WATER REPLENISHMENT DISTRICT
OF SOUTHERN CALIFORNIA

GROUNDWATER MANAGEMENT PLAN

1998

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1998 WRD Board of Directors

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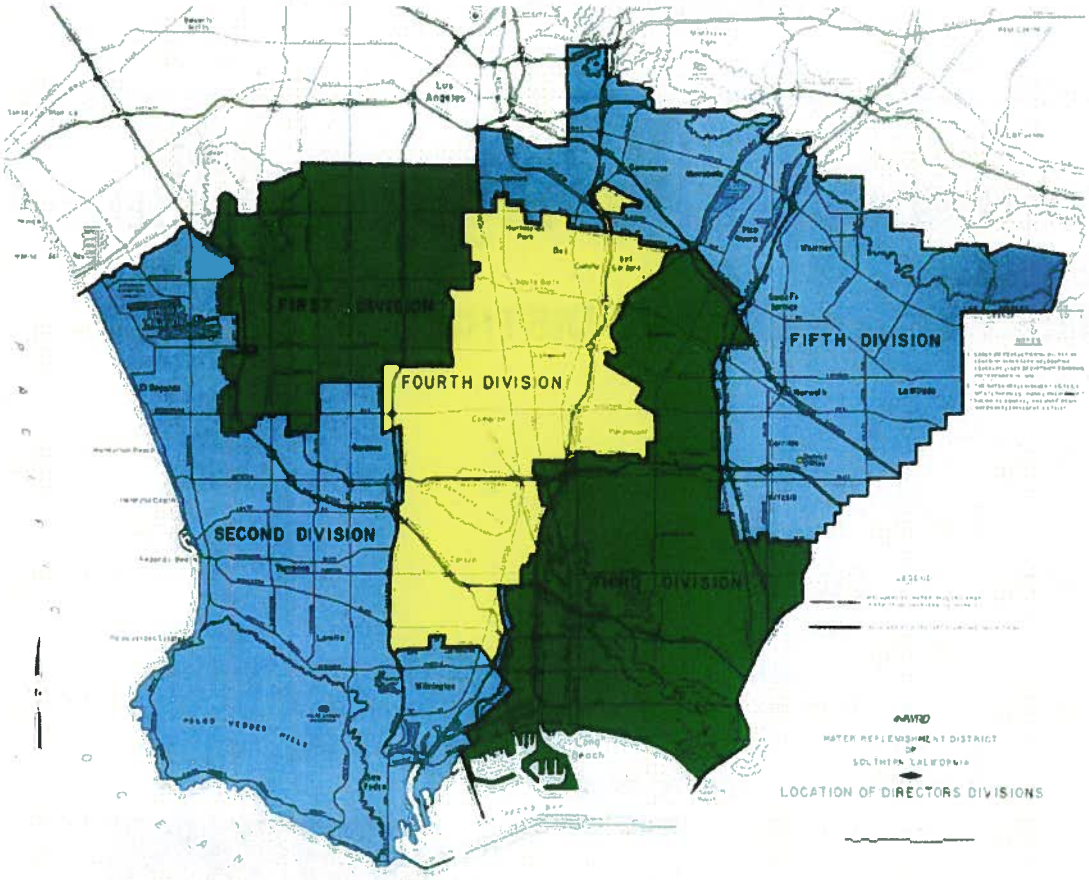
Jeffrey Helsley
Acting General Manager

WRD STATISTICS

District formation
December 9, 1959
Service region
Central and West Coast Groundwater Basins in Southern Los Angeles County
Service area size
420 square miles
Population in service area
nearly 4 million
Number of cities within service area
43
Total average water demand in service area
680,000 acre-feet
Total adjudicated groundwater rights in area
281,835 acre-feet
Average annual recycled water use
50,000 acre-feet
Average annual storm water use
40,000 acre-feet

Cities Served by WRD

Artesia
Bell
Bell Gardens
Bellflower
Carson
Cerritos
Commerce
Compton
Cudahy
Downey
El Segundo
Gardena
Hawaiian Gardens
Hawthorne
Hermosa Beach
Huntington Park
Inglewood
La Habra Heights
La Mirada
Lakewood
Lawndale
Lomita
Long Beach
Los Angeles
Lynwood
Manhattan Beach
Maywood
Montebello
Monterey Park
Norwalk
Palos Verdes Estates
Paramount
Pico Rivera
Rancho Palos Verdes
Redondo Beach
Rolling Hills
Rolling Hills Estates
Santa Fe Springs
Signal Hill
South Gate
Torrance
Vernon
Whittier



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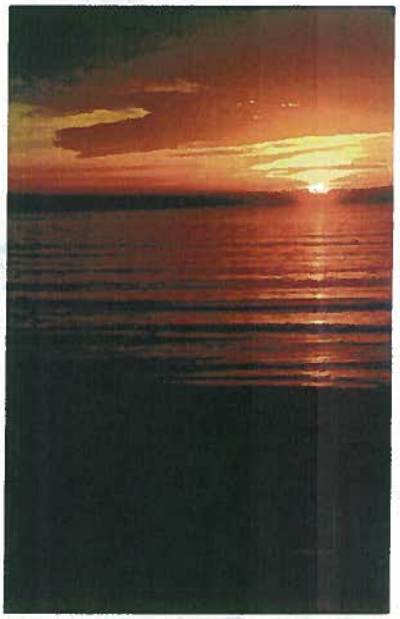
Groundwater Management Plan

for the

WATER REPLENISHMENT DISTRICT

INTRODUCTION

The Water Replenishment District of Southern California (WRD) faces important and critical challenges to the water supply and quality of the Central and West Coast groundwater basins. The WRD's Board of Directors and staff will implement strategic plans that include specific goals and objectives designed to meet these challenges. The goals and objectives must be clear and concise and the objectives must include innovative ideas, programs, and projects.



The purpose of the Groundwater Management Plan is to set long term- goals for the Water Replenishment District of Southern California.

This Plan presents general goals, measures, timetables and guidelines intended to improve the quality and supply of water in the groundwater basins. By approving the Plan, the Board of Directors for the Water Replenishment District of Southern California adopts the general goals, but does not expressly approve any particular project. Each project will be considered on its own merits, having due regard for the situation as of the date of such approval and the financing alternatives then available.

Executive Summary

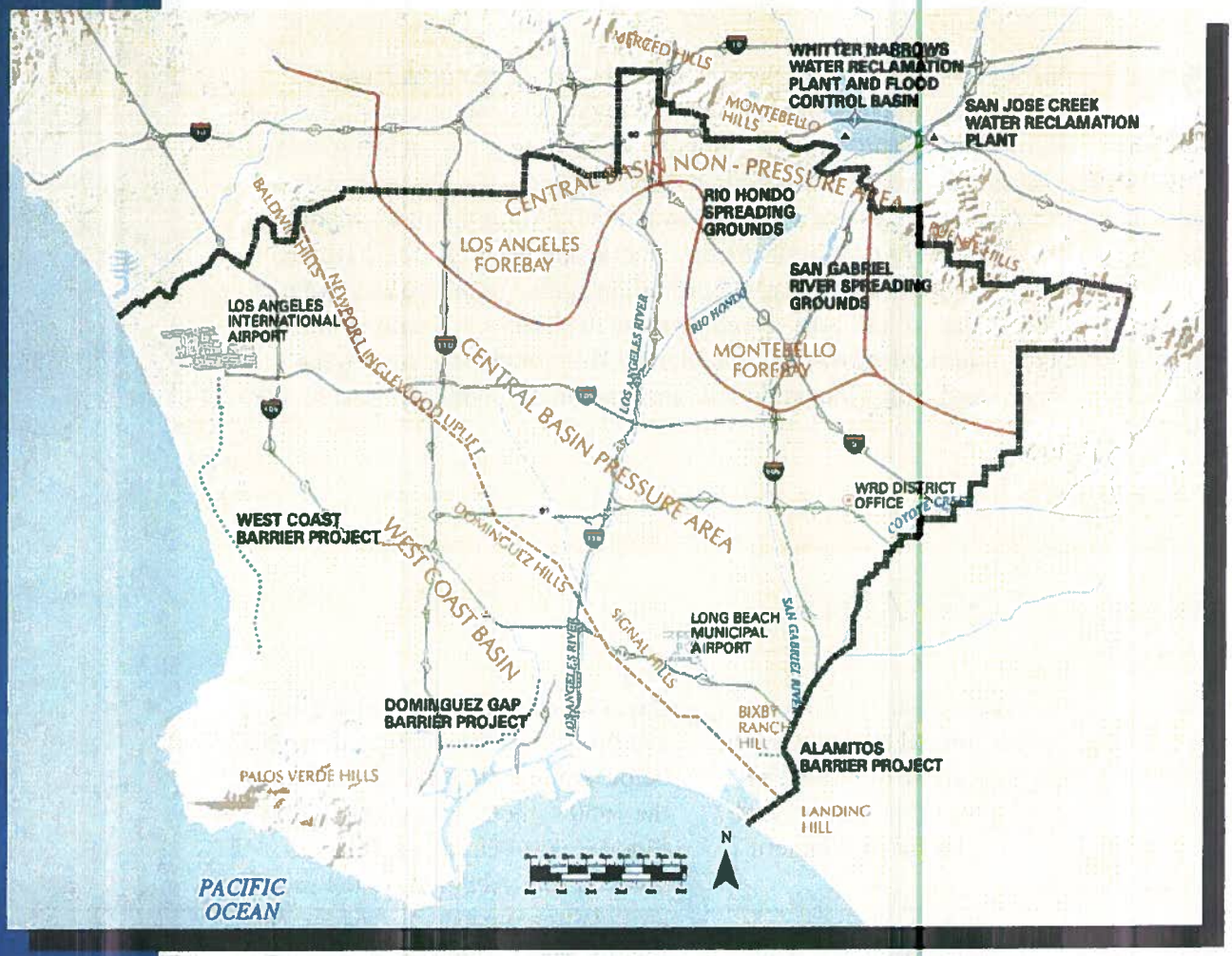
Recent drought years dramatically demonstrated the invaluable contribution of Southern California groundwater basins to the region's economy and public well-being. Groundwater basins provide a reliable water supply not subject to curtailment in droughts or natural disasters. In addition, groundwater is the least expensive, highest quality and most reliable supply of water available. Two of the most important groundwater basins in Southern California are the Central and the West Coast Basins. Together they provide groundwater to nearly four million people in the Coastal Plain of southern Los Angeles County. The area served by these two basins is bound in the north by the Whittier Hills, Whittier Narrows and the Merced Hills, extending west to the Baldwin Hills, on the east by the Orange County line, and on the south and west by the Pacific Ocean.

BACKGROUND AND HISTORY

The Water Replenishment District of Southern California (WRD) was formed by a vote of the people in 1959 for the purpose of protecting the groundwater resources of the Central and West Coast groundwater basins in Southern Los Angeles County.

WRD provides groundwater for nearly four million residents in 43 cities of Southern Los Angeles County. The 420 square mile service area uses about 250,000 acre-feet of groundwater per year, which equates to 40% of the total demand for water. Prior to the formation of the District, overpumping of both basins caused many wells to go dry and sea water to intrude into the potable water aquifers. In 1957, the accumulated overdraft in the Central Basin was almost 1 million acre-feet, and groundwater levels had dropped to below sea level in both basins. During the 1950's, the Los Angeles County Flood Control District purchased 500,000 acre-feet of imported water to artificially replenish the basins. The Central Basin Water Association and West Basin Water Association, comprised of the major groundwater producers from each basin, jointly proposed and obtained voter approval for formation of the Water Replenishment District of Southern California to manage the Central and West Coast groundwater basins.

Water Replenishment District Area Map



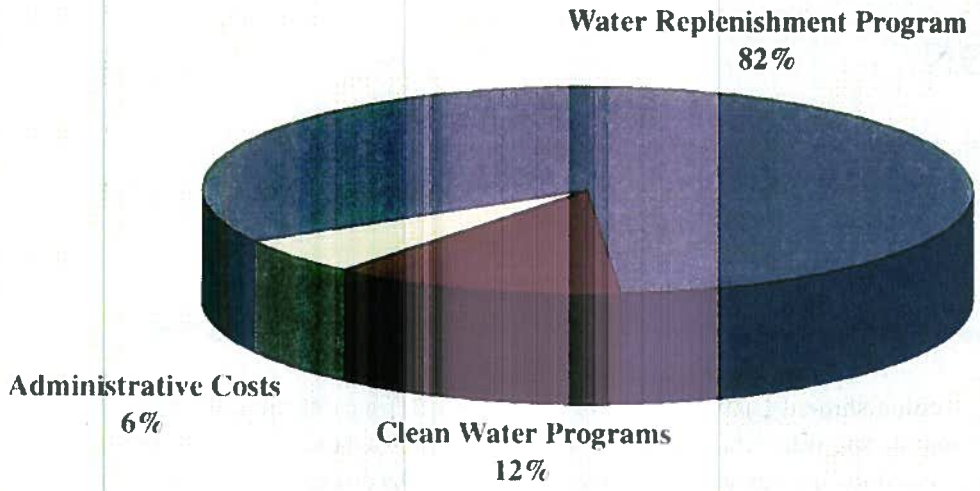
In ensuing years, WRD's role continued to expand as it developed programs to capture storm water, recharge recycled wastewater, monitor water quality and take advantage of evolving Metropolitan Water District of Southern California (MWDSC) water rates. In 1990, legislation was passed to strength WRD's role in groundwater quality protection and to provide a special assessment ability to WRD to fund clean water programs. The Water Replenishment District Act provides for local financing of the District's operations by empowering WRD to levy and collect a replenishment assessment on water extracted from the Central and West Coast groundwater basins.

The District's funding mechanisms include:

1. A "Water Purchase Assessment" on all pumping from the groundwater basins to fund the purchase of water to replenish and protect the Central and West Coast groundwater basins.

2. A "Clean Water Assessment" to fund programs designed to clean up existing groundwater contamination and prevent future contamination to the vital ground water supply in the Central and West Coast Basins.

3. An "Administrative Assessment" to fund administration of all groundwater basin management activities carried out by WRD.



With the increased engineering, environmental and institutional complexities of water resource management in the 1990's, WRD has significantly expanded the scope of its activities. In order to achieve maximum benefit from future District activities, the WRD Board of Directors authorized development of a District Strategic Plan. This plan is called the Groundwater Management Plan (GMP). The purpose of the GMP is to present a five-year approach to solving future water quality and supply problems so that WRD can better manage the Central and West Coast groundwater basins.

Based on the objectives identified in this Plan, WRD, the largest regulated user of recycled water in the nation, will increase its annual use of recycled water 19,000 acre-feet by the year 2005. An additional 13,000 acre-feet per year of local stormwater will be utilized by WRD by 1998 and development of alternative sources of imported water will total 30,000 acre-feet by the year 2000. WRD will manage activities to increase groundwater production within the Central and West Coast groundwater basins 20,000 acre-feet by the year 1999, saving the water purveyors and residents of the District millions of dollars in lower water costs relative to other sources.

MISSION

A key element in WRD's strategic plan is the creation of a Mission Statement which clearly defines the purpose of the District. Based on engineering, environmental, institutional and financial demands upon WRD, the following Mission Statement has been adopted:

"To provide a sufficient supply of high quality groundwater in the Central and West Coast Basins through progressive, cost effective and environmentally sensitive basin management."

VISION

The vision of the Water Replenishment District identifies the challenges facing the District and anticipates where the District will be in 2002 based upon the goals and strategies of the Groundwater Management Plan.

Problems and Challenges Facing the Water Replenishment District

The Water Replenishment District relies on three sea water barrier facilities to provide protection against sea water intrusion into the groundwater basins. These barriers are not completely effective, and sea water intrusion continues. As a result of historical and ongoing intrusion, a large plume of brackish or saline water exists in the groundwater aquifers in the West Basin. This plume not only affects water quality in nearby wells, it directly offsets the freshwater storage capability of the West Coast groundwater basin.

Costly potable water is used as the major source of water for the sea water intrusion barriers in addition to a small percent of advanced treated recycled waste water. Water used for groundwater recharge is facing rising costs. These increases are due to proposed changes in regulatory compliance regarding the use of recycled water and the increasing cost of imported water. Imported water is also subject to limited availability in times of drought and natural disaster. This affects the reliability of the use of imported water by WRD in the sea water barriers and for groundwater recharge.

In the past, improper disposal practices of industrial solvents allowed volatile organic compounds (VOCs) to seep into the groundwater aquifers. As a result, wells within the Central Basin have been affected and some have been removed from drinking water production.

A better understanding is needed of the reaction of the groundwater basins to various types and quantities of recharge water as well as the tracking of groundwater contamination migration. In an effort to maintain as low a groundwater assessment as possible, District activities to solve these problems must be implemented in a cost effective manner, with due regard to economic feasibility.

Issues facing the water industry in Southern California and WRD are complex. Because of this, it is important for WRD to communicate with its constituent base, to be informed of and involved in local, state and federal issues related to the water industry, and to develop a progressive working relationship with regulatory agencies.

Based upon these identified problems, the Water Replenishment District faces challenges in the areas of water quality, water supply, groundwater basin management and institutional communication. These challenges are:

Water Quality Challenges

1. Prevent sea water intrusion
2. Remediate existing inadequate sea water intrusion protection
3. Mitigate saline plume in groundwater basins
4. Remediate groundwater contamination
5. Prevent migration of contamination

Water Supply Challenges

1. Reduce cost of barrier and recharge water sources
2. Increase reliability of barrier and recharge water sources

Groundwater Basin Management Challenges

1. Optimize groundwater basin yield in Central and West Coast Basins
2. Increase working knowledge of Central and West Coast groundwater basins

Institutional Communication Challenges

1. Provide effective communication to District constituents
2. Remain informed of and involved in local, state and federal issues related to the water industry

Where the Water Replenishment District will be in 2002

By 2002, the Water Replenishment District will have implemented several efforts to meet the challenges facing WRD:

Water Quality Objectives

1. Improve deterrence of sea water intrusion into the Central and West Coast Basins
2. Utilize existing studies and desalting efforts along with proposed desalter plants to increase remediation of saline plume
3. Continue WRD Wellhead Treatment Program to remove VOCs from the groundwater basins and deter the spread of contaminants to other wells
4. Protection of Central Basin from San Gabriel Valley groundwater contamination

Water Supply Objectives

1. Reduce cost of basin replenishment and sea water intrusion protection
2. Increase capture and reuse of local stormwater runoff
3. Increase permitted use of recycled water for groundwater recharge
4. Increase availability of imported water
5. Increase use of recycled water for sea water intrusion barriers

Groundwater Basin Management Objectives

1. Develop a groundwater model for Central and West Coast Basins
2. Develop in-house database for basin water quality, water level and other groundwater data
3. Increase use of groundwater storage in the Central and West Coast Basins
4. Increase groundwater production in the Central and West Coast Basins

Institutional Communication Objectives

1. Communicate groundwater issues and information to appropriate local, regional, state and federal entities
2. Interact with relevant local, regional, state and federal entities and to proactively address critical water issues
3. Provide accountability to WRD's pumpers and residents regarding District policies and activities

Through these efforts, WRD will provide increased protection at the sea water intrusion barriers at a reduced cost. WRD will also secure lower cost groundwater recharge sources, with increased reliability of those sources. Saline plume mitigation will be in progress to halt the advancement of the plume and reclaim portions of the groundwater basins currently contaminated by saline water. All wells currently affected by volatile organic compounds will be addressed through treatment or other solutions with continuing formal efforts to prevent further groundwater contamination.

WRD will address changes to regulations affecting District activities that are currently proposed by agencies such as the California Regional Water Quality Control Board and the Department of Health Services. These objectives will allow WRD to increase the effectiveness of its management of the basins while exercising efforts to minimize increases to the assessment levied by the District.

The four challenges identified in the vision of WRD are equated to four separate but related plans that make up the basis for the overall Groundwater Management Plan:

The Water Quality Management Plan emphasizes water quality interests and activities of WRD.

The Water Supply Management Plan focuses on water supply issues facing WRD.

The Basin Management Plan deals with the need for well planned groundwater basin management.

The Institutional Communication Plan details the steps that WRD will take to implement an effective relationship with entities that affect WRD or are affected by WRD.

Goal 1 WATER QUALITY MANAGEMENT PLAN

Objectives

The protection and enhancement of the quality of groundwater in the Central and West Coast groundwater basins is the highest priority of the Water Replenishment District. Guided by sound Board policies with clear and concise objectives, activities to accomplish this effort are underway. WRD has studied the effects of seawater intrusion into the groundwater aquifers near the coast and is planning activities to mitigate the resultant plumes of saline water. WRD programs also include the removal of specific solvent compounds from the groundwater aquifers by pumping and treatment. WRD will continue to enhance its water quality monitoring programs to assure compliance with drinking water standards. The Replenishment District is also engaging in research and development programs to ensure the continued high quality of groundwater in the basins.

Water Quality Monitoring Programs

WRD maintains intensive groundwater monitoring programs. The monitoring can detect groundwater contamination, evaluate trends in water quality characteristics, and assure compliance with drinking water standards. These programs are also the first step toward detecting any degradation to the quality of the District's groundwater supply. Current studies and planned activities will lead to a more effective monitoring system and increased knowledge of how the Central and West Coast Basins function.

Joint Agency Reclaimed Water Quality Monitoring Program

In 1973, a Joint Agency Water Quality Monitoring Program was initiated with a network of wells in the Montebello Forebay and used to evaluate the various sources of replenishment water recharging the Central groundwater basin. The agencies participating in the program are the WRD, the Los Angeles County Department of Public Works, and the County Sanitation Districts of Los Angeles County. The primary purpose of the program is to detect any deviations in water quality that could result from the District's replenishment program.

The well network is comprised of 19 production wells owned by several groundwater producers in the District and 6 wells dedicated to groundwater monitoring. The network was designed to provide access to several levels of the aquifers that supply groundwater by including wells of varying depths. Monitoring these wells provides groundwater level data and samples drawn from the wells are analyzed for water quality data in laboratories on contract to the District. The Joint Agency Water Quality Monitoring Program is ongoing with a yearly cost of $500,000. At the outset, the Program established a data baseline from which subsequent data can be compared to identify, define, and evaluate water quality problems.

In-House Groundwater Quality Monitoring Report Development

The results of the Joint Agency Water Quality Monitoring Program are analyzed for WRD by Bookman-Edmonston Engineering, Inc., who then compiles and reports the results in the Annual Report on Results of Water Quality Monitoring. The report also takes into account results from the Safe Drinking Water (Title 22) Monitoring Program administrated by the Central And West Basin Municipal Water Districts. This program monitors the groundwater quality of the production wells within the basins. Results from LADPW monitoring of the sea water intrusion barriers and additional basin-wide monitoring are also included in the annual report.

WRD began to production of this report utilizing District staff in 1996. This will provide the development of in-house expertise regarding water quality within the District as well as allow real time access to water quality data and analysis.

Whittier Narrows Monitoring Program

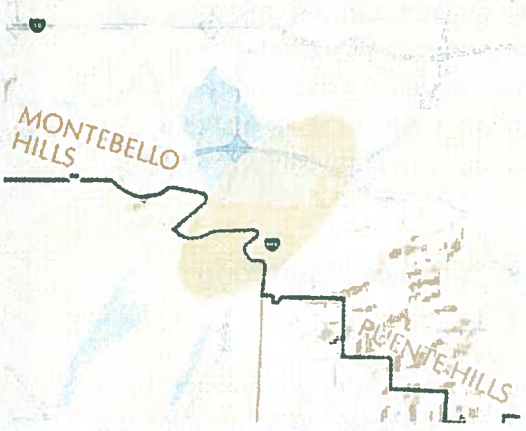
The San Gabriel Valley groundwater basin connects to the Central groundwater basin by way of a very narrow geologic formation. This area, bounded on the west by

the Merced Hills and on the east by the Puente Hills, is referred to as the Whittier Narrows. Extensive San Gabriel Valley groundwater contamination poses a serious potential threat should it migrate downstream through the Whittier Narrows into the Central Basin.

WRD has taken a lead role in addressing this issue both as the groundwater manager of the Central Basin and as a member of the Southeast Water Coalition (SEWC). WRD and SEWC, the joint powers authority comprised of 11 cities within the Central Basin, joined together to collectively address this potential threat. They successfully urged the U. S. Environmental Protection Agency (USEPA) to construct several monitoring wells in the Whittier Narrows. These wells provide an early warning system that detects any migration of groundwater contaminants from the San Gabriel Valley through the Whittier Narrows to the Central Basin.

The location, number, and type of wells was determined by the Local Agency Work Group, through the efforts of SEWC and WRD. This group, headed by WRD, contains members from the USEPA, SEWC, California Department of Health Services (California EPA), the California Regional Water Quality Control Board, Los Angeles County Department of Waste Management, the San Gabriel Water Quality Authority, the Main San Gabriel Basin Watermaster, and several Central Basin groundwater producers. The group has been very effective in providing a unified local voice to be heard directly by the USEPA.

Construction of a USEPA multi-port monitoring well in the Whittier Narrows



The Whittier Narrows area is located between the Merced and Puente hills formations (source: WRD Geographical Information System)

The monitoring network consists of four multi-port and eight single-depth monitoring wells located in the Whittier Narrows. The average depth of the multi-port wells is 900 feet and each well contains ports to provide water quality samples from between eight to eleven isolated zones at varying depths of the area's groundwater aquifers. The single-depth wells are constructed in clusters of two wells each. These wells are screened to allow a mix of groundwater from the

several depths of the aquifers that the well penetrates.

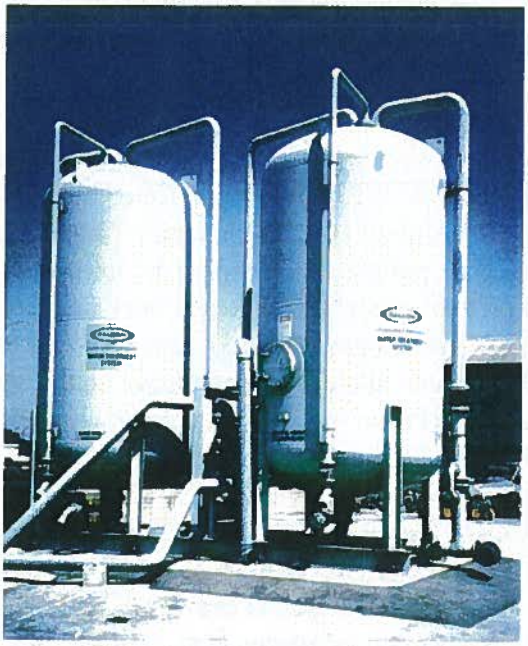
The wells provide an early warning detection system by monitoring any significant travel of contamination from the San Gabriel Valley into the Whittier Narrows. The USEPA is committed to monitoring these wells for five years. The total cost for construction and five years of monitoring is $5 million, which is being funded completely by the USEPA. At the end of the five year monitoring commitment, the USEPA will re-evaluate the program based upon the data gathered to determine if it should be extended.
The Local Agency Work Group together with the USEPA continues to collectively analyze the monitoring results of the USEPA wells, and will recommend any needed changes. WRD expects the Work Group to urge USEPA installation of additional monitoring wells in the Whittier Narrows by 1998.

Wellhead Treatment Program

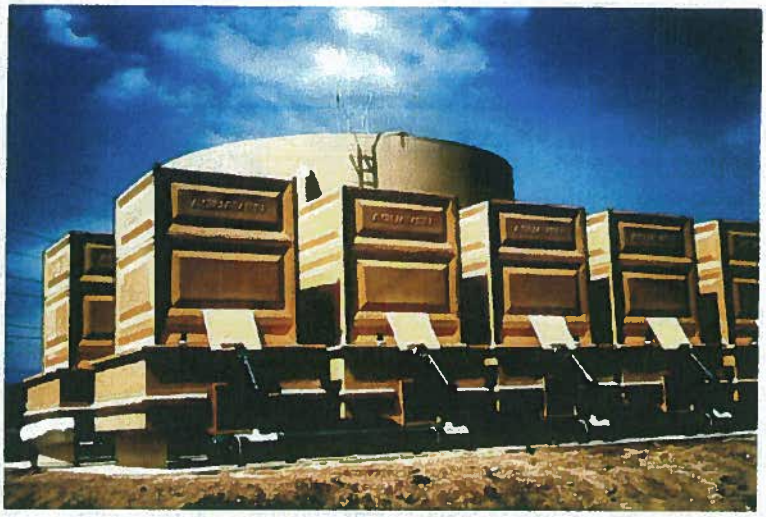
Past improper disposal practices of industrial solvents such as trichloroethylene (TCEs) and perchloroethylene (PCEs) allowed volatile organic compounds (VOCs) to seep into the groundwater aquifers within the WRD service area. Although not a major concern in the West Coast Basins, these constituents have been found in a number of wells in the Central Basin and some of those have been taken out of production. Stricter regulations have greatly reduced the source of this pollution, but the District is left with the task of removing the existing contamination from the groundwater.

In response to this problem, WRD established a Wellhead Treatment Program to address groundwater contamination. This program provides pumpers with treatment equipment to remove VOCs from the groundwater, allowing affected wells to meet public drinking water standards and remain in production. Through the program, the District will finance or construct wellhead treatment facilities for pumpers. These treatment facilities remove contaminants in water extracted from the groundwater basins by utilizing air-stripping, granular-activated carbon technology, or other state-of-the-art processes.

WRD's Wellhead Treatment Program is a cooperative effort with the groundwater producers



Two carbon vessels were used to treat the City of South Gate's Well Number 7



Air-stripping modular treatment units remove volatile organic compounds from the city of Pico Rivera's Well #1.

This treatment process adheres to strict clean air guidelines and operates under a permit with the South Coast Air Quality Management District.

Phase I of this program, completed in 1991, was a study that identified 19 potential well sites in need of treatment and determined the most appropriate wellhead treatment method for each well.

Phase II of the program is ongoing construction of a series of wellhead treatment facilities, each specifically designed for local conditions. Current participants in the WRD Wellhead Treatment Program include the City of South Gate, Southern California Water Company, the City of Huntington Park, and the City of Pico Rivera.

The South Gate project treats that city's Well #7, which has been affected by TCE at levels exceeding the maximum contaminant level (MCL). The treatment facility consists of two granular activated carbon filters to remove the contaminant. The total capital cost for this project was $250,000. Since the completion of this facility in 1991, the carbon filters have removed 80 pounds of solvents from that area's groundwater basin to date.

The cities of Pico Rivera and Huntington Park sought Wellhead Treatment Program assistance from WRD for wells affected by PCE and TCE contamination exceeding the MCL. The City of Huntington Park's Well #15 had already been shut down. The District provided six portable air stripping modules that treated the well and quickly returned it to a full production status. This treatment facility operates under permits from the Air Quality Management District of Southern California and the California Department of Health Services and can safely remove up to 180 pounds of solvents from the Central groundwater basin. Well #15 was returned to full production in 1994 after WRD invested $180,000 in facility costs.

The City of Pico Rivera relies solely on groundwater production to meet the water demands of its residents. Almost 40% of that demand is met by full production of the city's Well Number 1. The well exceeded the MCL for PCE and was removed from service in 1994. WRD provided eleven (11) treatment modules to Pico Rivera of the same type as used at Huntington Park's Well #15. This treatment facility went on line in 1995 after WRD invested $300,000. Well #1 is now in full production with the capability to remove seventy-five pounds of contaminants from the Central Basin each year.
Southern California Water Company (SCWC) owns and operates the Pioneer #1 Well,

located in the City of Norwalk. This well was shut down due to excessive TCE levels. WRD financed a wellhead treatment facility that consists of a single granular activated carbon filter, and returned the Pioneer well to full production in 1993, at a cost to WRD of $300,000. This facility operated for more than one year, successfully removing contaminants from the groundwater. After that time, the contaminant levels decreased to within safe drinking water limits, and treatment was no longer required by the Department of Health Services.

WRD is now working with SCWC to move the carbon filter vessel to its Dace Well which has been affected by VOC contamination levels exceeding the MCL. The cost to install the Pioneer filter vessel at the Dace site, located in the City of Norwalk, will total about $100,000 and will be equally shared by WRD and SCWC. This project demonstrates the flexibility of the WRD Wellhead Treatment Program to treat wells affected by VOC contamination.

The WRD Wellhead Treatment program improves groundwater quality and prevents abandonment of active groundwater production wells. The benefits of this program include removal of contaminants from local groundwater basins, improved drinking water quality, increased pumping flexibility in the basins, and prevention of contamination spread to other wells.

The WRD Wellhead Treatment Program was expanded in late 1996 to provide financing for treatment projects to remove additional constituents such as iron and manganese and taste and odor.

WRD plans to construct eight additional wellhead treatment facilities by 2000 at a total cost to the District of approximately $2 million. New wellhead treatment projects, along with current facilities, are expected to remove over 400 pounds of VOCs from the groundwater basins.

VOC Removal Rebate Program

Trichloroethylene (TCE) and perchloroethylene (PCE) are significant threats to the District's groundwater supplies. The characteristics and properties of these contaminants make them relatively more difficult to remove once they have infiltrated the soil strata. There is also an urgency to remove TCE and PCE, since under certain environmental conditions, both have the potential to degrade to vinyl chloride, a contaminant of great health concern.

As a means of combating the problem, WRD administers the VOC Removal Rebate Program. This program works to complement the Wellhead Treatment Program and also serve as an independent program where treatment is not necessary. The program encourages groundwater producers to pump contaminated water from the basin, thereby increasing the rate of VOC removal from the groundwater. Rather than abandoning these wells and leaving the contaminants in the groundwater to spread to other wells, the water is extracted, treated, and put to beneficial use.

Through a rebate plan, the pumpers are offered a financial incentive to pump these wells. The water in the wells must contain VOCs at a minimum of 60% of the MCLs and then meet all health regulations when delivered to customers. Currently, the rebate is $25 per acre-foot for all water pumped plus an additional $25 per acre-foot for the increased pumping amount as compared to a baseline period defined by the program. This rebate also applies to wells receiving treatment through the WRD Wellhead Treatment Program.

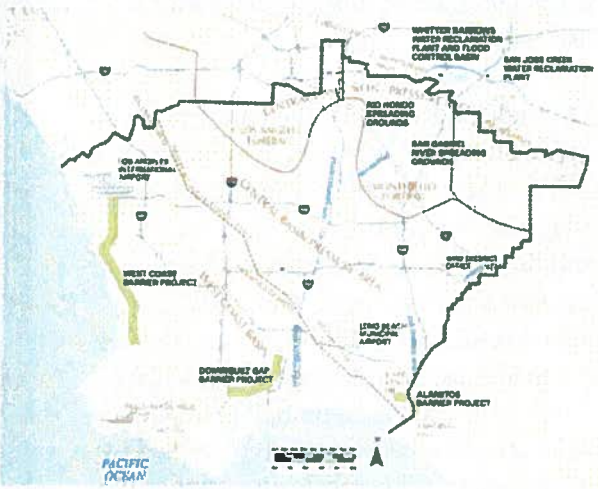
Qualified pumping for the rebate began in early 1991. A total of 12 purveyors are now enrolled in the WRD VOC Removal Rebate Program and have collectively received $1 million in rebates from WRD for removing 400 pounds of VOCs since the program's inception. WRD expects to use the VOC Removal Rebate Program to remove 1,000 pounds of VOCs from the groundwater basins by the year 2000 at a total cost of $2.5 million.

Seawater Intrusion Program

Historic overpumping of the Central and West Coast groundwater basins has resulted in coastal basin seawater intrusion, beginning as early as the 1920s. Seawater intrusion into a groundwater aquifer occurs when the groundwater levels drop below sea level along the coastline. Gravity and osmotic forces push the seawater into the aquifers, contaminating fresh groundwater with salt water.

To protect the coastal areas of the groundwater basins from salt water intrusion, three seawater intrusion barriers were constructed by the Los Angeles County Department of Public Works (LADPW) during the 1960's. Each barrier is comprised of a line of closely spaced injection wells installed along the coastline. Water is injected into these wells to form a mound of freshwater between the ocean and the groundwater basins. This mound acts as a dam to deter the sea water from flowing into the groundwater aquifers.

The West Coast Basin Barrier Project, the largest of the three seawater barriers, is made up of 150 injection wells located along the coast from the City of El Segundo south to the Palos Verdes Hills. The Dominguez Gap Barrier Project consists of approximately 30 injection wells located north of San Pedro Bay. The Alamitos Barrier Project, located along the Los Angeles - Orange County Border in the cities of Long Beach and Seal Beach, protects a portion of the Central Basin from seawater intrusion. Responsibilities for this barrier are shared by WRD and the Orange County Water District.



Location of seawater barriers highlighted in yellow (source: WRD Geographical Information system)

Operation of the seawater barriers is performed by LADPW. Since 1965, when all three of the barriers were completed and operational, an average of 36,000 acre-feet of water purchased from MWD has been injected into the barriers each year. In 1996, WRD's cost to supply water to these barriers was over $16 million.

As the entity responsible for the purchase of water for the seawater barriers, WRD possesses a high degree of economic motivation to reduce the cost of supplying the

water needed to prevent seawater intrusion at the barrier facilities. Based upon this motivation, WRD, in discussion with LADPW barrier staff, has identified opportunities and developed concepts with the potential to increase the efficiency of the barriers and reduce the costs associated with the operation of those facilities. WRD will conduct studies to evaluate these concepts and opportunities and implement those programs that provide cost reduction while increasing seawater intrusion control.

Saline Plume Program

Prior to the construction of three seawater barriers along the coastline of the Central and West Coast groundwater basins, seawater infiltrated into the groundwater aquifers and rendered many wells useless for drinking water production. The continuing presence of these plumes of saline water also decreases the ability of affected aquifers to provide groundwater storage.

WRD, in a cooperative effort with MWDSC, the West Basin Municipal Water District, and the LADPW, completed a study of the saline plume in 1992 that identified its extensiveness in the West Coast Basin and alternatives for remediation. The major plume is found on the landward side of the West Coast Basin Barrier Project, extending as much as 2.5 miles inland, and is estimated to occupy 250,000 acre-feet of the groundwater aquifer. An increasingly high degree of localized pumping in the Carson/Dominguez area is causing the saline plume to move inland where the advancing plume front will affect wells in its path. Eleven groundwater wells, located in the Torrance and Manhattan Beach areas, are expected to be impacted within the next ten years, with an annual groundwater production capacity loss of 11,000 acre-feet per year.

Objectives to address the saline plume problem in the West Coast Basin have been formulated. The objectives identify methods to halt advancement of the inland plumes, remediate the existing inland plumes, reduce the need for new and additional seawater barrier facilities, and maintain existing groundwater production capabilities. Construction of saline water desalters in the plume area will remove 35,000 acre-feet of saline water by the year 2005. Typical capital construction cost for a desalter with a 2,000 acre-feet per year capacity is $3 million.

Saline Plume Remediation Desalting Plants

The District is considering construction of desalting plants in collaboration with the City of Torrance and Cal-American Water Service Company. This plants will remediate the saline plume in the West Coast Basin and protect the groundwater wells within the city from further salt water contamination. Construction of these projects could be completed in 1998 at a cost of about $12 million. These facilities will remove over 30,000 acre-feet of saline water from the West Coast Basin by the year 2005.

Goal 2 WATER SUPPLY MANAGEMENT PLAN

Objectives

A reliable and abundant supply of water for replenishment purposes must be ensured. Furthermore, it must work in tandem with water quality programs as outlined in this plan's list of goals. Although concise and bold objectives have been identified in the past, future alternative objectives must also be considered if WRD is to succeed in its mission. Implementation of these objectives must be carried out with due regard to economic feasibility and in a cost effective manner to maintain as low a groundwater assessment as possible.

The complexity of issues facing WRD's management of existing and future water supplies has multiplied in recent years with the combined revamping of the imported water rate structure and the growing scarcity of traditional sources of supply. Increasingly stringent health regulations by the Department of Health Services and more sophisticated and additional monitoring requirements by the Los Angeles Regional Water Quality Control Board are currently proposed, likely adding to the cost of recycled water and potentially curtailing its use.

WRD's supply management goal is to ensure a reliable supply of replenishment water for the West Coast and Central Basins through a diversification of resources. While the combination of the traditional

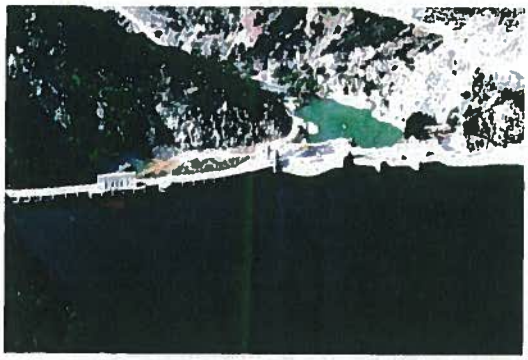
sources of local runoff flow, recycled water and imported water historically provided sufficient options to meet replenishment demands, the future requires investigation of alternative water supplies.

WRD is exploring methods to increase the use of local stormwater runoff for groundwater replenishment and is expanding current efforts to use recycled water in all three of the seawater intrusion barriers that protect the Central and West Coast Basins. Participation in the various programs offered by the Metropolitan Water District of Southern California (MWD) will ensure optimization of the use of imported water in the District's management of the groundwater basins.

Local Stormwater Runoff

WRD has utilized stormwater runoff for groundwater replenishment since 1959. This free local resource directly offsets the amount of imported water purchased by WRD, reducing the cost of groundwater replenishment.

The Central and West Coast Basins include two major river systems, the Los Angeles River and the San Gabriel River.



LADPW dams provide runoff storage from the San Gabriel Mountains

Through water conservation efforts of the Los Angeles County Department of Public Works (LADPW), WRD is able to benefit from the capture and use of 40,000 acre-feet of stormwater in an average year. Most of this conserved water is from the San Gabriel River. This is due to an existing system of dams and reservoirs located in the San Gabriel canyons and mountains. These facilities provide a high degree of control over the river, allowing for conservation and use of nearly 90% of the storm runoff in the San Gabriel River. In Los Angeles County, storms typically last for one to three days. Much of the runoff from these storms is diverted by storm drains into the Los Angles River, where it flows very quickly into the ocean. Though some of this river's stormwater is diverted to the Rio Hondo Coastal Spreading Grounds during storm periods, the percolation replenishment process does not occur quickly enough to take advantage of much of this water. As a result, over 95% of the stormwater runoff from the Los Angeles River is wasted to the ocean.

WRD is currently conducting studies and participating in efforts to increase the use of local stormwater runoff from the San Gabriel and Los Angeles river systems, including development of a groundwater recharge facility in the Los Angeles Forebay.

Offshore Freshwater Reservoir

With over 150,000 acre feet of stormwater runoff wasting to the ocean from the Los Angeles River in a typical year, this river is an important potential water supply for groundwater replenishment. Over the past several years, various methods have been investigated to increase stormwater conservation along the Los Angeles River. Of all the alternatives considered, the con-

struction of an offshore reservoir to capture Los Angeles River stormwater runoff was considered the most promising by several local and regional agencies.

Based on these findings and the potential for maximizing the use of this local water resource, WRD and the LADPW are co-funding a study to determine the feasibility of constructing such a reservoir in the ocean to collect stormwater runoff from the Los Angeles River. This study, which began in 1995 and will be completed in early 1997, will consider technical, economic, environmental and institutional aspects of this project.

Initial findings have determined that it is technically feasible to construct a reservoir in the San Pedro Bay, off the coast of Long Beach. Stormwater runoff would be diverted to the reservoir by submerged pipelines and stored for later use. Should all aspects of this study prove favorable, construction of this facility could provide an average of 150,000 acre feet of local water each year for groundwater replenishment supply and other purposes.

U.S. Army Corps of Engineers Water Conservation Study

The U.S. Army Corps of Engineers (ACOE) owns and operates several dams in Southern California. Though the main purpose of these dams is to provide flood protection in the event of significant storms, the dams can also be utilized for stormwater conservation. The ACOE and the LADPW are co-funding a study to investigate how additional water can be conserved by each of the ACOE dams and continue to maintain adequate flood protection. Increased stormwater conservation at two ACOE facilities, the Santa Fe Dam and the Whittier Narrows Dam, will directly benefit the District. Initial results from the study indicate that existing conservation at these facilities can be increased by an average of 1,000 acre feet each. This additional conservation storage can be utilized with each storm event during the year. With an average of three storm events per year, the added storage could account for 3,000 acre-feet of additional water from each dam in a typical year. Based upon the distribution of water conserved at these dams, and the time it would take to implement these potential changes, WRD could realize an average annual increase of 6,000 acre feet of local runoff supply each year beginning in 1999.

Recharge Facility Improvements and Operation Enhancements

The Los Angeles County Department of Public Works (LADPW) operates the Rio Hondo and San Gabriel Coastal Spreading Grounds under the authorization of the Flood Control Act of 1932. Based upon this Act, the LADPW conserves water from the Los Angeles and San Gabriel rivers. The Act does not provide goals to optimize the balance of imported water, recycled water and stormwater runoff. WRD has the incentive to seek a cost-effective and reliable supply of groundwater replenishment water, and therefore, is highly motivated to enhance the operations of LADPW groundwater recharge facilities.

WRD will work with the LADPW to study ways to improve the operation of the facilities to completely capitalize on the availability of free local stormwater and fully utilize the District's permitted amount of recycled water for groundwater replenishment. Various opportunities for improvement to the spreading basins will also be investigated to determine the most effective physical configurations of the facilities.

In addition to ensuring WRD's full use of its permitted amount of recycled water each year, these efforts will increase the use of stormwater runoff from the Los Angeles and San Gabriel rivers by 5,000 acre feet per year beginning in 1999.

The LADPW owns and operates 3 dams along the Upper San Gabriel River. These dams and their corresponding reservoirs provide a large degree of control over the flow in the San Gabriel River, allowing for storm runoff to be captured during periods of rainfall and later released for groundwater replenishment in the San Gabriel Valley and the Central Basin. WRD will work with the LADPW to evaluate operational enhancements that may increase the effectiveness of stormwater conservation at these dams. These changes may provide an increase in local storm runoff amounting to an average of 2,000 acre feet per year starting as early as 1998.

Increased Recycled Water Use

Groundwater within the regional basins of Los Angeles County provides approximately 40% of the total water demand and thus serves as a very important local resource. Increased demand for water in Southern California puts added burdens on local water agencies for identification of future adequate supplies.

Groundwater pumping in Southern Los Angeles County far exceeds nature's replenishment capability. Therefore, WRD combines the use of local stormwater, water imported from Northern California and the Colorado River, and recycled municipal wastewater to recharge the underground basin aquifers.

As the nation's largest regulated recycled water user, WRD uses as much recycled water as possible for groundwater replenishment since it is both cost effective and reliable. Despite proposed stricter guidelines, WRD is currently examining projects to expand recycled water use for the seawater intrusion barriers and groundwater replenishment.

Montebello Forebay Recycled Water Advanced Treatment Project

The State Department of Health Services (DOHS) limits the amount of recycled water used by WRD for groundwater replenishment to 50,000 acre-feet per year. One way to increase the use of this water beyond the current amount permitted by DOHS is to treat the additional recycled water to reduce total organic carbon (TOC).

The Montebello Forebay Recycled Water Advanced Treatment Project is a planned advanced water treatment facility to be owned and operated by WRD at the Whittier Narrows Water Reclamation Plant (WNWRP). By 1999, the Advanced Treatment Project will convert an additional 10,000 acre-feet per year of recycled water for WRD groundwater replenishment.

Phase I of the project evaluated several advanced alternative treatment methods that could provide additional recycled water amounts for recharge purposes. Phase II of the project determined the economic and technical feasibility of each alternative. Based upon the results of these phases, the selected optimum alternative at the WNWRP was construction of a separate granular activated carbon

treatment facility to remove TOCs. This advanced treatment would follow the tertiary process at the plant and be operated in cooperation with the County Sanitation District of Los Angeles County using its operations personnel. Capital cost for this project is estimated to be $9 million. Cost for the advanced treated recycled water is expected to be less than imported water rates initially, with increasing cost effectiveness in the future. WRD will fund this project and seek financial assistance from MWDSC through its Local Resources Projects program as well as federal assistance. Construction is expected to begin in 1999 and be completed in 2000.

Health Effects Studies

Since the early 1960s, the District has used nearly 1,000,000 acre-feet of recycled water to supplement local and imported water for replenishment purposes. This has conserved valuable water that would otherwise be lost to the ocean. WRD uses recycled water treated at Whittier Narrows, San Jose Creek, and Pomona Water Reclamation Plants. These plants are owned and operated by the County Sanitation Districts of Los Angeles County. The recycled water from these plants is treated to a tertiary stage, which means that this water is subjected to three distinct treatment phases. The result of this degree of treatment is recycled water that complies with safe drinking water limits for all but bacteria, virus, nitrate and total organic carbon levels.

The District's recycled water use has escalated dramatically over the past few years to reach an average of 50,000 acre-feet per year. It comprises 20% of the water resources replenishing the groundwater that serves the nearly 4 million residents in the WRD area. As the largest regulated recycled water user in the nation, WRD is obligated to assure the safety of its application and confirm that public health is not jeopardized. To that end, the District is updating a health effects study of recycled water used to recharge the Montebello Forebay area groundwater supply in urban Los Angeles County.

The Orange County Water District is also conducting a recycled water use health effects study relating to its groundwater management operations.

The results of these studies will assure the safe use of recycled municipal wastewater by WRD and other agencies throughout the United States. The studies will also quantify the public health effects of drinking water that has been infused with a limited amount of recycled water.

Should these studies determine no adverse public health effects due to recycled water use by WRD, the results of these evaluations and other research currently being conducted by WRD and others, may justify not only current use, but a 20% increase in the Districts application of recycled water for groundwater recharge by the year 2000. This increased use of recycled water would promote the use of local water resources and decrease the dependence on scarce and expensive water resources from northern California and the Colorado River.

Montebello Forebay Health Effects Study

The Montebello Forebay, which is located in the cities of Montebello and Pico Rivera, is geologically conducive to effective groundwater replenishment spreading in the Central Basin. The ground surface has a direct pathway to the subsurface groundwater aquifers that supply the Central Basin and part of the West Coast Basin. Further south, or closer

to the ocean, expansive layers of clay prohibit surface water from percolating into the deep groundwater producing aquifers.

The Los Angeles Department of Public Works (LADPW) owns and operates the Rio Hondo and San Gabriel Coastal spreading grounds located in the Montebello Forebay. These facilities allow groundwater replenishment water to collect in large ponds that are 12 feet in depth. The water percolates through the bottom of the ponds and ultimately replenishes the deep groundwater producing aquifers.

The Montebello Forebay Health Effects Study assesses the health effects of infusing treated municipal wastewater into the groundwater supply in the Montebello Forebay. The new evaluation will update the epidemiological findings of the 1984 study funded by the U.S. Environmental Protection Agency and the County Sanitation Districts of Los Angeles County (Epidemiological Impact of Water Reuse in Los Angeles County). The earlier report recommended that health impacts of recycled water be reevaluated in ten years. Since the completion of the 1983 report, WRD has significantly increased recycled water use for groundwater recharge in the Montebello Forebay. The District believes it is prudent to reassess the potential impacts, if any, of this resource application.

San Gabriel River Coastal spreading grounds

Rio Hondo Coastal spreading grounds. The spreading grounds in the Montebello Forebay are owned and operated by the Los Angeles County Department of Public Works

To meet the highest standards of research, WRD contracted with the Rand Corporation to conduct the study. Rand is performing the evaluation in two phases over a three year period. Phase I, which began in 1994 and was completed in 1996, is a geographic comparison study using existing health records that cite the number of deaths, cancer and infectious diseases occurring within cities in the vicinity of the Rio Hondo and San Gabriel Coastal groundwater recharge facilities. Rand then statistically evaluated the health effects of recycled water intake in that region. Phase I concluded that there are no adverse health effects due to the use of recycled water for groundwater replenishment by WRD.

The scope of Phase II includes a study of birth related outcomes. This phase will be conducted in the same manner as Phase I and will be completed in 1998. Rand will prepare a report summarizing the conclusions of the study and backup data. The total cost for this study is about $1 million.

Orange County Health Effects Study

The Orange County Water District has launched a separate extensive study to measure any adverse impacts from re-

cycled water in the Santa Ana River groundwater replenishment area. The Santa Ana River Study will cost between $4 and $6 million and will document the assimilation capacities of the recharge area soils covering a period of three to four years. WRD will monitor the progress of this study and will apply the benefit of its results to the District's recycled water recharge program in the Montebello Forebay.

WRD / U.S. Geological Survey Cooperative Study of Total Organic Carbon and Nitrates in Recycled Water

WRD use of recycled water is limited by the existence of total organic carbon (TOC) and nitrates in the water. In excessive levels, these elements can potentially cause adverse health effects. Additionally, TOC's in combination with some groundwater disinfection processes can generate by-products that are of concern to health. A better understanding of these components and how they react with and dissipate in the replenishment process is necessary for the continued and increased use of recycled water by the District.

As part of the District's effort to utilize more recycled water, WRD is jointly funding the Reclaimed Water Total Organic Carbon and Nitrate Study with the U.S. Geological Survey (USGS). The study will focus on determining the quantity of nitrates removed naturally from the reclaimed water as the water percolates through the soil at the spreading basins. Identification and fractionation of the total organic carbon during the percolation process will also be scientifically quantified.

To conduct this study, WRD constructed a research basin located within the San Gabriel Coastal spreading facilities under a Use Agreement Permit with the LADPW. The basin is isolated from the main spreading ponds by an earthen dike, which allows the research basin to operate independently of the other ponds. The research basin is supplied with recycled water from a dedicated pipeline constructed as part of the project.
Several wells were installed in the bottom of the test basin by the USGS. These wells contain technical equipment used to gather data from the basin. Three of the wells contain various lysimeters, which allow water samples to be drawn by suction from the area between the bottom of the pond and the water table. This area is known as the vadose, or unsaturated zone. This is the area that is partially saturated as water percolates from the bottom of the pond to where the ground is entirely saturated with water, also known as the water table level. The water samples drawn from the lysimeters are analyzed to determine nitrate and TOC concentrations as well as to identify the type of TOCs present in the sample. Other

WRD and the USGS Recycled Water Research Basin at the San Gabirel Coastal spreading grounds

wells in the test basin measure the change in gases in the soil. Tracking the degradation of the nitrates and the change in composition of the TOCs and associated gases will be used to determine the changes occurring in the recycled water as it reacts with the soil in its migration to the aquifer. The remaining test basin wells are used to determine the water table level beneath the basin.

The WRD / USGS Nitrate and TOC Study began in 1991 and will continue through 1997. The total cost for this study, which is equally shared by the District and the USGS, is $2 million. Additional future study in the test basin will evaluate operational methods that may enhance the degradation of nitrates and TOCs during the percolation process. Based upon this research and other studies including the health effects studies, WRD will seek regulatory approval to increase its use of recycled water for groundwater replenishment by 10,000 acre-feet by the year 1999.

Soil Aquifer Treatability Study

Soil Aquifer Treatment (SAT) refers to the treatment processes that take place in the subsurface as reclaimed water percolates through the soil to the groundwater and migrates through the aquifer to a production well. SAT takes place beneath the recharge spreading ponds in the Montebello Forebay of the Central Basin. The WRD / USGS Total Organic Carbon and Nitrate Research Project is an example of a study that looks into the detailed mechanisms that take place during this process.

A multi-disciplinary team consisting of WRD, other agency staff, university researchers, and the USGS have pooled their resources to undertake a three-year project with research sites in southern California (including the Montebello Forebay site) and Arizona. Laboratory research would occur in these areas as well as at Stanford and Colorado. The investigations will explore and answer issues that benefit all reclaimed water users in the Southwest.

Working with Regulatory and Other Agencies

WRD will continue to work with regulatory agencies that affect District activities. The Department of Health Services is currently developing proposals for new regulations related to the use of reclaimed water for groundwater recharge. The Los Angeles Regional Water Quality Control Board also has regulatory authority related to District reclaimed water projects. WRD will work closely with these agencies throughout the development and adoption of new regulations as well as the approval and permitting of District projects.

The Metropolitan Water District of Southern California (MWD) is currently revising its Local Projects Program and the Groundwater Recovery Program. These programs provide financial incentives to develop new sources of water, such as recycled water and the treatment of otherwise unusable groundwater. WRD will collaborate with other groundwater management agencies and MWD to make changes to these programs to benefit groundwater managers.

West Coast Basin Barrier

Starting in 1995, the West Basin Recycled Water Treatment Plant, owned by the West Basin Municipal Water District, has made advanced treated recycled water available for seawater barrier injection. This treatment plant is capable of providing 5,000 acre-feet of highly treated recycled water to the West Coast Barrier each year.

Alamitos Barrier

The District is in the pre-design phase of the Alamitos Barrier Recycled Water Project. This project will treat water from the Long Beach Water Reclamation Plant by reverse-osmosis. This advanced treated water will ultimately replace the imported water now supplying the nearby Alamitos Seawater Intrusion Barrier.

The first phase of this project, which will supply 3,000 acre-feet, or half of the total water demand for the Alamitos Barrier, could be completed by 1999 for a total cost of $13 million. This cost will be shared equally with the Orange County Water District (OCWD), who also benefits from the protection provided by the barrier.

The second phase of the project will provide 6,000 acre-feet of water, completely replacing the imported water needs for the barrier. This phase is expected to be completed in 2005 for $10 million dollars, with equal cost sharing by WRD and OCWD. Treatment cost per acre-foot is expected to equal the current cost of the imported water used for the barrier. As the cost of imported water rises, the Alamitos Barrier Recycled Water Project will become increasingly more cost effective.

Dominguez Gap Barrier Recycled Water Project

A project, similar to the Alamitos Barrier Recycled Water Project, has been proposed by the City of Los Angeles to WRD to supply the Dominguez Gap Seawater Intrusion Barrier. Water from the Terminal Island Treatment Plant (TITP), owned and operated by the city, will be treated using the reverse-osmosis method. This project will initially replace 4,000 acre-feet of imported water purchased by WRD for the barrier. As with the Alamitos Barrier Recycled Water Project, the TITP/Dominguez Gap Recycled Water Project will become increasingly more cost effective as imported water costs continue to rise. This project is anticipated to be completed in 1999. WRD's cost to participate in the project is estimated at $900,000. Planned expansion to the project will increase the availability of treated water from the plant to 8,000 acre feet per year by 2010. Capital costs for this expansion will be funded by the City of Los Angeles, which will sell the treated water to WRD.

Secure Additional Untreated Water Supplies

California has long enjoyed the luxury of receiving Colorado River water in amounts exceeding its allotment. As other states and entities take greater delivery of their respective allotments, Southern California's reliance on this water will need to decrease as the cost of the water will escalate.

Recent water transfer legislation encourages a balanced use of a variety of imported water supplies. Based on this, WRD is exploring the feasibility of securing additional untreated water from MWD and other sources. This includes arrangements with entities who have rights to the Colorado River and the State Water Project. The District is also cooperating with other agencies, both in and outside the state, to develop cost effective, reliable water supplies for groundwater replenishment. By the year 2000, these efforts could deliver up to 30,000 acre feet of water each year to WRD. Purchase of this water will depend upon the cost effectiveness of the supply compared to the cost of MWD water.

Colored Water Use

Colored water is groundwater that can meet all health requirements, but is not aesthetically appealing to the consumer. WRD plans to determine if this water can be put to beneficial use within the District, either by direct use or with treatment. Depending upon the location and amounts of this otherwise unusable water, up to 1,000 acre feet of this water could be utilized by WRD each year. This use could start as early as 2000 with costs ranging from $150 to $300 per acre foot.

Goal 3 GROUNDWATER BASIN MANAGEMENT PLAN

Objectives

With improved management of the Central and West Coast Basins, WRD would expand the capacity of the basins, improve pumping patterns and develop a better understanding of the basin hydrodynamics. As the guardian of the basins, the District will continue to protect both from damage or depletion.

Central and West Coast groundwater basin management is complicated further by the many institutions involved. Although WRD has the basin management role, other agency's programs overlap responsibilities and must be carefully coordinated in order for WRD to achieve its goals. Major Basin Management objectives are:

1. Develop a groundwater model for the Central and West Coast Basins
2. Develop an in-house database for basin water quality, water level and other groundwater data
3. Increase use of groundwater storage and groundwater production in the Central and West Coast Basins
4. Increase groundwater production in the Central and West Coast Basins

WRD projects and programs will meet the goal to better manage the Central and West Coast groundwater basins.

Basin Groundwater Model

The U.S. Geological Survey (USGS), in partnership with WRD, is currently conducting a Hydrogeological Study of the Central and West Coast Basins. This Study will allow the District to gain a better understanding of the physical and chemical mechanisms of the basins. The Study began in 1995 and will be completed by 1998 at a total cost of $1.3 million, to be equally shared between the USGS and WRD.

The Study will utilize data from new and existing wells to determine the groundwater flow patterns in the Central and West Coast Basins. The Study will result in a groundwater model for the basins. This model can be used by WRD to understand how the basins function and to predict conditions that may result from any proposed changes in basin management.

Groundwater Information Database Development and Maintenance

WRD will develop a Groundwater Information Database for the Central and West Coast Basins. The database will be a clearinghouse for basin information including pumping patterns, water quality data, and basin water levels and quantity. Much of this database will result from the WRD/USGS Basin Hydrology Study and it will serve as a vital tool for future Central and West Coast Basin management.

Water Systems Operations Database

In order to better manage District groundwater resources, WRD will produce a operational database for the Central and West Coast Basins. This database will serve as a central clearinghouse for information relating to all water supply and demand in the basins. This will provide the District and water-related agencies with information to better track the current and past use of water and to project future water demands, allowing for improved conjunctive use of the basins.

Conjunctive Use

Conjunctive use optimizes the combined use of water resources with regard to availability and economics. WRD will continue and expand programs with surface water suppliers and other groundwater agencies to further balance Central and West Coast Basin water resources. The District is currently working to increase conjunctive use in the basins with MWD, its member agencies, the Association of Groundwater Agencies, and groundwater producers.

In-Lieu Groundwater Replenishment Program

Pumper participation in the WRD In-Lieu Replenishment Program promotes District groundwater replenishment. This program provides an alternative means of groundwater replenishment by encouraging pumpers to purchase surplus imported water when available, instead of, or in-lieu of, pumping groundwater. Financial incentives are offered to the water producer which offset or make the imported water less expensive than groundwater

production costs. The unused pumping rights are retired one year in exchange for WRD's financial incentive. The financial incentive paid by WRD per acre foot for in-lieu replenishment is less than the average Central and West Coast Basin replenishment cost.

WRD initiated the In-Lieu Replenishment Program in the mid-1960's. In 1978, MWD implemented imported water pricing programs which further promoted the In-Lieu Program. This policy change increased annual replenishment from less than 1,000 acre feet to over 10,000 acre feet. Since the1983 water year, all District In-Lieu activities have been based upon MWD's pricing program.

Over the past few years, MWD has changed its pricing policy on available replenishment water. When MWDSC's program first began, surface water deliveries were limited to spring months and were subject to suspension if supply shortages occurred. During the 1981-82 fiscal year, MWDSC expanded the interruptible supply delivery to throughout the year. This plan, termed the In-Lieu Interruptible Program, continued until 1991. Subsequently, it was replaced by MWDSC's Seasonal Storage Service (SSS). Due to abundant imported water supplies, the MWDSC maintained the SSS throughout 1993 and WRD used this surplus water availability to induce higher participation in the District In-Lieu Program.

WRD will continue to enhance the In-Lieu Replenishment Program to increase its effectiveness. Over the next five years, continuation of the Program is anticipated to produce 150,000 acre feet of water stored in the groundwater basins.

Emergency Pumping Plan

During the recent California drought, the District developed an Emergency Pumping Plan to allow basin production that exceeded allowable pumping limits. The availability of this additional pumping will help Central and West Coast Basin water suppliers meet customer demands, even when imported water deliveries are curtailed. The Emergency Pumping Plan can be implemented on short notice with actions taken by WRD, the Central and West Coast Basin Municipal Water Districts, and the Water Associations for each basin.

Groundwater Banking

Groundwater basins allow for the storage of water in the ground for use at a later time. This underground storage provides a reliable supply of high quality, low cost water. With the increasing cost to store water above ground, there is added motivation to better utilize the storage capabilities of groundwater basins.

The Metropolitan Water District of Southern California (MWD) is currently looking for opportunities to store water imported from the Sacramento and Colorado rivers in groundwater basins for later use. This water would be put into storage during times of surplus water availability and taken from storage during times of decreased supplies.

Within the Integrated Resources Plan, MWD has associated a per acre foot cost with the development of above ground water storage. Therefore it is worth up to that cost for MWD to identify and utilize alternative storage opportunities for water. It is MWD's objective to increase groundwater basin yield and decrease peak demands for imported water during times of decreased availability through banking programs.

MWD's Banking Program seeks to bank an amount of water for a long term in an agreement with the party that administrates the groundwater basin. MWD associates a value to the storage of that water over the period of the program and derives an annual cost to MWD for the program. MWD also funds any capital improvement that is necessary to implement the program.

A banking program of between 30,000 and 60,000 acre-feet of water over a 10 year period could be implemented between MWD and WRD. Benefits from the program would be distributed to the groundwater producers in an equitable fashion through offsets to the groundwater replenishment assessment.

Balanced Basin Pumping

WRD service area businesses and residents rely on groundwater for 40% of their total water supply. With imported water availability decreasing, and costs persistently increasing, it is imperative that the District optimize the use of the groundwater basins. Replenishment capabilities in the Central and West Coast Basins have not yet been maximized. The capacity to recharge the Central Basin more than currently practiced would be possible with changes to groundwater extraction patterns. This would allow for an increased local reliance on groundwater.

With the Montebello Forebay area of the Central Basin more readily recharged, groundwater extraction from this area could be increased. This additional groundwater production would exceed current levels of extraction in the Central Basin. This water could be used for supply to the seawater intrusion barriers to offset potable water purchases. it could also be sold to purveyors located in areas of the basins that are difficult to recharge, offsetting groundwater pumping in these areas and aiding in the restoration of historical groundwater levels.

One method of implementing this concept is that WRD would secure and hold rights to this additionally produced groundwater and control the distribution and sale. These sales would directly offset the replenishment assessment. Sale price of the water would be set to avoid competition with the groundwater lease market and would fall between the price of imported water and the cost to pump groundwater. Distribution of this water could utilize existing delivery systems with minimal new piping requirements to interconnect these systems. A wheeling charge may be required by owners of the systems.

Program implementation could begin in 2000 and provide the District service area an additional 20,000 acre feet of groundwater per year.

Review of the Judgment and Amendment of Adjudicated Rights

The Central and West Coast groundwater basins were adjudicated in 1959. This court action determined water rights for groundwater producers and limited the overall extractions in the basins. The purpose of the adjudication was to end uncontrolled pumping that exceeded the natural replenishment rate of the groundwater aquifers. As part of the adjudication, WRD was formed to manage the groundwater basins and to provide recharge that would not only match the adjudicated pumping, but would steadily reduce the overdraft in the basins.

The adjudication of the Central and West Coast Basins allows for pumping that exceeds the extraction limits in times of emergencies, such as droughts. In view of the changing conditions in the water industry today and new approaches to water supply management, it may be desirable to modify the basin judgments that determine the operational limitations of the Central and West Coast Basins.

WRD will look at ways in which amendments to the current adjudication may safely increase the production capabilities of the basins. Changes to the basin adjudications within the next 3 years could provide for an increased groundwater supply of 20,000 acre feet per year. Revenue generated from WRD distribution of this additional water will directly subsidize the replenishment assessment.

Any proposed modifications will be fully discussed with the water rights holders before approaching the court for amendment to the judgments.

Replenishment Program for West Basin

The District will develop ways to increase replenishment in the West Coast Basin. Methods that are currently being considered include dry well percolation, additional injection wells, and spreading ground development.

Goal 4 INSTITUTIONAL COMMUNICATION PLAN

Objectives

WRD is committed to open, effective and timely communication of District activities with the entities that comprise its constituent base: the public, pumpers, regulatory agencies, and legislative bodies. Key objectives that form the cornerstone of this goal are:

1. Establish and maintain cooperative relationships with federal, state, regional and local governments.

2. Interact with relevant local, regional, state and federal entities and proactively address critical water issues.

3. Provide information to the District's constituent base regarding District policies and activities.

The Public

Nearly 4 million people live within the boundaries of the Water Replenishment District. This population base has water demands that are partially met by groundwater (40%). As the end users, it is the businesses and residents who ultimately fund WRD activities. The District disseminates information directly to the general public. Topics for public awareness range from clean water information, such as proper disposal of household hazardous waste, to the status of District activities and relevant topical water issues. A series of quarterly newsletters, information forums, and variety of media presentations are used to present District issues and activities.

The Water Industry

Issues facing the water industry in Southern California are complex. They affect similar agencies in very different ways, depending upon geographical location, water sources, and water uses. Conversely, some issues have the same ramifications to all types of water agencies. With this in mind, it is important for the District to establish and maintain cooperative relationships with relevant water industry groups. Working with others in the industry can reap three distinct benefits: reduce repetitive and overlapping issues that overwhelm and impede the industry; reduce the costs associated with overlapping activities and publications; and direct a unified local water industry toward action on critical issues.

The Central and West Basin Water Associations represent groundwater purveyors within those basins. Both of the Associations hold directors board meetings quarterly and monthly meetings with their executive committees. These meetings provide excellent opportunities for WRD to communicate with organized groundwater purveyor groups.

An organization of 14 cities and the Water Replenishment District, the Southeast Water Coalition (SEWC), unified efforts to address local water issues. SEWC has focused on the migration threat of groundwater contamination from the San Gabriel Valley through the Whittier Narrows into the Central Basin. Together, WRD and SEWC have urged the United States Environmental Protection Agency (USEPA) to go beyond the decade of study and construct in the Whittier Narrows area a network of monitoring wells. The USEPA funded the construction and committed to five years of monitoring the wells.

SEWC follows water issues on the state and federal level. Through their lobbying efforts, SEWC provides a strong local voice on major water issues like the reauthorization of the Clean Water Act and proposed changes to the Safe Drinking Water Act. As a SEWC member, WRD advises the cities of pertinent ways to address groundwater related issues.

SEWC officials tour water facilities in the Central Basin

WRD has taken an active lead role in the Association of Groundwater Agencies (AGWA). This group has drawn together several Southern California groundwater management agencies to collectively address groundwater issues . AGWA developed a mission statement that focuses member expertise and resources on improved Southern California groundwater basin management. AGWA objectives advocate desired import water pricing to encourage conjunctive use, expansion of basin water recycling efforts, improvement of the RWQCB basin plan, and promotion of appropriate groundwater/drinking water regulations.

The Metropolitan Water District of Southern California (MWD) imports northern California and Colorado River water and sells it wholesale to MWD member agencies. WRD uses this imported water for seawater intrusion protection and Montebello Forebay water replenishment spreading. The imported water cost directly affects the WRD groundwater pumping assessment. In order to curtail this ever-increasing cost, WRD along with other members of the Association of Groundwater Agencies (AGWA), will use its cooperative, open relationship with MWD to help attain a separate imported water rate structure for groundwater management agencies.

MWDSC also provides financial benefit programs for development of groundwater resources. The District will seek access to MWDSC's financial benefit programs, when and where available.

MWDSC wholesales its imported water to member agencies. WRD currently purchases this water from Central Basin Municipal Water District (CBMWD) and West Basin Municipal Water District (WBMWD). In 1995, WRD, CBMWD and WBMWD established a tri-agency partnership and formed joint committees to deal with common issues. The tri-agency partnership, elected boards and staff, holds meetings on an as-needed basis.

The Association of California Water Agencies (ACWA), with water industry members from California and elsewhere, has successfully presented State water industry issues to Sacramento legislators. As a result, the District Government Affairs staff monitors ACWA's legislative efforts and alerts. Of additional consequence are the relevant ACWA subcommittees that WRD will join to collectively address California water needs.

A permit from the Department of Health Services (DOHS) governs WRD's recycled water use. The District's two partners, the Los Angeles County Department of Public Works (LADPW) and the County Sanitation Districts of Los Angeles County (CSD), are additionally named on the permit. CSD supplies WRD with recycled water for Montebello Forebay groundwater replenishment and is the agency responsible for meeting the permit's water quality conditions. In light of increasingly stringent proposed water regulations, a strong working relationship with the CSD is more important than ever. Recently, WRD sought a more active role for the CSD in WRD recycled water research, namely the USGS Nitrate and TOC Study. CSD staff has been participating in a WRD technical advisory group that reviews results of the past research and gives direction for further study. As a result, the research conducted by the USGS has become more applicable to regulatory justification.

The Orange County Water District (OCWD) is a sister agency to WRD. As a groundwater management agency of neighboring Orange County, OCWD faces

similar challenges and hurdles balancing the supply and demand of Southern California water. Forming a partnership to address common concerns and share information offers increased, readily available expertise; OCWD and the District pledge to maintain that successful link and are working together to set new Association of Groundwater Agencies' goals and objectives.

The LADPW owns and operates the Rio Hondo and San Gabriel Coastal groundwater replenishment spreading grounds in the Montebello Forebay and seawater intrusion barriers along the coastline of the Central and West Coast Basins. Efficient facility operations are critical to effective WRD groundwater management. LADPW informs WRD of its operational objectives, which in addition to water conservation, include flood control responsibilities. The District plans an integrated agency approach to further improve operations of these facilities. This assures WRD of maximum use of recycled water and local stormwater runoff, resources that directly offset District purchases of expensive imported water.

WRD is also a partner with LADPW and the County Sanitation Districts of Los Angeles County on the recycled water use permit, and WRD involves those in activities that affect the recycled water use for groundwater replenishment.

Regulatory Agencies

Stringent requirements recently imposed by the Regional Water Quality Control Board (RWQCB) and regulations proposed by the DOHS are top priorities for WRD. The final resolution of these matters could severely impact District fiscal planning and operations. WRD will work cooperatively and constructively to assist staffs of both RWQCB and DOHS.

Regulations recently proposed by RWQCB and the DOHS would greatly reduce WRD's present recycled water use. Since the proposed regulations are not based upon scientific study, they appear to err considerably and be overly conservative. Therefore, it is in the water industry's best interest to research the currently proposed regulations and focus on necessary public health and safety protection. WRD will conduct relevant research to scientifically determine safe limits for recycled groundwater replenishment use. WRD has developed a cooperative working relationship with the RWQCB to inform them of the results. Toward that end, the District is prepared a recycled water white paper for RWQCB's benefit.

Legislative Bodies

WRD must pursue any state and federal opportunities to promote, legislate, support, and fund WRD projects. Regional and national approaches to access funds for water projects are more effective than individual efforts. In cooperation with other local water industry entities, WRD formed a coalition to lobby for mutual support from state and federal legislators. To further assist in these efforts, WRD has developed a work plan that redirects the efforts of District lobbyists.

SUMMARY OF WRD GOALS, STRATEGIES AND MEASURES

GOALS, STRATEGIES AND MEASURES

The following tables summarize the goals, strategies and measures associated with the four plans that comprise the WRD Groundwater Management Plan.

Water Quality Management Plan

Challenges	Objectives	Strategies	Measures (Short Term)	Measures (Long Term)
Sea water intrusion	**Provide complete deterrence of sea water intrusion into the Central and West Coast Basins**	*Determine effectiveness of barriers* *Develop projects to increase effectiveness of barriers*	*Develop new O&M strategy for barriers in 1999* *Complete pilot studies and review historical data to determine effectiveness of barriers in 1997*	*Begin implementation of plans to increase barrier efficiencies by 2000*
Saline plume in groundwater basins	**Utilize existing studies and desalting efforts along with proposed desalter plants to remediate saline plume**	*Saline Plume Study* *Torrance Saline Plume Remediation Desalting Plant*	*Construct desalination plant In1998*	*Remove 35,000 acre-feet of saline plume by year 2005*
Groundwater contamination	**Continue WRD Wellhead Treatment Program to remove VOCs from the goundwater basins and deter the spread of contaminants to other wells** **Expand Wellhead Treatment Program to provide financing for treatment of contaminants other than VOCs**	*Expand and continue WRD Wellhead Treatment Program* *WRD VOC Removal Rebate Program*	*Construct 3 additional wellhead treatment projects in 1997-98* *Evaluate effectiveness of VOC Removal Rebate Program*	*12 wellhead treatment facilities operational and continuance of VOC Removal Rebate Program to remove 1,400 pounds of VOCs from groundwater basins by year 2000*
Migration of contamination	**Protect Central Basin from San Gabriel Valley contamination**	*Work with Whittier Narrows Work Group to initiate USEPA Installation of additional groundwater monitoring wells in the Whittier Narrows*	*Award of contract by USEPA to construct additional monitoring well(s) in 1997* *Develop water quality objectives for the Central Basin related to San Gabriel Valley* *Obtain USEPA committment to protect Central Basin from San Gabriel Valley contamination*	*Implementation of Cental Basin water quality objectives by EPA in 1998*

Water Supply Management Plan

Challenges	Objectives	Strategies	Measures (Short Term)	Measures (Long Term)
Rising cost of barrier and recharge water sources Reliability of barrier and recharge water sources	Increase capture and reuse of local stormwater runoff	*Recharge Facility Improvements and Operation Enhancements* *U.S. Army Corps of Engineers (ACOE) Water Conservation Study* *Evaluate construction of Offshore Freshwater Reservoir*	*Capture and reuse 7,000 additional acre-feet through recharge facility improvements and operational enhancements by year 1999* *Capture and reuse 6,000 additional acre-feet through ACOE Water Conservation Study by year 2001*	*Capture and reuse up to additional 163,000 acre-feet of local stormwater runoff by year 2015 (includes potential annual capture of up to 150,000 from L.A. River into offshore reservoir)*
	Increase permitted use of recycled water for groundwater recharge	*Montebello Forebay Recycled Water Advanced Treatment Project* *Montebello Forebay Health Effects Study* *USGS TOC and Nitrate Study* *Cooperative Soil Aquifer Treatability Study* *Work with regulatory agencies*	*Work with regulatory agencies to formulate proposed regulations by 1998* *Determine health effects from use of recycled water for groundwater recharge* *Determine fate of constituents that limit recycled water use for groundwater recharge during recharge process*	*Use additional 10,000 acre-feet of recycled water for groundwater recharge by 2001*
	Explore increasing availability of imported water	*Secure additional untreated water supplies*	*Determine feasibility of utilizing untreated imported water for barriers by 1998*	*Increase availability of imported water by 30,000 acre-feet per year by year 2000*
	Use recycled water at Alamitos Barrier	*Alamitos Barrier Recycled Water Project*	*Use 3,000 acre-feet of recycled water per year by 1999 (Phase I)*	*Use 6,000 acre-feet of recycled water per year by 2005 (Phase II)*
	Use recycled water at Dominguez Gap Seawater Barrier	*Terminal Island Treatment Plant Reuse Project*	*Prepare engineering report and associated documentation for permitting in 1997*	*Use 3,000 acre-feet of recycled water by year 2000*
	Capitalize on under-utilized groundwater resources	*Colored water use*	*Develop program to utilize colored water*	*Increase production in West Basin through colored water production by 1,000 acre-feet by year 2000*

Groundwater Basin Management Plan

Challenges	Objectives	Strategies	Measures (Short Term)	Measures (Long Term)
Groundwater basin yield in Central and West Coast Basins	Develop a groundwater model for the Central and West Coast Basins	*Jointly fund USGS Hydrogeological Study & Groundwater Model*	*Complete construction of supplemental wells and collection of baseline data in 1998* *Complete groundwater model in 1997* *Utilize model for groundwater basin management starting in 1997*	*Complete solute transport groundwater model by 1999*
	Develop an in-house database for basin water quality, water level and other groundwater data	*Jointly fund USGS Hydrogeological Study to develop GIS database* *Maintain database in-house*	*Complete development of GIS database in 1997* *Acquire necessary hardware to utilize database in-house*	*Update and maintenance of GIS database by WRD staff starting in 1997* *Utilize database for groundwater basin management starting in 1997*
Knowledge of Central and West Coast groundwater basins	Increase use of groundwater storage in the Central and West Coast Basins	*Bank MWD water in the Central and West Coast Basins* *Develop recharge in the Los Angeles Forebay*	*Work with MWD and MWD member agencies to develop plan to bank MWD water in the Central and West Coast Basins* *Determine feasibility of recharge n the Los Angeles Forebay*	*Implement banking program to store additional 60,000 acre-feet of water in basins starting in 2000* *Initiate recharge in the Los Angeles Forebay by year 2000*
	Increase groundwater production in the Central and West Coast Basins	*Balanced Basin Pumping*	*Develop program to increase groundwater production in areas of basins that are more effectively recharged by 2000*	*Increase production in Central Basin by 20,000 acre-feet per year by year 2000*

Institutional Communication Plan

Challenges	Objectives	Strategies	Measures (Short Term)	Measures (Long Term)
Remain informed of and involved in local, state and federal issues related to the water industry	**Establish and maintain cooperative relationships with federal, state, regional and local governments**	*Host legislative sessions with newly elected officials* *Outreach and meet regularly with state and federal legislators* *Regularly update water agencies and local officials on WRD programs and activities* *WRD Newsletter*	*Maintain rapport with decision makers*	*Maintain recognition as vital water agency tnecessary o the stability of Southern California water reliability* *Maintain support from federal, state, regional and local officials of WRD's activities and programs*
	Interact with relevant local, regional, state and federal entities and proactively address critical water issues	*Attend and deliver presentations on groundwater reliability and quality at meetings and conferences*	*Establish reputation as groundwater authority* *Sensitize representatives on the importance of groundwater to overall water supply reliability in Southern California*	*Position WRD among the leading and innovative wate agenies of the 21st century*
Effective communication to District constituents	**Provide information to the District's groundwater purveyor base regarding District policies and activities**	*Develop speakers bureau* *WRD Newsletter* *college & universitiy events* *conduct community forums*	*Maintain open and direct access for residents and other constituents to give and receive input on policies governing groundwater supply, quality and reliability.*	*Establish mechanism of exchange between constituents and WRD officials and staff to provide permanent understanding of the vital role WRD plays in improving the quality of life and economic security*

WRD Groundwater Management Plan Overview

MISSION

"To provide a sufficient supply of high quality groundwater in the Central and West Coast Basins through progressive, cost effective and environmentally sensitive basin management."

VISION

Problems and Challenges Facing the Water Replenishment District

Water Quality Challenges	Water Supply Challenges	Groundwater Basin Management Challenges	Institutional Communication Challenges
Improve sea water intrusion prevention	Reduce cost of barrier and recharge water sources	Optimize groundwater basin yield in Central and West Coast Basins	Remain informed of and involved in local, state and federal issues related to the water industry
Remediate existing inadequate sea water intrusion protection	Increase reliability of barrier and recharge water sources	Develop working knowledge of Central and West Coast groundwater basins	Provide effective communication to District constituents
Mitigate saline plume in groundwater basins			
Remediate groundwater contamination			
Prevent migration of contamination			

Where the Water Replenishment District will be in 2002

Water Quality Measures	Water Supply Measures	Groundwater Basin Management Measures	Institutional Communication Measures
Begin implementation of plans to increase barrier efficiencies by 1998	Capture and reuse up to additional 163,000 acre-feet of local stormwater runoff by year 2005	Complete solute transport groundwater model in 1997	Maintain recognition as vital water agency to the stability of Southern California water reliability
Remove 35,000 acre-feet of saline plume by year 2005	Use additional 10,000 acre-feet of recycled water for groundwater recharge by 2001	Update and maintenance of GIS database by WRD staff starting in 1997	Maintain support from federal, state, regional and local officials of WRD's activities and programs
12 wellhead treatment facilities operational and continuance of VOC Removal Rebate Program to remove 1,400 pounds of VOCs from groundwater basins by year 2000	Increase availability of imported water by 30,000 acre-feet per year by year 2000	Utilize database for groundwater basin management starting in 1997	Position WRD among the leading and innovative water agencies of the 21st century
Install additional multi-port monitoring wells in Whittier Narrows by 1998	Use 6,000 acre-feet of recycled water per year at Alamitos Barrier by 1999	Implement banking program to store additional 60,000 acre-feet of water in basins starting in 1998	Establish mechanism of exchange between constituents and WRD officials and staff to provide permanent understanding of the vital role WRD plays in improving the quality of life and economic security
Implementation of Central Basin water quality objectives by EPA in 1998	Use 3,000 acre-feet of recycled water at Dominguez Gap Barrier by year 2000	Develop recharge in the Los Angeles Forebay	
	Increase production in West Basin through colored water production by 1,000 acre-feet per year by year 2000	Increase production in Central Basin by 20,000 acre-feet per year by year 1999	

Glossary

Adjudication An adjudication establishes groundwater rights for pumpers within a groundwater basin. Two court settlements in the early 1960s established individual water rights and limited the amount of water that can be pumped from each of the Central and West Coast groundwater basins.

Air Stripper Treatment A method of groundwater remediation where volatile organic contaminants are removed from the water when air is passed through the water. The contaminants change from their aqueous to their gaseous forms and are carried away in the air stream.

Aquifer An underground geologic formation, such as a layer of gravel or sand, through which groundwater can travel.

Carbon Filter Vessel Treatment A method of groundwater remediation where inorganic or organic contaminants are removed from the water by sticking to carbon particles that form the filter.

Conjunctive Use The optimization of water resources through their combined use with regard to availability and economics.

Colored Water Colored water is groundwater or surface water that can meet all health requirements, but is not aesthetically appealing to the consumer due to discoloration.

Desalting/Desalination A process to remove salt or chlorides from water. The processes for salt removal varies from reverse-osmosis treatment to distillation or evaporation methods.

Groundwater Water that is stored underground in the cracks and crevices between gravel, sand, and rock formations.

Groundwater Model A computer model that simulates and predicts the flow of groundwater or the transport of contaminants in the groundwater.

Lysimeter An instrument that is inserted into the soil to measure the moisture in soil particles.

Multi-port Monitoring Well A type of well used to gather water samples from different depths in the ground. The well consists of one pipe that has several perforated zones along the length of it where water can enter. A sampling device can then be lowered to one of the perforated zones, and water from that particular zone can be collected.

Nitrates A form of nitrogen (NO_3^-) that is sometimes found in groundwater. It has been shown to cause blue baby syndrome, and so is carefully monitored.

Percolation A process where surface water trickles down into the ground and becomes groundwater. The rate of percolation changes with the condition of the underlying gravel and sand; if the spaces between gravel and sand particles are plugged, then water will percolate more slowly.

Pumper An entity that extracts groundwater from a groundwater basin. A pumper generally owns or leases rights for the extracted water.

Purveyor A private or municipal agency that delivers imported water and/or groundwater to local homes and businesses; the cost of the water is reflected in the monthly water bills. Usually, local purveyors operate pumps and extract groundwater for domestic, agricultural or industrial uses.

Recycled Water Reusable water that is of wastewater origin. The water is treated at reclamation plants, where contaminants are removed after passing through multiple stages of treatment, using chemical, biological and physical separation methods.

Replenishment The act of maintaining or increasing the amount of groundwater stored by natural or artificial means. Rain is a natural source of replenishment, but is not enough to make up for water extracted each year. Artificial replenishment includes spreading of high quality water in large holding ponds and the injection of water into water-bearing zones.

Rubber Dam A dam made out of rubber that can be inflated or deflated to regulate the flow of water in a stream or channel. Water can be backed up in the stream or channel bed or diverted to another facility.

Saline Plume A large volume of seawater that has intruded upon the fresh groundwater zones in the coastal portions in the West Coast Basin.

Seawater Barrier A way to stop or slow down the spread of seawater into the inland groundwater aquifers. The method most commonly used is to create a hydraulic barrier by injecting large amounts of freshwater into wells along the coast to reverse the flow of seawater towards the ocean.

Spreading A common way to artificially replenish the groundwater supplies. Water is retained in large holding ponds where it can freely percolate into the ground.

T.O.C. Total Organic Carbon. The sum of all kinds of organic carbon that may be found in groundwater samples. Although hundreds of types of organics can be individually tested for in the laboratory, it is possible that unknown (and undetectable) forms of organics may exist. Because of this, TOC is commonly measured and represents the bulk concentration of organics found in groundwater.

Tertiary Treatment An advanced wastewater treatment process where the water from secondary treatment undergoes additional processing to further improve the quality of the water. Usually coagulation, sedimentation, filtration, and disinfection methods are involved in the process.

V.O.C. Volatile Organic Carbon. Organic contaminants that can easily exist in both the aqueous and the gaseous forms.

Vadose Zone / Unsaturated Zone The portion of the ground located between the top of the groundwater level and the ground surface elevation.

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