiate a mid-basin injection scheme, the Water District will be required to supply detailed information on aquifer characteristics, groundwater flow rates, injection and withdrawal rates, and ambient water-quality conditions. Monitoring wells will have to be installed at various points along the anticipated groundwater-flow paths, and detailed hydrologic analyses will have to be performed to ensure that residence-time and mixing-ratio requirements are satisfied. Some existing supply wells may have to be abandoned to avoid violating the travel distances required by the Department of Health Services.

The Water District has demonstrated that purified wastewater produced by the Groundwater Replenishment System will meet all drinking water criteria. In light of the numerous endorsements from water agencies, health officials, and environmental specialists, strong arguments could be made for regulators to grant waivers from restrictive requirements, which could reduce the time needed to obtain permits for a mid-basin injection project. If data collected during the initial phases of the Groundwater Replenishment System confirm that purified wastewater does not threaten public health, waivers to enable rapid installation of mid-basin injection wells should be requested.

FINDINGS

Under California Penal Code Sec. 933 and Sec. 933.05, responses are required to all findings. The 2003-2004 Orange County Grand Jury has arrived at the following findings:

1. Increased urbanization in the upper Santa Ana River basin will increase the amount of Santa Ana River water available for capture in the Anaheim recharge facilities.

2. Using Kraemer Basin to recharge purified wastewater will reduce capacity to capture Santa Ana River floodwater and result in the loss of some floodwater during abnormally wet years.

3. Increased rates of recharge in the Anaheim recharge facilities will cause local groundwater levels to rise.

4. Depressed groundwater levels near the coast have exacerbated the inland advance of saline water.

5. Seasonal increases in groundwater withdrawal rates place added stress on the aquifer.

6. Saline water is migrating around the eastern end on the Talbert Gap seawater-intrusion barrier.

7. There are physical limits on the aquifer's capacity to transport water from areas of recharge to areas of withdrawal.

8. Changes in groundwater management strategies will be required to increase the current rate of groundwater withdrawals to satisfy future water needs.

A response to each finding is required from the Board of Directors of the Orange County Water District.

RECOMMENDATIONS

In accordance with California Penal Code Sec. 933 and Sec. 933.05, each recommendation requires a response from the government entity to which it is addressed. These responses are to be submitted to the Presiding Judge of the Superior Court. Based upon the findings, the 2003-2004 Orange County Grand Jury recommends that:

1. Orange County Water District continue to explore opportunities to increase recharge capacity in the Anaheim recharge facilities including plans to increase the capacity of pipelines that transport water to the deep-basin system. (Findings 1 and 2)

2. Orange County Water District develop inland well fields to increase the rate of groundwater withdrawals near the recharge facilities. (Finding 3)

3. Orange County Water District curtail groundwater withdrawals from deep wells and obtain blending water for the Talbert Gap seawater-intrusion barrier from other sources. (Finding 4)

4. Orange County Water District discourage seasonal increases in rates of groundwater withdrawals to minimize stress on the aquifer. (Finding 5)

5. Orange County Water District initiate data-collection programs to define the lateral and vertical extent of permeable zones on the east side of the Santa Ana River to facilitate easterly extension of the Talbert Gap seawater-intrusion barrier. (Finding 6)

6. Orange County Water District expedite planning, data-collection and analysis efforts to secure necessary permits for a mid-basin injection program. (Findings 7 and 8)

7. Orange County Water District seek waivers from regulatory agencies to expedite mid-basin injection based on laboratory and field investigations, which demonstrate that purified wastewater from the Groundwater Replenishment System will pose no risk to public health. (Finding 8)

A response to each recommendation is required from the Board of Directors of the Orange County Water District.

COMMENDATION

The 2003-2004 Grand Jury commends the staff of Orange County Water District for their foresight, expertise and dedication in managing the County's precious groundwater resources and planning for the decades ahead. The Groundwater Replenishment System is only one of many innovative programs implemented by Orange County Water District to enhance groundwater production for current users while preserving the resource for future generations. Orange County Water District efforts to capture and recharge floodwater have been particularly noteworthy. The average of 70,000 acre-feet of storm flows captured each flood season saves Orange County water users more than $17 million per year.

REFERENCES

Boyle Engineering Corporation, November 8, 2001, "Technical Feasibility Study, Inland Wellfield/EOCF #2, Well Water Conveyance Project," Engineering Report to Orange County Water District

California Department of Health Services, July 21, 2003, "DHS' Groundwater Recharge Reuse Regulations," July 2003 Draft Regulations

Camp Dresser & McKee, July 2000, "Groundwater Replenishment System, Project Development Phase—Development Information Memorandum #26, Future Injection Wells," Engineering Report to Orange County Water District

Orange County Water District, November 1998, "2020 Master Plan Report for the Orange County Water District," Final Report

Orange County Water District, 2003, "Orange County Water District Strategic Plan," Report to Orange County Water District Board of Directors

Orange County Water District, February 2003, "2001-2002 Engineer's Report on Groundwater Conditions, Water Supply and Basin Utilization in the Orange County Water District," Report to Orange County Water District Board of Directors

Orange County Water District, June 2003, "Orange County Water District Budget Report, Fiscal Year 2003-2004," Report to Orange County Water District Board of Directors

Orange County Water District, October 9, 2003, "Orange County Water District's Recharge Study," Draft Report

Public Resources Advisory Group, January 26, 2001, "Groundwater Replenishment System Financial Study," Financial Study to Orange County Water District and Orange County Sanitation District

Santa Ana River Water Master, April 30, 2002, "Thirty-First Annual Report of the Santa Ana River Watermaster for Water Year October 1, 2000-September 30, 2001," Annual Report to the Superior Court of Orange County