GETTING OUT OF THE TRAP:

CHANGING AN ENDANGERED COMMONS

TO A MANAGED COMMONS

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This is dedicated to my father,

Bernard Blomquist --

If there were Ph.D's in Wisdom, Love, and Patience,

he'd have one of each

PREFACE

As I have been engaged in this research, I have from time to time been asked what it is about. Usually, I have replied either, "water problems in southern California", or, "groundwater basins in southern California". In fact, this research is "about" these matters, but it is about more than these, too. The water problems and groundwater basins serve as examples which allow for a discussion of some broader questions. Among these broader questions are those of collective action and commons problems. This study is a theoretical inquiry into commons problems plus an examination of some actual commons in the form of four southern California groundwater basins.

The "trap" referred to in the title of this study is what has been called "the commons dilemma" or "the tragedy of the commons". In discussing this "trap" and the process of getting out of it, I will turn to the principal prevailing policy prescriptions of the literature on commons problems. These prescriptions leave little room for divergent experimentation in various forms of commons management by the local users of a commons. In the view presented in this study, significant local experimentation and variety are incorporated, while a basic structure of needed components for effective action is introduced for the comparison of necessarily different processes.

When I have given my usual responses to those who have asked of me what my research is about, those who knew that my field of study was political science have looked at me as if to inquire, "what's a political scientist like you doing in a research project like this"? I will not attempt to persuade readers that the problems of groundwater basins in southern California are <u>the</u> central problems of political science. However, perhaps I can indicate some of the issues touched by this work.

The area of collective action, and especially of why people fail to achieve collective action, is of some considerable importance for the understanding of political behavior and of the emergence of certain institutions and the failure of others. From the failure of the Articles of Confederation two hundred years ago to the issues of the growth of government spending and the difficulties of deficit reduction we confront today, questions of free-riding and failure to generate collective benefits are raised. And an ongoing issue of concern to political scientists -- why some interest groups form and succeed while others do not -- engages very closely related considerations. When individuals in interdependent action situations face incentive structures conducive to their detriment, the question of whether and how they can alter their relationships with one another to change destructive tendencies to productive tendencies is the same basic question whether the particular application is to groundwater basins or to international organizations.

In the study of political behavior, we have often witnessed cases where the rational pursuit of individualized gains generates collectively undesirable outcomes. In the 1600s, Thomas Hobbes reasoned that a Leviathan was necessary to accomplish to collective goals of peace and security in light of the ceaseless pursuit by individuals of their own gain which would lead to the "war of each against all". In the 1970s, in the <u>American Political Science Review</u>, Orbell and Wilson wrote of the collective action problem (and its game-theoretic counterpart, the Prisoner's Dilemma) that it "provides what is probably the most widely accepted, and certainly the most coherent, justifying theory of the state available today" -- Hobbes lives.

But the question remains, what kind of a "state" does the logic of collective action justify? Must it be a unitary Leviathan, centrally directing the resource allocation decisions of people with respect to truly local concerns? Or might it be a compound and multi-centered system, to which people have access at whichever of various levels is most appropriate to their problem, and through which people might create institutional arrangements to fit their circumstances if there are none readily adaptable? Despite the "collective-action" character of many commons problems, their existence does not necessarily justify the kind of state some have wished and argued for. Resource management has occasionally worked, in spite of the absence of a centralized, omniscient state. A few such cases are offered here, as food for the thought that, while Hobbes may live, so too do Madison, Jefferson, and Tocqueville.

In the course of a study such as this, one incurs several debts, most of which (the non-financial ones) will not be repaid in like currency. They can only be acknowledged.

At the risk of bringing her more business of this sort, I will state here that Elinor Ostrom is the ideal advisor and editor for a project such as this one. She has shown an amazingly effective mix of patience and encouragement through the period when all I could tell her was what I was <u>going</u> to do, and a nearly superhuman ability to read, analyze, edit, and return the various portions of this manuscript when I finally passed out of the "going to do" into the "doing" stage. (She will be pleased with the length of the previous sentence, as she will know therefrom that those praises were from my heart, unabridged.) I might add that although there are many references to her work throughout this study, we have collaborated over a long enough period on these issues that I am at times in doubt as to which ideas are hers and which are mine, and so however many references to her work I make, they will still insufficiently capture her influence. Most likely the good ideas are hers.

I owe a great many thanks also to the other members of the committee who have had to review this study. Russell Hanson, Richard Pacelle, and Daniel Conkle have all endured long silences and lack of production from me, and then responded when there was product to review with a quickness and attentiveness which was much more than I was due.

The staff of the Workshop in Political Theory and Policy Analysis and the Department of Political Science at Indiana University also helped tremendously. Kristin Crose made it possible for this project to be completed on time, which it would not have been if I had done all of the typing. Patty Zielinski, Julie English, Steve Flinn, Barb Hopkins, and Sharon LaRoche also helped in making sure I hit all the marks and got the work out.

The financial assistance and the facilities of the Workshop in Political Theory and Policy Analysis, the Department of Political Science, and the Graduate School at Indiana University are gratefully acknowledged. I was especially honored to receive the John V.

Gillespie Dissertation Fellowship during the period when most of what follows was written. In addition, the research presented here was supported by grants from the National Science Foundation (SES 83-09829) and the United States Agency for International Development (DHR1096-G-SS-6042-00).

Most of this was written between August 1986 and August 1987. I would like to thank Jo Ella and Jason for putting up with me during that time, when I was even more difficult than I usually am. Jo Ella also provided the "word processor" with which much of this was written.

The members of the Department of Political Science at IUPUI heard the first presentation of this research, and I would like to thank them for hiring me anyway. They also provided the incentive I needed to finish this study.

This was written in Indiana, but it could not have been done wihtout the assistance of some very fine people in California. On my visits out there, and in response to correspondence and phone calls, several individuals were of especial assistance. At the Orange County Water District, Lola Handy provided me with a pleasant tour and responded promptly to requests for follow-up information. At the Foothill Municipal Water District, and with the Raymond Basin Management Board, Ron Palmer gave me space to work, some very enjoyable conversation, and the reassurance that my understanding of the Raymond Basin was on the right track.

John Joham, Jr. , General Manager of the Central and West Basin Water Replenishment District, was so very generous with his time, his reflections on activity in the two basins, and information.

Similarly, Chris Nagler at the Southern District Office of the California Department of Water Resources spent hours chasing down data and talking about the Raymond, West, and Central Basins with a kid from Indiana who must have seemed terribly dense at times. I am especially grateful to these men.

The people I met in southern California who are working daily on the difficult water problems of that area exemplify the best in public service. It is a privilege to know them.

GETTING OUT OF THE TRAP: CHANGING AN ENDANGERED COMMONS TO A MANAGED COMMONS

William Blomquist

This dissertation examines possibilities for management of a commons by resource users. A commons is a jointly-accessible resource generating subtractable yields. Resources used by multiple individuals are often endangered; indeed, the supposedly inevitable destruction of such resources is called "the tragedy of the commons".

The prognosis of doom for the commons has produced two prescriptions in the literature: central government management, and privatization. The prognosis and the prescriptions presume that all commons are alike, that the problems associated with the commons inhere in the nature of such resources, and that the commons is identical to such "social traps" as the collective action problem and the Prisoner's Dilemma game. These presumptions, and the prescriptions derived from them, are reviewed and criticized.

In an alternative approach, the commons is reconsidered as a form of organization of the use of a resource. That organization is shaped by rules defining access and use. Those rules may be changed, and rule changes can transform a commons situation from resource endangerment to resource management. Furthermore, such changes need not be imposed by external regulators, and need not mean centralized governmental control or privatization. Resource users themselves may devise well-fitted rule systems for use of the commons.

Successful transition from an endangered commons to a managed commons will involve action by users on seven steps in a process of resolution of commons problems. The likelihood of successful resolution is affected by variables concerning the attributes of the resource, attributes of the user community, and institutional capacities available to users. That successful, as well as unsuccessful, user-based resolution is possible is demonstrated by comparative case studies of four groundwater basins in southern California, each of which has been an endangered commons. The situations, conditions, and processes of resolution in the basins are described and compared, and the outcomes attained are compared and evaluated. The cases demonstrate that, where users are able successfully to complete a resolution process, destruction can be averted, and efficiency of resource use can even be improved, without converting the commons to individually-held private property or centrally-controlled public property.

Doctoral Committee

Professor Elinor Ostrom, Chair	Professor Russell Hanson
Professor Richard Pacelle	Professor Daniel Conkle

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CHAPTER ONE

INTRODUCTION: WHAT IS GOING ON HERE

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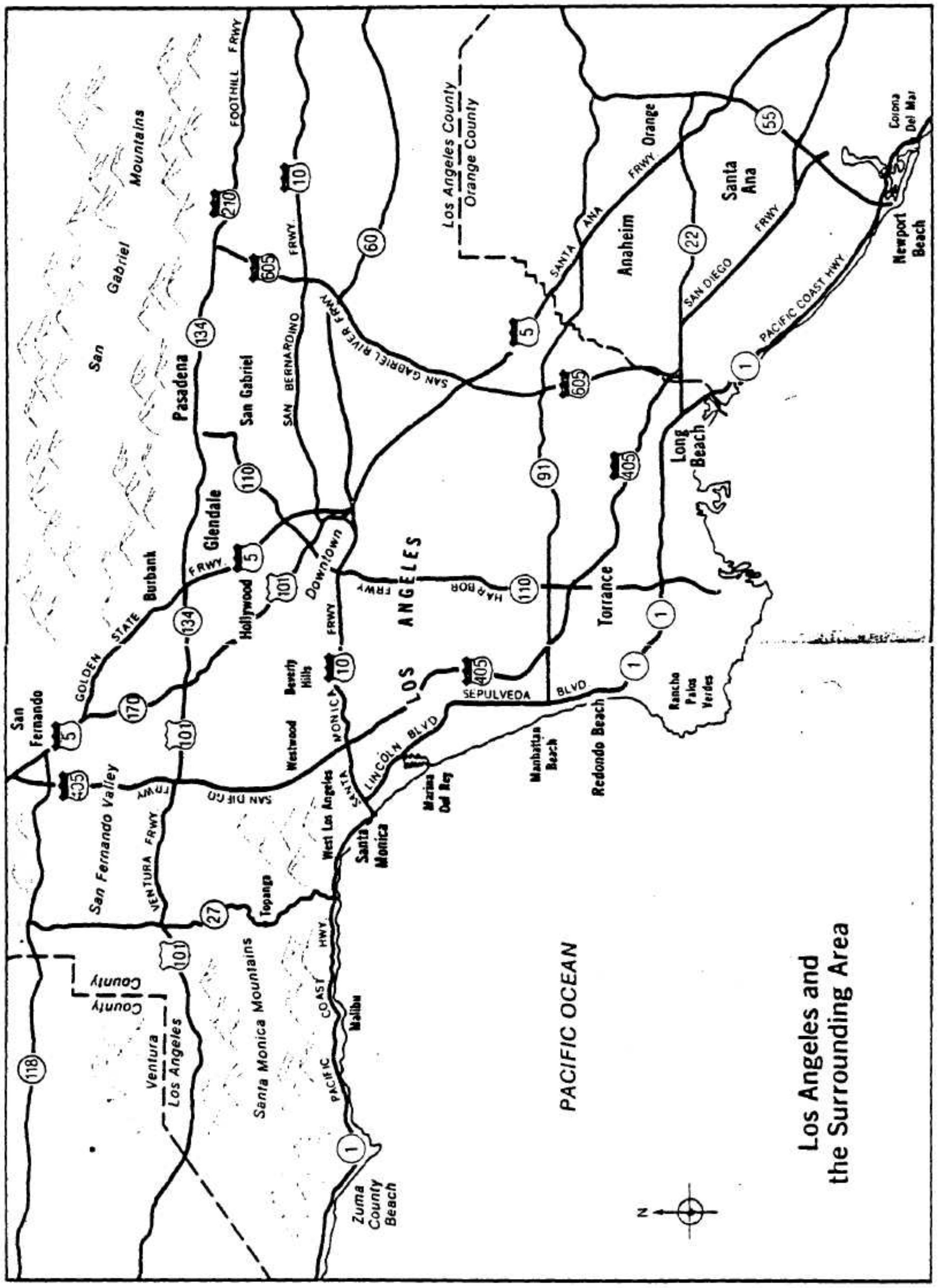
> Doth a fountain send forth at the same place sweet water and bitter? Can the fig tree, my brethren, bear olive berries? either a vine, figs? so can no fountain both yield salt water and fresh.
>
> James 3: 11-12

Los Angeles lies between desert and ocean. Mountain ranges form an arc around the lower, flatter Los Angeles Basin, which extends from the foothills of those mountains to the Pacific Ocean (see Map 1-1). The mountains -- the Santa Monica, San Gabriel, and Santa Ana ranges -- shield the Los Angeles Basin from the desert heat to the east, and catch the ocean breezes coming from the west. The same geologic characteristics that have caused the area's smog problems in recent times have given this place a climate that belies its position between desert and ocean. Occasionally, the Santa Ana winds come from the east over the mountains to remind the inhabitants of what might have been -- hot and dusty winds blow through the Los Angeles area, bringing the desert's weather all the way to the ocean.

But normally, in this place between the mountains and the Pacific, abundant sunshine and cool temperatures combine to create one of the most enjoyable climates in North America, or perhaps anywhere. The coolness of the air tempts one to forget that the Los Angeles Basin is nonetheless an arid place. The temptation is sufficiently strong that the 464 square miles of the Los Angeles Basin now contain a population of some 13 million people. These millions live in an area where the average annual rainfall is 15 inches, as compared with 50 inches in the New York City area or 35 inches in and around



Map 1-1. The Los Angeles Basin

Source: <u>Fodor's Los Angeles 1987</u> (New York: Fodor's Travel Guides, Chicago. And even 15 inches is somewhat misleading. Rainfall is almost entirely confined to the cooler months of November through March; during the warmer months of June through September, it hardly rains at all. The second largest metropolitan area in the United States has been built in a water-deficient place.

The mountains around the Los Angeles Basin catch much of the precipitation moving inland from the coast during the winter storms and return it to the Basin floor. Various streams drain from the hillsides and combine into the Los Angeles, San Gabriel, and Santa Ana Rivers, which cross the Basin and empty into the Pacific. In years of heavy rainfall, these rivers have flooded the Los Angeles Basin, and at times have changed their courses. In the process of draining the mountains, flooding the Basin floor, and changing their courses time after time for thousands of years, the streams and rivers have deposited layer upon layer of sands and gravels upon the Los Angeles Basin.

Over the same thousands of years, the Pacific Ocean itself covered differing amounts of the Basin floor. The shore line moved inland and out as seismic activity raised, lowered, and reconfigured the ocean floor, the Basin bed, and the mountains. With each move inland and with each retreat, the Ocean deposited its own layers of sediments -- finer sands and clays -- so that the Basin floor can be thought of as having been built up in layers over thousands of years. There are layers of gravel, layers of coarser sand, layers of finer sand, and layers of clay sandwiched between the land surface and the bedrock below.

The same seismic activity that raised and lowered the mountains and the valley floor and brought the ocean in and back also manifested itself in discontinuities between and among those sandwiches of sediments in the Los Angeles Basin. Fault lines or fault zones are sharp disjunctures in the underground strata that interrupt the layers of sands, gravels, and clays. These underground schisms separate the subsurface soils into distinct adjoining sections.

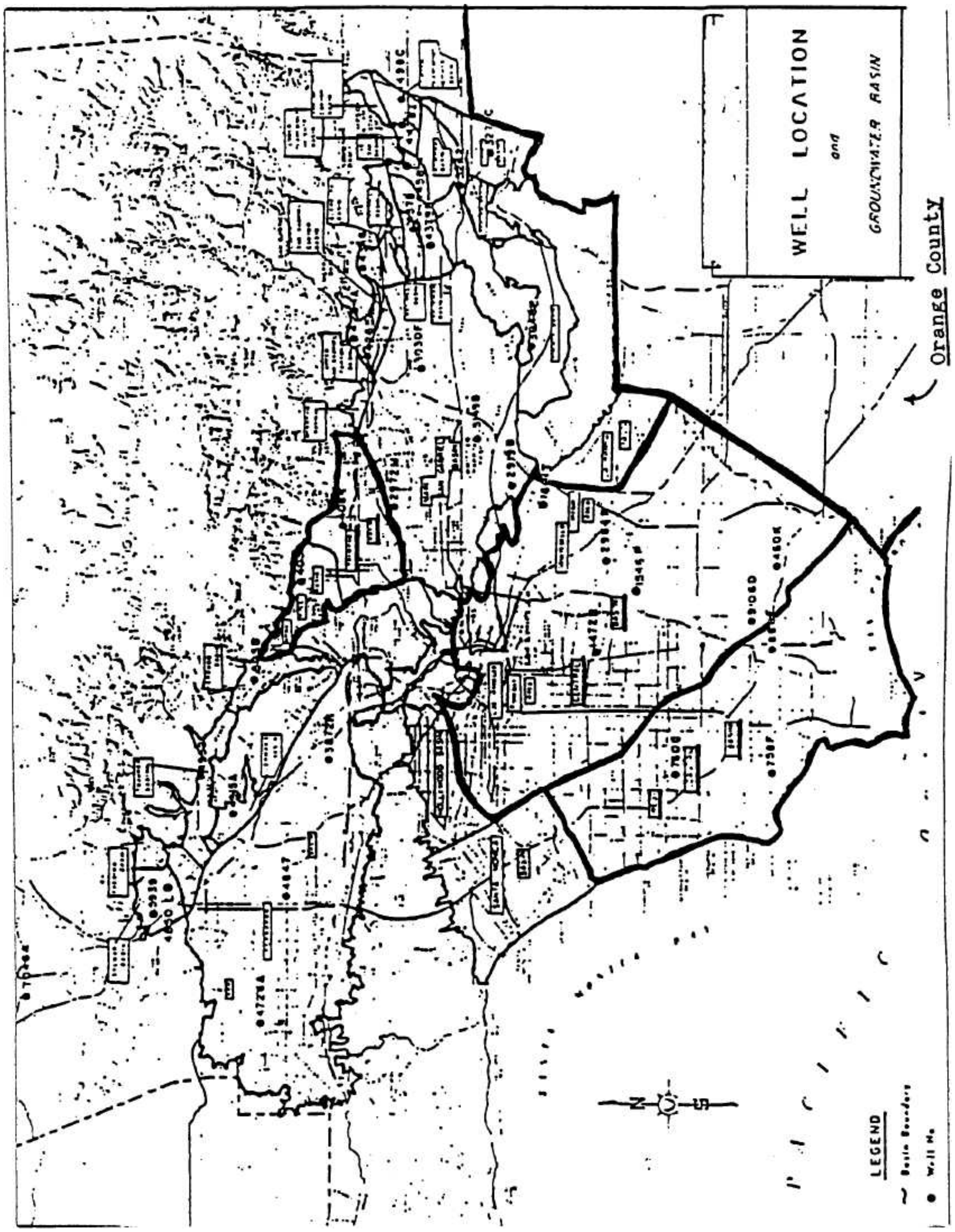
A. The Problem of a Groundwater Basin

These sections of sandwiched sediments are capable of holding water. The more porous layers -- those made up of gravel and coarse sand -- are composed of rough particles with minute spaces between them. If these porous layers can be reached from the ground surface (that is, if they are not covered by some impervious layer of clay or rock), then water from surface streams or rivers or from precipitation can flow downward through the soil to be contained in these coarser layers. This downward movement of water through the soil is called percolation. The water-bearing layers in which the water is retained underground are called aquifers. Aquifers of relatively coarse material have the dual advantage of not only retaining water but also of yielding water readily when penetrated by a well or when they come into contact with the ground surface as a spring.

When an aquifer or a set of aquifers (which may themselves be layered on one another) are contained within an area which is separated from other underground strata by fault lines, mountains or other bedrock formations, such an area is referred to as a ground water basin. Because of the considerable faulting and folding of underground material in the Los Angeles Basin, there are as many as 29 separate ground water basins in the Los Angeles area, several of which are shown in Map 1-2.

Aquifers in a ground water basin may be confined and under pressure, or unconfined. The ground water basins in the Los Angeles Basin contain both kinds of aquifers. Figures 1-1 and 1-2 present representations of cross-sections of groundwater basins. Figure 1-1 shows a valley-fill basin; Figure 1-2 shows a coastal basin adjacent to the ocean. A confined aquifer is composed of water-bearing material deposited beneath a more nearly impervious layer of material (such as clay) known as an aquiclude, an aquitard, or a confining bed. If the aquifer is completely confined (i.e., its entire surface is covered by impervious sediments), then its only source of water will be very slow leakage of water through the aquiclude. Such a completely confined aquifer is analogous to a vein of coal: any use or withdrawals therefrom take the form of mining, and the resource is non-renewable in a practical sense. Other confined aquifers may not be completely covered, and thus may be directly accessible to the ground surface through permeable deposits. Such partially-covered confined aquifers may have significant rechargeability, depending on their component materials, and may be able to take in and to release significant amounts of water in a given period without being mined or losing their net amount of water in storage. (1)

Water that enters confined aquifers and moves beneath the aquiclude is under pressure. The upper materials tend to press down toward the bedrock, and the water in the pore spaces in the confined aquifer is compressed as it moves toward some point where it will be



Map 1-2. The Underground Water Basins in the Los Angeles Area

Source: Los Angeles County Flood Control District, unbound map released. Depending upon the pressure on the confined water and the vertical distance to the ground surface, water may actually flow to the surface through fissures and appear as spring water. Or, if the confined aquifer is penetrated by a well, the water may flow to the surface; this is known as an artesian well or flowing well (see Figures 1-1 and 1-2). Even if the water from a confined aquifer does not reach the surface, when a well reaches into a confined aquifer, water rises in the well above the level of the water in the aquifer. The level the water reaches in the well is called the piezometric, or pressure, level. (2)

An unconfined aquifer is not shielded from the ground surface by an aquiclude. The unconfined water-bearing material can directly receive water from precipitation on the surface and from surface streams (see Figure 1-1). The level of saturated material in an unconfined aquifer defines a surface called the water table. The water in an unconfined aquifer is not under pressure and must be pumped to the surface when penetrated by wells (see Figure 1-2). When the water storage in an unconfined aquifer reaches and exceeds its saturation capacity, the overlying land may become swampy or marsh-like.

Ground water basins not only store water, they can regulate variations in supply. Natural recharge and natural disposal are equilibrated over time by an underground reservoir. Over any considerable period, recharge and escape are equal, even though recharge is variable due to seasonal and annual variations in precipitation and surface stream flow. As the water table rises, disposal increases and as the water table falls, disposal decreases.

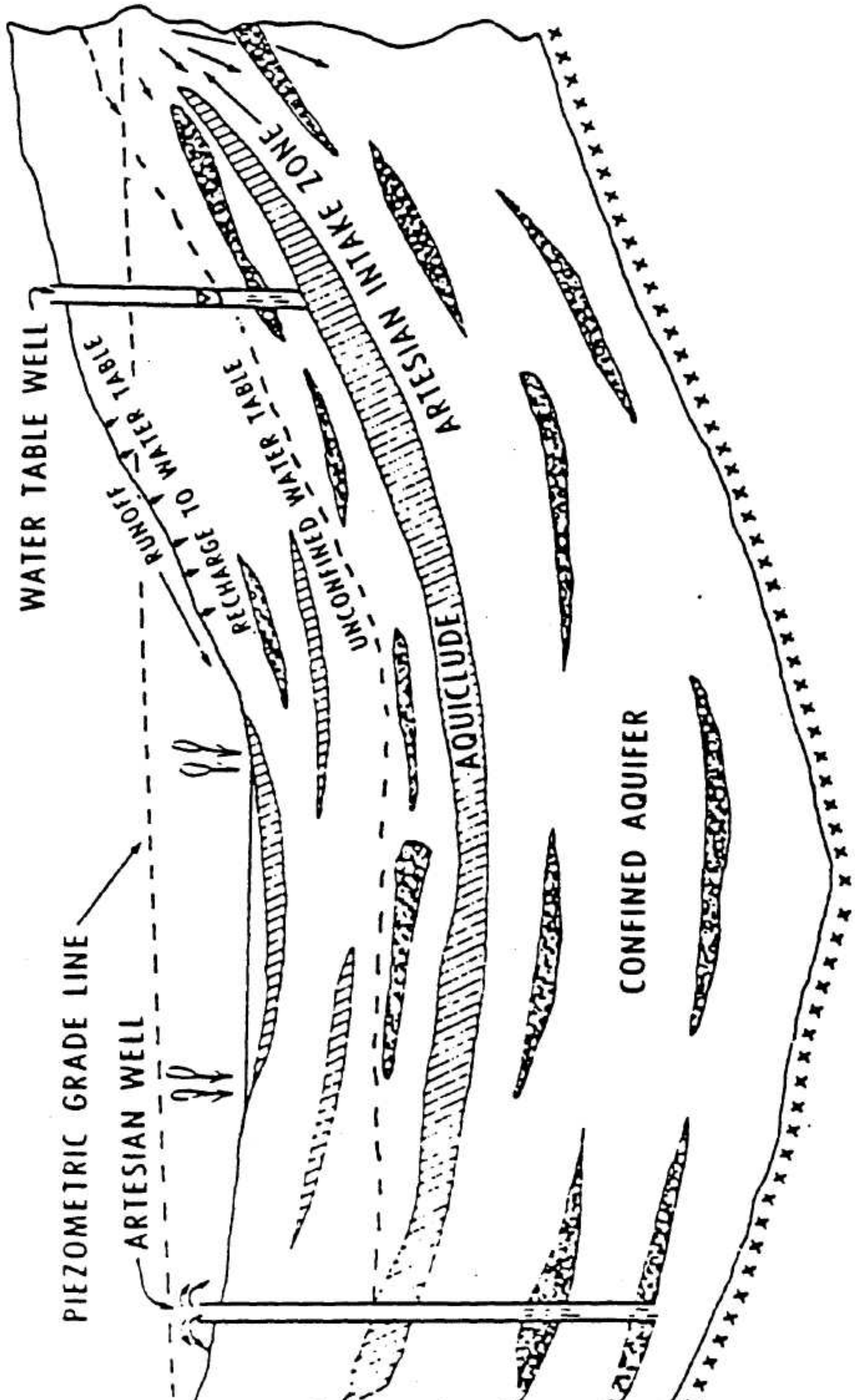


Figure 1-1. Cross-Section of a Valley-Fill Basin

Source: Blackburn (1961)

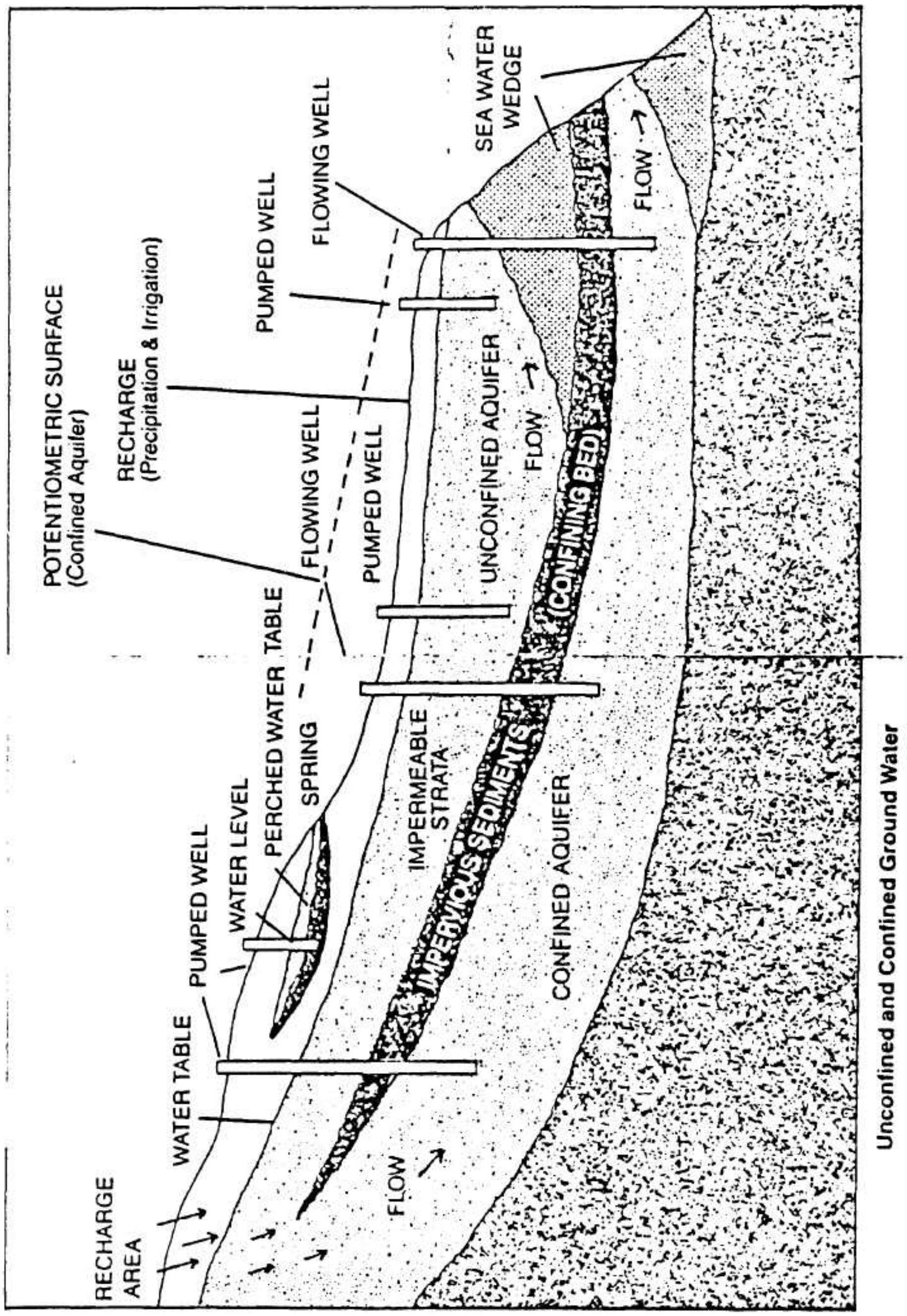


Figure 1-2. Cross-Section of a Coastal Basin

Source: Coe (1986)

If there is pumping or artificial extraction the equilibrium is still maintained, but at a lower level of water elevation; "the level is rising or falling as the difference between recharge and pumping is positive or negative, respectively." (3)

The fact that water levels in underground aquifers can rise or fall depending on the balance between recharge and extractions introduces two important potential problems: overdraft and contamination. Overdraft occurs when the amount of water being removed from an aquifer through natural escape and artificial extraction exceeds the amount of water being restored to that aquifer. When overdraft persists over time, several adverse consequences can follow. (4) The lowering of water levels causes undesirable economic effects for users of the underground supply: wells must be deepened after levels fall below a certain point. If water is being lifted to the surface by pumps, increased pumping lifts impose increased costs on users. Those persons using the underground water who cannot meet these increased expenses may find themselves excluded from the water supply.

Moreover, as the water is removed from the pore spaces within the water-bearing material and not replaced, compaction of the sediments can occur. This can result in the loss of storage space in the aquifer -- the pore spaces simply no longer exist for the water to fill -- and may even progress to the point where land subsidence occurs, which could yield extremely dire consequences for structures built on the overlying ground surface.

Contamination is also a possibility when underground water levels decline sufficiently. As pore spaces are dewatered and sediments are compacted, minerals contained within the sediments may emerge and mingle with the remaining underground water, causing a loss in water quality. In addition, and of particular importance in the Los Angeles area, if an aquifer lies adjacent to a salt-water body such as the Pacific Ocean, lowered underground water levels can permit invasion of the fresh water supply by the salt water from the Ocean. As long as the pressure levels in the underground aquifer are higher landward than they are seaward -- or, in technical terms, there is a seaward-sloping hydraulic gradient -- then the ocean water which comes into contact with the fresh water in the aquifer will remain static and not contaminate the fresh water supply (see Figure 1-3). However, if water levels in the coastal aquifer are drawn down so far as to generate a landward-sloping hydraulic gradient, then sea water will move into the aquifer, displacing the fresh water (see Figure 1-4). Salt water has greater density than fresh water, and so will replace fresh water from beneath when the two come in contact. When this salt-water intrusion occurs, wells overlying the aquifer that used to bring fresh water to the surface will begin to pull brackish water. Since salt water is not usable for most of the purposes for which fresh water is withdrawn, the excessive withdrawal of fresh water from a coastal aquifer can render the water supply useless.

Ground water basins thus provide a source of water supply and water storage, but their use is problematic, since overuse can destroy their value both as sources of supply and as reservoirs of storage. Falling water levels lead to increased costs of use, compaction and loss of storage capacity with possible dangerous land subsidence, and (depending upon the relative location of the basin and the composition

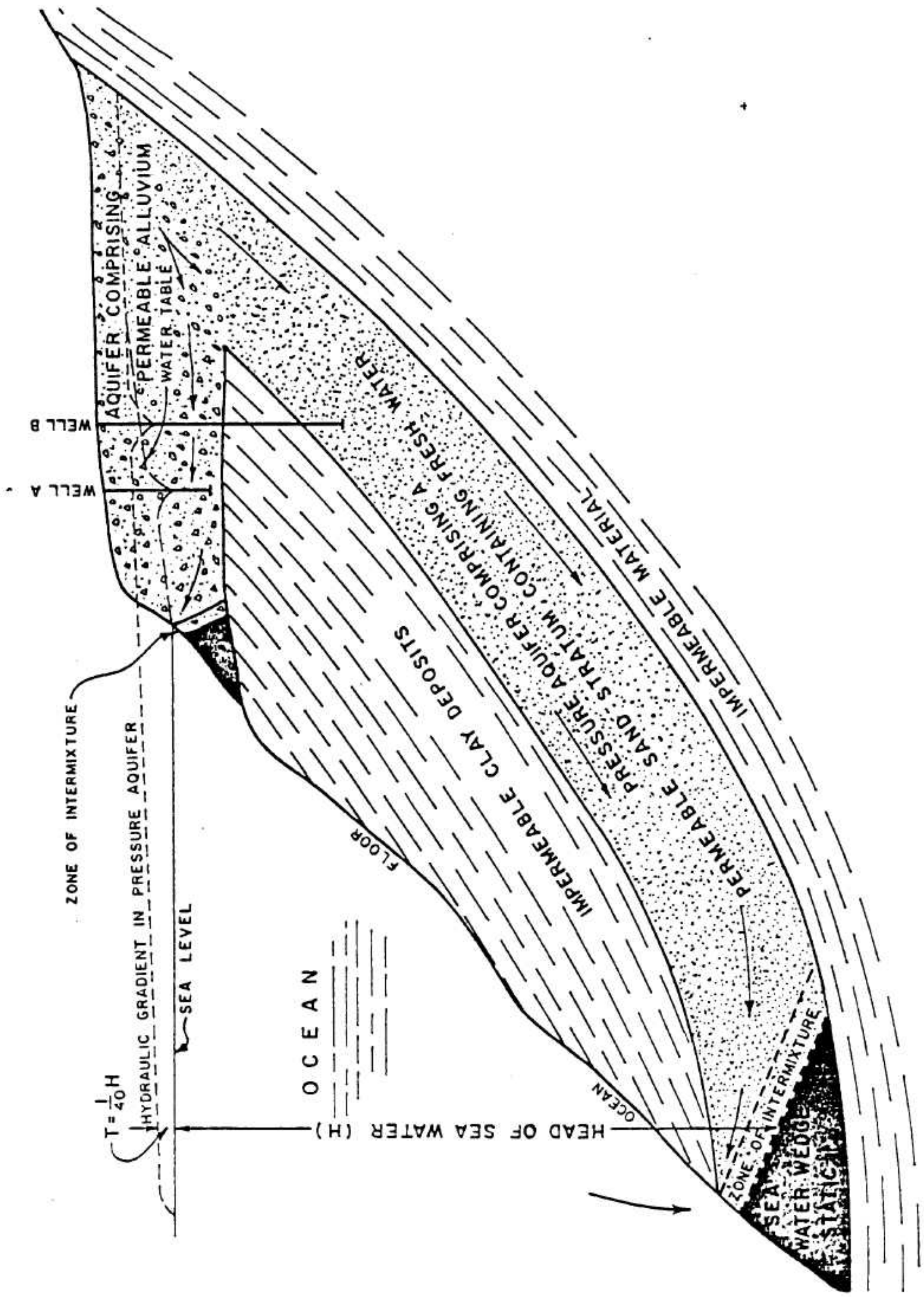


Figure 1-3. Cross-Section of a Coastal Basin, With Static

Source: DWR Bulletin No. 104, Appendix B, 1968

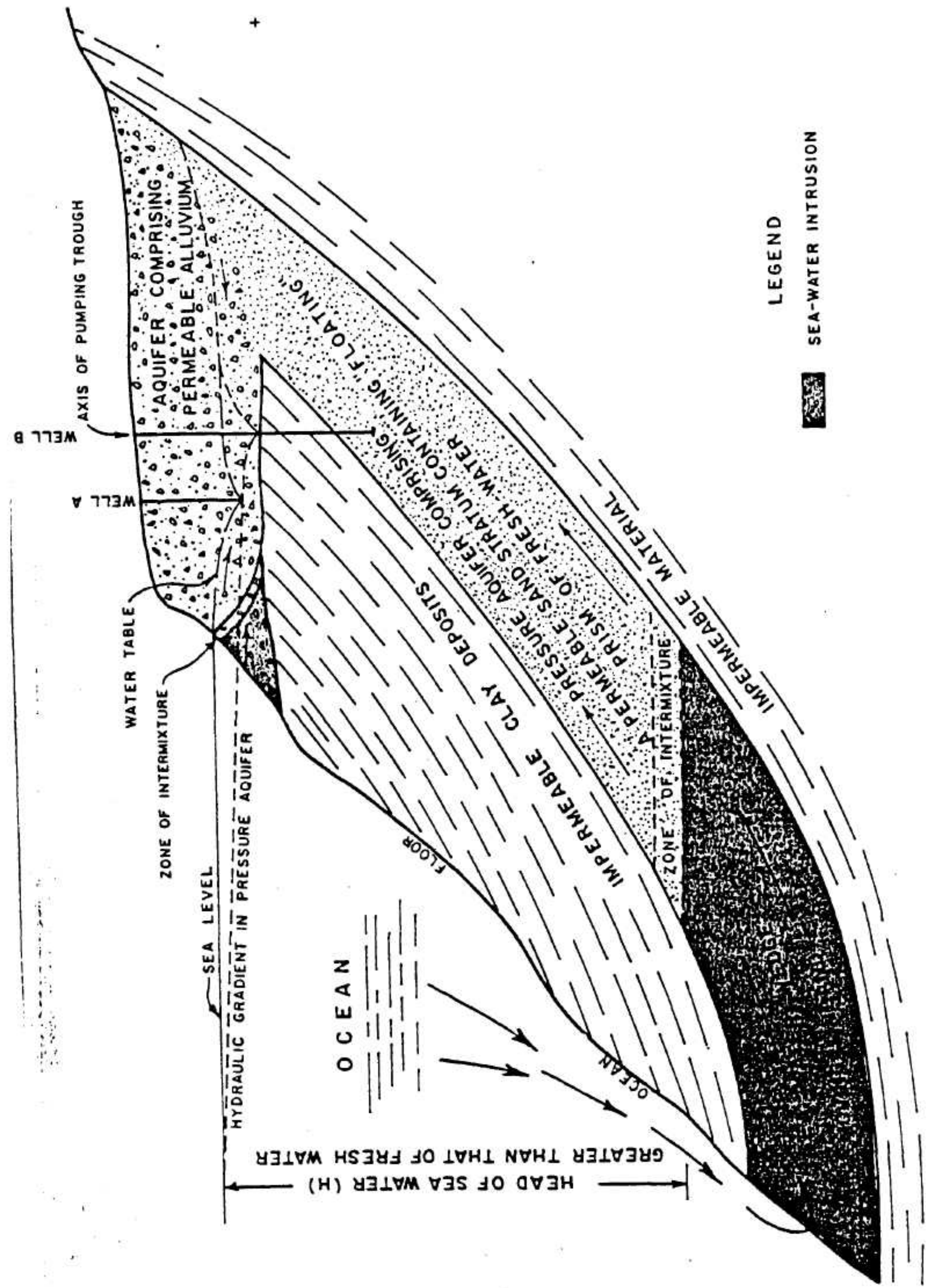


Figure 1-4. Cross-Section of a Coastal Basin, With Intruding Sea-Water Wedge

Source: DWR Bulletin Mo. 104, Appendix B, 1963 of the water-bearing material) contamination of the water supply. B.

The Problem of Water Supply in the Los Angeles Basin

The characteristics of ground water basins can now be related to the development of the Los Angeles area. As noted earlier, the Los Angeles Basin is now home to 13 million people, but has an average annual rainfall of about 15 inches. Compounding the relative scarcity of precipitation is its erratic nature. Precipitation is concentrated in a few "wet" months, and the area is given to cycles of consecutive dry years in which rainfall may be as little as 5 or 6 inches followed by wet years with 25 or 30 inches of rainfall.

The wet years in the Los Angeles Basin historically caused as much of a problem for the inhabitants as the periods of drought. Although it may be difficult to conceive for non-residents of the Pacific Southwest, arid lands are susceptible to disastrous flooding when precipitation is plentiful. As the surface soil of sands and clay harden during a dry cycle and surface streams disappear and stream beds dry up, conditions ripen for flooding when a sudden wave of storms from the ocean hit the area. Water drains from the mountain sides and runs onto the Basin floor faster than the diminished absorptive capacity of the ground surface can handle. Flash flooding can devastate property holdings, mud slides wash away surface structures, rivers and streams may completely re-locate their channels, and precious fresh water races seaward and is lost in the ocean.

Such an episode is then followed by months during which it does not rain at all, or perhaps an entire cycle of dry years during which the surface streams again dry up and the surface soils harden. This alternating between drought and flooding is a principal reason why the development of Los Angeles as an urban center lagged behind that of San Francisco, despite Los Angeles' more hospitable climate. The development of the Los Angeles area in the second half of the nineteenth century was focused on irrigated agriculture, where ranchers and growers took advantage of the plentiful sunshine and mild temperatures, until the occasional flooding would erase their crops and fields and they would start over.

How, then, did the Los Angeles Basin become the place of residence for so many millions of people, and billions of dollars' worth of assessed property valuation? The answer lies partially in a fact noted above: underlying the Los Angeles Basin are some 29 ground water basins. These basins can capture and store water and yield it up for later use.

> "With such erratic seasonal runoff... it would not be possible to conserve any substantial portion of the runoff, were it not for the fact that many valleys in the South Coastal Area are favored by being underlain by large ground water reservoirs. These underground reservoirs lie mainly in the basins of the... Los Angeles and San Gabriel Rivers in Los Angeles County, and in that of the Santa Ana River and its tributaries in San Bernardino, Riverside, and Orange Counties." (5)

In certain places along these river courses -- the forebay areas where confined aquifers can be recharged by percolation from surface water -- the porous soil deposits from the rivers "are capable of receiving immense quantities of water. Historically, much of the water flowing in the rivers as they crossed their forebays disappeared into the alluvium and moved underground toward the sea. Precipitation which fell on the forebay area was also a source of supply for adjoining ground water basins." (6)

The volume of water stored in these ground water basins is tremendous. According to a California Department of Water Resources study completed in 1968, the fresh water storage in the ground water basins of the Coastal Plain (which is a substantial part of the total Los Angeles Basin) was estimated at 35 million acre-feet. (7) The ground water basins of the Los Angeles area provide water storage capacity roughly equivalent to that of Lake Mead behind Hoover Dam. (8)

These observations concerning the storage capacity of the underground reservoirs in the Los Angeles Basin do not contradict the earlier observations about the problems of alternating drought and flooding. The percolation of surface water into ground water basins, and the underground movement of water through the aquifers, is a slow process. It is best served by steady application of water to the surface in those areas where basin recharge can take place. Sudden bursts of precipitation can and do overrun the intake capacity of the underground basins. Precious water can and does waste to the ocean during these times. Then, during drought periods, the overlying surface may carry so little water that recharge to the underground storage is deficient. The underground basins may help regulate the erratic precipitation cycle, but they are not open collectors that catch and hold all of the water arriving during the wet periods. It bears noting also that much of the ground water storage capacity is in confined aquifers, so that rainfall and surface stream flow overlying the aquiclude do not provide substantial recharge to the aquifers beneath the aquiclude.

The deficiency of surface water supplies led to early development of ground water in Los Angeles. Ground water conditions in the late 1800s were especially conducive to this development, since the underground water reservoirs were full and extractions were comparatively small. The overlying land surface was largely used for irrigated agriculture, so that much of the water applied to the land returned underground. At this early stage of the area's development, underground water levels were so high and the hydraulic gradient so nearly flat that as the land surface receded to sea level near the coast, water flowed from artesian springs and wells in the lower reaches of the coastal area. In fact, swampy conditions existed in some places close to the ocean. (9) Under these circumstances, irrigating land was easy and relatively inexpensive. Early development of ground water actually improved the area, as some of the swampy lands dried up enough to become usable for additional agricultural development.

Economic development in the Los Angeles Basin was not spatially uniform; some areas developed more rapidly than others. A 1904 survey performed by W. H. Mendenhall for the United States Geological Survey noted a shrinkage of the area of artesian water in the coastal reaches of the area and declining water levels in wells. By 1900, the City of Los Angeles had grown to a population of over 100,000 people in an area overlying a relatively small part of the total Los Angeles Basin. City planners looked at population growth trends and forecast that water from the surface flows of the Los Angeles River and from the aquifers underlying the City itself would become insufficient to support the City's population. The City made a considerable capital investment in a 200-mile aqueduct from the San Fernando Valley north and east to the undeveloped Owens River Valley east of the Sierra Nevada Mountains. The Owens River aqueduct was completed in 1913, and the City of Los Angeles began importing Owens River water for direct use in the City, with the excess spread in the San Fernando Valley for later withdrawal from the underground storage in that Valley. (In 1940, the Owens River aqueduct was extended north to Mono Basin, making the total aqueduct length 340 miles.) (10)

Thus, in the early 1900s, water levels in area wells were already declining, and the City of Los Angeles was already concerning itself with securing a supplemental water supply. Yet at the same time, concerns with the occasional flooding of the Los Angeles area prompted other activities. By special authorizations of the California Legislature upon petition from local residents, the Los Angeles County Flood Control District (LACFCD) was established in 1915 and the Orange County Flood Control District was established in 1927. In order to reduce the flooding potential from the rivers that traversed the area, the Flood Control Districts engaged in programs of channel improvements. The LACFCD even routed the Los Angeles River and the Rio Hondo through new, high-walled, concrete-lined channels. Ironically, this action ensured that nearly all of the storm flow of the Los Angeles River would run directly to the ocean, as would that of the Rio Hondo below the Montebello Forebay, thereby eliminating these rivers as sources of fresh-water percolation into the underground basins along those parts of their courses that had been lined with concrete.

Continued economic development of the Los Angeles Basin during the first three decades of this century saw the beginning of its transformation from an agricultural production center to a thriving (and sprawling) urban-suburban area. Industrial, commercial, and residential growth began to outpace agricultural growth, and agricultural uses of land were replaced with urban uses. This transition was accompanied by the paving over of the Los Angeles Basin, which had an effect on the ground water supply similar to that of lining the river channels with concrete. The underground water basins of the Los Angeles area have been deprived of much of their natural percolation by the rapid development of streets, buildings, and parking lots, turning rainfall into runoff. When the rainfall falls on the ground, it produces about 20 percent runoff; when the same rainfall hits pavement, it produces about 80 percent runoff. The runoff finds its way through the drainage systems, built as part of the flood control plan, into the river channels and out to the ocean.

The first few decades of the 20th century, thus, brought about the simultaneous increase in the use of fresh water from underground along with the decrease in the recharge capacity of the underground supply system. Over half of the water used in the Los Angeles Basin was being withdrawn from below the ground. The introduction to the area in 1909 of the deep-well turbine pump made it possible to withdraw the ground water faster and from greater depths, thereby accelerating ground water use. The City of Los Angeles had secured a supplemental supply of water, but the rest of the area remained dependent on the ground water basins for water as demand grew. In four of these ground water basins -- the Raymond Basin adjacent to the

San Gabriel Valley, the West and Central Basins in the Coastal Plain area, and the East Coastal Basin in Orange County-- the problems associated with the use of ground water basins had become acute by the close of the 1920s.

The stakes involved in the water supply problem of the Los Angeles area are huge. A major metropolitan area, with millions of people and their property, has been built on this semi-arid plain. The building of this metropolis was accomplished not only with the borrowing of financial capital, but also with the borrowing of natural capital. Every year after the early decades of the twentieth century, the people of the Los Angeles Basin consumed more water than nature supplied. They borrowed much of the deficit from the storage capacity of the underground water system. In so doing, they endangered that very same storage capacity. Water levels fell, pumping lifts increased, wells were abandoned, compaction occurred, and the sea water intruded.

A continuation of these developments threatened to destroy the water supply on which this boomtown depended. The potential monetary losses alone from the destruction of the underground water supply could turn the boomtown into a ghost town, or turn the life of the remaining inhabitants into a war of each against all over the dwindling water supply (violence in water disputes in the western United States is not unheard of). In the Los Angeles area, water supply is not an abstract issue about which futurists speculate; it is a real problem faced by real people on a continuing basis.

C. The Kind of Problem This Is -- The Commons

Imagine some typical ground water users in a coastal area such as the Los Angeles Basin. Over the course of a few years, a vegetable grower notices something disturbing at the well he has been using for irrigation and for his own consumption. The underground water he uses is receding. The pump he uses to extract the water from the ground has to lift the water farther than it had to be lifted before. This longer pumping lift is increasing his cost of obtaining water with which to pursue his livelihood. Yet market conditions prevent him from raising his selling price for his crop.

Miles away, along the ocean, employees at an oil refinery begin to notice another problem. The water extracted from underground that passes through the narrow network of pipes within the walls of the refinery structures is beginning to leave deposits. In a fairly short time, this could create blockages that would be extremely costly to repair. An analysis performed by one of the refinery engineers shows that the water the refinery has been using from underground has become salty -- it resembles ocean water.

Somewhere between the refinery and the vegetable grower, a city water department's employees are beginning to notice problems. The distance to the water in their wells is increasing. Costs are going up. Water quality is beginning to show some troubling signs, too. The grass on the lawn outside City Hall is blanching and dying even as the groundskeepers keep watering it.

The problems continue, and they grow worse. Wells are deepened;

or, old wells are abandoned and new ones are drilled. Newer and better pumps are bought, with improved capabilities for lifting the underground water to the surface. Yet the distances it must be lifted continue to increase. The demand for water from the city water department continues to grow with the population. Along the coast, salt concentrations increase; the clogging of pipes accelerates, more lawns die.

The vegetable grower does not know the refinery workers. The refinery workers do not know the water department employees, and so on. Each of them knows only that there is a problem. They do not know how big the problem is, or who else is being affected. And they do not understand why it is happening now.

Yet the behavior of these strangers is closely related. The actions of the vegetable grower are a part (albeit a small part) of the reason why salt deposits are clogging the pipes down at the beach. The actions taken at the refinery are part of the reason for the increasing pumping lifts and costs of the vegetable grower and the city water department. These strangers, though they are unaware of it, are drawing their water from a common source, a ground water basin. They are users of a commons.

C.1. Common-Pool Goods and Other Goods

A commons (or a common-pool resource) is a resource that is not under the ownership of an individual, to which more than one individual has access, and that generates subtractable yields that are appropriated by the individuals who have access to that resource. A typical ground water basin meets this definition. No individual owns the ground water basin. More than one individual has access to it, and it produces an appropriable yield -- the water brought to the surface -- for those persons who exercise their access to the basin.

There is, then, a defining duality to the commons: there is the jointly-accessible resource and the individually-appropriated yield from that resource. The vegetable grower, the refinery, and the city water department all have access to and use the ground water basin, which is the jointly-accessible resource. Yet the water extracted from the basin (the individually-appropriated yield) by the refinery is not the same water that is extracted from the basin by the vegetable grower. The individuals using their access to the commons appropriate yields that are rival in nature. The water withdrawn by the city water department is then no longer available to another pumper, and in fact subtracts from the total supply available to that other pumper.

Why belabor what may appear to be so trivial and obvious a point? The dual nature of the commons is essential to distinguishing it from other types of "goods" scholars have focused analysis upon (11), and to thinking clearly about prescriptions made by various analysts for common-pool resource management.

The idea of a "good," and of "types of goods," has been brought into political science and other social sciences from its original principal use in economics. As a result of this lineage, it is easy to think of the term "good" as designating only tangible objects. But this tendency unnecessarily excludes many of the things human beings create or destroy, enjoy or disprefer. A better way of conceiving of a "good" is as something valued, positively or negatively. A "good," as used here, is a "value," whether tangible or intangible, and so includes services, conditions, benefits, "bads," etc. (as in Easton's "authoritative allocation of values," by which he meant "things valued").

All goods are not alike. Some goods are less amenable to privatized means of production, distribution, and consumption than others. Examination of distinctions among goods yielded ideal types of goods-- the "private good" and the "public good," conceived in pure polar terms. But these pure polar types did not encompass the variety of goods. Anything other than a private good seemed susceptible to difficulties in production, distribution, or consumption, regardless of whether it met the definition of "public good". The problem is the problem of the "non-private good."

Non-private goods present problems of adequate provision, problems of adequate maintenance, problems in the distribution of benefits and costs, and problems in use or consumption. What, then, distinguishes these private goods and non-private goods? The distinction between private goods and public goods was variously made by different scholars on the basis of feasibility of exclusion or of subtractability (or rivalness) of use. (12) Private goods differed from public goods because persons other than the proprietor could be excluded from access to a private good, whereas a public good (such as national defense) was available to all relevant persons once it was provided. It was also argued that private goods differed from public goods in that once a private good was consumed or used by an individual, it no longer was consumable or usable by another, whereas the consumption of a public good by one individual left it available in undiminshed quantity and quality by another (e.g., my enjoyment of defense does not leave less defense for you to enjoy).

In fact, private goods differ from public goods on both dimensions. However, the use of two dimensions -- feasibility of exclusion and subtractability in use -- actually allows for more than two types of goods. There may also be goods with high feasibility of exclusion and low subtractability in use, and goods with low feasibility of exclusion and high subtractability in use. The use of two defining dimensions creates a four-cell typology of goods (13), with private goods high on both dimensions and public goods low on both dimensions (see Figure 1-5). The other "non-private" or "problem" goods (represented here as polar types themselves, though both excludability and subtractability may vary by degrees), which are not pure public goods, lie in the off-diagonal cells.

"Toll goods" are characterized by high feasibility of exclusion but low subtractability in use. An example of a "toll good" is a program on cable television, from which you and I may readily be excluded if we have not paid the requisite fee (or met some other qualification), but which is such that, if you and I both pay the fee, my consumption does not leave you less program to consume. A toll good is thus not a public good like national defense, from which you and I cannot be excluded. Nor is it a private good like an apple, my consumption of which precludes you from consuming in the same fashion.

The remaining type of non-private good is the common-pool good, where exclusion from access is low but subtractability in use is high. (14) Common-pool goods are thus neither private goods nor public goods, although their dual nature gives them a shared characteristic

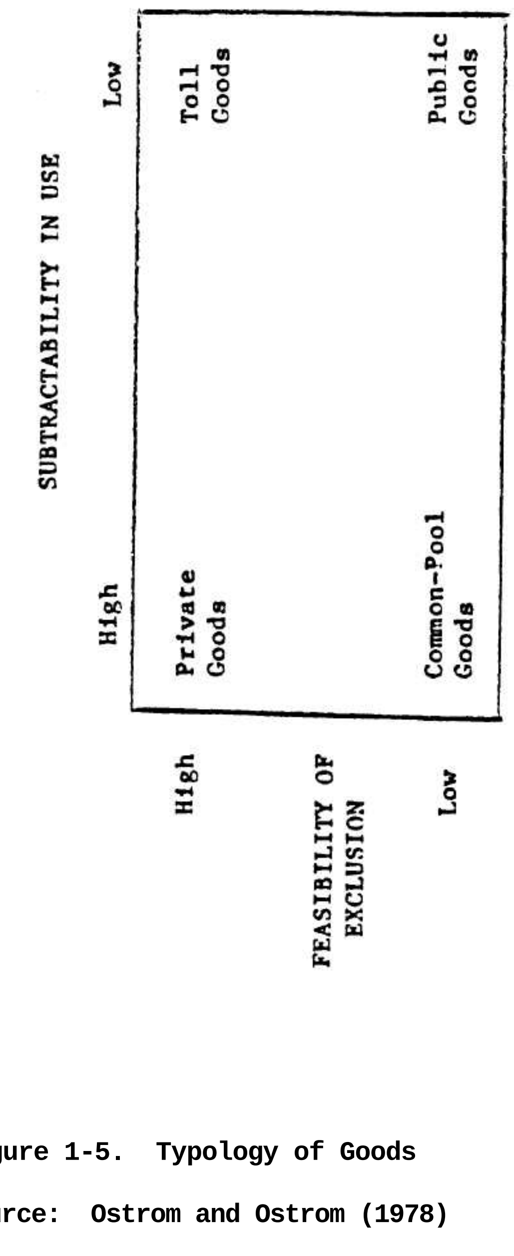


Figure 1-5. Typology of Goods

Source: Ostrom and Ostrom (1978)

with each of those types. A commons is a jointly-accessible resource that produces an appropriable yield. The units of appropriable yield are the directly-consumed and directly-valued items for which access to the resource is sought. These we may call "use-units." (15) The resource is "used" by individuals only in the sense that through access to the resource they are enabled to appropriate the use-units. It is the resource that exhibits low feasibility of exclusion; joint uses of the resource are eminently feasible, as the ability to keep individuals from using the resource is limited. It is, on the other hand, the use-units that exhibit high subtractability in use; joint uses of a use-unit are not so feasible and may even be practically impossible (as with a fish extracted from a body of water). Examples of common-pool resources and the use-units they produce are plentiful: oil fields yield units of petroleum (barrels, litres, or whatever -- the unit of measure does not affect the analysis); ocean fisheries yield fish, forests yield timber, grazing areas yield fodder, bridges yield crossings (16), and ground water basins yield water.

Why is a commons a "problem good?" What is it about low feasibility of exclusion from the resource and high subtractability in use that generates difficulties for the users? Difficulties arise from the interplay of four factors: the subtractability of the use-units, the fact that the use-units are linked through a production process to the resource, the "carrying capacity" or finite limit of the resource as a producer of use-units, and the presence of numerous users appropriating use-units from the commons simultaneously.

The subtractability of the use-units and the presence of a finite limit on the ability of the resource to produce use-units gives rise to the possibility that, within a particular period of time, all of the use-units generated by a commons may be appropriated. The connection between the use-units and the resource as their producer implies that appropriation of an excessive number of use-units within a period may "feed back" into the production process and damage the production capacity of the resource itself. This has already been noted with respect to ground water basins where withdrawals of ground water may lead to compaction of sediments, eliminating the pore spaces that hold water. Other commons face similar problems: removal of too many fish from a body of water might lower the fish harvest in future time periods by reducing the number of fish reproducing and generating new fish; over-grazing of rangeland or over-harvesting of timber may reduce seed availability to the point where future crops of grasses or trees are diminished. Combining these factors with a multiplicity of users of a commons means that no one proprietor is able to make decisions balancing the consumption of use-units with the carrying capacity of the resource. The several users may inflict losses upon each other through their various individual appropriations of the commons.

This interdependence of the users of a commons is, perhaps, its most oft-remarked feature. When, as described above, one individual (such as the refinery) extracts water from a ground water basin, that individual's extraction is not available for another (such as the vegetable grower) and may even reduce the availability of water to that other (when, for instance, underground water levels decline). The behavior of the users of a commons is physically interconnected. There may be a "physical medium through which the effects of one agent's activities are transmitted to other agents.... The distinguishing feature of a common property resource is that it transmits influences directly from one economic agent to another." (17) Behavior in a commons is contingent (18)-- in the use of such a resource, each person's actions are partly the cause of his own problem and partly the cause of other's problems.

The result of this interdependence of multiple users of a commons, who may fully appropriate its use-units and indeed overrun its carrying capacity, is the so-called "tragedy of the commons." The biologist Garrett Hardin gave us the powerful expression "the tragedy of the commons" to describe these problems, using the old sense of the commons as open land available to those in a community for grazing their animals. Hardin's reference to the commons as pasturage (19) may be embellished with a numerical example to provide the following account.

Suppose there is a pasture used by five herders, each of whom has 10 animals. There are 50 animals, which we will suppose to be worth $1,000 each if raised and marketed in this fashion. In addition, let us suppose that the addition of a 51st animal, competing for fodder with the other 50 animals, reduces the final market value of each animal by 1/50, or $20.

Now, if herder A adds an 11th animal to his herd (and thus a 51st animal to the total), the total social cost from the addition of that 51st animal is 50 times $20, or $1,000. However, the value of herder A's herd changes from $10,000 (10 animals worth $1,000 each) to $10,780 (11 animals worth $980 each). So, herder A's action in increasing his herd inflicts a total social cost of $1,000, but realizes for him a $780 gain.

Herder A, and each of the herders, has an incentive to add to his herd and appropriate more of the fodder produced by the pasture, until the crowding has become so severe that the addition of another animal no longer increases the total value of that herder's herd. If we presume no more than that each herder is capable of assessing his situation and responding rationally to the incentives in that situation, each herder will make additions to his herd. In the meantime, the total social costs have been overrunning the individual gains to the herders. The pasture's ability to reproduce fodder for the next season may be reduced.

This is the typically-conceived working-out of a situation where multiple individuals use a finite resource producing subtractible use-units where use today may reduce the supply available for use at a later date. "Thus, as long as each hersdman selects the strategy most advantageous to himself as an individual, he will add a head of cattle to his herd, and so will they act all, as individuals."(20) Yet in so doing, they inflict losses upon each other and damage upon the pasture, so that in the future they may be unable to generate herd values approaching those realized as they overran the carrying capacity of the pasture. This "inherent logic of the commons," according to Garrett Hardin, "remorselessly generates tragedy," noting Alfred North Whitehead's observation that the "essence of dramatic tragedy is not unhappiness. It resides in the solemnity of the remorseless working of things." (21)

C.2. The Problem of Collective Action and the Commons

Continuing with the example of the common pasture used by the five herders, one finds that the herder's situation is something of a trap. The trap is that the arithmetic of the commons does not work in reverse. Unilateral increases will increase herd value while others keep herd size constant (or reduce herd size), but unilateral decreases in herd size will not improve herd value while others are over-grazing the pasture.

Suppose now that herder A has increased his herd to 11 animals, and the other four herders have followed suit. What happens if herder A, witnessing the effects of his actions and those of the other herders and alarmed by the results or the prospect of further increases, considers reducing his herd from 11 animals back to 10?

At this point, there are 55 animals on the commons, the value of each of which has diminished to, say, $900. If herder A reduces his herd back to 10 animals, and thus raises the value of each animal to $920, he increases the value of each other herder's herd by $220, and increases the value of all of the animals on the commons by $1,080. However, herder A's herd at 11 animals is worth $9,900 (11 animals worth $900 each), and herder A's herd at 10 animals would be worth $9,200 (10 animals worth $920 each). His action of reducing his herd would create a $1,080 total social gain, but he would incur a $700 loss for doing so. Again, presuming only that a herder is capable of assessing his situation and responding rationally thereto, herder A will not sustain the $700 loss in order to generate a gain for the other herders.

When there are 50 animals on the pasture, each of which is worth

$1,000, the total value of all the herds is $50,000. When there are 55 animals each of which is worth $900, the total value of all the herds is $49,500. There is, then, a collective <u>gain</u> to be realized by the herders from moving herd size back from 55 animals to 50 animals. Yet the situation faced by an individual herder contemplating a unilateral reduction from 11 animals to 10 is such that the herder anticipates a <u>loss</u> from such an action.

This is a disturbing situation - - a collective benefit is foregone and damage to the commons continues as a result of the individually rational choices of the herders. It is the sort of disturbing situation Garrett Hardin had in mind when he wrote of the "inherent logic of the commons" remorselessly generating tragedy.

Hardin's warnings about the tragedy of the commons appeared just a few years after the publication of Mancur Olson's <u>The Logic of Collective Action</u>. That work focused on the problem of collective benefits foregone as a result of the individually rational choices of the members of the collectivity. Olson observed that economists and political scientists typically took it for granted that individuals in groups with a common interest, or with a prospective collective benefit to be attained, would act to further that common interest; indeed, it was assumed that groups would "act," much in the same way as individuals act, to pursue their interests. (22)

Olson argued instead that what followed consistently from the presumption of individual rationality was <u>not</u> successful group action to achieve collective benefits, but rather quite the opposite. According to the logic presented by Olson,

> If the members of a large group rationally seek to maximize their personal welfare, they will not act to advance their common or group objectives unless there is coercion to force them to do so, or unless some separate incentive, distinct from the achievement of the common or group interest, is offered to the members of the group individually on the condition that they help bear the costs or burdens involved in the achievement of the group objectives.... These points hold true even when there is unanimous agreement in a group about the common good and the methods of achieving it. (23)

The Logic of Collective Action bears the subtitle, "Public Goods and the Theory of Groups." It has already been noted that public goods and common-pool goods are not the same, because they differ on the dimension of subtractability in use. Because of their non-subtractability, public goods are not given to the problems of overuse, depletion, and contamination that common-pool goods experience. Public goods have different problems arising from their non-subtractability, especially revelation of preferences (24) and consequent distribution of costs of provision among public-good consumers (it may, for instance, be possible to say that I enjoy national defense more than you do, but it does not make any sense to say that I enjoy more national defense than you do). Bearing in mind that public goods and common-pool goods differ along the subtractability dimension, they share the other defining characteristic of low feasibility of exclusion. It is this characteristic of non-excludability alone on which Olson bases his definition of public goods: "The very fact that a goal or purpose is common to a group means that no one in the group is excluded from the benefit or satisfaction brought about by its achievement." (25) Therefore, Olson's logic extends beyond public goods to common-pool goods since he does not differentiate between them.

With respect to the problem of achieving the collective gain which might inure from reducing overuse of a commons (as with the increase in total herd value available in the example above), non-excludability is a crucial characteristic. If herd size is reduced (presuming that reduction occurs from a beginning point of overuse), increased herd value accrues as a benefit to the herders of the commons and is not "captured," or internalized, by the herder who makes the reduction. One may therefore be tempted to ask why the herders do not all reduce their herd size as a group, and therefore avoid the problem of having an individual herder "go it alone?" This is where Olson's analysis bites into the problem for public goods and common-pool goods alike, in its prediction that such joint action will fail.

The problem of achieving joint action to bring about a non-excludable benefit is the problem of the "free rider" and the "hold-out." In the context of a commons, if a reduction in use will provide a non-excludable benefit to the members of the group of users of that commons, then an individual user chooses between a strategy of reducing his use and sharing in the benefits of reduced use and a strategy of not reducing his use but nonetheless sharing in the benefits of reduced use by others. The strategy of not reducing use provides the commons user with the dual benefits of greater use of the commons and improvements in the condition of the commons. A user following such a strategy does not reduce his use of the commons and takes a "free ride" on the actions of others to reduce their use of the commons. In the context of public goods, the "free rider" is one who avoids contributing to the cost of provision of a public good, yet enjoys the benefits of that good once it is provided by others, since (by definition) they cannot exclude him therefrom. In the context of common-pool goods, the "free rider" is one who avoids curtailing his use of the commons yet enjoys the benefits of curtailment of use by others since they also cannot exclude him therefrom. Indeed, if a group (either of potential consumers of a public good or of users of a commons) attempted to develop a voluntary agreement for joint action, the "free rider" would be led to adopt a "hold-out" strategy, (26) in order to get the others either to go ahead without him or to offer him some additional inducement to cooperate.

To this point, the "free rider" or "hold-out" has been described as if he were an individual in a group -- indeed, as if he were a rather obstinate individual in a group. But the thrust of Olson's analysis is that the entire group is composed of such individuals, each of whom faces the same choice of strategies. Olson's analysis, and the reason his work is sometimes informally re-named "the illogic of collective action" or "the logic of collective <u>in</u>action", is that each individual faces the temptation to "free ride" and that if each of these individuals selects the strategy that maximizes his own personal welfare, each will adopt the "free-rider" choice and collective action will fail. Thus, to the extent that the improvement or survival of the commons requires joint action to curtail use, there is no comfort for the commons from Olson's analysis.

There are, however, some important qualifications in <u>The Logic of Collective Action</u> that merit attention, because Olson's conclusion is not that all groups will always fail to provide themselves with collective benefits. As quoted earlier, Olson makes an exception to the prediction of failure both for groups that are able to coerce their members' behavior and for groups which are able to offer separate inducements to members conditioned on their cooperation, thus securing their cooperation as a "by-product" of the inducements.

Within the category of groups remaining -- i.e., those that neither coerce nor offer separate inducements -- Olson differentiates among their prospects for successful collective action based upon the distribution of interests among the members and upon the "noticeability" of individual members' actions. The distribution of interests among the members in the provision of the collective benefit may be such that one member finds that the gains to himself of having the benefit outweigh the cost of providing that benefit by himself. The benefit may be obtained through the actions of that individual even though others in the group will also enjoy the benefit without having incurred any costs of its provision. Such a group Olson terms "privileged," and associates with small group size. Assuming that the collective good provided is divisible, Olson still predicts that the level of provision is likely to be suboptimal, even in a privileged group, since the individual who "goes it alone" will only provide as much of the collective good as he individually desires.

Olson presumes (27) that the likelihood of a group being "privileged" declines as the group's size increases -- although since "privileged" status turns on the issue of distribution of interests within the group rather than on the issue of the number of members, this does not appear to be a logically compelled presumption. Olson also suggests that the interaction of members in a small group may enhance the prospects for joint action, since it is "not only economic incentives, but also perhaps social incentives, that lead their members to work toward the achievement of the collective good." (28) And upon stating his general prediction that collective action is likely to fail, Olson qualifies: "None of the statements made above fully applies to small groups, for the situation in small groups is much more complicated." (29)

Beyond small groups, groups that can coerce, and groups that can use the "by-product" approach, Olson distinguishes the remainder as to their likelihood of achieving collective action on the basis of the noticeability of individual members' actions. Noticeability distinguishes "intermediate" groups from "large" groups. The intermediate group lies in the "size range where the group is not so small that one individual would find it profitable to purchase some of the collective good himself, but where the number in the group is nonetheless sufficiently small that each member's attempts or lack of attempts to obtain the collective good would bring about noticeable differences", in that others would be aware of the presence or absence of his contributions. (30)

In such a group, a person desiring the collective good may contribute out of a rationale that, if he does not, "the costs will rise noticeably for each of the others in the group; accordingly, they may then refuse to continue making their contributions, and the collective good may no longer be provided." (31) In an intermediate group, depending on the level of group coordination or organization, "a collective good may, or equally well may not, be obtained." (32) By contrast, the large group in Olson's typology (which he likens to a perfectly competitive market in which no one firm's output makes a perceptible difference on price) is one in which "the loss of one dues payer will not noticeably increase the burden for any other one dues payer, and so a rational person would not believe that if he were to withdraw from an organization he would drive others to do so."(33) In such a large group, according to Olson, "it is certain that a collective good will not be provided unless there is coercion or some outside inducements." (34)

The Logic of Collective Action suggests that users of a commons will fail to alter their use of the resource, to their collective detriment, unless: (a) the group is sufficiently small and/or "privileged;" (b) the group of users has the capacity to coerce or induce such alteration; or (c) the group of users is fortunate enough to be one of those "intermediate" groups which succeeds somehow. The example of the herders using the pasture above involved only five members, but is not a privileged group --no one herder has an incentive to "go it alone." The herder's actions do have a noticeable effect on one another, though, so (barring some social connection among the herders) even a group with as few as five members may fall into Olson's "intermediate" category.

The five-herder example of a commons was deliberately made artificially small for the sake of ease of presentation of the arithmetic of the commons. Common-pool resources on the scale of a ground water basin are unlikely to have only five users. Depending upon the size of the basin and the density of the overlying population, there may be hundreds of users of a basin besides our vegetable grower, refinery, and city water department. If these users are so numerous, and their distribution of use sufficiently unconcentrated, as to make individual pumpers' increases or decreases in ground water extractions imperceptible to other pumpers, the "logic of collective action" would appear to hold little promise for overcoming "the inherent logic of the commons."

C.3. The N-Person Prisoner's Dilemma and the Commons Dilemma The "problem of collective action in social contexts," according to political scientist Russell Hardin, "is the Prisoner's Dilemma writ large." (35) Interest in game theory's Prisoner's Dilemma game intensified contemporaneously with the appearance of Mancur Olson's book and Garrett Hardin's "Tragedy of the Commons" article. The Prisoner's Dilemma game structure has been thought to capture in an essential and formal manner the problem of joint benefits foregone as the result of individually rational choices made by the players -- the very problem described also as the problem of collective action and the problem of the commons.

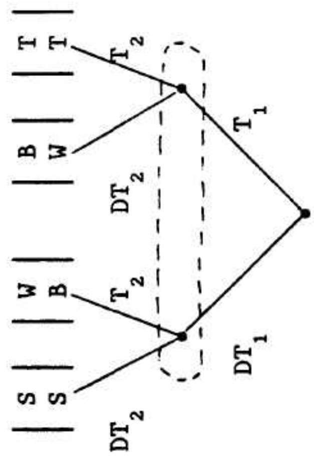
In the Prisoner's Dilemma game, two prisoners are detained in separate cells on suspicion of crimes they allegedly committed together. There is insufficient evidence to convict them of the greater offense, carrying a sentence of twenty years, but there is sufficient evidence to convict them both of a lesser offense that carries a sentence of five years. Only a confession will allow the prosecutor to obtain a conviction on the more serious charge. The prosecutor offers each of the prisoners a deal. If the prisoner will turn state's witness and aid in the conviction of his partner on the more serious charge, he will be allowed to go free and his partner will be sentenced to twenty years in prison. On the other hand, if both he and his partner confess, the prosecutor will convict them of the more serious charge but ask for a lighter sentence of ten years in prison.

Each prisoner's choice, whether or not to confess, must be made in isolation from his partner. But the outcome, in terms of years in prison, for the suspect making the choice, depends not only on what he does but also on what his partner does. If his partner confesses, he can either confess and go to jail for ten years or not confess and go to jail for twenty. If his partner does not confess, he can either confess and go free or not confess and go to jail for five years. Therefore, regardless of which choice his partner makes, he is better off confessing. Presuming only that he is rational enough to assess his situation accurately and that he is motivated by a desire to spend as little time in jail as possible, the predicted behavior of the prisoner is that he will confess. His partner, following the same reasoning, does likewise, and off they go to jail for ten years each. Yet refusing to confess would have resulted in five years in jail each. In fact, of the four possible outcomes --no years in jail, five years, ten years, or twenty -- each prisoner who acted to achieve his best result actually obtained his third-best outcome.

The basic representations of a Prisoner's Dilemma game are given in Figure 1-6. Abstracting from the particular numbers of years of imprisonment in the example above, the outcomes for individual players are re-designated as best (B), second-best (S), third-best (T), and worst (W). The Prisoner's Dilemma is then arrayed in extensive form as a decision tree. One of the prisoners is designated player 1, who chooses between the options "talk" (T_1) and "don't talk" (DT_1) . The

	Don't talk	Talk
Don't talk	S,S	W,B
Talk	B,W	T,T

In Normal Form



In Extensive Form

	Don't talk	Talk
Don't talk	5,5	20,0
Talk	0,20	10,10

With Example in Years Imprisonment

Figure 1-6. The Prisoner's Dilemma

other prisoner, player 2 also chooses between the options "talk" (T_2) , and "don't talk" (DT_2), without knowing which choice player 1 has made (hence the dotted-line "balloon" around the choice nodes at which player 2 decides). The four possible combinations of choices (DT_1-DT_2, DT_1-T_2, T_1-DT_2, T_1-T_2) lead to four combinations of "payoffs" to the players (with player l's shown above player 2's).

The Prisoner's Dilemma is also arrayed in Figure 1-6 in normal form as a four-celled box formed by the four combinations of the individual players' binary choices. Here player 1 chooses between the rows labeled "Don't talk" and "Talk," and player 2 chooses between the columns labeled "Don't talk" and "Talk." The resulting outcomes of the choice combinations are shown in the cells by pairs of payoffs, with the payoff to the row player, player 1, listed first. The Prisoner's Dilemma in normal form is then filled in with the years of imprisonment from the example used as the payoffs.

Using the Prisoner's Dilemma in normal form with the abstract payoffs B, S, T, and W, some general observations can be made outside the context of a particular example. In a situation structured like the Prisoner's Dilemma, a player is said to have a <u>dominant strategy</u>, a strategy that he should follow no matter what the other player does. Because the Prisoner's Dilemma game is symmetric, each player has the same dominant strategy; he is better off talking if the other player talks (T beats W) and if the other player does not talk (B beats S). The predicted behavior in any Prisoner's Dilemma game is that both players will follow their dominant strategies and end up in the cell with the payoff pair (T,T).

The second general observation is that the outcome of the

Prisoner's Dilemma game is a *deficient equilibrium*. A game outcome is an *equilibrium* if neither player has an incentive to move away from that outcome *by himself*. This is easily seen in Figure 1-6. Once the (T,T) outcome has been reached, either player may be dissatisfied with the outcome and may wish to consider a different choice. But, for either player to change from "Talk" to "Don't talk" by himself would only trade his third-best outcome for his worst outcome, provided the other player's choice remains constant. Neither player can change his outcome from T to S or B without the other player changing also. Thus, the (T, T) outcome is an equilibrium. It is, nonetheless, a *deficient* equilibrium because there exists a different possible outcome that would be preferred by both players.

A third general observation has to do with why the players don't arrive at (S,S) in the first place, since they both prefer it to (T,T). The problem in the Prisoner's Dilemma lies not in the players' failure to recognize that, of the two diagonal cells, (S,S) is preferable to (T,T). The problem lies in the off-diagonal cells (B,W) and (W,B). (S,S) is the joint best outcome, but it is not an equilibrium. If (S,S) were somehow arrived at, each player *would* have an incentive to move away from that outcome by himself. By changing from "Don't Talk" to "Talk" while the other player remains unmoved, either player can trade S for B, his best possible outcome in this game. The player will be tempted to "defect" from the joint best outcome to obtain B, his individually best outcome. B is therefore referred to as the "*temptation payoff*." W, by contrast, is referred to as the "*sucker's payoff*" -- each player is motivated to avoid being "suckered" by not talking when the other player talks. It is the attempt to capture the temptation payoff and to avoid the sucker's payoff that results in each player choosing to talk, and so the joint best outcome (S,S) is foregone.

A fourth general observation is that the magnitudes of the actual payoffs do not affect the predicted outcome as long as their relative ordering remains the same (given the usual game-theoretic assumptions which abstract from risk-aversion and presume an absolute interest in utility maximization). That is, it does not matter whether B is zero years in jail, S five, T ten, and W twenty, or B zero, S one, T two and W three, or if B is a positive payoff of $100, S is $99, T is $98, and W is $97. The comparisons made, and the predicted resulting choices, are the same, as long as B is preferred to S, S to T, and T to W.

The "Don't Talk" - "Don't Talk" combination that yields the joint best outcome (S,S) can be re-conceived as the two players "cooperating" with each other so as to achieve (S,S). And, borrowing a term used just above in discussing the temptation payoff, the "Talk" choice can be re-conceived as "defecting" from the joint best outcome in an effort to capture the individually-best outcome. Thus, if we re-label the choice "Don't Talk" as "Cooperate" and the choice "Talk" as "Defect", we move the Prisoner's Dilemma game outside its particular context and make it a generic game - - a "social dilemma" or "social trap" -- with a generic structure such that each individual receives a higher payoff for a defecting choice than for a cooperative choice, no matter what the other player does, and such that each member would receive a higher payoff if each would cooperate than if they both defect. (36)

The extension of the two-person Prisoner's Dilemma game to the case of multiple actors yields the n-person Prisoner's Dilemma game. In an n-person Prisoner's Dilemma, as in the 2-person game, strategic players encounter a circumstance wherein their joint best outcome occurs when all cooperate, but each individual player's best outcome would be to defect while all others cooperate and each individual player's worst outcome would be to act cooperatively while the others defect. Thus, in the n-person Prisoner's Dilemma, as in the 2-person game, each individual player's dominant strategy is to defect.

The n-person Prisoner's Dilemma game has also been termed the "commons dilemma game" (37), reflecting its applicability as a metaphor for the situation where the point of overuse of the commons has been reached ("defecting" is not a relevant concept if demand placed upon a resource is sufficiently low that an individual can increase use without causing any harm to others). (38) Once the point of overuse has been reached, the users' situation may be, and has been, modeled as a commons dilemma game.

If, for example, in a ground water basin, the point of overuse has been reached, and water levels are falling, and (in a coastal basin) sea water is intruding because people are removing too much water, then if enough of them would change their actions, water levels would stop falling (or even rise) and the water quality could stop deteriorating (or even improve). But who will stop, or restrain, their pumping? Those individuals who try restraint would find that all they obtained by their forebearance was a lesson in the workings of the commons. If others do not curtail use, those who do so will have foregone water use and nonetheless experienced erosion of their water supply. These "volunteers" would end up as "suckers", cooperating while others defect.

Those who, on the other hand, increase their use of the ground water supply, like the herder who adds an animal to the common pasture, are able to spread the losses resulting from their conduct among all of the users of the commons while appropriating for themselves the benefits from their increased use of the commons. So, all users of the commons benefit from the restraint of individuals who act cooperatively by curtailing their use of the commons, while the cost of that curtailment is borne by the individual who exercises restraint. And all users of the commons share the losses resulting from the defecting behavior of those who increase use of the commons, while the benefit of that increased use accrues to the individual who increases use. This combination, which underlies the commons dilemma, along with the presumption that the users of the commons are utterly self-regarding, leads to the twin conclusion that (a) the defecting strategy of increasing use dominates the cooperative strategy and (b) the degree to which the defecting strategy dominates the cooperative strategy increases with the number of players. (39) Nevertheless, if all users of the commons pursue their defecting choice, all end up worse off than if all would have pursued their cooperative strategy. The commons dilemma game, too, results in a deficient equilibrium.

The logic of the n-person Prisoner's Dilemma game or commons dilemma game, the "logic of collective action," and "the inherent logic of the commons" all point to one conclusion: individuals will not cooperate in their use of a common resource and will indeed pursue strategies that lead to the destruction of the resource. In the groundwater basins of the Los Angeles area until the middle third of this century, the "inherent logic of the commons" appeared indeed to be well on its way to "remorselessly generating tragedy". Drawing from the different analyses of a commons as a problem of collective action or as a "social dilemma", the only prediction to have been made would have been that the ground water supplies would be depleted and destroyed, with severe consequences for the Los Angeles area. The users of the ground water supplies were in a "trap", seeking their own interest and realizing their collective detriment.

D. The Plan of the Remainder of the Study

As a result of the structure of the situation faced by ground water users - - the trap they were in - - problems in some of the Los Angeles area groundwater basins had become acute by the close of the 1920s. Water levels fell, pumping lifts increased, wells were abandoned, compaction occurred, and sea water intruded along the Pacific coast. The extremely valuable underground water supply system of the area was under threat.

The identification of the problems of a ground water basin as the problems of a commons, and the identification of the commons with the problem of collective action and with the Prisoner's Dilemma game, leave little hope that the difficulties encountered in the ground water basins of the Los Angeles area would have been successfully overcome. Indeed, the anticipation would be that the problems in the basins would only have grown worse over time.

What, then, was to be done? How would a group of resource users get out of the trap, and change an endangered resource to a managed resource? Scholars concerned with resource issues have made recommendations for resource management policy. We shall review and consider the two principal sets of recommendations, each of which advocates institutional change to convert resources away from common-pool ownership and management. One set of recommendations proposes converting common-pool resources to public property with centralized public management. The other set of recommendations proposes converting common-pool resources to private property with individual management.

Neither of these sets of recommendations satisfies, because of difficulties inherent in their arguments and because neither path out of the trap was followed in the ground water basins that are treated in this study. We turn, then, to another set of scholars who have proposed that common-pool resources can be used successfully without either a central public manager or private division of the commons. Their conditions for the successful maintenance of a commons are reviewed and considered, and the difficulties of their formulation considered in light of practical considerations involved in the use of a common-pool resource.

After the work of other scholars has been reviewed and considered in Chapter Two, Chapters Three and Four present an alternative approach to the understanding of commons problems and of the possibilities for their resolution. This alternative approach focuses on the users themselves as actors within the context of a community, with opportunities and constraints presented by their institutional setting for altering the rules in use for regulating the use of a common-pool resource, without the imposition either of public management or of privatization. This is more nearly descriptive of the actual occurrences in four groundwater basins described in the study.

Chapters Five through Eight present four case studies of Los Angeles area ground water basins, each of which faced critical overdraft conditions in the middle of this century, and none of which is in critical overdraft condition today. Chapter Five describes the case of the Raymond Basin - - a relatively small, relatively confined groundwater basin at the foot of the San Gabriel Mountains, underlying the Pasadena area. Chapter Six gives an account of the West Coast Basin - - a coastal ground water basin in Los Angeles County that experienced overdraft and sea water intrusion and from which hundreds of individual entities extracted water. Chapter Seven adds the case of Central Basin - - a larger basin in south central Los Angeles County, extending from Los Angeles to Long Beach, supporting millions of people and hundreds of water producers. Chapter Eight describes the Orange County case - - a coastal groundwater basin that experienced both overdraft and sea water intrusion and which extended beneath an area that witnessed explosive growth and rapid urbanization between 1920 and 1980.

Why use these groundwater basins, clustered together in the Los Angeles area, as case studies with which to examine general propositions about common-pool resources? These basins were selected for the following set of reasons:

(1) because groundwater basins illustrate especially sharply the difficulties users of a commons may encounter as they endeavor to overcome the obstacles and threats of their situation, among which difficulties are lack of

information about the boundaries of the resource, lack of information about the full set of users, lack of information about the conditions and characteristics of the resource, difficulty in observing the actions of other users, and the physical transmissibility of external effects of users' actions upon one another;

(2) because the stakes involved in the choice between preservation and destruction of these ground water basins were enormous, given the size of the population and the economic community which depended upon these resources, thus rendering this choice a non-trivial problem;

(3) because detailed information about the conditions of these basins and the actions of users during the period of the study has become available, whereas such information might be less accessible or less complete for resources in another part of the world, thus forcing greater reliance on inference and impression in lieu of firm quantitative data (40);

(4) because the very fact that the case studies are all ground water basins within the same general metropolitan area aids in eliminating several possible sources of confusion in making comparisons across cases (such as problems of comparing different resource types, differing cultures, different legal systems, and so forth), thus sharpening the comparisons among the cases on those variable which theoretical work has identified as important to commons problems;

(5) because the similarity among the basins in environment occurs within a setting such as California, which has a strong home-rule tradition of allowing local populations to formulate differing approaches to local problems, thereby generating the possibility of a variety of attempted solutions to these commons problems within a shared cultural, legal, and physical context. (41)

Conclusions from the alternative approach of Chapter Three and Four and the case studies of Chapters Five through Eight will be presented in Chapter Nine. Throughout the study, the emphasis is upon the commons as a real problem faced by real people for whom relevant theoretical considerations may be useful, and not upon the commons as an interesting theoretical exercise for which real commons problems are "applications". The vegetable grower, the refinery workers, and the municipal water department staff need a way out of their trap, and theoretical political economy is at its best when it understands and helps.

Notes to Chapter One

1. Coe (1986), p. 4.

2. California, State of, Department of Water Resources, West Basin Reference Continuance-- Report of Referee, 1961, p. 16 (hereinafter referred to as "1961 West Basin Referee Report").

3. Anderson, Burt, and Fractor (1983), p. 229.

4. See Coe (1983), p. 3 and (1986), p. 6.

5. Meyer (1950), p. 5.

6. E. Ostrom (1965), p. 105.

7. California, State of, Department of Water Resources (1968), Planned Utilization of Ground Water Basins: Coastal Plain of Los Angeles County, Bulletin No. 104, p. 9 (hereinafter referred to as "DWR Bulletin No. 104"). Note that an acre-foot is a unit of measure of water equivalent to the amount which would cover one acre of area standing one foot deep. It is equal to approximately 360,000 gallons of water.

8. I am indebted to Vincent Ostrom for this observation.

9. E. Ostrom (1965), p. 107.

10. Coe (1986), p. 12; Meyer (1950), p. 7. The construction and operation of the Owens River Aqueduct has been a subject of considerable controversy. On these issues, see V. Ostrom (1953).

11. This point is also stressed in E. Ostrom (1985b), p. 4.

12. Samuelson (1954); Head (1962).

13. Ostrom and Ostrom (1978), p. 12.

14. Ibid., p. 13.

15. See also Blomquist and Ostrom (1985), p. 383.

16. Minasian (1979).

17. Dorfman (1974), p. 7.

18. Schelling (1978), pp. 27-28.

19. Hardin (1968), p. 1244.

20. Muhsam (1977), p. 37; see also Ostrom and Ostrom (1977), p. 157.

21. Hardin (1968), p. 1244.

22. Olson (1965), p. 1; also, R. Hardin (1982), p. 2.

23. Olson (1965), p. 2.

24. See, for example, Plott and Meyer (1975), p. 66.

25. Olson (1965), p. 34.

26. Ostrom and Ostrom (1977), p. 159.

27. _Ibid_., pp. 28-29.

28. _Ibid_., p. 63.

29. _Ibid_., p. 3.

30. _Ibid_., p. 43; see especially E. Ostrom (1987).

31. _Ibid_.

32. _Ibid_., p. 50; emphasis added.

33. _Ibid_., p. 12.

34. _Ibid_., p. 44.

35. R. Hardin (1982), p. xiii.

36. See Samuelson and Messick (1984), p. 3.

37. Dawes (1973), _passim_.

38. Blomquist and Ostrom (1985), p. 383.

39. Dawes (1973).

40. See Weatherfor et al. (1982), p. 17, on the uniqueness of the role of the California Department of Water Resources as a supplier of professional expertise and reliable data.

41. E. Ostrom (1965), p. 88; Rolph (1982), p. 16.

CHAPTER TWO

PLAYING WITH TRIGGERS, COERCIVE FORCE, AND PRIVATE PROPERTY: COMMONS PROBLEMS AND THEIR TREATMENT BY SCHOLARS

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"A vision of the best has all too often proved the enemy of the good."
Carruthers and Stoner (1981), p. 45.

The analysis of resource management issues as problems of the commons, and the identification of the commons with the problem of collective action and with the Prisoner's Dilemma game, presents researchers with a problem. Individually rational choices lead to collectively undesirable outcomes in Hardin's commons, Olson's collective action problem, and game theory's Prisoner's Dilemma. These three models of resource problems have been treated as interchangeable -- indeed, as one and the same -- despite their inherent differences and the differences in the actual situations described. Through these metaphors, such diverse problems as urban crime and depletion of fisheries have been united as a single "problem." (1)

A. The Two "Solutions"

Analytically-trained researchers are likely to look at any "problem" as being in need of a "solution." Upon identification of the commons/collective action/Prisoner's Dilemma problem, it appeared to various scholars that we needed <u>a solution</u> for <u>the problem</u>. However, <u>the</u> solution turned out to be different for different scholars. One approach, suggested by a number of scholars, "involves the establishment of a superordinate authority to manage resources in the best interests of the group." (2) This idea of a public "manager" for the commons was countered by other scholars who advocated the transformation of the resource from common property to private property, to be used by individual owners.

The differences among scholars are rooted in differing agendas and differing views of the objective to be attained. It was partly a reflection of the prevailing political agendas of the times that scholars directing their attention to the commons in the late 1960s and early 1970s called more frequently for governmental intervention, while in the later 1970s and early 1980s, "in tune with a more conservative political cast to public policy in America, the same problems, also codified as 'tragedies of the commons,' trigger discussion of another solution: privatization." (3)

The presence of two principal "solutions" in the literature and of a persisting debate between them, however, reveals that more is at influence than merely the prevailing political winds. There is the additional element of scholars' perceptions of what "the problem" is, and thus of the objectives of public policy. The problem, to some, may be perceived as the destruction of the resource, and the aim is preservation of the resource in perpetuity. Alternatively, the problem may be perceived as inefficient use of the resource, and the aim is efficiency regardless of whether efficient use results in depletion of the resource. Serious value conflicts are involved in the differences between these positions. As one writer described it, "It is not surprising that discussions involving the management of common pool resources often resemble religious arguments conducted by non-theologians." (4)

A. 1. Public Management of the Commons

Perhaps the most prominent non-theologian is Garrett Hardin, whose 1968 article energized scholars' attention to the commons. Hardin, described by one pair of authors as an "intellectual descendant" of Hobbes, "saw the centralized authority of government as the main remedy to the shortcomings of decentralized choice." (5)

Hardin's reasoning is as follows. Our reliance upon the belief that the rational decisions of individuals seeking their own self-interest will also inure to the benefit of the community in general has led us to organize decision-making about resource use in as non-centralized a manner as feasible. The limits of feasibility may be broader, however, than the limits of good sense if the self-serving decisions of individuals do not always work out for the best of the community. (6) Our reliance upon the beneficent "invisible hand" may be especially misplaced with respect to the use of limited resources, for there is a discrepancy between the time horizons of individual economic actors and the time horizon of a population that depends upon those resources. "The theory of discounting, using commercially realistic rates of interest, virtually writes off the future," reasons Hardin, "How soon is it [i. e., depletion of the resource] so? 'In the long run', an economist would say, since disaster is more than five years off. 'In the short run', according to biologists, since disaster occurs in much less than the million or so years that is the normal life expectancy of a species." (7) We are mistaken, according to Hardin, in letting individuals make calculations about resource use, because the commons is posterity's property, not ours. (8)

The maximization of individual freedom in the use of common resources must be re-examined, and is ultimately indefensible. Freedom in a commons is at best an illusion: "Individuals locked in to the logic of the commons are free only to bring on universal ruin." (9) At worst, freedom in a commons is the accelerator of destruction: "Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all." (10) Freedom must be "traded off", or given up, for the sake of the preservation of the common resource.

Definite social arrangements that secure the preservation of the common resource will infringe personal liberty, and will restrain or eliminate some persons' access to the commons. Such "social arrangements that create responsibility," according to Hardin, for whom "responsibility" means "restraint", "are arrangements that create coercion, of some sort." (11) Not only freedom, but equity becomes jeopardized when social arrangements that create coercion are devised. Equity, too, may have to be "traded off" for the sake of the preservation of the resource. The various means of restraint available -- "selling off" the commons, or allocating rights of entry by auction, queuing, first come-first served, etc. -- will in some fashion alter the free and equal access enjoyed under the commons system. But, asserts Hardin, an "alternative to the commons need not be perfectly just to be preferable.... The alternative of the commons is too horrifying to contemplate. Injustice is preferable to total ruin." (12)

The alternative social arrangements, Hardin acknowledges, "are all objectionable. But we must choose --or acquiesce in the destruction of the commons." (13) How shall we choose? Hardin favors only "mutual coercion, mutually agreed upon by a majority of the people affected." (14) Such agreement is possible, because "everyone wants the collective good supplied, or, as in the case of Hardin's 'Tragedy of the Commons,' protected, [so] the centrally imposed policy may be unanimously supported." (15) People may, indeed must, come to realize that in "this crowded world of ours unmanaged commons are no longer tolerable," and the question turns to "how shall we manage them?" (16)

Although Hardin includes "selling off" the commons as private property among the possible alternative social arrangements, other statements indicate that this is not the approach he prefers. He notes that "the air and waters surrounding us cannot readily be fenced, and so the tragedy of the commons as a cesspool must be prevented by different means." (17) "Experience indicates", he writes, that restraint "can be accomplished best through the mediation of administrative law," with "custodians" administering resource access and use. (18) The change to this form of restraint must be instituted with "whatever force may be required to make the change stick... if ruin is to be avoided in a crowded world, people must be responsive to a coercive force outside their individual psyches, a 'Leviathan' to use Hobbes' term." (19) The coercive force of Leviathan must be accepted; "we do not have much time to save the world from galloping destruction. It is (as the ancient Chinese were fond of saying) later than you think." (20)

Garrett Hardin may accurately be called a seminal thinker on the issue of the commons; his work has spawned further work by both followers and critics. The "tragedy of the commons" reasoning leads directly for some to the necessity of public ownership and management, the conversion of common property to public property. Others link the commons to the Prisoner's Dilemma or the collective action problem and reason from there to the need for state intervention. Either way, the idea is that a central authority apart from the users of the resource themselves can "coordinate individual behavior to produce an 'optimal' level of negative and positive externalities." (21)

The statements of the advocates of public management are unequivocating. "It is clear", writes one, "that coercive solutions are required to save the commons." (22) William Ophuls declares that "because of the tragedy of the commons, environmental problems cannot be solved through cooperation... and the rationale for government with major coercive powers is overwhelming." (23) When "there is no agency with the power to coordinate or to ration use," adds John Baden, "action which is individually rational can be collectively disastrous." (24) Users' behavior adversely affects social welfare, generating a demand for governmental intervention," so "governmental action is required [in] the management of common pool resources." (25)

Particular application of this reasoning has been made to the area of groundwater resources. In a 1981 report for the World Bank, Ian Carruthers and Roy Stoner argued the necessity of governmental control on both efficiency and equity grounds. They assert: "Technological progress in the groundwater field, in terms of managing projects, is virtually limited to the public sector." Such matters as the design and operation of a conjunctive use of surface water supplies and underground storage "can be undertaken by a public authority, but cannot be done in the private sector." (26) If privatized, groundwater resources will be "monopolised by the few", and if left common, they will be "over-exploited by the many"; therefore, "there must be a degree of public control if equitable distribution is an objective and if the exploitation is to be managed and planned." (27) Public intervention "will be required to obtain a fair allocation of groundwater resources." (28) As for optimal use, "Common property resources require public control if economic efficiency is to result from their development"; (29) so, "some form of overall government control would provide the best compromise." (30)

A. 2. Converting the Commons to Private Property

Not surprisingly, the call for public control and management of the commons has elicited criticism. The emergence of the "new resource economics" has posed a challenge and an alternative to the public-management approach. If the public-management advocates are "intellectual descendants" of Hobbes, their critics might trace their lineage to Aristotle, and his observation that "that which is common to the greatest number has the least care bestowed upon it." Their alternative "solution" to the commons is to convert common property to private property.

The new resource economists are concerned that the true values of the resource and its appropriable supplies are not reflected by the cost to users of using the resource -- hence, what is undesirable is that the resource is being used inefficiently. "Common and usufruct policies are inefficient" (31), according to W. P. Welch, because "[c]ommon property is, in general, overused" and "[u]sufruct property- is not necessarily put to its most valuable use." (32) Any system of property other than full-ownership private property generates problems. Robert Smith states, "it is clear that the problem of overexploitation or overharvesting is a result of the resources being under public rather than private ownership. The difference... is a direct result of two totally different forms of property rights and ownership: public, communal, or common property vs. private property." (33) Smith amplifies this difference by means of a series of illustrations:

> Why do cattle and sheep ranchers overgraze the public lands but maintain lush pastures on their own property? Why are rare birds and mammals taken from the wild in a manner that often harms them and depletes the population, but carefully raised and nurtured in aviaries, game ranches, and hunting preserves? Which would be picked at optimum ripeness, blackberries along a roadside or blackberries in a farmer's garden? (34)

Forms of ownership other than private property are associated, by the reasoning of the new resource economists, with the following problems: an underestimation by users of the costs to them resulting from their consumption of its appropriable yield; interdependence among users resulting in uncompensated externalities; and, a political or other basis for decision-making rather than an economic basis for decision-making about resource use. The source of these problems is not the absence of property rights. Indeed, as Dorfman points out, in Hardin's commons, there is not a paucity of absolute rights, but a superfluity of them, which "when exercised, turn out to be incompatible." (35) And public ownership, as well, is not an absence of property rights, as Bish has noted: "public ownership means that some political official is going to decide by whom, how, and how much a resource is used.... That is, the political official rather than the private owner has been assigned the property rights." (36) Anderson and others note that although water supplies are indeed scarce and finite, and demands are increasing, "it does not follow that centralized regulation is necessary." (37) This is especially so since the setting of water prices by political agencies makes it "unlikely that necessary price increases will occur." (38)

The problem is not the absence of property rights, but of the correct kind of property rights -- full-ownership, well-defined, transferable individual property rights. What is needed is the privatization of the commons, so that each user is protected in his share of the commons and can respond to market signals that accurately indicate the value of that share. Economic reasoning suggests that each individual owner will then seek to maximize the present value of his share. This does not necessarily mean that each individual owner will preserve his share - - if the present value of that share is maximized by depleting or destroying it, that is what the owner will (and, by this reasoning, should) do. With respect to a particular resource such as a groundwater basin, the privatization advocates would support assigning rights to the stock as well as to the flow -- thus, if at some point the value-maximizing course of action would be to deplete the basin's water stock, individuals would be not only permitted, but protected in their rights, to do so.

The advocates of converting common property to private property are as unequivocating in their assertions as are the advocates of public ownership and management. "The crucial element of resource dilemmas, interdependence among users, is eliminated by privatization," according to two authors summarizing the privatization argument; "the costs of overconsumption of the resource are visited solely upon the private owner." (39) So, "individuals will reap the benefits and bear the costs of their decisions and actions." (40) And this will lead to the best possible use of the resource, such as the classic common pasture: private ownership would

> surely eliminate the overgrazing on the land.... Once this step is taken, the private owners of the land have an incentive to restrict the usage of the scarce resource to socially optimal levels. Land will be used efficiently; total social product will tend to be maximized by the private utility-maximizing behavior of individuals. (41)

Not only will privatization yield these beneficial results, it is essential to the avoidance of the problems associated with resource exploitation. According to Welch, "the establishment of full property rights is <u>necessary</u> to avoid the inefficiency of overgrazing." (42) And Smith makes the same claim even more forthrightly: "Both the economic analysis of common property resources and Hardin's treatment of the commons suggest [that] <u>the only way</u> to avoid the tragedy of the commons in natural resources and wildlife is to end the common-property systems by creating a system of private property rights." (43)

The usual reasons cited by privatization advocates for the failure thus far to convert natural resources and wildlife to private property are political feasiblity and transaction costs, which is a "catchall phrase" for "everything from technological constraints on establishing rights to information and negotiation costs." (44) There is no doubt that the conversion of the commons is the proper path: the "real problem" of groundwater, for instance, is the failure to assign "proper water rights," and "the creation of a legal system capable of defining and enforcing individual groundwater rights is the relevant agenda." (45) W. P. Welch concerns himself primarily with the means by which a private-property scheme could be introduced into a system of common resource usage. He finally identifies "grandfathering" as "the most promising" of the feasible alternatives (46), but his conviction of the necessity of privatization is unwavering. "Welch is convinced that division of the commons is the optimal solution for all common-pool problems. His major concern is how to impose private ownership where considerable opposition exists among those currently using a commons." (47)

A. 3. Discussion: The Problems of Package Solutions The relative merits of these alternatives -- administrative management of the commons as public property or the division of the commons into private properties -- can be and have been debated extensively. The debate between these positions can be useful, from the standpoint of clarifying concepts and raising issues about the desirability of certain outcomes. One does pause, however, upon finding a literature in which opposed positions like these dominate. Each side offers its solution as not just best but as "the only way." One thing that is clear is that both cannot be right. Privatization cannot be "the only way" if public control is "required" and vice versa. One group may be right and the other wrong, or both may be wrong, but something and someone is in error somewhere. So we turn to an examination of the difficulties involved in the two "solutions." While there are significant contrasts in these positions, they share remarkable similarities. The first such similarity is the focus on <u>outcome</u>, on "the solution" to commons problems. The particular outcomes advocated differ widely, but the arguments share an important presumption. They presume an omniscient regulator who oversees the commons, identifies a problem of overuse, and alters the situation to match the advocated solution. It is fairly clear that such a presumption underlies the public-management argument. Privatization advocates favor privatization partly because of Hayekian arguments about the preferability of market options that do not rely on omniscience. Nonetheless, they argue for the creation of property rights and a market in such a way that specifies what the outcome should look like in advance and then presumes that a change from one system of property rights to another can simply <u>happen</u>. It is as though there were a switch to be thrown by someone who combines control of the situation with a solid background in the theory of property rights.

Both of the alternative positions in the current debate neglect discussion of the <u>process</u> for arriving at their respective solutions. Neither the public-management advocates nor the privatization advocates have written about how the people facing a commons problem might reach some workable resolution of their problem. This is of special concern when we acknowledge the possibility that those people do not begin with a full awareness of their problem, nor is such an awareness held by some external actor or regulator. The literature is filled with descriptions of end-states, and notably short on reasoning about the process by which interdependent persons lacking significant knowledge of their circumstances and acting without an omniscient regulator might work toward some means of preservation and efficient use of the resource they share.

Some account of the <u>process</u> of resolution of a commons problem is necessary whether the project undertaken by the researcher is description of actual resolutions or prescription of possible resolutions. A focus on outcomes is not instructive for either purpose.

The privatization and public-management literatures share another similarity in their neglect of the significance, characteristics, and problems of engaging public authority. Either of the alternative "solutions" advocated in the literature involves a change in the structure of property rights to the common resource, whether it is a change from joint to public ownership or a change from joint to individual private ownership. Both types of advocates presume that an external public authority will re-define rights through condemnation or division, and will enforce whatever structure of rights ensues.

The public-management advocates necessarily acknowledge the involvement of public authority, but neglect the significance and problems entailed in the use of public authority. There is no acknowledgement of the variety of organizations of public authority that could be engaged, and of the significant differences among various forms. Hardin favors an administrative approach for its speed and flexibility relative to legislation. He shows no interest in other possible forms of public authority. Hardin advocates "mutual coercion, mutually agreed upon" through the use of coercive devices such as taxation or other "social arrangements that produce responsibility." The problem of public authority this raises is the boundary problem. Who shall be the persons involved in mutually-agreeing upon their mutual coercion? Who shall be taxed to pay for the public management of the commons, and who shall receive the benefits of that management? Different organizations of public authority will generate different answers to these kinds of questions.

Privatization advocates also tend to overlook the significance and characteristics of public authority, though some of its problems are certainly recognized, as they form the basis for the privatization argument. The work done in the area of public choice in recent decades on the motivation and the behavior of politicians and bureaucrats generates a large part of the privatization advocates' reasons for preferring the creation of private property rights and markets to deal with the use and distribution of a common resource. Here the questions arise: how shall such rights and such a market structure be created, and who shall be involved in the creation? How shall these rights be enforced, and adjusted if necessary? Are the public-choice observations about bureaucrats and politicians applicable to all possible organizations of public authority, or are they tied to certain forms?

The privatization advocates contend that private market transactions will generate efficient use of the resource, but they neglect the essential observation that "private" market transactions are heavily dependent on public authority. A system of private property rights can internalize externalities only if there is a system of law to which parties can resort when damaged by another's actions. A substantial public infrastructure of rights definition and enforcement undergirds their creation and transfer. How does a system of private property rights "occur?" One of the lessons of Mancur Olson's work is that, just as political scientists have had a weakness for taking public agencies as a given and not inquiring into issues of their creation, so too economists have had a weakness of imagining that if the benefits of a potential social arrangement outweigh its costs, it will be created.

Further, how does one assign rights to a commons that no one can define, i. e., the boundaries and production characteristics of which are unknown? A tremendous amount of information is simply assumed by both positions in the literature, and the information assumed is in fact highly complex and likely to be difficult to obtain.

There is another notable similarity to the alternative positions of the public management and privatization advocates. In order to reach a set of conclusions specifying the solution to commons problems, these scholars necessarily diminish the significance of the variety of commons problems and the variety of resolutions of such problems that have already been reached throughout the world. At the very least, one should be wary of pursuing a singular solution for a set of problems as varied as commons problems, which run the gamut from wildlife to watersheds, from budgets to bridges. Proceeding more cautiously, even in the face of Garrett Hardin's warnings of impending ecological doom, may be desirable, bearing in mind Roland McKean's caveat that while pursuit of a single approach to a problem may be undertaken with rigor and precision, we may end up like the man who, by running very fast, succeeds in jumping aboard the wrong train.

Juxtaposed with a literature that proposes the solutions for commons problems is a history of many resolutions that usually lie somewhere between the extremes of complete public management or complete privatization. They display a remarkable amount of flexibility and "tailoring" of resolutions to the actual commons situations. Actual commons situations vary according to the technical characteristics of the resource, but also according to the size, customs, and institutions of the community of users. Neither the privatization nor the public-management literature has been informed by a sensitivity to the variety and specificity of actual commons resolutions and of the processes that resulted in such resolutions.

These problems - - a focus on outcome, failure to engage the issues of public authority, and the imposition of a single "solution" on a variety of problems - - are shared by the privatization and the public-management camps. Each of these literatures can be consulted for statements of the weaknesses of the other. Only two problems, one for each, will be dealt with separately here in closing.

The privatization advocates show little concern for the distributional consequences of their favored reforms. Forced enclosures of the commons do not have a happy history, especially in developing nations, where wealth inequalities are more disparate and where many current resource problems occur. Efforts to impose private property schemes have failed in many cases. "In addition to failing to stop overuse, in many cases they have contributed to further inequality in already unequal distributions of wealth." (48) In the foreboding words of Kenneth Boulding: "If we privatize the commons, we will create an upper class who owns and administers it. It will be administered well. There will be no overgrazing." (49) There may also be no access for people whose subsistence in the past was derived from the commons.

The public-management advocates have in large measure drawn their conclusions and prescriptions from Garrett Hardin's description of the "tragedy of the commons." In the course of that description, Hardin argued (as noted earlier) that we must be willing to "trade off" both freedom and justice (by which he appears to mean equity) for the sake of another value, namely, the preservation of the commons. Hardin does not propose any criterion of choice, leaving us with a question: is it always the case that wherever and whenever we encounter a commons problem, we. should give up whatever amounts of freedom and justice will allow us to save the commons? If not, is Hardin's advocacy of such a trade-off advanced because he perceives the population problem as qualitatively different from other commons? And if this is so, what then is the general applicability of his analysis? The public-management advocates who have favored turning the commons over to a central manager have based their arguments upon Hardin's portrayal of the "tragedy"; does it follow from that portrayal that any and all commons problems must be handed over to Leviathan with "whatever force is required to make the change stick"?

B. Loading the Question and Pulling the Trigger: The Institution-Free Approach

The Leviathan solution has troubled other scholars. Some of these scholars have been interested in pursuing whether the users of a common pool resource might achieve a cooperative joint use of the resource without formal institutions for resource management, either private property rights or a central manager. The pursuit of this alternative has been undertaken to address the question of whether the commons dilemma is in fact, as it appears on its face, insoluble. If it is not, then neither of the two nostrums prescribed in the public-management vs. privatization debate may prove to be the only palliative. The "institution-free approach" relies upon conditional threat strategies employed by the users against one another to keep each other from over-using the commons, with each user as the enforcer of his own threat.

B. 1. Mutual Assured Destruction as Resource Policy The threats involve, speaking metaphorically, taking the commons itself hostage and threatening to destroy it if another user harvests more of the appropriable yield of the resource than the resource itself can generate in any harvesting period -- this is the "sustainable yield" or "safe yield" of the resource. The users endeavor to attain an optimal level of harvesting by appropriating in any time period the entire safe yield of the resource, but no more than that safe yield, since appropriating more than the safe yield would damage the renewal or regeneration capacity of the resource, resulting in a reduced appropriable yield in subsequent periods.

Users of the common pool resource are presumed to be appropriating the yield of the resource for their own gain, but they look beyond the present time period in calculating their gain from the use of this renewable resource. They value not only their current harvest, but an entire stream of earnings resulting from use of the resource, now and in the future. Because they gain from their appropriation of the use-units yielded by the resource, each user would prefer to have a greater harvest in any given period; nonetheless, each user also desires to be able to appropriate a yield from the resource in the next period, and the next, and so on. The utility derived from these future harvests is discounted to reflect time preference and the uncertainty users have about their future, resulting in a present discounted value calculable for different harvesting strategies.

Provided that the future is not discounted so strongly as to be largely eliminated from consideration, users may find that a particular conditional strategy offers the highest present discounted value. In the language of game theory, such a strategy is a "Friedman strategy," and it takes this form: cooperate in the first time period (i. e., by restraining one's harvest) and cooperate thereafter as long as others do, but defect (i. e., maximize one's harvest) in <u>all</u> succeeding periods if any other player defects in a period. (50) Such a strategy has the following virtues: (a) as long as cooperation is received from all other players, the player pursuing this strategy obtains his share of a sustainable level of harvest (i.e., such that the total harvest of all players equals the maximum sustainable yield of the resource) in this and all future time periods; (b) if cooperation fails, the player pursuing this strategy avoids the "sucker's payoff." Each succeeds in capturing his own maximum from the resource as it is being depleted and destroyed. Recalling the payoff structure of the Prisoner's Dilemma game, one finds that this strategy is desirable because the payoff to a player from cooperating when others cooperate is greater than the payoff from defecting when others defect, but the payoff from defecting when others defect is greater than the payoff from cooperating when others defect.

The availability of conditional strategies such as the Friedman strategy makes joint cooperation a possibility in a Prisoner's Dilemma game that has a future. The Friedman strategy may also be described as a "trigger strategy." The player following such a strategy cooperates while, figuratively, resting his finger on a trigger, prepared to pull that trigger and destroy the hostage commons by defecting if he perceives a "first-strike" defection from another player. It is a strategy of "mutual assured destruction" --if you over-harvest the resource once, I'll over-harvest it from then on and impose even greater losses on you than you imposed on me by playing me for a sucker. The application of this "mutual assured destruction" approach to a hypothetical example of an ocean fishery as a commons has given us the "cold fish war."

Just as there are those who would argue that the adoption by both superpowers of a strategy of "mutual assured destruction" has kept the peace for three decades now, so too the scholars who have written about the "cold fish war" show that this "trigger strategy", when played in the commons dilemma game, yields an indefinitely-extended "cooperative" equilibrium in the joint use of an open-access fishery. The "cold fish war" model is presented in an article by Lewis and Cowens, who draw from it the possibility of "individuals efficiently utilizing common property without the aid of a regulatory body to oversee their activities." (51) Those users of the commons "could construct cooperative schemes for conserving the resource that are self-policing. The incentives for one user to deviate from the cooperative arrangement would be eliminated by the threat of retaliation by others." (52)

This seems a happy result -- cooperation in the joint use of a commons without paying the costs of either a central manager or of privatization. How does it come about? The reader may already have a question in mind, which it is now time to address. Granted that the payoff from cooperate-cooperate beats the payoff from cooperate-defect, what ever happened to the "temptation" payoff from defect-cooperate? The answer to this question, and to the immediately-preceding question of how this cooperation without institutional change comes about, resides in a set of assumptions made about the users of the commons. (53)

The first and most important assumption is that the users are identical. This assumption drives the proof more than halfway home. Each user of the commons uses it in the same way and in the same amount, derives the same benefits from use, and has the same utility function, rate of future discount, and array of available strategies. Therefore, analysis of the best strategy for a single user yields the best strategy for every user. If there are N users, each user is entitled to 1/N of the maximum sustainable yield as his harvest in a given period. There is, therefore, no difficulty in determining shares of the total harvest. This assumption is necessary for the proof of a sustainable cooperative self-policing scheme to work; we may call it the symmetry condition.

If each user is entitled to 1/N of the total harvest, which is set equal to the safe yield of the resource, the question remains, what is 1/N of the total harvest? A second assumption at work in the "cold fish war" is that each user has complete information about the situation and the resource, and processes this information without error. Users know the capacity and growth rate of the commons, and therefore know perfectly its safe yield. Users also know the total number of users, N, and so can relatively simply calculate their sustainable share, which is 1/N of the safe yield. In addition, somewhat trivially, users know the sustainable shares of all other users, by symmetry, since they know their own. Users also know the amount by which they would increase their harvest if they were to defect from the cooperative arrangement, and so they also know the depletion of the resource that would occur if every other user defected from that arrangement. This assumption of perfect information and information-processing ability may be called the information condition.

How do users signal their intentions to one another, so as to arrive at their cooperative arrangement? Such communication is abstracted away by the symmetry condition. Since each user knows what he intends to do, and since each user is identical, each user also knows what every other user intends to do. Communication is unnecessary, which is equivalent to assuming that communication is perfect and costless; this may be referred to as the communication condition.

But how does the cooperative arrangement work? Each user is a perfect monitor of every other user's actions, and this perfect monitoring is also costless. It is necessary, in order for the trigger strategy to work, that each user be aware if any other user harvests more than the 1/N of the safe yield that is his share. This is accomplished by assuming that each user accurately observes the total harvest in any period, compares it to the (known) safe yield, and thereby detects if someone has cheated by harvesting more than the allotted share. This is <u>the monitoring condition</u>.

Now with complete information, perfect and costless communication, and perfect and costless monitoring, the trigger strategy can be made to work. A user maximizes present value by harvesting 1/N of the safe yield in every period, while standing ready to defect and over-harvest if, in any period, the total harvest exceeds the safe yield. Or, at least, the trigger strategy works <u>provided</u> three more assumptions are met. First, the number of users must be large enough that their joint defection would deplete and destroy the resource quickly enough to weight the loss heavily in the present-value calculations of the users (far distant losses will receive little weight in the discounting process). Second, the discounting of the future must not be so great as to eliminate future losses from present-value calculations; otherwise, the game approaches a single-shot affair and complete use of the resource in the present becomes the value-maximizing strategy. Third, the rate of growth of the resource must be, in Goldilocks fashion, "just right"; if it is too low, the resource approaches non-renewability and harvesting only the "safe yield" becomes an inferior strategy to mining the stock, while if the growth rate is too high, cooperative sharing of the "safe yield" becomes trivial as the resource approaches the point of renewing itself whole from one time period to the next.

Now, if these three values all remain within their desired ranges, the individual user will adopt the trigger strategy as the strategy that maximizes present value. And, by the symmetry condition, every user therefore adopts this same strategy. That, then, is what happens to the "temptation payoff" from defecting while others cooperate -- it is driven out by the symmetry condition and the trigger strategy. If one user attempts a defection while others cooperate, his over-harvesting is perfectly and costlessly detected by every other user, each of whom has adopted the same strategy of retaliating against defectors; so "the cooperative agreement breaks down, and in the next period all fishermen revert to permanently pursuing their noncooperative... strategies." (54) The weighted stream of future losses, calculated together with the benefit in the one time period from overharvesting while others exercise restraint, yields a present value that is lower than the present value of the cooperative strategy. The breakup of the cooperative arrangement harms all users, and more importantly, "the cheater would suffer after the breakup and this is intended to be a deterrent to his cheating." (55) In the cold fish war, mutual assured destruction eliminates the temptation payoff; it is no longer possible to defect while others cooperate and get away with it. This leaves the individual user to choose among the remaining three options: cooperate while others do, defect while others do, or cooperate while others defect. Of these three, the most advantageous (under the cold fish war conditions) is cooperating while others cooperate. Therefore, with N fingers on the trigger, joint use within the safe yield of the common resource is sustained by a self-policing deterrent strategy.

B. 2. Discussion: The Unreality of the Cold Fish War

The necessary conditions for the working of the institution-free cooperative arrangement known as the cold fish war are extreme, to say the least. To ask how identical users with perfect information, perfect and costless monitoring, just the right discount rate, size of group, and growth rate of resource can develop a cooperative arrangement is to load the question before pulling out the trigger strategy. Lewis and Cowens acknowledge that the "requirement of perfect monitoring is too strong to be realized in practice, particularly in a stochastic environment," and the effect of this is that it "may not be possible to enforce perfectly cooperative behavior using deterrent strategies with imperfect detection." (56) They suggest that some less efficient or second best outcomes may nonetheless be attainable if this assumption is relaxed.

However, there are even more necessary conditions than this one at stake. For example, as pointed out by Bendor and Mookherjee, the trigger strategy also requires absence of uncertainty about the connection between effort and output. Attempted restraint must result in actual restraint; accidentally large "catches" are not allowed. For if we allow the perfect monitoring condition and relax this absence of uncertainty condition, and make the relationship between effort and output probabilistic, the trigger strategy as an effective punishment mechanism falls apart. (57) In the absence of uncertainty, "retaliation will never be triggered by mistake. But in the more realistic uncertain setting, a group that uses this 'grim' strategy is a political disaster waiting to happen." (58) A commons-management system so unforgiving that it would destroy a valued resource due to a trembling hand is not desirable if human fallibility is recognized as part of reality. Not just a cheat, but a stumble, with N fingers on the trigger, produces destruction. The "cold fish war" is not only unattainable; if attainable, it is undesirable.

But even more, the cold fish war is not useful, in the sense of being instructive, for the actual users of an actual commons. Consider another condition -- the information condition. Conditional strategies and self-policing sanctioning mechanisms "require some perfection of information on the part of the actors." (59) These information requirements are not only "very restrictive", (60) they render a model based upon them of very little utility for people facing real commons problems. Of course, in a model that does not contain an information source and excludes the consideration of institutions, it is necessary to assume that users of the commons already hold all necessary knowledge. "They begin their participation in the use of the commons already comprehending all that is important to their decisionmaking." (61)

Yet, in an actual commons situation, it may be precisely their lack of information about each other and about the resource that presents an obstacle to the users in developing some form of commons-sharing arrangement. The hopefulness that might first be experienced in reading the work of scholars who show by means of a proof that a joint cooperative commons-sharing arrangement is possible without an external regulator or privatization is quickly deflated once it is discerned that a necessary condition for such an arrangement is that the users already know everything about each other and the resource. The remainder of the "cold fish war" solution is silent to them once this nearly impossible condition goes unsatisfied;

the problem they face is not whether or not to harvest their fair share of the safe yield, but to begin even to learn what the safe yield _is_.

This is the difficulty with the literature on the commons, from the public-private debate to the institution-free approach: it is largely meaningless to people facing actual commons problems. This is not because of academic language; academic language can always be translated for the non-academic. Even when the mathematics of the cold fish war are translated into ordinary language, even when the marginal private cost and marginal social cost curves of the privatization advocates are turned into lines of prose, even when the algebra of the tragedy of the commons used by those who call for Leviathan is unpacked and explained, they do not address the problem faced by the users of a commons. Their respective "visions of the best" do not aid in a search for the "good."

The most immediate problem users face is not whether to privatize their resource or turn it over to some central manager, but instead to find out what is going on, what the nature and dimensions of the resource are, and who are the users. "Solution" of their problems lies at the end of a process with many steps. An alternative approach that digs into the models and metaphors that are the bases for various prescriptions, that identifies the steps in the resolution of the commons dilemma and the institutional changes that must occur, may more directly address their problems, especially if it is able to account for the process of resolution of some actual commons cases. That alternative approach is the subject of the next two chapters.

Notes to Chapter Two

1. This insight owes to Elinor Ostrom.
2. Samuelson and Messick (1984), p. 4.
3. McCay and Acheson (1986), p. 2.
4. Baden (1977), p. 137.
5. Bendor and Mookherjee (1985), p. 3.
6. G. Hardin (1968), p. 1244.
7. G. Hardin (1977a), p. 113.
8. G. Hardin (1977b), p. 275.
9. G. Hardin (1968), p. 1248.
10. Ibid., p. 1244.
11. Ibid., p. 1247.
12. Ibid.
13. Ibid., p. 1245.
14. Ibid., p. 1247.
15. Bendor and Mookherjee (1985), p. 3.
16. Hardin and Baden (1977), p. xii.
17. G. Hardin (1968), p. 1245.
18. Ibid., p. 1246.
19. Quoted in E. Ostrom (1986b), p. 7.
20. Hardin and Baden (1977), p. xii.
21. Orbell and Wilson (1978), p. 412.
22. J. Anderson (1977), p. 41.
23. Ophuls (1973), p. 228.
24. Baden (1977), p. 139.
25. Ibid., pp. 137-138 (emphasis added).
26. Carruthers and Stoner (1981), p. S-3.

27. <u>Ibid</u>., p. S-2 (emphasis added).

28. <u>Ibid</u>., p. 29 (emphasis added).

29. <u>Ibid</u>, (emphasis added).

30. <u>Ibid</u>., p. S-4 (emphasis added).

31. Welch (1983), p. 167.

32. <u>Ibid</u>., p. 166.

33. Smith (1981), p. 444 (emphasis added).

34. <u>Ibid</u>., pp. 443-444.

35. Dorfman (1974), pp. 7-8.

36. Bish (1977), p. 223.

37. Anderson, Burt, and Fractor (1983), p. 224,

38. T. Anderson (1983), p. 3.

39. Samuelson and Messick (1984), p. 6.

40. T. Anderson (1983), p. 5.

41. Buchanan (1970), p. 57.

42. Welch (1983), p. 171 (emphasis added).

43. Smith (1981), p. 467 (emphasis added).

44. Anderson, Burt, and Fractor (1983), p. 236

45. Gisser (1983), p. 1009.

46. Welch (1983) , p. 167.

47. E. Ostrom (1985a), p. 3.

48. Runge (1983), p. 2.

49. Boulding (1977), p. 285.

50. Raub and Voss (1986), p. 91.

51. Lewis and Cowens (1982), p. 2.

52. <u>Ibid</u>.

53. This set of assumptions has also been reviewed in Blomquist and Ostrom (1985), pp. 385-386.

54. Lewis and Cowens (1982), p. 4.

55. Ibid., p. 5.

56. Ibid., p. 13.

57. Bendor and Mookherjee (1985), pp. 7-8.

58. Ibid., p. 12.

59. Raub and Voss (1986), p. 94.

60. Bendor and Mookherjee (1985), p. 8.

61. Blomquist and Ostrom (1985), p. 385.

CHAPTER THREE

THE COMMONS SITUATION: AN ALTERNATIVE APPROACH

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> there is no use wishing it were a simpler problem or trying to make it a simpler problem, because in real life it is not a simpler problem . . . . We may wish for easier, all-purpose analyses, and for simpler, magical, all-purpose cures, but wishing cannot change these problems into simpler matters . . . no matter how much we try to evade the realities and to handle them as something different.
>
> Jane Jacobs (1962), p. 434.

Thus far, we have discussed the problems associated with the use of groundwater basins (such as those underlying the Los Angeles metropolitan area) as instances of the problems of a commons. We have discussed common-pool goods as a particular type or category of goods, the commons and its relation to the collective action problem, the commons and the Prisoner's Dilemma game, the commons and the debate concerning public management vs. privatization, and the commons and the "cold fish war." With reference to the debate about public management and privatization and with reference to the "cold fish war" literature, we have also considered questions concerning those approaches to the resolution of a commons dilemma, and shortcomings of these approaches.

Consideration now turns to how we might build a better account of the nature of commons problems and of the resolution of commons problems. Another account is desirable because of the divergence between what empirical observation of the world discloses and what much of the reasoning from modelling of commons problems predicts. The conclusion to be drawn from much of the literature is that, in the absence of either unified public management or the conversion of the commons to private property, common resources will be destroyed, just as public goods will not be provided and just as players in a Prisoner's Dilemma game will not cooperate with one another. By contrast, in actual settings we find, in addition to resource overuse and destruction, a considerable amount of collective action and of sustained management of common property under a variety of institutional arrangements. (1) Indeed, "the presumption that one best form of institutional arrangement exists for all common-pool resource problems can be empirically falsified." (2) In southern California, for example, local entities engaged with water resource problems have devised a variety of institutional arrangements that have helped them preserve the groundwater basins and indeed to direct them to higher-valued use, and have done so without the imposition of a public-management solution by some central regulator, without privatizing the groundwater basins, and without "mutual assured destruction."

We cannot make sense of this variety of sustained commons management experiences within the prevailing analysis found in the literature on commons problems. The variance between actual experience and the predictions of analysts points indicates a need to try to reach more congruent formulations. So, since we cannot make sense of the actual experiences within prevailing analysis, and since we cannot gainsay that the actual experiences have occurred, we should study them. Data and natural experiments for the testing of theory are, to say the least, "hard to come by" (3), and when we have them, "we need to study such 'success' stories carefully." (4) Examination of actual experiences can contribute to theoretical development, while theory aids in identifying the relevant characteristics we look for in empirical settings. The sort of findings this process leads to is what Richard Fenno terms "limited generalizations" -- observations somewhere between presuming all cases to be alike and presuming each case to be unique. (5)

While prevailing analyses cannot make sense of many actual experiences, it does not follow therefrom that we must demolish and sweep away that which has been done before. We can form the desired better account of commons problems and their resolution by building upon the several positive contributions of the literature while recognizing simultaneously its limitations. We can incorporate information from sustained commons management experiences while recognizing simultaneously that some commons management attempts fail and some resources are destroyed. Such a formulation is termed here "an alternative approach", because it offers alternative conceptions for key elements of the existing commons literature:

(1) instead of a good and a game, an action situation structured by rules, attributes of the good, and attributes of the community;

(2) instead of a "solution," steps and rule changes in a process of resolution; and,

(3) instead of conditions, variables making successful resolution more or less likely.

In this Chapter, we shall reconstruct the commons as an interdependent action situation, an alternative conception to that of regarding the commons as a Prisoner's Dilemma game or of regarding the commons and its demise as determined by the nature of common-pool goods. In the Chapter to follow, we shall explore the steps of a process of resolution, changing the commons situation from one tending toward destruction to one of preservation and sustainable use, and the characteristics of various commons situations which render them more or less amenable to such changes.

The policy prescriptions of unified public management and privatization are based on the perceived hopelessness of the commons situation, which is in turn based on the ways we think about commons problems. The ways we think about commons problems have been built on: (a) reasoning from static analysis of the collective action problem and the Prisoner's Dilemma game, and (b) definition of the commons problem as wholly structured by the type of good in question. A more realistic, but admittedly more complex and less determinate, conception of the commons can be gained from dynamic analysis of the commons problem as generated by an interaction of attributes of the good with rules within the context of a community of users.

A. Dynamic Analysis: What a Difference a Play Makes

A static analysis of the incentive structure of a commons dilemma, which has been equated with the collective action problem and the Prisoner's Dilemma game, leads one to the dire predictions of Garrett Hardin's "The Tragedy of the Commons." The logic of the static, or single-play, commons dilemma, like the logic of collective action and the equilibrium outcome of the Prisoner's Dilemma game, is indeed undeniable. Each actor has an incentive to withhold cooperation and to defect in pursuit of his temptation payoff. Within the static context, pursuit of a cooperative strategy simply does not make sense.

To the extent that we have analyzed the use of common resources by reference to these static models, we have drawn the conclusion that common resources will be destroyed and that some intervention is required to convert the commons to something else - - a centrally-managed public property or individually-owned private property. We have accepted the notion that it is the commons that is the problem, rather than inquiring whether we have appropriately pictured the commons through the use of static analysis. In fact, reasoning from static models is problematic, on empirical and logical grounds.

Empirically, common-pool resources do not fit our static models well; neither do many actual collective action problems or experimental Prisoner's Dilemma situations. Typically, we face ongoing collective action problems and not once-only, isolated interactions (6). "An iteration of social interactions indeed appears to be a common empirical characteristic of our paradigmatic examples of problematic situations," such as commons problems. (7) The "interesting collective action problems are clearly dynamic in that they recur or are ongoing." (8) This is especially likely to be the case with common resources, which are not expected to be "raided" once and once only but rather to be used in a succession of time periods. In experimental constructions of social dilemmas, this disjuncture between the predictions from static analysis and actual or simulated behavior in iterated situations has been frequently observed. Application of a static analysis to an ongoing situation may produce misperceptions about what is actually going on, and what is to be expected as an outcome.

In addition to the suggestion from observation that static models may poorly fit empirical reality, there is a noteworthy logical difficulty in reasoning from static analysis, as well. The issue of "cooperating" vs. "defecting" becomes somewhat ambiguous if there is no future; there is, after all, no point in cooperating to save the commons if there is no future. To base ideas about the "solution" for commons problems on an analysis that presumes no future begs the question, for it is unclear what is to be "solved" if the game is to be played only once. Resolution of a commons problem is only worth pursuing if the common resource is to be used again and again. Under those circumstances, we need to consider ongoing behavior rather than merely the static incentive structure.

What difference, then, does repeated interaction make? Can we expect that more than one "play" of the social dilemma "game" will yield a different outcome? Dynamic analysis gives the actors in the game a past, in which interactions have occurred, and the results of particular choices have been observed. And, perhaps more importantly, dynamic analysis gives the actors in the game a future, so that present choices are evaluated in light of their implications for the coming iterations of play. (9) Of course, the future only makes a difference to the actors' choices if it matters to them; if actors discount the future heavily enough, any repeated choice situation collapses into a single-shot affair. (10)

Provided that actors value not only their present but their future, the analysis of the collective action problem and the Prisoner's Dilemma game does indeed change. In the single-play, or static, case, "collective action must generally fail unless it need not be collective at all," while in the repeated-play, or dynamic, case, collective action can succeed or it can fail. (11) In the Prisoner's Dilemma game, the "most striking result of iteration is that two players who should rationally 'defect' (that is, not cooperate) in a 2-person single-play game, commonly should cooperate in iterated play. In general, in an n-person single-play Prisoner's Dilemma, defection is narrowly rational. In iterated play it may not be." (12) Indeed, some have concluded that in the iterated n-person Prisoner's Dilemma, there is no dominant strategy to defect. (13)

In the dynamic view of a social dilemma, there is not just one choice to be made, but a sequence of choices. The outcomes are generated by the combination of the actor's choices. Thus, what one does may be affected by one's perception of what others will do, which may in turn be affected by information about what others have done in the past and by anticipation of how others will respond to one's own actions in the present, all of which affects what sort of future may be attained.

In repeated play, actors' choices may be contingent-- "indeed, may be <u>made</u> contingent"-- on others' choices. (14) One's best strategy "may be <u>learned</u> after playing for a while, because what is the best strategy depends on the behavior of other players." (15) Repeated play opens up the possibility for players to adopt contingent strategies in an effort to elicit cooperative responses from others, and opens up the possibility of learning over time that a more desirable outcome exists and may in fact be attainable. Cooperative actions, which simply make no sense in the single-play or static context, may become understandable as adaptations to iterated interactions, and may arise without the intervention of outside parties or some other exogenous change to the situation. (16)

We have, then, two vital conclusions to draw. First, on logical and empirical grounds, a dynamic view makes more sense as a way of thinking about commons problems than a static view. Second, within the analyses of collective action problems and Prisoner's Dilemma games, the change from static to dynamic analysis yields an important change in the predictions generated from those models, a change from predicted failure of cooperation to an indeterminate range in which cooperation might emerge, and then again might not. This is important to underscore: the change to a dynamic view does <u>not</u> mean that cooperation <u>will</u> occur and be sustained. (17) Dynamic analysis just opens up possibilities that are not available in the static case. And this indeterminacy, while it may prove frustrating to some, in fact suggests that we are approaching a more realistic conception of commons problems, since commons sometimes have been successfully maintained and in other cases have been destroyed.

B. Examining Game Structure: The Analytical Traps of "Social Traps"

Having noted the dangers of direct reasoning from static models to ongoing situations, we now move a level deeper, to the dangers of direct reasoning from models that are structured in one way to actual situations that are structured in another way. The analysis of commons problems and the prospects for their resolution has largely been centered on models of "social traps," such as the Prisoner's Dilemma and the collective action problem. We need now to consider the "fit" of these models to the kind of problem we are after, to see if our thinking about commons problems has itself been trapped by these "social trap" models.

We have described the so-called "commons dilemma" game as a particular form of the n-person Prisoner's Dilemma, which is itself described by Russell Hardin as the essential structure of the problem of collective action. The equating of these three situations -- the problem of the commons, the problem of collective action, and the Prisoner's Dilemma -- sounded the alarm for analysts of commons problems. Clearly, we needed some way out of the commons. After all, anyone could see that the commons was a Prisoner's Dilemma and thus that everyone would defect. Or so the reasoning went. There are, however, two faults with this reasoning: first, in its view of a Prisoner's Dilemma game as some sort of immutable structure, and second, in its identification per se of the problem of the commons with the Prisoner's Dilemma game so conceived.

In addressing the first of these problems, we refer back to the "cold fish war" (which is, it bears noting, a dynamic game). There are lessons to be carried away from the "cold fish war" literature, and built upon. While the institution-free, "mutual assured destruction" approach of the "cold fish war" may be impractical as a guide to action and undesirable as an outcome, that literature nonetheless makes a contribution to our thinking about commons problems and Prisoner's Dilemma games. The "cold fish war" unlocks the Prisoner's Dilemma game, removing its appearance of immutability. Those who have described the "cold fish war" have, through their combination of (admittedly unattainable) conditions, produced a situation where the choices available to the users remain unaltered, but the outcomes linked to those choices are altered. The alteration eliminates the outcomes yielding the "temptation" and "sucker" payoffs, which influence the likelihood of defection. (18) In the "mutual assured destruction" setting, it is not possible to defect while others cooperate, nor would any of the identical players cooperate while all others defect. This leaves each player with the possible outcomes of "all cooperate" (to which is linked the second-best payoff) and "all defect" (to which is linked the third-best payoff). In such a case, cooperating dominates defecting. (19) Thus, an indefinitely-extended cooperative equilibrium is induced by a change in the structure of the Prisoner's Dilemma.

What we take away from the "cold fish war" is a recognition that if the structure of the game is changed, without either the imposition of a central regulatory authority or the elimination of the commons through privatization, then the incentives facing actors, and the strategies they choose and the actions they take, may be changed also. There is, therefore, another sense in which the Prisoner's Dilemma represents a "trap". It is a trap in our thinking. The danger lies in viewing the game as immutable.

The Prisoner's Dilemma game, as normally conceived, has a structure, which is set somehow. This can be revealed by asking ourselves some questions about the game. For example, how did we arrive at "Player 1" and "Player 2", or "Player 1" through "Player N"? Why do they have only two choices, "Cooperate" and "Defect"? Where did these payoffs come from? Why are the choices made simultaneously, without communication, instead of sequentially with an opportunity to discuss and observe each other's actions? There are more such questions we could ask, but these suffice to make the point, which is this: the structure of a game is set by a combination of rules.

For any game, there is a stipulation - - a rule -- setting the exact number of players, or the maximum number of players, or the minimum number of players. There is a stipulation of the qualifications for entering the position of "player" (note that this includes the "default" possibility of there being no qualifications, which is an "anyone can play" rule). There is a stipulation of what choices are available for someone in the position of "player". There is some definition of what information players have, and whether and how they may obtain information from other players or other sources. There is a relation of actions taken by players to outcomes realized in the game. There is a relation of payoffs (benefits gained, costs incurred) from the possible outcomes. There is some stipulation of how many "rounds" of the game will be played. The game, thus, is established by a configuration of rules (20), and an alteration in a rule, or in a set of rules, can alter the actions taken by the players.

We shall return to the discussion of rules and their relation to the problem of the commons. For now, let us examine the set of rules which give structure to the Prisoner's Dilemma game. Typically, the players in the Prisoner's Dilemma have no capacity to communicate with one another and coordinate their strategies, have only a binary choice available ("Cooperate" or "Defect"), cannot observe the present choices made by other players, cannot enforce sanctions on other players whose behavior is socially defecting, operate within a isolated context such that the game itself is their only interaction with one another, and have no control over the structure of the situation, which is treated as a "given."

By contrast, let us bring to mind an actual common-pool resource in an actual setting (such as a water supply, a pasture, a forest, etc.). In such a case, the users of the common resource may come from some community in which they have diverse and multiple interactions with one another, can vary their use of the resource by degrees, may be able to observe and sanction each other's behavior, and may be able to communicate and perhaps even enter into agreements about use of the resource. If the use of the commons is to be conceived as an ongoing social situation (which, recall, it must be for resolution to be interesting at all), then the applicability of a model that presumes "no communication among the participants, no previous ties among them... and no capacity to promise, threaten, cajole, or retaliate" (21) may be quite limited.

A Prisoner's Dilemma is a _model_ of a particular situation structured in a particular way. The commons is not a Prisoner's Dilemma game any more than a voter _is_ a rational utility-maximizer or international conflict _is_ a computer simulation. The danger of direct reasoning from a model structured in a particular way to a situation structured in a different way is that we may be unable to account for the outcomes of that different situation because of our reliance on that model. The identification of the commons with the Prisoner's Dilemma can become part of our problem in understanding the commons, if we come to accept the model, a representation of reality, as reality itself. We may become, to borrow Tocqueville's phrase, like those who worship the statue and forget the deity it represents.

Before reasoning from the Prisoner's Dilemma to policy prescriptions for the commons, it is important to remember: (a) that the structure of a commons situation is not identical to the structure of a Prisoner's Dilemma game; and (b) that the structure of a situation, as given by a set of rules, is not immutable and may, as with the Prisoner's Dilemma and the "cold fish war," be altered in such a way as to yield a different outcome. The combination of dynamic analysis, giving the commons a future, and the recognition that games have underlying structures shaped by rules, opens up the possibility that the users of a commons may be able over time "to design their own institutional arrangements that change the very structure of the situation in which they find themselves." (22) That this possibility exists may be confirmed by empirical observation, through the identification of a case (or of cases) where such has occurred.

C. Attributes of the Good: Is the Fate of the Commons Determined?

Some may accept the idea that distance from static analysis and from the equating of the commons with the Prisoner's Dilemma is desirable in building a better account of commons problems and their resolution, yet still contend that unified public management or privatization is the "only" solution because the problem of the commons is inherent in the nature of common-pool goods. Garrett Hardin alludes to this contention in classifying commons problems as "no technical solution" problems, whose characteristics intrinsically lead to undesirable outcomes. If this is the case, that the problem of the commons inheres in the nature of the good itself, then "solution" will indeed require the conversion of the commons to something else --to public property centrally managed, or to private property individually held. In fact, there is a two-stage question here: the first stage inquires whether the physical properties of a good determine what type of property arrangements will be employed with respect to that good; the second stage inquires whether certain kinds of property arrangements -- e.g., public, private, common -- are ipso facto detrimental or beneficial.

In the typology of goods presented earlier, common-pool goods were identified as a class of goods exhibiting low exclusion and high subtractability in use. Let us consider exclusion first. Does low exclusion inhere in the nature of a good? Security, or defense, is often cited as an example of a "public good," which shares with common-pool goods this characteristic of low excludability -- indeed, national defense was referred to earlier in this work as an example of a public good. But let us consider "domestic defense," or security, for a moment.

Recently, on a visit to southern California, I rode past and around the estate of publisher Walter Annenberg in Palm Springs. The estate is surrounded by a fence and two parallel rows of tall oleander plants with a space between them wide enough for a patrolling vehicle. The access driveways have guarded gates. Cameras in the trees survey the property from all angles. The Annenberg estate is, by my guess, about the size of an average housing subdivision or neighborhood in a typical American city or suburb.

Now, in a typical neighborhood, security is provided by a police force, with patrols and emergency response. And indeed, we coerce people in the neighborhood to pay for their security through taxation. We do this on the theory that my house cannot be excluded from, or enjoys, the security that is afforded my neighbors, and therefore I should be made to contribute to the protection from which I cannot be excluded.

The Annenberg estate and a typical neighborhood are both provided with security, and cover about the same area of property. Now, is security a public good or a private good? Am I excluded from Annenberg's security? Of course. Am I excluded from the security provided by the police in my neighborhood? Of course not. Security seems more nearly to approach a private good on the Annenberg estate and yet more nearly to approach a public good in a neighborhood.

With that puzzle in mind and unresolved, let us proceed to the other dimension on which we have differentiated types of goods, that of subtractability in use. Let us choose for our example this time a surface body of water, such as a lake or a navigable stream. (23) If I take a boat out on the water and enjoy a pleasant time of boating, do I leave less water for you to boat on? No. If I take water from the lake or stream to drink, wash, water my lawn, etc., do I leave less water for you to drink, or wash, or water your lawn? Yes. Is the water of the lake or stream, then, subtractible in use or non-subtractible? It appears to be more nearly non-subtractible if you and I are using it for boating, and it appears to be more nearly subtractible if you and I are using it for drinking or watering our lawns.

What do these examples mean? Here we must be careful to understand what they do demonstrate and what they do not demonstrate. They do demonstrate that excludability and subtractability in use are not wholly determined by the nature (meaning, the technical or physical properties) of the item in question. They do not demonstrate that the nature of the item in question is meaningless or irrelevant. It is the organization of the chosen use of an item which determines its classification as a public good, a private good, a toll good, or a common-pool good, but the organization of its chosen use is affected by its nature, which will make various possible organizations and various possible uses relatively more or less costly (where "cost" embraces time, effort, and opportunity costs as well as financial costs).

Exclusion from the enjoyment of others of an item will be more costly for some items than for others. If, in a typical neighborhood, I post a large light on my land to enhance the security of my home, because of the nature of light, it is likely also to illuminate (at least partially) my neighbor's property as well, and thus enhance his security. By contrast, if I lock up my bicycle, I can, at relatively low cost, exclude my neighbor (or anyone else) from access to my bicycle. This does not mean that my bicycle is excludable and the light is not. If I choose, I can exclude my neighbor from the light by building walls between my property and his, or I can confine the light to my property by buying up all of the adjacent property on which the light falls. The point is that the light is more costly to exclude my neighbors from than is the bicycle. The nature of the item -- e.g., light vs. a bicycle -- affects the organization of its chosen use, but light is not non-excludable by virtue of its being light, and a bicycle is not excludable by virtue of its being a bicycle.

Similarly, subtractability in use of an item is determined by the organization of its chosen use, which is affected by the nature of the item in question. Mono Lake in California has been used, via an aqueduct, for water supply to the City of Los Angeles. That consumption of the water of Mono Lake by the people of Los Angeles has reduced the availability of the water in Mono Lake to a sufficient level that boating on the Lake is no longer possible in places where boating would otherwise have been possible, because of the reduced level of water in the Lake. The nature of water in a lake is such that if it is extracted, less is available for recreational use, but if it is not extracted, the same quantity remains for recreational use. However, the nature of Mono Lake did not determine whether its waters would be extracted or put to recreational use. Hence, the degree of subtractability exhibited by an item is determined by the organization of its chosen use, though this is affected by the nature of the item in question.

In sum, what we conceive of as exclusion is the result of how an item is used, and how that use is organized, which choices will be affected by the nature of the item. As Plott and Meyer stated, "if there is a principle called the exclusion principle, it is likely to involve some interrelationship between behavioral laws and institutional structures." (24) Further, what we conceive as subtractability in use similarly results from such an interrelationship, such that, in the case of water, diversion of water from is source "appears to mean essentially the same as appropriable use in the sense that economists refer to appropriable goods" (25), while a different type of use of the water does not produce the same result, though the water is the same in either case.

Therefore, to the extent that a type of good is identified by its excludability and subtractability in use, that type of good is not fully determined by its inherent nature, but by the organization of its chosen use. Hence, a common-pool good does not have to be a common-pool good by virtue of some intrinsic characteristics it carries. Common property arrangements are used by people as their organization of their chosen use of the good. Some goods will be organized as common property while others are not, although some goods may be more likely to be organized as common property than others.

Resources to which access can physically be had by more than one person are more likely to be organized as common property than other goods. This is a result of the physical attributes of such jointly-accessible resources, but may also result from the legal system or from the customs of the area in which the resource is located.

The physical attributes of jointly-accessible resources affect their likelihood of being organized as common property in two principal ways. First, jointly-accessible resources are likely to be costly to enclose (or otherwise enforce exclusion). The available technologies for excluding people from the resource and the extent and type of the resource's boundaries affect the cost of exclusion (26), so that "one of the major reasons why these resources are classified as common property is that the costs of appropriating and defending exclusive use rights are felt to be higher than the added returns that such appropriation might bring." (27) Choices are made concerning the costs of exclusion, in light of the magnitude of the task of exclusion, relative to the benefits of attaining exclusion. Second, the physical characteristics of jointly-accessible resources make them particularly susceptible to "externality" problems (or "spillover effects"), such that one person's use creates positive or negative consequences for the use of the resource by others. (28) We have already noted, for instance, the interrelatedness of water producers in a groundwater basin. Externalities can be a complication in organizing use along private-good lines, in making private-good proprietors compensate others for diseconomies generated by use of the proprietor's private good.

An area's legal system, and customs, may also account for why jointly-accessible resources are organized as common-pool resources. Basic law may prohibit people from making enforceable claims to proprietorship over natural resources, or from engaging in exchange or transfer of those resources. Such legal stipulations may be seen as a codification of the difficulties or costs of exclusion, or as a recognition of the externalities involved in certain uses of jointly-accessible resources. In the view of others, such stipulations may simply be irrational and sentimental remnants of some traditional views that do not make economic sense. Where an English common law tradition has been followed, for example, ownership of land has been held to carry with it unrestricted access to all resources appurtenant to that land, including water. In arid lands, "where there is more land than can be served by the water, values inhere in water, not in land" (29), and the English common-law system may not make sense.

Customary patterns of organization of use may not reflect newfound scarcities. "It has been a firmly based American tradition, for example, that all citizens should have an equal right to hunt or go fishing." (30) Such a tradition may continue to affect the organization of use even into a time when the supply of fish and game is no longer compatible with free and equal access.

Thus, the organization of property rights in a resource may be compatible with the physical state and characteristics of the good in question, or it may be incompatible. The property rights in a good are not determined by the nature of the good, though the choice of property rights may be affected by the nature of the good. The organization of the use of the good is an intermixture, then, of the attributes of the good with the rules governing its access and use, which themselves operate within and arise from a community of persons. (31)

If the attributes of a good do not by themselves determine the form of property arrangements for the use of that good, then we still have the second stage of inquiry to consider: are certain categories of property arrangements bound to lead to destructive and inefficient use of the good? If so, then the problems encountered with common-pool goods are inherent, if not in their physical attributes, in their organization as common-pool goods. Then the problem of the commons would still be that it is a commons, and the prevailing literature's prescriptions, that all commons must be changed into either centrally-managed public property or individually-held private property, are merited.

Can the category of property arrangements for a good be separated from the issue of its constructive and efficient use? Are, for example, goods organized as private goods efficiently used, while goods organized as common-pool goods are necessarily inefficiently used, as Welch (32), among others, has argued?

Consider the statement: privately-owned, fully-transferable property may be inefficiently used. If this statement is untrue, much of the theory of markets and industries must fall with it. That theory asserts that less efficiently operating firms and sellers will be driven out of markets or industries, while those who may operate more efficiently may enter or enlarge their shares of markets. Those assertions would make no sense, if private property is never used at less than maximum efficiency. On the other hand, if the statement is true, then fully-transferable private property rights are not the same thing as efficient use of resources. Efficiency is a characteristic of market equilibrium, not of the presence of private property. Within the category of private property, or of goods organized as private goods, efficient use takes on a range of values from maximum inefficiency to maximum efficiency.

If this is the case, that efficiency is a variable criterion to be applied within the category of private property, then similar application of the efficiency criterion may be made within the other categories of property rights. That is, public property may be efficiently or inefficiently used as public property, and common property may be efficiently or inefficiently used as common property.

If this is so, then it cannot be the case that common property is necessarily inefficiently used just because it is common property, which is at the heart of the contentions of those who advocate privatization of jointly-accessible resources. Nor can it be the case that the conversion of common property to private property in and of itself will produce more efficient use of that property. (33) It must at least be logically possible that common property may be efficiently used, if private property may be inefficiently used. If efficiently-used common property is converted to private property that is inefficiently used, efficiency losses may result from the conversion. Whether efficiently-used common property is more efficiently used than efficiently-used private property is ultimately unanswerable, for the criterion of what makes sense as efficient use will depend upon the category of property rights. To apply critiera that only make sense within the context of private property to common property and then to judge the use of the common property as inefficient is a questionable exercise, analogous to stating that if an apple were an orange, you could peel it with your hands. The commons, as a commons, may be used more or less efficiently. (34)

The category of property arrangements does not determine efficient resource use, any more than the physical attributes of a good determine the category of its property arrangements. Within a category of property arrangements, the actions of the users, shaped by the rules ordering their behavior and structuring their situation, will determine whether the property is efficiently used. What this conception means is that a destructive commons situation or a constructive commons situation may be generated by the configuration of the rules, the attributes of the good, and the community of users. Rules that encourage destruction of the commons, or rules that poorly fit the attributes of the good or the attributes of the community or both, are likely to generate destructive commons situations. Similarly, the efficiency with which a particular commons may be used will depend on the rules organizing access and use, and on the appropriateness or "fit" of those rules with the attributes of the good and the community. But the nature of the good itself, and the category of property arrangements, do not in and of themselves generate destruction and inefficient use.

Let us now explore this conception of the "fit" of rules and efficient use within the context of a groundwater basin organized as a common-pool resource. As discussed in Chapter One, a groundwater basin is such that it may provide a supply of extractable water alternative to surface supplies, it may provide storage capacity for water so as to regulate uneven surface flows and precipitation, and as part of the underlying geologic structure of an area, it provides support for overlying structures (in that de-watering of the underground aquifers can cause land subsidence), The organization of use of a groundwater basin interacts with these physical attributes of a groundwater basin. That interaction may produce efficient use of the basin (i.e., putting it to its most valued use), inefficient use of the basin (i.e., putting it to a lesser-valued use), or destruction of the basin (i.e., its elimination altogether as a valued resource). We can, then, broaden our inquiry into the use of the groundwater basins of southern California beyond simply whether those basins, while retaining their character as common property, have been preserved (contrary to the predictions of many analysts), but indeed to whether those basins have been put to their most valued use.

This prompts us to recall the so-called "duality" of common-pool goods. A common-pool good was earlier defined as consisting of a resource that generates an appropriable yield or use-units. Consideration of the optimal use of a groundwater basin organized as a common-pool good then consists of inquiring whether the resource (i.e., the underlying aquifer system) is being put to its most valuable use and whether the appropriable yield (i.e., the water extracted from the aquifers) is being put to its most valuable use.

In a circumstance where ground water is being used in conjunction with surface water supplies or imported water supplies or both, the most valuable use of the underlying aquifer system may be as a storage reservoir with the capability of "smoothing out" variations in these other supplies. This value would be approximated by determining the cost of constructing artificial storage facilities on the land surface sufficiently voluminous to contain surface or imported supplies when they are plentiful for use later when they are not. Water from storage is then used to meet peak demands or to meet demands when other supplies are scarce.

Use of stored water for "peaking" means that distribution systems for surface and imported supplies need only be built with enough storage capacity to handle base supply requirements, and need not be built with peak-load capacity, which is excess capacity at other than peak demand times. Thus, construction of surface storage capacity is avoided. Construction of surface distribution systems is kept to a minimum, while the basin provides water to meet peak demands and demands in times when surface or imported supplies are unavailable (e.g., due to drought). Such a "conjunctive use" of ground water and surface or imported supplies is deemed to maximize the general efficiency of a water system. (35) Where we find such systems in use, under whatever property arrangements, we may regard them as instances of optimal resource use.

Different institutional arrangements may be employed by users to achieve such a use system. For example, management and ownership of the basin's storage capacity may be organized in one way, so as to provide the availability of peak-load water to many water consumers at lower cost, and to regulate cycles of scarcity and abundance. At the same time, ownership and management of the appropriable yield, the water extracted from the basin, may be organized in a different way, allowing individual water producers to determine their own mix of extracted ground water with surface and imported supplies to meet their varying demands most economically or to achieve certain quality levels they require for different purposes, and allowing them to transfer among themselves rights to extract ground water. Thus, in addition to the possibility that different groundwater basins would exhibit different institutional arrangements, there is the possibility that there may be different institutional arrangements within the same groundwater basin for managing its different aspects.

Such a possibility is not contemplated by those scholars who would advocate one package of ownership and management arrangements for all groundwater basins for all of their possible uses in all of their particular circumstances. As Vincent Ostrom has observed, "Few areas . . . offer a richer variety of organizational patterns and institutional arrangements than the water resource arena. Yet these patterns of organization have developed in a way that seems to conform neither to the prescriptions of political scientists nor to the prescriptions of economists." (36) Not only may it be the case that unified public management or complete privatization are unnecessary for a common resource to be preserved; it may also be the case that neither of these two prescriptions is necessary for a common resource to be used efficiently. What is essential is that the rules organizing use of the resource be fitted to its attributes and the attributes of the community of users in such a way as to make preservation and efficient use possible.

D. Rules and the Structure of an Action Situation

Before proceeding with the discussion of rules and their effect on the preservation and efficient use of common-pool resources in particular, we consider now the structure of situations and the relation of rules thereto, in more general terms. A commons situation is an instance of the more general concept of an action situation, which is a basic unit for analysis. Given that the physical attributes of goods do not determine their own use, that instead human action and human choice determine that use, attention to the likely outcomes of an action situation, such as a commons situation, properly turns to the institutional arrangements governing human action and influencing human choice.

The interest in rules and their effects on human action arises from three main sources. First, interest in rules arises from dissatisfaction with mechanistic or deterministic interpretations of apparently non-random regularities in human behavior. (37) A focus on rules itself does not provide deterministic interpretations, since although deviations from rules are subject to sanctions (which is a key difference between rules and norms) (38), "rules are soft-constraints, and human beings are perfectly capable of acting at variance with them." (39)

In addition, the conception of human beings as having less than perfect information and somewhat limited information-processing capabilities has gained increasing currency among social scientists. There is likely to be a "gap" between the competence of human beings and the difficulty and complexity of the tasks they face. (40) This gap is a strong inducement for people to rely on rule structures to order their behavior and to limit their choices to a manageable level, Human beings, especially in interdependent choice situations, make their behavior understandable and predictable by operating with reference to rules.

Finally, the emergence of interest in property rights, which are in their essence enforceable claims made to goods, directly leads to interest in rules, which are the basis for enforceable claims. According to the institutional economist John R. Commons, a rule

> lays down four verbs for the guidance and restraint of individuals in their transactions. It tells what the individuals must or must not do (compulsion or duty), what they may do without interference from other individuals (permission or liberty), what they can do with the aid of the collective power (capacity or right), and what they cannot expect the collective power to do in their behalf (incapacity or exposure). In short, the working rules of associations or governments, when looked at from the private standpoint of the individual, are the source of his rights, duties, and liberties, as well as his exposures to the protected liberties of other individuals. (41)

If we accept the significance of rules for understanding action situations, how then do we characterize the relationship of rules to action situations in an organized way? First, we characterize the elements of an action situation. These have been identified by Elinor Ostrom as follows: participants, positions, outcomes, action-outcome linkages, information, control, and benefits and costs. (42) These elements are affected by (43):

> position rules that define what positions participants may, must, or must not hold;
>
> boundary rules that define what characteristics participants may, must, or must not have in order to enter or leave positions;
>
> scope rules that define what states of the world participants in positions may, must, or must not affect by their actions;
>
> authority rules that define what actions participants in positions may, must, or must not take independently;
>
> information rules that define what information participants in positions may, must, or must not acquire or reveal;
>
> aggregation rules that define what formula may, must, or must not be used for decision-making by more than one participant; and
>
> payoff rules that define what rewards or penalities may, must, or must not be assigned to actions or outcomes.

Any action situation fully specified and described will have participants, positions, outcomes, action-outcome linkages, information, control, and benefits and costs. Any action situation will have participants, for example; the boundary rules for that action situation will define how many participants there will be and what characteristics persons may, must, or must not have in order to enter or leave positions in the action situation. The rules may be fairly non-specific -- boundary rules, for example, may even take on a "default value" of "anyone can participate or leave at any time".

The rules structuring a situation may be explicit, formally adopted, even written -- from professional sports to professional legislatures, one finds extensive rule books and even rules committees elaborating on who can enter or leave positions and what actions they can take while participating. Alternatively, the rules structuring a situation may be quite informal and even may require some exercise of investigation and interpretation to determine what they are. Languages have rules, but may exhibit neither rule books nor rule makers. One may have to observe and engage in discourse with users of a language for a considerable period before ascertaining with any assurance what the rules in use are.

Formal games, such as the Prisoner's Dilemma, are structured by sets of rules. We alluded to them above, in Section B -- how many positions, how many participants, with what choices, what information, etc. Formal games are instances of action situations. So, too, commons situations -- which are also instances of action situations -- are structured by such sets of rules, which establish (among other things) how many persons may have access to and become users of the commons, what actions users may take, what costs users may incur as a result of their use, and by what means users may take joint decisions (if any) concerning use of the commons. Institutional arrangements, the rules in use for structuring an action situation, thus may yield more or less nearly optimal organization of use of goods. (44)

When the rules governing access to and use of a resource exhibit a particular configuration, we may anticipate destruction of that resource (or, at a minimum, suboptimal use of that resource) to follow. Through the rules focus, in other words, we can generate commons situations where the "tragedy of the commons" is the likely-result. Common property, for example, is often taken to mean "open access" (45), as when Garrett Hardin calls us to consider "a pasture, open to all." (46). This is a boundary rule stating that anyone may have access to the resource. If the position rules define only the position of "user", for whom authority rules place no restrictions on use of the resource and no obligations to maintain or invest in the resource, then any entrant may harvest as much of the resource's yield as desired. If information rules do not induce gathering or sharing of information about the resource, and aggregation rules do not enable joint or contingent decision-making, users are "free" to pursue individual use strategies in relative ignorance and isolation. And if payoff rules allow each user to appropriate completely his individual harvest while incurring only his direct production costs (without compensating others for the external effects of his actions), then the calculus of the commons will indeed very likely lead to over-production. Such a configuration of rules, interacting with a jointly-accessible resource yielding valued use-units, is a recipe for a destructive commons situation.

This, however, is not the only configuration of rules that may attend common property, even though it appears to be the only configuration of rules some scholars are able to associate with the category of common property. Different rules may be employed to organize access to and use of a common property resource.

Through a change in boundary rules, for example, a resource may remain common property but no longer be "open to all." Access may be restricted to a defined community of users. Different positions may be created in addition to that of "user", or differentiations may be made among different categories of "users". Authority rules may prohibit certain actions and compel others. Disclosure of information, such as size of individuals' harvests, may be compelled by a rule change. Changes in aggregation rules may establish formulae for joint decision-making about actions taken with respect to the commons. Payoff rule changes can establish sanctions for proscribed behaviors, or assess access or use charges, the proceeds of which are used for some collective investments in the resource or for monitoring of users' activities.

Consider the following two rule strings describing crudely the rules in use for a jointly-accessible resource. In the first column are the codes ("Y" for "Yes", "N" for "No") for an "open-access" regime (OAR), and in the second column are the codes for a type of "common-property" regime (CPR). One rule from each set is given in each row (designated "B" for boundary rule, "P" for position rule, "S" for scope rule, "A" for authority rule, "I" for information rule, "G" for aggregation rule, and "C" for payoff rule). (47) The difference between these two systems, even at such an extreme level of generality, is readily seen by comparing the "strings" that describe the rules concerning access and use of this common resource. The "OAR" case may very well be headed for destruction; the "CPR" case may have a different future.

	OAR	CPR
B-- Restriction on access?	N	Y
P-- Designated position of "monitor"?	N	Y
S-- Restriction on outcomes?	N	N
A-- Restriction on use?	N	Y
I-- Required disclosure?	N	Y
G-- Rule for levying sanctions?	N	Y
C-- User charges assessed?	N	Y

The use of different rule configurations may substantially alter the behavior of users of a commons in such a way as to preserve, and even improve, the commons without converting it from a commons to some other property arrangement. Such rule changes may be arrived at by the users themselves, if they value the resource. We need not assume them to be ignorant or incapable. Indeed, rule configurations arrived at by the users themselves may be more likely to be well fitted to the attributes of the resource and the attributes of the community than ones imposed by external regulators.

> If neither private ownership nor central public control are necessary, and if different rule configurations enable individuals to achieve regulation of delicately balanced common-pool resource systems, then individuals jointly using a commons may be able to exercise real choice in the design of their institutions. (48)

The question then becomes, how do they proceed?

E. Summary

Nothing guarantees that a commons will be preserved and successfully managed. It is, however, important to bear in mind that neither is a commons doomed to destruction, or even to inefficient use, just because it is a commons. Our thinking that such doom is inevitable has derived from conflating commons situations with Garrett Hardin's open pasture, static Prisoner's Dilemmas, and "collective inaction" problems, though they in fact differ from these in ways that become important. Among these ways are that commons situations have a future and a past, that they have a community of users who may interact over time, and that there are a variety of rules structuring a commons situation that may make inefficient use or destruction likely or less likely.

A commons situation can be constructed, as can any other action situation, by a set of rules which includes boundary, position, scope, authority, information, aggregation, and payoff rules. This opens up the possibility that the users themselves may undertake, and successfully complete, a set of rule changes which will enhance the survival and efficiency in use of their commons. In doing so, they will engage in a multi-step process of resolution of their commons problem. The likelihood of their initiating such a process, completing it, and arriving at a sustained and even improved use of the resource will be greater in some situations than in others, depending upon the characteristics of those situations. It is to this process, and to the variables affecting the chances for its initiation and successful completion, that we now turn.

Notes to Chapter Three

1. E. Ostrom (1977), p. 174.

2. E. Ostrom (1985a), p. 5.

3. From the Foreword by Clifford Russell in R. Hardin (1982), p. xii.

4. E. Ostrom (1986a), p. 9.

5. Fenno (1973), p. xiv.

6. R. Hardin (1982), p. 3, also p. 13.

7. Raub and Voss (1986), p. 89 (emphasis added).

8. R. Hardin (1982), p. 13.

9. Ibid., p. 3

10. Bendor and Mookherjee (1985), p. 2.

11. R. Hardin (1982), p. xiii.

12. Ibid., p. 13.

13. Bendor and Mookherjee (1985), p. 2.

14. R. Hardin (1982), p. 13.

15. Ibid., p. 183.

16. Raub and Voss (1986), p. 88.

17. See, for example, Bendor and Mookherjee (1985), p. 5.

18. Axelrod (1970), p. 74.

19. Blomquist and Ostrom (1985), p. 388.

20. E. Ostrom (1986b).

21. E. Ostrom (1986a), p. 9.

22. Ibid., p. 22.

23. For this example and the analysis thereof, I am indebted to Vincent Ostrom, who discusses it in V. Ostrom (1962).

24. Plott and Meyer (1975), p. 72.

25. V. Ostrom (1962), p. 451.

26. E. Ostrom (1985b), pp. 3-4.

27. Christy and Scott (1965), p. 6.

28. Dorfman (1974), p. 6.

29. Powell (1890), p. 112.

30. Christy and Scott (1965), p. 7.

31. E. Ostrom (1982).

32. Welch (1983), pp. 165-166.

33. This point is similarly made by Runge (1983), Field (1986), and Magrath (1986).

34. See Runge (1983), especially pp. 3, 7, and 17.

35. Coe (1986), p. 6; see also Krieger (1955), p. 5; Krieger (1961), p. 2; E. Ostrom (1986a), p. 10.

36. V. Ostrom (1962), p. 450.

37. Shimanoff (1980), p. 32.

38. Ibid., p. 30.

39. V. Ostrom (1980), p. 312.

40. Heiner (1983).

41. Commons (1968), p. 6.

42. E. Ostrom (1986b), p. 460.

43. Ibid.

44. See Kiser and Ostrom (1982), especially p. 198.

45. Runge (1983), p. 12; Schlager and Ostrom (1987), pp. 1-3.

46. G. Hardin (1968), p. 1244.

47. This format derives from E. Ostrom (1986a).

48. E. Ostrom (1985a), p. 6.

CHAPTER FOUR

CHANGING AN ENDANGERED RESOURCE TO A MANAGED RESOURCE

THE PROCESS AND THE VARIABLES

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CHANGING AN ENDANGERED RESOURCE TO A MANAGED RESOURCE: THE PROCESS AND THE VARIABLES

Here we focus on how the users of a resource might bring about changes in their situation that lead them away from a destructive dynamic toward preservation and management of a commons which they value. Since we do not propose that all commons will be successfully preserved and managed, we also consider the variables involved in commons situations that affect the likelihood that success will be achieved.

The alternative conception of a commons situation as structured by rules stipulating access and use, attributes of the good, and attributes of the community of users opens up a variety of possibilities not recognized by the established conceptions of the commons that have led to the recommendations of unified public management or privatization. First, the change from a static analysis to dynamic analysis gives the commons a future, without losing sight of the vulnerability of jointly-accessible resources. How long that future will be depends upon the rate of renewability of the resource (i.e., how much appropriable yield it is capable of producing over a sustained period), which determines whether there will be a future at all and how far into that future a level of demand upon the resource can be supplied, and upon the rate of time preference of the users, which determines how much that future is valued. But the existence of a future for the commons means that there may be time to develop a resolution of the problems of overuse and contamination to which jointly-accessible resources are exposed. The established conceptions of the commons, based solely on the incentive structure of the n-person Prisoner's Dilemma, tend to lead to such statements as that of Hardin and Baden quoted earlier: "We do not have much time to save the world from galloping destruction. It is . . . later than you think." (1)

Second, the recognition of the variability of game structure opens up the possibility that an incentive situation that generates jointly-suboptimal outcomes is not immutable. Within the setting of the commons dilemma, or the n-person Prisoner's Dilemma, we have seen that elimination of the "temptation" and "sucker's" payoffs changes the situation so that the same players with the same choices will choose cooperating rather than defecting. Such structural changes are possible through changes in the rules that comprise the game structure. The lesson of the "cold fish war" is that elimination of the "temptation" and "sucker" payoffs generates an indefinitely-extended cooperative equilibrium; the lesson of our alternative conception is that such a change may be effected by institutional design and choice, without the restrictive (indeed unattainable) conditions of the "cold fish war" and without an outcome based on "mutual assured destruction."

Third, the examination of the interrelationship of goods with the organization of their use through rules operating within a community of users yields the recognition that neither the existence of jointly-accessible resources nor their organization as common property must in and of themselves lead to disastrous or inefficient outcomes. It is at least possible that common property as common property will be efficiently used, and it is at least possible that the organization of the use of a jointly-accessible resource may yield constructive commons situations in addition to the destructive one upon which attention has previously been principally focused. The physical attributes of goods may make their constructive and efficient use more or less complicated, but goods do not, indeed cannot, doom themselves to destruction. Neither is it the case that goods are doomed to destruction or inefficient use simply because they are organized as common-pool goods, which is the premise for the arguments of those who would convert all commons to either centrally-managed public property or individually-held private property.

Fourth, and most importantly for the remainder of this Chapter and the remainder of this study, the alternative conception advanced here opens up the possibility that the users of a commons may themselves become active participants in the preservation and the development of efficient use of that commons. Such a possibility is not conceived by the advocates of unified public management or privatization, for they have based their recommendations on models of the commons that carry with them assumptions that users cannot communicate, cannot change the structure of the game they are playing, cannot enter into agreements, and so forth. If a commons situation is conceived as involving a community of persons using a resource in conjunction with a set of rules, the possibility of the users themselves altering their situation becomes viable.

A. Instead of a "Solution", Steps and Rule Changes in a Process of Resolution

We have discussed at some length that "neither the development of fully individual property rights nor allocating control of the commons to a central authority" (2) is necessary for a commons problem to be resolved. (3) Some steps may, however, be set forth as necessary for a commons problem to be resolved. Those steps may be taken by the users themselves, and there may be a variety of means of changing institutional arrangements so as to achieve those steps. The process may succeed or it may fail. If the users of a commons retain open-access rules, place no constraints on individual actions in using the resource, and create no mechanisms for making decisions about the resource or for sanctioning violators of the constraints they do develop, then destruction may indeed come toward them at a gallop. But if the users take some necessary steps and make necessary rule changes, destruction may be postponed indefinitely. The first step in the process is to find out what is going on. If all users of the resource possessed perfect information, reaching optimal use of the resource would be relatively much simpler. However, the open access rule regarding information -- i. e., the information expected to obtain in the absence of some efforts to gather information --is that no individual is required to disclose their prior use or current withdrawal practices. This has the effect in a commons situation that individuals know about their own use but do not know much about use patterns of others. If this rule persists, subsequent actions to control access and use patterns either will fail to be forthcoming or will be poorly fitted to the actual circumstances of the particular commons. Efficient use of a common pool resource requires that the rules organizing resource use be well fitted to the nature of the resource and the way the resource is used. (4) Poorly fitted rule systems produce perverse incentives for resource use that lead either to overuse and the tragedy of the commons or underuse and the tragedy of underdevelopment. (5) Users may attempt to change rules governing access and use in the absence of detailed and accurate information about their particular use, but if they do so, they are likely to generate rules that are either more or less restrictive than necessary for efficient and equitable management of the commons. (6)

Thus, in order to progress with resolution of their commons problem, users will need to acquire specific, accurate information about their resource, the use thereof, and the options available to them. They will need ultimately to share a "map" of their situation (though not necessarily a literal map) in order to reach agreement about the nature of the difficulties they face and the possibilities for resolution of those difficulties. Further, the users themselves will have to know who all the users in fact are, so as to know whom to include in any changes in rules regarding access and use. Such information "would be valuable to all," but "may be too costly for any individual owner to acquire." (7) "Management of a common pool resource normally requires extensive investment in information-gathering facilities." (8) It is, therefore, entirely possible that collective action to turn an endangered resource to a managed resource will fail, if users do not value the resource sufficiently to find some way to pay the costs of information-gathering, for without adequate information-gathering, the remaining steps in the process of resolution will either become meaningless, unattainable, or be suboptimally attained.

The second step, if resolution is to be achieved by the users themselves, is communication. We should not assume, as does the "cold fish war" literature, that communication is immediate, perfect, and costless. Communication methods will have to be developed by the users. If a commons-management plan is not to be externally imposed upon the users, then either it will have to be arrived at by each user acting in isolation (which is both unlikely and something which could not meaningfully be called a "rule change"), or it will require communication media and fora through which users can disseminate information, signal intentions, negotiate agreements, and identify violators. (9)

Experimental work on "social trap" situations has indicated the significance of communication among participants (10), as has empirical observation of actual commons situations: "The first response in most areas to some type of water problem is the creation of a water association to provide a forum for discussion." (11) Indeed, in one of the commons cases examined later in this study as Chapter Seven, it was stated by one of the participants that the "primary purpose" of the commons-management plan "is to reduce friction and increase rapport among water users of a water supply that is in critical demand." (12)

The third step is the establishment of some collective decision-making mechanism, which may be the same as the communication forum or may not. Any one of a number of particular decision-making rules may be employed -- for example, there may be some representation system or users may participate directly, decisions may be made by consensus or by some share of those involved (such as a majority), votes may be apportioned per capita or on proportionate use of the commons, and so forth. But in order to develop rules regarding access and use, assignment of costs, assessment of sanctions, etc., for the community of users, some collective decision-making mechanism will have to exist with shared understandings about membership, what privileges and obligations are conveyed by membership, how decisions will be made and how conflicts will be resolved. (13)

A key element determining whether the collective decision-making mechanism will generate optimal rules regarding the commons is, in addition to the means it uses for making decisions, the appropriateness of its boundaries. Very occasionally, the users of a commons may be blessed with an existing public jurisdiction which can function as a collective decision-making mechanism and the boundaries of which exactly match those of the resource in question. More likely, though, the boundaries of existing public jurisdictions will be too small or too large. (14)

If the boundaries of the collective decision-making mechanism are too small, two biases toward suboptimal decisions arise: (a) people who are users of the commons are excluded from decision-making; (b) benefits from collective actions will be shared by persons who did not contribute to sharing the costs, and who may even exploit the restraint of those within the boundaries. Such an occurrence marks the history of the Metropolitan Water District of Southern California (MWD), the boundaries of which did not coincide with the boundaries of the groundwater basins of the area. As a result, residents within MWD boundaries paid taxes to secure an imported water supply and reduced their reliance on groundwater supplies, while those living outside MWD's boundaries but within the groundwater basins increased their use of the groundwater supplies at the expense of those within the MWD. Over time, MWD changed its policies to induce areas to annex to and become part of MWD.

On the other hand, if the boundaries of the collective decision-making mechanism are too large, then two other biases toward suboptimal decisions arise: (a) people who are not users or direct beneficiaries of the commons are included in decision-making, increasing the likelihood of under-investment in the resource; and (b) to the extent that actions are taken to preserve or enhance the resource, costs will fall on persons to whom benefits are not forthcoming. If the users of a commons represent a minority within a larger collective decision-making mechanism which uses a majoritarian decision rule, they may be unable to use that decision-making process to effect collective actions to preserve or improve the resource. If, on the other hand, the users represent a majority (or are able in some other way to control the decision), they may be able to spread payments for benefits they receive over the entire jurisdiction, exploiting individuals who do not benefit from or depend upon the resource.

Assuming that existing collective decision-making mechanisms (whether they be public agencies or private associations) do not have boundaries matching those of the commons, users will need to create such mechanisms. This boundary issue, of course, begs the information question: identification of the boundaries and of the users of the resource logically precedes development of the needed collective decision-making mechanism.

The fourth step in the process of resolution is the establishment of some cost-sharing arrangements The development of information, of media and fora of communication, and of a collective decision-making mechanism, and the ongoing maintenance of these, involve costs. Their maintenance, and the establishment of the steps to follow, will fail unless they are supported in some fashion. This cost-sharing problem may be trivial if, as assumed in the "cold fish war", all users are identical and consume equal shares of the commons. But the cost-sharing problem is non-trivial, indeed is both vital and difficult, if users are asymmetric. (15) In fact, Russell Hardin suggests that cost-sharing formulae are best worked out before decisions are taken regarding share assignments or supply levels, because cost-sharing arrangements worked out after benefits have been obtained or restrictions have been set in place take on the aspect of a zero-sum game, where participants seek to minimize their contributions at the expense of others. (16) Cost-sharing arrangements are thus necessary, may be complicated by asymmetries, and are more likely to be sustained if perceived as "fair", which is more likely the case if these arrangements precede assignment.

Assignment is the fifth step in the process. Assignments are rule changes that restrict and allocate access and use. The "open access" rule is unrestricted use. Unrestricted use of a valued, limited resource will lead to overuse, depletion, and contamination. Rules restricting use (through assignment of harvest shares, restrictions on equipment, etc.), combined with boundary rules to restrict access, are necessary to the preservation of a commons and to its optimal use; they are, in fact, what defines a jointly-accessible resource as common property (res communes) rather than, to coin an oxymoron, unowned property (res nullius).

The sixth step in the process is the establishment of sanctions. To refer back to the incentive structure frequently discussed earlier, this is the step by which the "temptation" payoff is reduced and, accordingly, so is the likelihood of defection from the assignment and cost-sharing arrangements developed by users. Solutions to common-pool problems involve some form of assurance that collective decisions can be enforced against users. (17) Users may develop some means of enforcement of assignment that is private -- i.e., is internal to the user community --or that has reference to public institutions, where they are available, for the enforcement of agreements. In the latter case, users employ a third party source of force, "the law." (18)

In either case, without changing the physical characteristics of the resource, users may alter the institutional technology in such a way as to generate a cooperative outcome by the assessment of penalties that eliminate the attempted gains of defecting from the assignment of access, use, and costs. As Plott and Meyer show, for example, by supplying a follow-up step of punishing defectors, one can obtain a changed situation structure in which the most attractive strategy is to cooperate but punish defectors. (19) Such sanction mechanisms can be made effective without the "mutual assured destruction" approach of destroying the resource in order to punish defectors.

The detection of defectors brings us to the seventh step in the process of resolution of a commons problem -- monitoring. Without assuming perfect and costless monitoring, we can nonetheless specify the necessity of monitoring for the maintenance of the previous steps in the process and for the threat of sanctions to have any deterrent effect upon defectors. That deterrent effect can be adequate without the attainment of perfection in the monitoring mechanism, and the monitoring mechanism itself may take a variety of forms. "The question is whether participants can structure a capacity that provides sufficient monitoring to deter participants from defecting and to sanction those who do. Every criminal act does not have to result in conviction and incarceration for law enforcement to work." (20)

Within a community of users, institutional changes that simply make previously non-noticeable actions noticeable, such as recordation, can serve a deterrent effect. An example of this is found in the annual report of the designated monitor in the case discussed in Chapter Seven. The monitor reports on the defecting actions of a couple of users in the following manner (21): "Of the number of parties who have been guilty of not submitting their reports on time, two parties, namely Frank J. Ross and Oriental Foods, Incorporated, have been chronic offenders. Continued laxity . . . could result in Superior Court proceedings for contempt." While the back-up threat of contempt proceedings existed, it was not employed; the reporting of the failure to observe the rules apparently sufficed. The next annual report indicated no difficulty in receiving production reports from these or other parties.

If they are to develop their own resolution of a commons problem and to achieve optimal use of their common-pool resource, users will have to take these seven steps:

(1) development of accurate and sufficiently detailed information

(2) media and fora of communication;

(3) establishment of some collective decision-making mechanism with appropriate boundaries;

(4) adoption of cost-sharing formulae;

(5) assignment of rights to access and use;

(6) establishment of sanctions for defecting behavior; and,

(7) development of a monitoring mechanism.

There is no presumption, under this alternative approach, that any of these steps must be taken purely privately or purely publicly. Public institutions may be used in order to facilitate some of these steps, or may in fact (where basic law allows) be created to supply these needs. The same may be said of private organizations (although it should be noted, as it was alluded to in Chapter Two, that establishment of fully tradeable access and use rights would involve public authority).

In addition, there is no presumption that information-gathering methods, communication media, collective decision-making mechanisms, cost-sharing formulae, or monitoring mechanisms must take some particular form or follow some prescribed format in order to work. Indeed, we expect variety, rather than uniformity, in the particular types of means and mechanisms developed by resource users. Finally, there is no presumption of sufficiency about this process of resolution. Neither optimal use nor indefinitely-extended preservation of the resource is guaranteed to users who take some action with respect to each of the seven steps.

The seven-step process is a series of changes in the rules structuring a commons situation. Position rules may be altered to establish monitors and representatives in addition to the position of user. Boundary rule changes place restrictions on entry to the position of user-- i.e., make assignments of access rights-- as well as to other positions. Changes in authority rules mandate certain actions by users and restrict other actions-- i.e., make assignments of use rights-- as well as define the actions of others. Information rules defining what information is held by the various positions, and whether and how information is transferred among participants in positions are changed to generate the information and communication steps in the resolution process. The onset of collective decision-making is achieved by changing aggregation rules, which relate individuals' actions to group decisions. Payoff rules assign costs to the various positions and actions, including sanctions attached to outcomes resulting from proscribed actions.

Through changes in the rules that structure their situation, users can produce an altered situation in which they behave differently with respect to the common-pool resource they jointly use. Of course, rule changes do not work automatically: people must be aware of the change, the change must be such that it affects individuals' strategies, and the aggregation of changed individual strategies must produce different results (22) . When these conditions are met, a commons situation can change, without either privatization of the resource or the imposition of central public regulation.

B. Instead of Conditions, Variables Making Resolution More or Less Likely

How likely is it that users of a commons will engage in and successfully achieve a resolution that turns their situtation from one of destruction or inefficient use to one of sustained or even optimal use, and that they will do so without the imposition of either unified public management or complete privatization? In the "cold fish war," the answer is simple: if the specified conditions are met, the resource will be indefinitely sustained and optimally used; if the conditions are not all met, the resource will be destroyed. The alternative approach presented here does not have such a simple, "on-off" answer. Users will be more or less likely to cooperate in the management of their resource, depending on the setting in which they act. Their attempts at action may succeed or they may fail, or, attempts may not be made at all.

We can, based on theoretical analysis and empirical observation, define certain sets of variables that will be present in various commons situations. Some of these variables are reconsiderations of the conditions specified in the "cold fish war". Others derive from studies of common property resources in actual settings, such as those conducted by the participants in the Panel on Common Property Resource Management of the National Academy of Sciences, (23) and the study of common-pool resources around the world currently being undertaken by Elinor Ostrom and colleagues at Indiana University.

These variables may take on a range of values. Some values are very favorable to collective action and others are unfavorable to collective action. Some of these variables relate to the characteristics of the common resource. Another set of variables has to do with the community of users. A third set deals with the institutional capacities available to users: their ability to use, alter, and invent institutional arrangements to aid them in resolving their resource problems. (24) These sets of variables can then be used to analyze any commons situation, in terms of the likelihood of successful resolution and the path or paths it may take.

B.I. **Attributes of the Resource**

It has already been noted that goods with certain kinds of characteristics are more likely to be organized as common-pool resources, because their characteristics make them more costly to organize as private goods or as public goods. Now, within the set of goods that tend to be organized as common-pool resources, those resources themselves exhibit characteristics that make them more or less costly to organize and manage, and thus more or less likely to be the subject of a process of resolution by the users.

A threshold variable already alluded to is the rate of renewability of the resource. As that rate ranges from zero to one, the resource goes from non-renewability to total regeneration every time period. A non-renewable resource can only be mined. If used at all, it will be depleted. The other end of the range is equally uninteresting. If the rate of renewability is one, the resource can never be depleted. The rate of renewability must be non-zero for there to be a future and any possibility for sustained management of the resource to occur. Yet, users are unlikely to engage in a costly and complicated process of resolution if there is no urgency or threat to the resource because its renewability rate is very high. Therefore, we would expect collective action to preserve and to optimize use of the resource in cases where resource renewability is non-zero but limited, so that depletion effects are evident from overuse.

This leads directly to another observation: the condition of the resource affects the likelihood that users will take actions to preserve and manage it. The condition of the resource -- i.e., whether it is in surplus or deficit, experiencing depletion or contamination -- is of course an interaction of supply characteristics of the resource and the demands being placed upon it (which are not an attribute of the resource itself). Given the costs involved for users in gathering information, establishing communication fora and decision-making mechanisms, etc., we should not expect users of a common resource to incur those costs unless and until they are experiencing costs from overuse, depletion, and contamination. (25) As long as the resource is generating adequate appropriable yield or a surplus, there is no reason for users to undertake institutional changes to alter their situation. This has been confirmed both in actual settings and in experimental constructions. (26)

One variable likely to affect the condition of the resource is the location of the resource relative to other resources if there is an interconnected system. If, as is often the case with such resources as air and water, there is a direction of flow to a resource in such a manner as to exhibit an "upstream-downstream" differentiation, actions are most likely to be taken in the downstream location first. Downstream users, those using the downstream end of a stream or irrigation system or the last in a series of interconnected groundwater basins, are first to suffer supply losses and contamination effects resulting not only from their own actions of upstream users. Upstream users pass their externalities downstream; downstream users receive them. Whenever we observe a series of interconnected resources or a resource system such as an airshed or watershed, we should expect action first to occur at the downstream end. This may take the form of action by the downstream users to improve their own resource and regulate their own demand, or action by downstream users against upstream users, or both.

Another attribute of the resource affecting the likelihood and prospects for success of collective action is the size of the resource. All other things being equal, we anticipate that information-gathering, communication, joint decision-making, and monitoring will be more costly and difficult to establish in larger resources than in smaller ones. "Problems such as the control of ocean fisheries, migratory wildlife, and international air pollution are an order of difficulty higher than localized common-pool problems such as grazing lands, irrigation projects, inshore fisheries, etc." (27) These localized resources are the most likely to be the focus of successful resolution, because of their greater likelihood to be used by an identifiable community of users (rather than multiple communities of diverse users), and the greater "noticeability" of users' actions in a smaller setting.

Noticeability is also affected by the visibility of the resource.

The boundaries (and therefore the full set of users) of, for example, an underground water basin are more difficult to identify than are those of, say, a lake or river. This will affect the ability to develop effective communication fora, cost-sharing formulae, and decision-making mechanisms. The ability to perceive individual contributions to the contamination of an airshed is likely to be more limited than the ability to perceive individual contributions to the contamination of an irrigation canal or a water hole in a grazing area, and this will affect the effectiveness of monitoring and sanctioning systems. Information impactedness and difficulty in detecting and punishing defectors are more likely to be serious obstacles to establishing and maintaining resource management in resources characterized by low visibility.

B.2. Attributes of the Community of Users

Identification of the community of users will be more or less difficult for different resources. Characteristics of that community of users will then in turn affect the prospects for their achieving successful commons management. One such variable that has received considerable attention in the literature on collective action is the size of the group. As the size of the group of users increases, the noticeability of individual members' actions will decline, all other things being equal, and this will reduce individuals' incentives to cooperate in joint efforts. (28) Also, increasing group size increases the "transaction costs" involved in communicating, organizing, and deciding, as well as information-gathering about past and present use patterns. To the extent that shared information among the users about the resource is crucial to achieving collective action, increasing group size also inhibits those prospects: "The fund of common knowledge is likely to be far more narrowly defined for very large than for small groups. Hence, a large group is less likely to be able to focus on a mutually cooperative behavior that involves precise or complex understanding of alternative ends or means to group ends." (29) In addition, social incentives to cooperate are likely to be weaker in large groups than in small ones. (30) All things considered, given a set of resources facing problems of overuse and deterioration, we would anticipate collective action for resource management to arise among the smallest group of users first.

The likelihood that collective action for resource management will arise is also affected by the distribution of interests within the group. There are two aspects to the concept of "interest" as used here: magnitude and intensity. Taking magnitude first, the presence of an asymmetric distribution of quantities of use may lead either to a situation approaching Olson's "privileged group" or to something like Russell Hardin's "efficacious subgroup" or van de Kragt, Orbell, and Dawes' "minimal contributing set." (31) In such a case, there is a single user or a subgroup of users using a disproportionately large share of the appropriable yield of the commons, who may, by their actions, control effectively the demands placed upon the resource and the contributions to the maintenance of the resource. Even in a large community of users, there may be a small subgroup of relatively large users able to coordinate their actions to manage the resource, or at least able to provide leadership in establishing information-gathering processes, communication fora, decision-making mechanisms, and so orth. Such disproportionately large users can either "go it alone" or "take the lead" in the process of changing an endangered resource to a managed resource. "Interest" may also mean "intensity": in a set of users, there may be some (regardless of their magnitude of use) whose very livelihood depends upon their use of a resource, while others may use the resource for convenience or for economic advantage. In such a case, there may be a process of self-selection where those most intensely affected by overuse and deterioration take the lead in establishing the necessary steps in a process of resolution. (32) Where there are disproportionately large users of a resource, or users who are heavily dependent upon that resource, or both, we should anticipate greater prospects for successful collective action, even where total group size is large.

Asymmetries can become barriers, however. Homogeneity of the user community is another variable to be considered, which embraces not only the distribution of interests, but also such issues as cultural differences that can impede communication and trust among joint users of common resource. Asymmetries of interests may enhance the prospects for user-based commons management, but they do have their limits. Asymmetries complicate the development of cost-sharing arrangements; when users are perfectly symmetric, cost-sharing is a trivial problem, but asymmetries give rise to the need for some designed cost-sharing arrangement that may become a source of conflict. Asymmetries may become source of envy, or of class or status differences, which become barriers to the tasks of developing communication and collective decision-making, and of sharing information and costs. The distribution of interests most conducive collective action may be said to be one that provides for idership without reaching the point of engaging issues of envy and ploitation, and of status differentiation among users. In addition, 'mogeneity of the user community in social and cultural composition 3 an aid to collective action; user communities that are subject to inguistic, ethnic, and religious cleavages have considerably greater bstacles to overcome in developing their own resolution of problems irising from their joint use of a resource.

The wealth and income of the user community is itself a variable affecting the likelihood that users will be able to engage in sustained and optimal commons management. Where users are eking out a subsistence existence, there may be too little or no time, energy, and disposable funds available for investing in information, engaging in communication, determining assignments of rights, monitoring and sanctioning, etc. Users groups where disposable time, energy, and funds are available may be thought of as "privileged groups" in a different sense then the one in which Olson coined the term. Indeed, a user community may even pursue a strategy of temporarily over-using a valued common resource in order to build an economic base from which they may then draw in pursuing a process of resolution-- a sort of "deficit financing" approach. Nonetheless, all other things being equal, we anticipate that user communities with some disposable assets at their command are more favorably situated than user communities lacking such reserves.

Homogeneity of the users community and the income and wealth of the users bring into consideration the broader context in which these people operate; they do not exist solely as users of a resource. As a lit, the extent of other interactions among; the users may also Luence the likelihood of their achieving collective action with pect to the commons. The iterative nature of most actual commons :tings means that users may repeatedly come into contact with one Dther, depending of course on the attributes of the resource. If ers also are in a localized setting, they may also have a variety of :her contacts with each other, as members of a village, a tribe, an idustry association, etc. Under such circumstances, users may borrow xperience and norms or habits of behavior from their other nteractions into their relationship as users of a commons. This may lid them in developing communication, joint decision-making arrangements, and other needed institutional arrangements. In addition, the existence of other interactions among members of the user community may give them additional arenas for the sanctioning of socially defecting behavior. Individuals who act uncooperatively in the use of the commons may be subject to a variety of losses in other arenas of action. The presence of other interactions among the users, then, may be anticipated to enhance the prospects for development and maintenance of cooperative commons-sharing arrangements.

The existence of repeated interactions among users of the commons raises the issue of another variable, the stability of the user community and of their use of the commons. The development of the various steps and rule changes in the process of resolution will be considerably complicated if the user community undergoes substantial changes in size or composition, or if new equipment or technology of use alters the patterns of use of the resource. Sudden escalations in demand may occur from the presence of new users, the introduction of lew means of withdrawal of use-units from the resource, or an increase In the valuation of the use-units that may make it economically feasible for users to incur higher marginal costs involved in additional harvesting of use-units. (33) Any of these instances or their combination could complicate or disrupt the development of cost-sharing arrangements, assignments of rights, and collective decision-making mechanisms. Resolution of commons problems is thus expected to be more likely where the user community and the use of the commons remain relatively stable over time.

Stability of the user group is likely to contribute to their anticipation of future use of the resource, which leads to another important variable previously discussed, the rate of time preference or rate of future discount of the users. Users may not have a uniform rate of time preference, nor do we need to rely on the assumption that they do. But users, or a necessary subgroup of users, will have to value their future use of the resource (or the availability of the resource for use by future generations) enough to incur the costs of the various steps and rule changes in a process of resolution. The greater the extent to which future use of the commons is valued by users, the more likely they are to undertake and complete that process.

The future of the resource and the likelihood of development of a resource management scheme will also be affected by the availability to the users of an alternative supply of use-units. The time involved in a resolution process and the task of assignment of shares to an overused resource will be facilitated in situations where alternative sources of valued use-units are available. Such availability takes ome of the pressure off of the potentially difficult problem of estraining demands upon one particular resource. A detailing of the rater supply sources for southern California, for example, lists .mported water from the Owens River, the Colorado River, and northern California, as well as local runoff and reclaimed waste water, in addition to the ground water stored in underground basins. (34) Such supplemental sources aided considerably in the development of arrangements to manage underground water resources.

B,3. Institutional Capacities

Also aiding in the development of resource management may be a number of variables having to do with the institutional setting of action and the capacities available to users within that institutional setting. The basic reasoning concerning institutional capacities and the resolution of a commons problem has been developed elsewhere. (35) Here, I will focus on a few key variables.

The first key variable is the degree of real control users can have over their situation. In the search for institutions capable of expanding supply (where feasible) and of allocating supplies among various rival demands, not all analysts are drawn to coercive central regulators. Recognizing the boundary problem described earlier, Mancur Olson acknowledged that collective action problems appear in a variety of sizes, and with differing characteristics, and that "both the ideology that calls for thoroughgoing centralization of government and the ideology that calls for maximum possible decentraization of government are unsatisfactory, and that efficient government demands many jurisdictions and levels of government." (36) Tailoring of tutional arrangements to the boundaries of the resource will de the greatest opportunities for stability and efficiency, •based organizations of resource use with maximum control over c own membership, access and use rights, and enforcement and tioning mechanisms, are expected to be the most stable and most ily to make optimal management decisions. (37) According to Runge, aeed "to let individuals have full freedom to innovate self-binding perty rules which best serve their needs before adding enforcement ihanisms from outside." (38) Units of collective decision-making tted to the boundaries of the problem will be most responsive to the ecific characteristics of that problem; "All facets of local control \d cooperation should be exhausted before a master agency with unique owers is invited to take control." (39)

But such well-fitted organizations of control will only develop, survive, and flourish in settings where they are allowed to do so. If a resource exists within the boundaries of a nation or some sub-national general governmental unit (such as a province or state), that national or sub-national government must allow for the development of jurisdictions conforming to the boundaries of special problems. There must, in other words, be something like a "home-rule" commitment allowing local individuals to establish their own organizations. Such organizations, if they require popular approval for their formation, are likely to be extended only to those who will benefit therefrom (40), since they will require authority to assess property and/or rights to use and to tax those, to condemn property and to construct needed facilities. (41) When the larger governmental jurisdictions have such a local-control or home-rule commitment, users owered to develop the institutions they perceive they need. :nia is an example of a state with such a commitment, at least area of groundwater management, as shown by this extraordinary .ent in a California Department of Water Resources publication: 'The Coastal Plain ground water managers can best understand the as in their water service requirements and the political, legal, .1, and organizational forces that influence management lions.... For these reasons, basin management must remain in 1 hands."

Recent trends in the groundwater.area, it must be said, do not i well for a continued commitment to user-based local control, ditionally, groundwater regulation has been the responsibility of .te and local governments, with considerable variation from place to ice. (43) However, in the 1982 U. S. Supreme Court decision in orhase v. Nebraska, groundwater was ruled to be an article of immerce and thus subject to federal regulation under the commerce Lause. (44) That the federal government is willing to use this uthority seems clear, since it has already used its control over the :unding of surface water projects to pressure states into adopting centralized groundwater management plans. This was most recently and most blatantly done next door to California in Arizona, where the U.S. Department of the Interior used funding for the Central Arizona Project as its leverage to induce Arizona to adopt the Arizona Groundwater Management Act in 1980, (45) establishing state control over "the withdrawal, transportation, use, conservation and conveyance rights to the use of groundwater," (46) something the central public-management advocates Carruthers and Stoner call "an imaginative, indeed an exciting, prospect." (47) The days of real local control over groundwater resource management may be numbered, which underscores an important point: the questions of user-based local management versus imposition of external regulation are not mere academic arguments -- policy decisions are made and people's lives and livelihoods are affected by officials who follow the prevailing thought on a subject. Analysts are not engaged in idle discourse: we write scripts that later actors follow.

The degree of real control available to users is thus one variable in the institutional setting affecting the likelihood that the users will successfully engage in a process of resolution. Another variable is the availability of information-gathering facilities. All other things being equal, "increased information concerning the problem should increase the likelihood that individuals will solve common pool problems." (48) If, as noted earlier, we do not assume that individuals using a common-pool resource begin with full information, then a relevant question becomes: is there some way for them to find out what is going on? Now, if each individual user must gather full information about the commons, the prospects for successful resolution may be quite dim. "If, on the other hand, a participant or group or participants can invoke an existing institutional arrangement to aid them in finding information about their problem, better prospects may arise." (49) There may be a variety of existing institutions or agencies with expert personnel who either have information about a particular resource or have the expertise to acquire such information. (50) If so, one of the principal barriers to successful resolution may be removed. In the water resource area, for example, a federal agency such as the United States Geologic Survey, or a state agency such as the California Department of Water Resources, may possess considerable information to which the users of a water source may have access. Admittedly, "a state water development agency such as the California Department of Water Resources, with a professional staff of engineers, hydrologists, and managers is not common" (51), especially in developing areas. This does not mitigate the point that where users have such information-gathering facilities available to them, their chances of successfully completing a resolution process improve.

The ability to make and sustain enforceable agreements is another characteristic of the institutional setting affecting the prospects for a successful resolution process. Where users can be bound by enforceable agreements, chances of cooperation improve. (52) Where private agreements can be enforced by resort to already existing institutions without the parties having to create their own enforcement process, chances of users entering into and sustaining enforeceable agreements improve. Thus, in institutional settings where a legal framework exists that will honor privately-made agreements -- i.e., where there is something like what we know as "contract law" -- the ability of users to make and sustain assignments of shares to the commons is enhanced. Enforceable agreements may be seen, in the context of the Prisoner's Dilemma incentive structure, as ways of reducing the "temptation" payoff to a value less than the payoff from joint cooperation.

In addition, where a particular form of agreement -- the "contingent contract" --is available to users, this form of agreement may be used to effectively eliminate the "sucker's payoff." (53) A "contingent contract" is an agreement among multiple individuals structured in such a way that is does not bind any party who commits to it until a certain pre-agreed proportion of the parties have committed to it (e.g., three- fourths, four-fifths, etc.). If such a form of agreement is used, then no one party risks being "suckered" by committing to an agreement while the rest of the parties defect therefrom. Enforceable agreements and contingent contracts make available to users the possibilty of eliminating from their incentive problem the "temptation" and "sucker" payoffs, and thus improve the possibility of arriving at and sustaining a cooperative assignment of use of the commons.

Finally, the presence of a single institution availing users of most or all of these capacities places users in a more favorable position with regard to achieving the several steps and rule changes involved in the resolution of a commons problem. An example of such an institutional facility (which will occupy a considerable part of the remainder of this study) is a court. Courts may be of considerable aid to users of a commons. First, courts by their nature take "problem-specific" jurisdiction. At least under American civil procedure, persons who are not "real parties in interest" will be excluded as parties to an action (though some may have a voice as expert witnesses or amici), and persons who are subsequently found to be real parties in interest can generally be added as parties to an action, even where their inclusion crosses other jurisdictional boundaries (depending on the theory of personal jurisdiction which applies). So, a resolution process that engages a court facility can onsiderably alleviate the "boundary problem" discussed previously.

Second, the involvement of courts does not eliminate the users :hemselves from having real control over the resolution of their situation. "Heavy reliance upon adjudication for the resolution of conflict unquestionably reflects efforts to minimize risks of external control by superior decision-makers. In litigation, adversaries define the issues and consequently limit the areas of discretion." (54) Courts are institutions into which users can bring conflicts over resource use without necessarily giving over their resource to some central manager.

Third, courts provide a default condition, thereby encouraging parties to consider seriously bargaining and negotiating and reaching their own agreements. Courts may not be public managers, but they are "deciders." (55) Ultimately, when a conflict is brought into a court, if the parties do not resolve the dispute, the court will do so. (56) Therefore, "what happens or might happen inside the courtroom impacts the out-of-court bargaining process," (57) and induces parties to proceed in resolving disputes "in the shadow of the court." But, equally importantly, courts can endorse the stipulations and settlements arrived at by parties, make them enforceable -- make them, in fact, the law -- thereby enabling the parties to purchase third-party enforcement of their agreement in the future.

Fourth, courts can facilitate the gathering of information and its communication among the parties. Civil court procedure can be used to compel parties to divulge information they hold, through the process of discovery. In addition, judges may use a variety of devices to bring information into the dispute (58) , including questioning of expert witnesses and the appointment of expert individuals or agencies to serve as "fact-finding referees" or "special masters" in complicated cases with considerable factual detail. (59) When such a procedure is used, the information so acquired becomes the shared factual picture of the parties and the court on the basis of which conflict resolution is pursued.

Courts have been active in resolution of commons problems with respect to water resources for centuries, extending back into English common law. (60) Courts can act quickly to prevent irreparable harm through injunctive relief and buy themselves time to deliberate, or they can deliberate and then assess damage and award relief. (61) In either course, courts provide participants with a structure for information-gathering and communication and an inducement to negotiate, and civil remedies provide possibilities for rule alteration and the engagement of authority to establish, monitor, and enforce whatever resolution evolves from the process. The presence of a single institution, like a court, which is reasonably accessible to the users of a commons and can aid in several of the steps in the resolution process enhances the prospects for a successful resolution by the users themselves.

C. Summary

To change their commons situation from one that endangers the resource to one that sustains and even improves the resource, users will have to undertake a series of steps. They will need to develop information, establish communication, devise a collective decision-making mechanism, arrive at a cost-sharing arrangement, make an assignment of rights, establish sanctions for uncooperative behavior, and arrange for monitoring of users' behavior.

The likelihood that users will initiate and then complete such a process will differ from one commons setting to another. The factors that will influence that likelihood include the resource's rate of renewability, condition, location, size, and visibility, the size of the user group, its distribution of interests, homogeneity, wealth, stability, and rate of time preference, as well as the extent of users' other interactions and the availability to them of alternative sources of supply, plus characteristics of their institutional setting such as the degree of real control users can have over their situation, the availability to them of information and information-gathering facilities and their ability to make and sustain enforceable agreements, and whether an institutional facility exists to aid them in conducting several of the steps in their resolution process.

In the chapters that follow, four southern California groundwater basins are used as examples of common-pool resources which are, in varying ways, managed by local users (and experts they have hired). Each of these basins was at one time in a deteriorating overuse condition, and each is at present in good condition.

None of the basins has been converted to public property managed by a central regulator. None of the basins has been converted to individually-held private property. These basins are important, then, as empirical cases demonstrating that neither centralized public management nor privatization is "the only way" a common-pool resource can be preserved from "galloping destruction". While these basins do not serve as a "critical test" of the alternative approach presented here, and cannot "prove" the propositions concerning the steps in the process of resolution of commons problems and the variables affecting the likelihood of successful resolution, they do illuminate and extend the discussion of how the users of a common resource might avert destruction, and even enhance efficiency, in their use of a commons.

Each of the cases illuminates different aspects of the alternative approach presented here. The format of presentation of each case will be similar, but different elements of the actions of users will be emphasized in each chapter. In the next chapter, the case of the Raymond Basin in Los Angeles County will be described, with particular emphasis on the changes in California water law that were made through an adjudication of the competing claims on the common supply. The chapter following Raymond Basin describes the case of West Basin, also in Los Angeles County, with emphasis on the variety of arrangements devised to address problems of demand control, supply enhancement, and alleviating contamination. After West Basin comes Central Basin, the basin "upstream" from West Basin, where considerable learning from the Raymond and West Basin cases combined with considerable pressure from "downstream" West Basin to produce a similar resolution. Finally, the case of Orange County presents a contrast to the Raymond, West, and Central Basins, one where share assignments have not been made and most commons management efforts have been on the "supply side". At the close of each chapter will be a recapitulation of the process of resolution and the outcomes attained by the users.

Notes to Chapter Four

1. Hardin and Baden (1977), p. xii.

2. E. Ostrom (1985a), p. 25.

3. Blomquist and Ostrom (1985), p. 384.

4. Wynne (1986).

5. Ibid.

6. E. Ostrom (1985b), pp. 35-36.

7. Bish (1977), p. 223.

8. V and E. Ostrom (1977), p. 161.

9. Blomquist and Ostrom (1985), p. 187.

10. See, for example, Fox and Guyer (1978), Isaac and Walker (1986).

11. Coe (1986), p. 15.

12. State of California, Department of Water Resources, Report on Watermaster Service in the Central Basin [herinafter referred to as "Central Basin Watermaster Report"], 1970, p. 1.

13. E. Ostrom (1985b), p. 9.

14. V. and E. Ostrom (1977), pp. 160-161; also, Coe (1986), p. 10; Olson (1965), p. 171.

15. Blomquist and Ostrom (1985), p. 388.

16. R. Hardin (1982), p. 91.

17. V. and E. Ostrom (1977), p. 159.

18. Leff (1970), p. 8.

19. Plott and Meyer (1975), p. 69.

20. Blomquist and Ostrom (1985), p. 389.

21. Central Basin Watermaster Report, 1970, p. 58.

22. Kiser and Ostrom (1982), p. 180.

23. Panel on Common Property Resource Management (1986).

24. Blomquist and Ostrom (1985).

25. Ibid., p. 387; also, Anderson and Hill (1977), p. 214; Anderson, Burt, and Fractor (1983), p. 235.

26. See, for example, Samuelson and Messick (1984), p. 2.

27. E. Ostrom (1985b), p. 20.

28. Olson (1965), passim; also, R. Hardin (1982), p. 13; Bendor and Mookherjee (1985), p. 1.

29. R. Hardin (1982), p. 182.

30. Olson (1965); also, Bendor and Mookherjee (1985), p. 1.

31. R. Hardin (1982), p. 41; van de Kragt, Orbell, and Dawes (1983).

32. Blomquist and Ostrom (1985), p. 387.

33. See, for example, Christy and Scott (1965), p. 9.

34. West Basin Watermaster Report, 1969, p. 9.

35. Blomquist and Ostrom (1985).

36. Olson (1965), pp. 172-173.

37. E. Ostrom (1985b).

38. Runge (1983), p. 19.

39. Krieger (1961), p. 15.

40. V. Ostrom (1962), p. 453.

41. Coe (1986), p. 11.

42. State of California, Department of Water Resources, Bulletin No. 104, p. 17.

43. Z. Smith (1985), p. 145.

44. Ibid., p. 149.

45. Ibid., pp. 149-152.

46. Carruthers and Stoner (1981), p. 38.

47. Ibid.

48. E. Ostrom (1977), p. 177.

49. Blomquist and Ostrom (1985), p. 388.

50. Anderson, Burt, and Fractor (1983), p. 236; E. Ostrom (1985b)'

p. 36.

51. Weatherfor et al. (1982), p. 17; also, E. Ostrom (1985b), p. 36.

52. Snidal(1985),p. 927; Runge (1983), P• 15-

53. Blomquist and Ostrom (1985), p. 388.

54. V. Ostrom (1962), p. «5.

55. Thompson (1972), p. 19•

56. Rosenblum (1974), p. U3.

57. Coursey and Stanley (1985), p. 1.

58. Thompson (1972), p. 43.

59. Ibid., p. 44; also, V. and E. Ostrom (1977), p. 171.

60. Thompson (1972), p. 2.

61. Ibid., p. 32.

CHAPTER FIVE

THE RAYMOND BASIN: THE COMMONS IN COURT

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THE RAYMOND BASIN: THE COMMONS IN COURT

As discussed in Chapter Three, within the set of jointly-accessible resources yielding separable flows is the set of common-pool resources. Not every natural resource that could be used as a commons is or necessarily must be used as a commons. While the physical attributes of the resource affect the necessary complexity and restrictiveness of rules concerning access and use, it is nonetheless the organization of use and not the physical existence of a jointly-accessible resource that defines a commons situation. The organization of use of a resource can structure a situation in a way that generates behavior leading toward destruction of that resource. By availing themselves of capacities for altering rules (if such capacities exist and are accessible), participants in a commons may transform the institutional arrangements for use of that resource from a tendency toward destruction to a tendency toward preservation.

The rules in place for the use of groundwater supplies in California in the first half of the twentieth century were conducive to destruction of those supplies. A relatively small-scale example of such a threatened supply was the Raymond Basin in Los Angeles County. Producers of water from the Raymond Basin did, however, through the availability of an equity court, have access to a capacity for changing the rules structuring their situation. In Raymond Basin, the users of a jointly-accessible resource took their commons into court, and changed the organization of its use. The results of that action markedly transformed the prospects for the resource, and served as an example for actions by users in other basins in southern California.

A. The Nature and the Problem of Raymond Basin

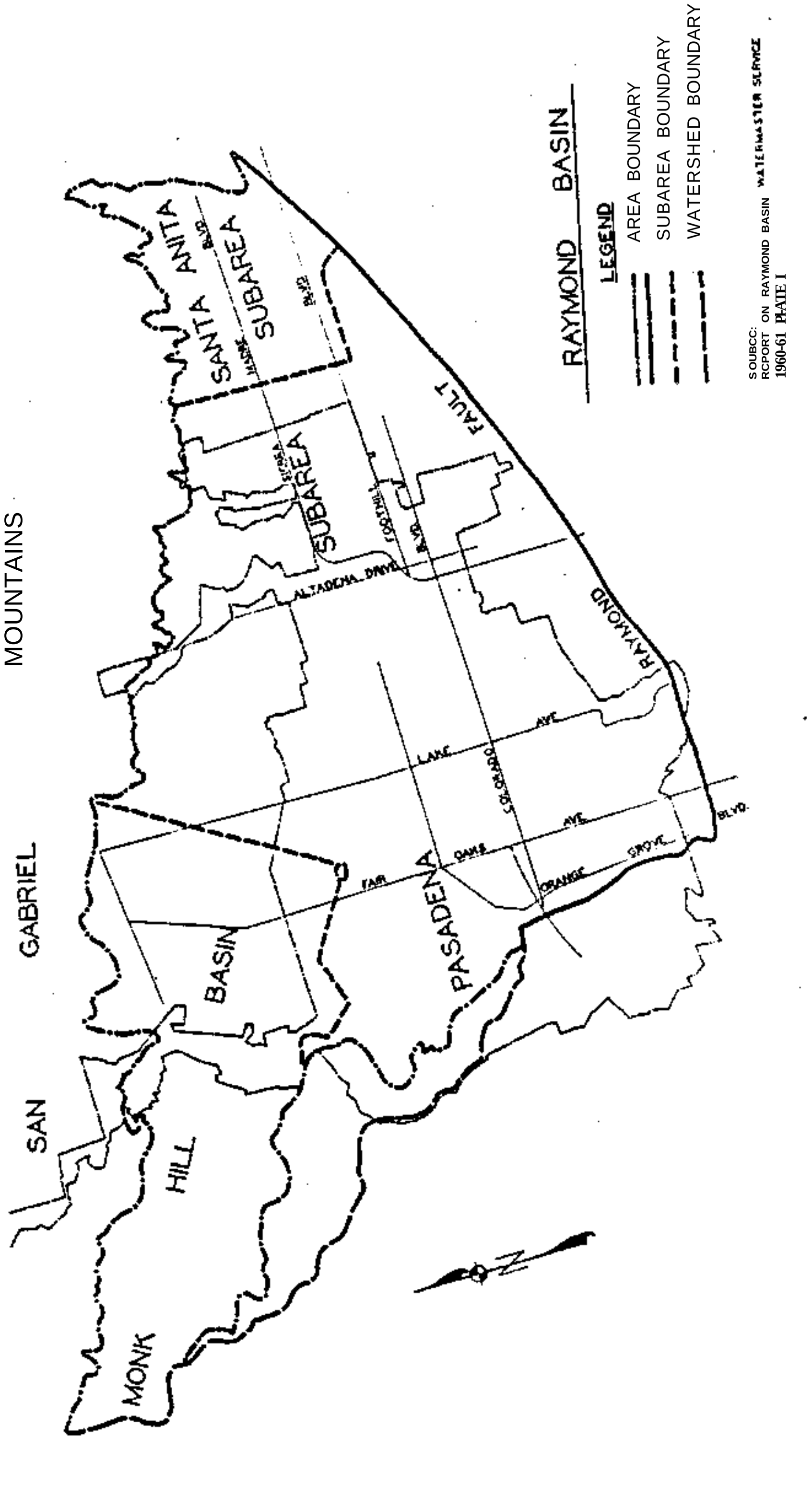
In the center of Los Angeles County, northeast of the City of Los Angeles, are the forty square miles of the Raymond Basin. Overlying the Raymond Basin are all or parts of the cities of Pasadena, Sierra Madre, Arcadia, Altadena, La Canada-Flintridge, South Pasadena, San Marino, and Monrovia. Bordering the Basin are the cities of Alhambra (which appropriates some water from Raymond Basin for its own use) and San Gabriel. The area is now highly urbanized, part of the Los Angeles metropolitan area (see Map 1-2).

The Raymond Basin is shaped as a triangle, with one corner to the south and the other two to the northeast and northwest. The northern boundary of the basin, which runs from northwest to southeast, is at the foothills of the San Gabriel Mountains. The western border of the basin, which runs more nearly from north to south, is formed by the San Rafael Hills. The ground at the base of these hills and mountains, which is the "valley floor" or the "basin field", consists of alluvium, which is porous material such as sand and gravel deposited by streams washing down the sides of the mountains and hills. The underground sides and bottom of the basin consist of dense, virtually impervious rock, that serve as the sides and bottom of a great bowl. The bowl is filled with this porous alluvium, which absorbs the water flows that come down the hillsides and contains them so that they may be extracted later.

Water not only moves into such a basin but also through it. Such movement is slow, and depends upon whether and to what extent there is a slope to the basin, plus the porosity of the water-bearing underground material. In the Raymond Basin Area, there is both a pronounced slope and porous underground material. The Basin slopes to the south from elevations of 1,000 to 2,000 feet above sea level at the foot of the mountains down toward the San Gabriel Valley.

This would make the Raymond Basin little more than an important underground stream in the northwest corner of the San Gabriel Valley, feeding into the Main San Gabriel Basin, were it not for one notable geologic formation, the Raymond Fault. The Raymond Basin Area is a wedge-shaped valley fanning outward from the hills toward the San Gabriel Valley, until a seven-mile-long fault in the bedrock thrusts upward through the alluvium, acting as a sort of underground ridge. This barrier, the Raymond Fault, runs northeasterly along the valley floor and serves as the third side of the Raymond Basin triangle (see Map 5-1). The Fault appears on the valley surface as a sudden rise in the ground. Beneath the valley surface, the Fault impedes the flow of water underground from the mountains to the Rio Hondo and San Gabriel Rivers, creating an underground basin or field of water behind the Fault. Thus the Fault defines the Raymond Basin from the Main San Gabriel Basin, with a water table elevation 200 to 300 feet higher on the Raymond Basin side. The Raymond Fault is an underground dam and the Raymond Basin is its reservoir.

The Raymond Fault is an example of a hill beneath the surface of the ground, formed in a second period of mountain-making, during which the bottom of the basin was thrust up in places. Within the Raymond Basin itself, there are two more underground ridges that divide the



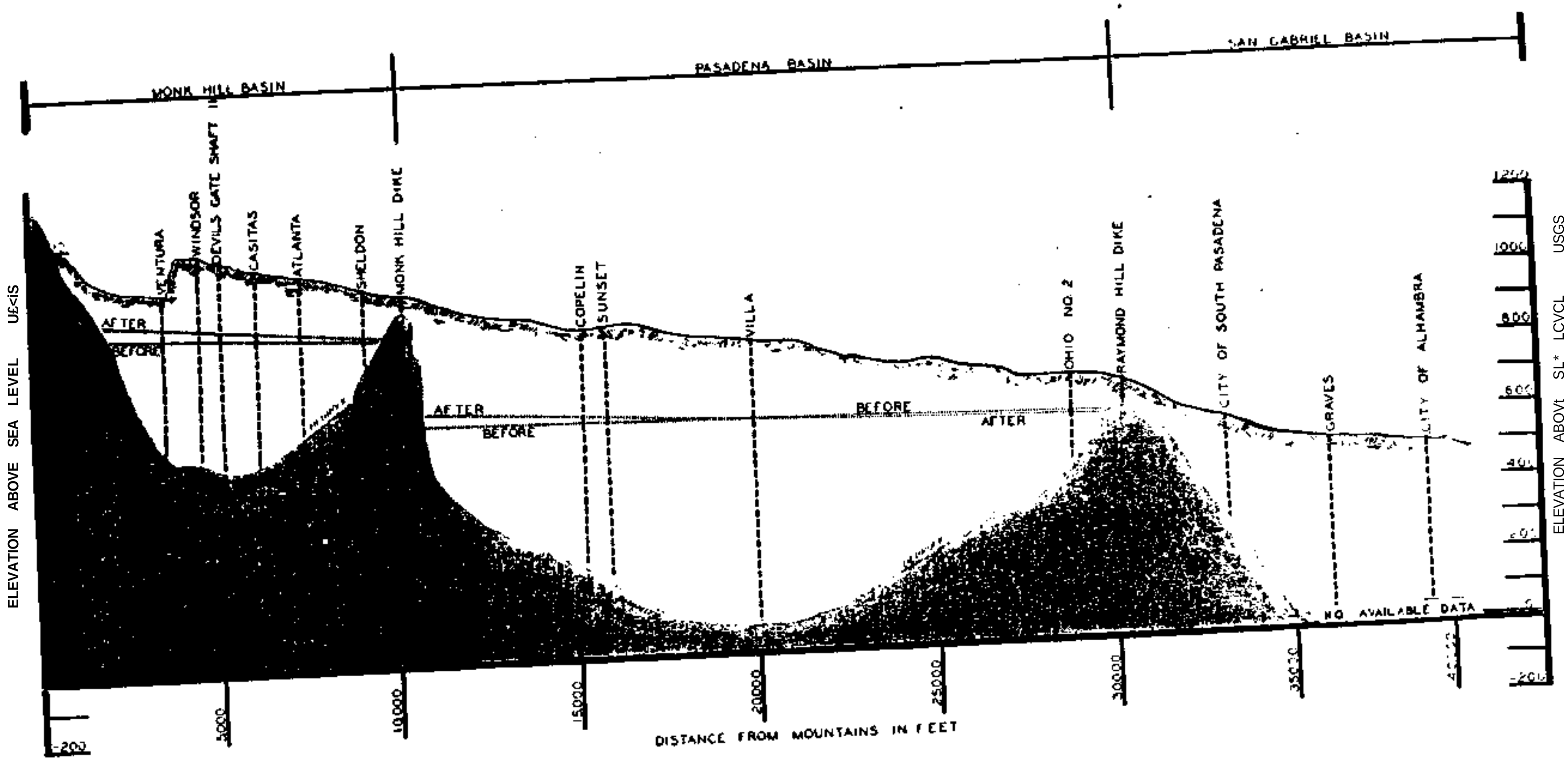
Map 5-1. Raymond Basin Boundaries

Source: Blackburn (1961)

Raymond Basin into three sub-areas (see Map 5-1). Monk Hill, northeast of the Rose Bowl and southwest of Altadena, is the main point of a ridge that defines the northwest corner of Raymond Basin as the Monk Hill Sub-Area (see cross-section, Map 5-2). The large center of the Raymond Basin is known as the Pasadena Sub-Area. The northeast corner of the Raymond Basin triangle is known as the Santa Anita Sub-Area, which is divided from the Pasadena Sub-Area by another less pervious underground barrier.

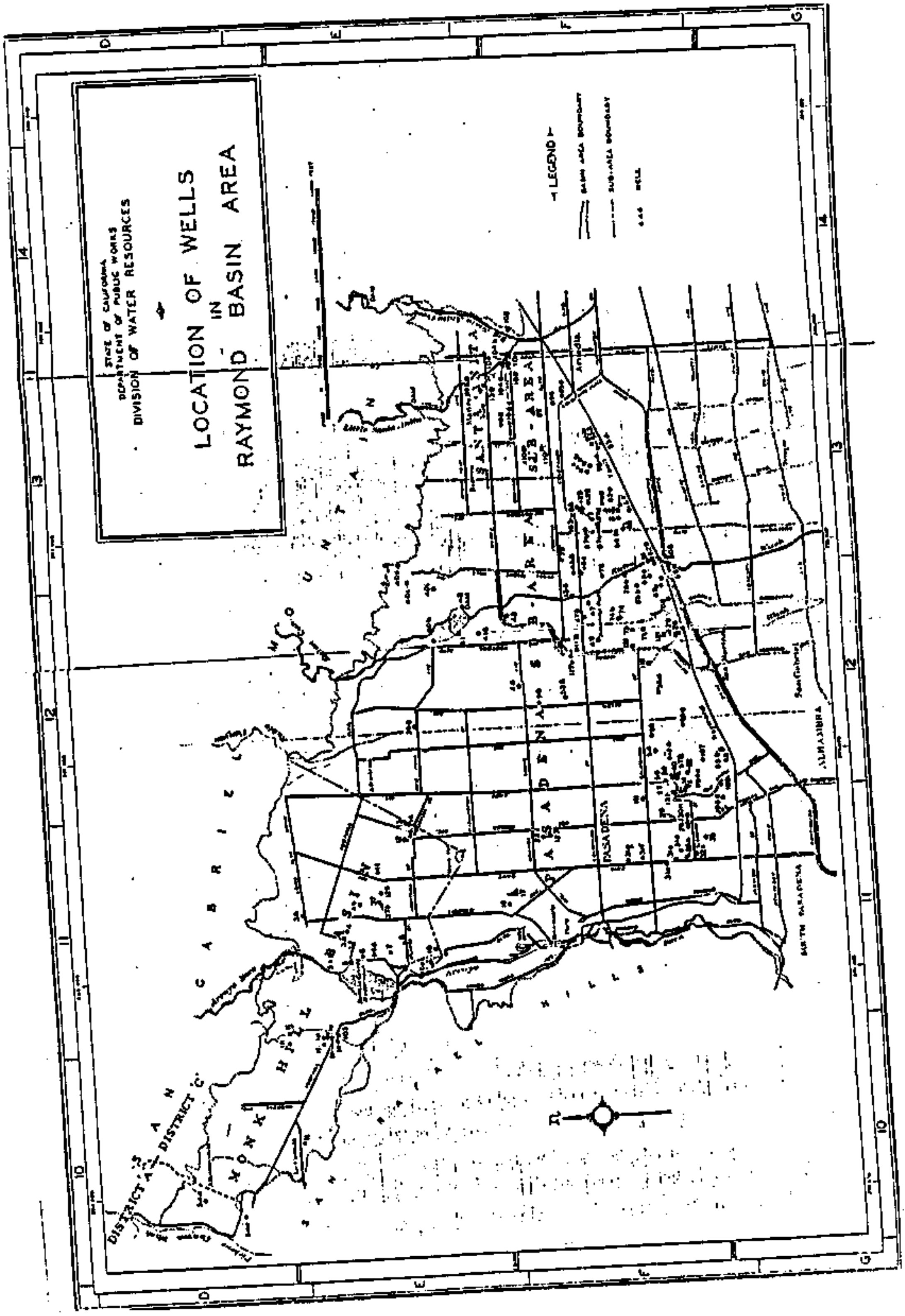
Each of these three Sub-Areas is traversed by a surface stream (see Map 5-3). The streams are drainage channels of the San Gabriel Range. The Arroyo Seco, the largest stream in Raymond Basin, flows through the Monk Hill Sub-Area and along the western edge of the Pasadena Sub-Area. The Arroyo Seco contributes approximately one-third of the total natural inflow into the Raymond Basin Area. It departs the Area to the southwest, cuts through the San Rafael Hills, and flows into the Los Angeles River. The Eaton Creek, also called Eaton Wash, passes through the Pasadena Sub-Area and flows out of the Area to the south into the Rio Hondo. In the Santa Anita Sub-Area, the Big Santa Anita Creek and the Little Santa Anita Creek (known also as the Sierra Madre Creek) join, and the resulting Santa Anita Creek departs the area to the southeast and flows into the Rio Hondo.

In relation to other basins in southern California, the Raymond Basin is a comparatively small underground reservoir. As a water supply and storage facility, however, it is of tremendous importance to its overlying and adjacent communities. Raymond Basin is in a semi-arid region. The valley floor itself has an average annual rainfall of 21 1/2 inches, and the Basin supplies water to an area



5-2. Raymond Basin [illegible]ion

Source: [illegible] (1961)



Map 5-3. Ray-nd Basin Streams and Well Locations

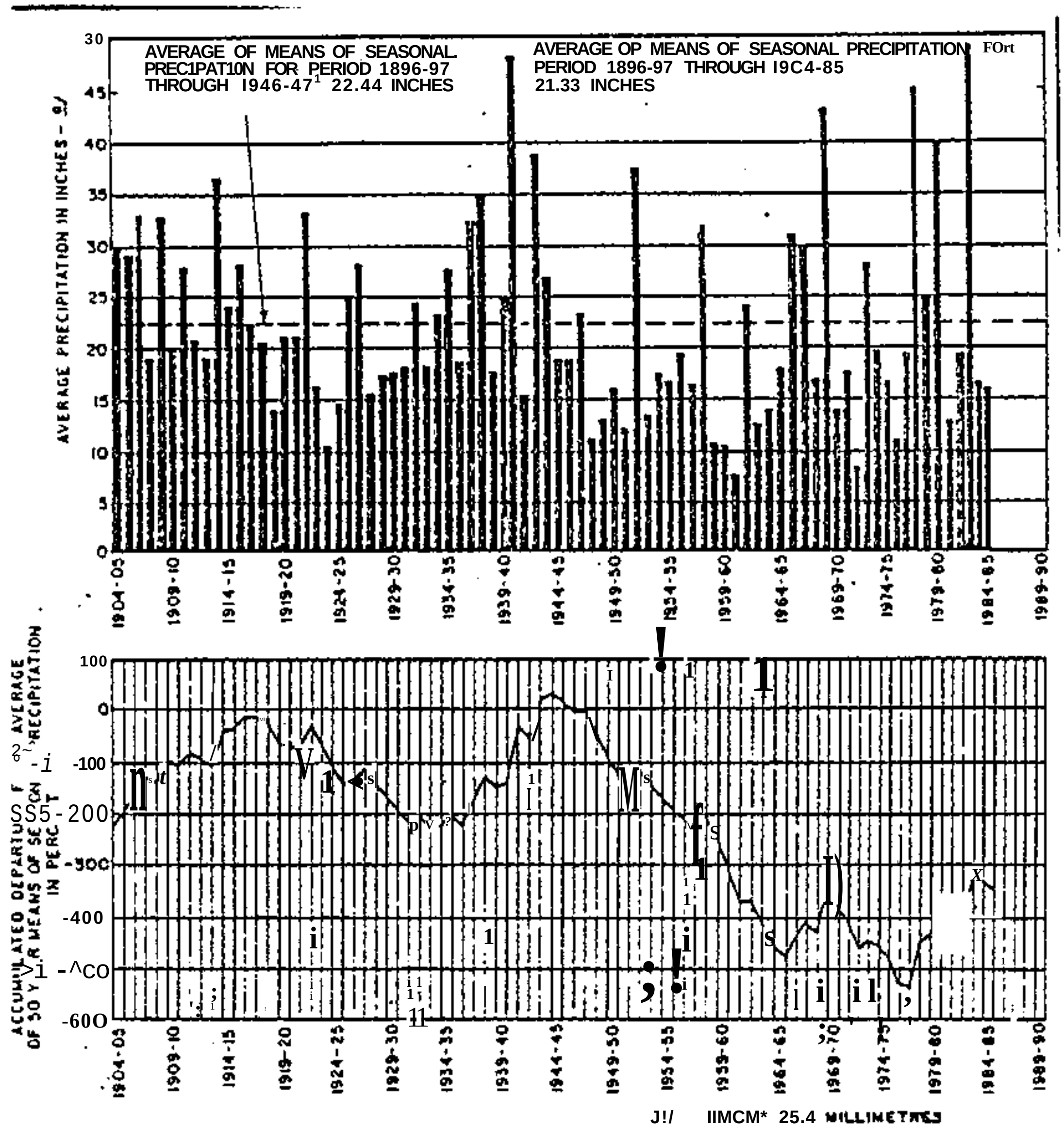
Source: Raymond Basin Watermaster Report, 1945 which now has over 300,000 inhabitants.

The earliest recorded use of waters from the Raymond Basin Area was over two hundred years ago, when Fra Junipero Serra established the San Gabriel Mission south of the Basin in 1771. The Mission was located entirely outside the Basin, but water for the Mission was diverted from ground water springs and cienagas caused by the Raymond Fault. For a century, these local supplies were both reliable and sufficient to sustain the small settlement without any further development of water supplies (1).

It was not until around 1870 that California's population (and agricultural) explosion was strongly underway. Water demands for irrigation and for use by residents escalated rapidly thereafter. All available surface water was diverted and put to use, and other sources were sought and developed.

In 1881, the first well was drilled in Raymond Basin (2). Subsequently, development of ground water production grew dramatically. A 1908 United States Geological Survey study of the area reported 141 water wells operating in Raymond Basin. Many of these wells, especially those close to the Raymond Fault, were artesian (3). The individual wells were quite small by contemporary standards, but each was used steadily. They provided a low-cost supply of high-quality, highly-valued water, and the prevailing rules concerning water use and water rights in California encouraged maximum use.

Although the period from 1908 to 1920 was a period of above average rainfall (see Figure 5-1), water levels in wells began to drop. By 1913, an overdraft condition had occurred (4) -- more water



RAINFALL SEASON JULY 1-JUNE 30

Figure 5-1. Raymond Basin Annual Precipitation Compared With Mean

Source: Raymond Basin Watermaster Report, 1985 was being extracted from Raymond Basin than was being replenished by nature, despite the wet years. The lowering of the water table as a result of the overdraft was observed in the wells of the ground water producers (5), led to well failures or increased well operating costs due to longer pump lifts, and "caused some concern among those involved in water supply." (6) In every year after 1913 until 1934-1935, there was an overdraft. The annual safe yield of the Raymond Basin was approximately 21,000 acre-feet. The average annual draft was 28,000 acre-feet, resulting in an average annual overdraft of 7,000 acre-feet.

Raymond Basin water producers confronted a classic commons problem. They operated in a situation that placed no constraints on ground water extractions and indeed encouraged extraction of all the ground water one could possibly use. Collectively, the water producers had already overrun the carrying capacity of the resource. The overuse was imposing an increased cost on each of them. Yet each of them had an incentive to continue extracting water at the same or an increasing rate.

B. Responses to the Problem in Raymond Basin

From the appearance of an overdraft in the Raymond Basin through the present, those actors appropriating water from the Basin have attempted to respond to the overdraft problem, and to protect their water supply. The responses were taken within a setting of obstacles and opportunities for collective action, and in light of available and devised institutional capacities. With the use of those capacities, Raymond Basin became "the first controlled ground water basin in the State of California." (7) During the past fifty years, Raymond Basin producers have developed a management system for the Basin, which continues to evolve at this time.

B.I. The Setting for Action

Analysis of the situation in Raymond Basin during the early decades of this century indicates that those dependent upon the Basin for their water supply faced some important impediments to the possibility of cooperative collective action. They also enjoyed some advantages in achieving collective action. Together, these obstacles and opportunities establish the setting for the strategic actions of the participants.

One of the two principal obstacles to actions by the participants was their lack of information about resource. Overdrafts occurred as early as 1913, at which time the exact boundaries of the basin, the location and interaction of the sub-basins, the historical record of extractions from the basin and natural flow into it were not known. Over time, it became apparent that there was some sort of problem with water supply in Raymond Basin. However, analysts often impute to actors rather precise sorts of calculations regarding decisions about optimal levels of use in the face of scarcity, which would require a degree of knowledge not available to Raymond Basin water producers generally during the first two decades of overdraft. In response to their lack of information, water producers proceeded with their extractions without a full understanding of the effects of their actions on each other and on the Basin.

The other principal obstacle to collective action to preserve the Basin was State of California water law. (8) The individualistic incentives inherent in the structure of a commons situation were aggravated by water law, which denied ownership of bodies of water to individuals, though it enabled them to acquire rights to its use (9). The common law tradition defines bodies and streams of water as *res communes*, common to all and the property of no one. The Constitution of the State of California and the California Water Code institutionalize this conception, stating that water in the State is the property of the people of California. Private ownership of the *stock* of water is precluded by basic state law. Thus, decisions regarding the present value of a resource such as a groundwater basin and the optimal use thereof could not be centered in one private owner.

What can be owned or obtained is a right to the *use* of water. This usufructory right is regarded and protected as a property right. The acquisition of such a right can take different forms.

A traditional common-law means of acquiring a usufructory right to water is through ownership of land adjacent to a surface body of water or overlying an underground body of water. With respect to surface streams, this right is known as a *riparian* right. A landowner with a riparian water right is entitled, by virtue of that land ownership, to the use of the full flow of the stream running through or along his property.

There is a groundwater equivalent of the riparian right to surface water. Under English common law, adopted by California courts, ownership of the right to use ground water reposed in the ownership of the overlying land. "Any overlying land owner can drill a well on his property and pump water . . . . Ground water is considered to be appurtenant to the land and the right to its use is analogous to a riparian surface water right." (10) Such use might be on the overlying owner's land, or the water could be exported from his land and sold to others. This latter point was of particular significance in a basin like Raymond Basin. Depletion is considerably more likely to occur when some are producing water from the basin and exporting it for consumption elsewhere. When water is extracted from a groundwater basin and most of it is used on the overlying land, for the most part it is returned to the basin by percolation, less that portion lost by consumptive use. When the water is exported, it is lost from the basin altogether.

The riparian/overlying water rights system made a low-cost allocation of water rights where water supplies were abundant as they were where the common law developed, in England and the eastern United States. Conferring absolute ownership to the "full flow" of a supply of water to more than one owner generates no problems when there is abundance. In arid lands such as southern California, however, it is far more likely that multiple riparian or overlying owners would find their absolute ownerships of the full flow conflicting with one another. As against each other, then, California riparian or overlying owners found their absolute ownership modified into correlative and proportional ownership. "The common law rule that underground water belonged absolutely to the owner of the overlying land was found inapplicable when the ground water use exceeded the supply." (11)

In the 1903 California Supreme Court decision in Katz v. Walkinshaw (12), the doctrine of absolute ownership was recognized as self-contradictory, in that each taking of water from the common source affects all others with rights to the use thereof. The opinion of the Supreme Court described the problem of joint use as follows:

> If the water on his lands is his property, then the water in the soil of his neighbors is their property. But when he drains out and sells the water on his lands, he draws to his land, and also sells, water which is the property of his neighbors . . . . In short, the members of the community have a common interest in the water. (13)

When a shortage occurred, resulting in a dispute among overlying owners, a court would have to adjudicate the competing interests, treating the disputing parties as correlative and co-equal rights owners, and determine for each his reasonable proportion of the water supply (14).

Thus, through the adoption of the doctrine of "correlative rights," the overlying owner's absolute right was transformed into a proportional right. The Katz v. Walkinshaw decision was reiterated in 1921 in the California Supreme Court decision in San Bernardino v. Riverside, where the court stated: "Each owner of [overlying] land...may take such water on his land for any beneficial use thereon, so long as such taking works no unreasonable injury to other land overlying such waters... if the natural supply is not sufficient for all such owners, each is entitled only to his reasonable proportion of the whole." (15)

But overlying owners had not only each other to be concerned with; there were also appropriators, who diverted water to non-overlying or non-riparian lands. Appropriative rights had arisen by custom during the early development of the West, and are linked by historians to the diversion of water by those in mining camps. At that time in the western states, it was possible to divert water from unowned or public land to one's own property. Later, water users were more likely to hold both overlying and appropriator status, as they produced some water for use on their own land and also diverted water for use on non-overlying land.

The appropriative rights system had three principal defining elements: (a) a "first in time, first in right" practice assigning priority in rights to seniority in use; (b) recognition of a right only to the amount of water actually put to use, such that rights did not accrue to capacity for diversion or to water diverted but wasted; and (c) accrual of rights contingent upon continuity in use, with cessation of use tantamount to abandonment of the right. The acquisition of an appropriative right to the continual use of a specific amount of water gave the appropriator an enforceable claim against other, less senior appropriators. Among appropriators, then, a shortage would be handled by the reduction or elimination of use by the most junior appropriator, then the second junior appropriator, and so on. The most senior appropriator was thus protected against invasion of his right by junior appropriators.

This appropriative rights system was made part of the statutory law of the State of California with the adoption of the Civil Code in 1872. Thus California had a dual system of water rights, one based on land ownership conferring a non-specific right to use, the other based on actual use conferring a "first-come, first-served" right to a specific quantity.

While the most senior appropriator was protected against all junior appropriators, any appropriative right was deemed subordinate to the rights of overlying owners. As development of southern California progressed through the turn of the century, it became increasingly evident that water scarcity would produce a situation where the claims of overlying owners could be enforced to eliminate appropriative rights wherever water from the same source was being drawn for both types of uses. The California courts recognized that this might present difficulties in light of the declared policy of the State that its water resources be used to the fullest beneficial extent possible. If overlying owners could enforce claims to rights to water they were not even using against appropriators who were (by definition) using the water, then the water resources of the State would not be used to the fullest possible beneficial extent. (16)

Reasoning from this policy of the State, the California Supreme Court concluded that the general welfare of the people of California would be furthered by a water rights doctrine that allowed no one to "sleep on his rights" and by determining a person's water right by the amount he pumps and puts to beneficial use (17). So, in the same case in which the "correlative rights" relationship among overlying owners was enunciated -- Katz v. Walkinshaw -- the California Supreme Court further reined in the right of the overlying owners. The superior right of the overlying owner, the Court decided, extended jointly to that water put to "reasonable use" for some beneficial purpose (18). The "reasonable use" language was subsequently formulated as an Amendment to the California Constitution. The landowner was limited, not only by his correlative relationship with other landowners, but by a rule of reasonableness in the claims he could enforce against others seeking to use water from the same source.

The implications of the "reasonable use" doctrine were profound. First, appropriators were enabled to take and acquire rights to the "surplus" water -- i.e., any water beyond that to which the landowner's superior right extended, which was that amount reasonably necessary for use on his land. Had this not occurred, the system of appropriative rights might eventually have become mere print in the statute books as, in one case after another, overlying and riparian rights were enforced against appropriative rights. Instead, California continued to live with a dual system of water rights, based on what the Court had once called "diametrically antagonistic principles." (19) Second, the restriction of an overlying owner's right to the amount of water needed for "reasonable use" on his own land, and the availability of the "surplus" for appropriation encouraged overlying owners (who had no institutional incentive previously to maximize water production) as well as appropriators to pump as much ground water as they could possibly use in order to expand and protect their rights.

The law of water rights in California in the first three decades of this century, then, allocated usufructory rights as follows: (a) with respect to each other, overlying owners had correlative rights and would share proportionately in reduction in water supply; (b) with respect to each other, appropriators had a seniority system of rights based on actual and continuous use, with reductions in water supply handled in a fashion analogous to lay-offs in a firm facing a reduction in output; and (c) as between overlying owners and appropriators, overlying owners had a superior right to the amount of water for their reasonable use, and appropriators had a right to the surplus remaining, if any. This was complicated enough, but there was a compounding factor -- the common law tradition of acquiring possession by adverse use.

Possession by adverse use is sometimes referred to as "squatters' rights." In our context, it is called "prescriptive rights." Through the "open and notorious" taking or holding of property belonging to another, continuously for a period prescribed by statute, a person could acquire a common-law ownership of the taken property. Thus, if you openly and continuously occupied a part of someone's real property for the prescribed period and if that person took no action to eject you therefrom, that person would thereafter be estopped from ejecting you, having lost the right to the property to you through adverse use. Similarly, by open, notorious, continuous adverse use of water for a five-year period, one could in California acquire a prescriptive right to the use of that water. The riparian or overlying owner of the original right to the use of that water could not dislodge one from that right. The prescriptive right, once perfected, is superior even to the right of the riparian or overlying owner.

Prescriptive rights could not be gained against an appropriator, because an appropriator had only a right to that amount of water he was actually and continually using. There would, therefore, be no possibility of acquiring a prescriptive right to the use of water that an appropriator was not using, since the appropriator had no right to water he was not using anyway. Such a newcomer would simply acquire a junior appropriative right to the water he diverted. Similarly, after

Katz v. Walkinshaw, one could not acquire a prescriptive right against an overlying owner by diverting water available in excess of that required for the overlying owner's reasonable use. In such a case, one would be diverting "surplus" water and would acquire a junior appropriative right. To acquire a prescriptive right, one must openly, notoriously and continuously divert and use water for a five-year period that would be included in the definition of that amount needed for the overlying owner's "reasonable use" -- i.e., non-surplus water. A taking of surplus water would not be considered an invasion of the rights of the proper owner -- indeed, after Katz v. Walkinshaw, there would be no "proper owner" per se. Only a taking that harmed the original owner could ripen into a prescriptive right superior to the right of the original owner.

By all appearances, then, the availability of water rights through possession by adverse use would seem a rather innocuous additional element in the water rights scheme. But this common-law rule seriously affected the incentives and behavior of water producers. For, while the range of possibilities for perfecting a prescriptive rights appear by description to be quite limited, in fact the possibility was much greater, due to an ironic coincidence in the law. The process by which one would acquire an appropriative right was to divert and use a specific quantity of water openly, notoriously, and under claim of right, and to maintain that use continually. The process by which one would acquire a prescriptive right was to divert and use a specific quantity of water openly, notoriously, an under claim of right and to maintain that use continually for the prescribed five-year period. The key difference between the two acquisitions of right was the question of whether the water diverted and used was "surplus" water or not. If the water was surplus, the right obtained was an appropriative right; if not, the right obtained was a prescriptive right.

Yet the question of whether the water diverted was surplus water was a factual question to be determined on a case by case basis. Moreover it was a question that could not readily be determined by an individual water producer.

The factual question of whether the water taken was surplus water, thereby determining the rights and relationships of the users, could be settled meaningfully only by an adjudication of the competing interests. The burden of initiating such an adjudication rested with the overlying owner, who had a superior right to assert against the appropriator and had to protect himself against the possible encroachment of the "squatter." Here, then, was the litigation choice faced by the overlying owner: (a) if he went to court before all "surplus" water had been appropriated, and the court ruled that the water being diverted by the defendant was indeed surplus water, the overlying owner would suffer the costs of the litigation and receive no remedy; (b) if he waited too long to go to court, the overlying owner might find that the defendant had perfected a prescriptive right if the court ruled that the water being diverted was non-surplus water. There was, in other words, no way for the overlying owner, on whom the burden of initiating litigation rested, to succeed in protecting his right until it had been invaded, and yet within a short time after the right had been invaded, the overlying owner would have lost the right he sought to protect due to prescription.

To complicate the choice further, no clear guidance existed for when water would be ruled to be surplus and when not. For instance, in the 1921 decision of the California Supreme Court in San Bernardino v. Riverside (20), despite clear evidence of a falling water table, it was ruled that the water being appropriated by the City of Riverside was surplus water. So even falling water levels would not necessarily serve as a cue to the overlying owner to take action to protect his right. Further, the Court declared in that case that the courts would not undertake an ongoing responsibility for determining when the surplus was gone and adverse use began.

Thus, the existence of prescriptive rights, and the coincidence between the process for obtaining such a right and the process for obtaining an appropriative right, meant that by the same actions that would generate an appropriative right subordinate to the right of an overlying owner, one could obtain a prescriptive right superior to the right of the overlying owner. The obtaining of either right required continual diversion and use of water. And the uncertainty of the overlying owners' situation induced away from pre-emptive securing of rights. "In this environment of legal uncertainty, attorneys often advised water producers to pump as much as they needed and to defend later. The pumping race was on." (21) The system of water rights in place in California early in the twentieth century presented the relevant actors with a set of incentives that aggravated the dangers of overuse.

While the legal doctrines concerning water rights presented an obstacle to collective action, the availability of the court system itself was an advantage for the participants. The courts provided access to public authority for a determination of rights, provided an investigative mechanism for the acquisition of needed information, and provided a forum for changing the rules structuring their situation.

Two key characteristics of the California court system contributed to its status as an advantageous vehicle for the handling of a commons situation. First, the use of the courts allowed the dispute, and the application of public authority to its resolution, to encompass all of the relevant participants and yet to be restricted only to those relevant participants --in other words, it addressed the "boundary problem" referred to above. Second, in the California court system at the time, any civil court in California was enabled to function as a court of equity as well as a court of law. Equity jurisprudence had broader discretionary rules for procedure and remedy, could be invoked for the protection of a right or the redress or prevention of a wrong (22), and applied to those circumstances where ordinary legal remedies (the redress of a damage already suffered) did not afford adequate or timely relief. Equity jurisprudence was especially well suited to a conflict over water rights because: (a) the water rights situation was one in which an ongoing relationship among parties was implied and so compensation for actual instances of damages past could be seen as an inadequate remedy; and (b) it permits the parties and the court to search beyond prevailing rules of law for a solution that will effect justice among the parties, even if that means devising a new set of rules, for one of the maxims of equity jurisprudence is that "when the reason of a rule ceases, so should the rule itself."

The other principal advantageous circumstance in Raymond Basin was the distribution of interests among the participants, which gave the Raymond Basin water producers very nearly the status of a "privileged group." The City of Pasadena was not only the largest producer of water from the Raymond Basin, but indeed Pasadena's water production equaled the production of all other producers combined. In gross terms, Pasadena had far more to lose than any other producing entity from the continuing depletion of that basin, and more to gain from arresting that deterioration. If the Raymond Basin water producers indeed constituted a privileged group, the City of Pasadena should have undertaken some action on its own, without the cooperation of other producers. This was indeed the case.

The potential problems of water supply were objects of debate within the City of Pasadena as early as 1914 as is evidenced by this statement in a report of the City of Pasadena Water Department: "The insistence of an adequate water supply by some of our people and the denial by others has now raised a doubt in the public mind as to the permanency of our water supply." (23) Starting that year and continuing until 1924, the City of Pasadena acted alone in undertaking a water spreading program to replenish the Raymond Basin, a program that benefited all Raymond Basin producers. The Pasadena Water Department captured flood waters and spread them on gravel areas at the foot of the San Gabriel Mountains, where those waters percolated into the underground basin. During the spreading program, the City of Pasadena replenished the Basin by over 20,000 acre-feet, using water that would otherwise have made its way to the Los Angeles River and perhaps been wasted to the ocean (24).

At the close of the spreading program, the City of Pasadena turned its attention to the acquisition of a supplemental source of water. It was the City of Pasadena that initiated proceedings leading to the incorporation of the Metropolitan Water District of Southern California (MWD) in 1928. Eventually, the MWD would construct the aqueduct that brought water to the southern California region from the Colorado River 250 miles to the east. The citizens of Pasadena were among the first to tax themselves to pay for the MWD's activities, which did not yield imported water from the Colorado River for over a decade.

B.2. Pasadena v. Alhambra: The Raymond Basin Goes to Court

> It is apparent, I am sure, that the owner of the largest water right, such as the City of Pasadena, has to take the lead in protecting its rights as well as the rights of others in this basin. (25)

Those words, from a long-time water official for the City of Pasadena, reflect upon the City's position as the pre-eminent water producer from Raymond Basin. As the pre-eminent water producer, Pasadena had taken actions on its own. Yet during the 1930's the City of Pasadena saw water levels at its wells continue to fall, thirty to fifty feet over the period 1930 to 1937. "Privileged group" status may be an advantage to action, but it is not in and of itself a solution. The actions of the pre-eminent participant will also be affected by the alternatives available, so that at some point "going it alone" may become a less-preferred strategy, and "taking the lead" appears more advantageous.

Such a change of approach was taken by Pasadena's officials. They called together representatives of other producers known to be producing from the basin, shared Pasadena's information about the basin with them, advised them of the approaching danger, and sought a possible negotiated settlement on a cooperative rather than an adversarial basis. "After this and other meetings, it became apparent that no such agreement could be obtained short of legal procedure." (26)

Why would Pasadena consider legal procedure, in light of the description of water rights law in the foregoing section? The City of Pasadena withdrew and utilized most of its water in an area of Raymond Basin (the Pasadena Sub-Area) where the draft exceeded the safe yield by approximately thirty percent. To redress this imbalance alone, the City of Pasadena would have to have reduce its own production by one-half, without a supplemental source to make up the deficit. This the City was unwilling to do. In addition, Pasadena held a potential dual status with respect to water rights law. Pasadena owned lands overlying the basin and used water it produced on those lands. Pasadena also distributed water as a municipal water supplier to the property of its residents. With respect to its actions as a municipal water supplier, Pasadena was an appropriator. Pasadena thus was both an overlying owner and an appropriator with great seniority. Most of the other known producers were primarily appropriators with some overlying use -- six municipal corporations, a county water district, an irrigation district, public utilities and mutual water companies. If each of these producers could be held to their reasonable use for their overlying lands, since that use was a relatively small proportion of their total use, the surplus remaining could be allocated among appropriators on the basis of seniority. In such a case, Pasadena could secure its right to Raymond Basin water and have a judgment with which subsequently to protect that right. Pasadena was thus uniquely positioned to move the Raymond Basin commons situation into court.

On September 23, 1937, the City of Pasadena initiated proceedings in Superior Court of the State of California in and for the County of Los Angeles against the City of Alhambra and thirty other defendants. The action by Pasadena sought to adjudicate the ground water rights in the area, to quiet title to those rights, and to enjoin the annual overdraft that threatened to deplete the basin.

City of Pasadena v. City of Alhambra et al, case number Pasadena C-1323, "was the first case in California wherein the Court undertook a comprehensive adjudication of multiple rights to extract water from a ground water basin." (27) The State of California had established the capacity for such an undertaking through the authorization of the Court Reference Procedure, Sections 2000 to 2070 of the California Water Code. That statute provided for a referral of a case involving a determination of water rights to the Division of Water Resources of the State Department of Public Works for investigation of the physical facts involved. The formal establishment of such a procedure, linking the court with a particular state agency to be called upon for a factual reference in particular types of cases, is unusual. The significance of the Court Reference Procedure to the course of this litigation and others that followed would be difficult to overstate.

The Raymond Basin was the first application of the Court Reference Procedure to ground water in the State of California (28). On January 31, 1939, twenty of the original parties petitioned the trial court to refer the factual issues in the case to the Department of Public Works for investigation. The judge, Frank Collier, did refer the matters to the Department on February 8, 1939, to act as fact-finding referee to review all physical facts, to determine the "safe yield" of the basin, and to ascertain whether there was a surplus or an overdraft. (29)

The investigation of the facts and the accumulation of data by the parties themselves and by the Department of Public Works, Division of Water Resources, was expensive and time-consuming (30). The reference to and investigation by the Court-appointed Referee nonetheless served to prevent multiple concurrent investigations by the several parties, and presented to the court and to the parties a coherent, single view of the Basin and its problems.

Among the facts discovered by the Referee were the basic geology of the Raymond Basin Area, including the existence of the three Sub-Areas: the Monk Hill Sub-Basin, the Pasadena Sub-Area, and the Santa Anita Sub-Area. The Monk Hill Sub-Basin and the Pasadena Sub-Area make up an essentially separate part of the Basin from the Santa Anita Sub-Area. The Santa Anita Sub-Area has come to be called the Eastern Unit of the Basin, and the Monk Hill and Pasadena areas combined are called the Western Unit. Movement of water from the Western Unit to the Eastern Unit was very small, but could be increased by a lowering of underground water elevations in the Eastern Unit, which would then pull water from the Western Unit, aggravating the problem there. There was, from a practical consideration, no movement of water from the Eastern Unit to the Western Unit. (31)

The most serious problem of overdraft was in the Western Unit.

There the average water production per year had exceeded the annual replenishment since 1913, creating an annual overdraft in that Unit and the falling water levels noticed by producers. According to the Referee's estimates based on investigation, the average annual replenishment in the Western Unit was 18,000 acre-feet and the average annual extractions totaled 24,000 acre-feet, resulting in an average annual overdraft of 6,000 acre-feet (32). Only in the years 1934-1935 and 1936-1937 (12-month periods, known as "water years," commencing October 1 and ending September 30), was the Western Unit replenished by an amount greater than the parties extracted. In each other year since 1913-1914, the Basin producers had created an overdraft.

These findings concerning the geology of the Basin, the patterns and ease of water movement, the safe yield of the basin and the history of extractions therefrom were compiled into a draft Report of Referee. During the period of investigation and the preparation of the draft Report, the Superior Court Judge had at times ordered payments from the parties to the Referee for expenses incurred. One party to the action, California-Michigan Land and Water Company, had objected to the partial payment of those expenses, and on July 29, 1942, had filed its notice of appeal from Judge Collier's June 2, 1942 order for payment. The appeal failed.

The draft Report of the Referee was circulated among the parties on March 3, 1943, and formally submitted to the court on March 15, 1943. The draft Report showed expenditures for the reference up to and including February 28, 1943 to be $52,516.17. The draft Report also stated that the safe yield for Raymond Basin as a whole was 21,900 acre-feet per year, and that the total of actual withdrawals and claimed rights was 29,400 acre-feet, creating a total overdraft of approximately 8,500 acre-feet per year. In addition, the Report included recommendations for remedying the overdraft, specifically: (a) limitation of withdrawals to the 21,900 acre-foot safe yield; and (b) use of imported water to meet demands beyond the safe yield, since there is (from the basin's standpoint) a one-to-one replacement ratio when imported water is used in lieu of pumped water, as compared with a .41 replacement ratio for water extracted that is replaced by natural and return flow processes. The final version of the Referee's Report was served to the Court on July 12, 1943, after receipt of comments and objections by the parties. It contained 392 printed pages, plus a 555 page volume of data, an updated expense total of $53,274.73, and an apportionment of that expense among the parties based on their historical use.

The submission of the draft Referee's Report, with its findings concerning the severity of the overdraft and its recommendation for curtailment of pumping, prompted activities by the parties and a difficult decision for the Court. On March 24, 1943, nine days after the submission of the draft Report, the California-Michigan Land and Water Company filed a motion to dismiss the action for failure on Pasadena's part to diligently prosecute the action. It had been five and one-half years since the commencement of the lawsuit, and the California Code of Civil Procedure entitled a defendant to dismissal in such an instance unless it could be shown either that a partial trial had been held in the interim or that proceeding to trial any earlier would have been impracticable. On the latter ground, Judge Collier denied the motion to dismiss. California-Michigan petitioned the California Supreme Court for a writ of mandate commanding the trial court judge to dismiss the action. That petition was denied July 8, 1943. Four days later, the final Referee's Report was filed with the Court, and on August 11th, the California-Michigan Land and Water Company filed objections to the Refereee's Report. After a hearing on those objections, the judge issued an order on November 24, 1943 determining the expense of the reference and apportioning the cost thereof. Two days thereafter, the City of Pasadena moved to set the case for trial, and California-Michigan again moved for dismissal. Pasadena's motion was granted; California-Michigan's was denied. Again, California-Michigan petitioned the State Supreme Court, this time for a writ of prohibition forbidding the trial of the case. On March 13, 1944, the petition was denied, ending California-Michigan's series of attempts to avert a trial on the merits.

While California-Michigan Land and Water Company chose to pursue a strategy of protecting its rights by avoiding trial, Pasadena and the other parties selected a different approach. With the draft Referree's Report providing a common source of information about the Basin and the history of use by the various producers, the parties began to negotiate with one another concerning curtailment of use. Negotiating had been unsuccessful prior to litigation, but proved more promising when it took place "in the shadow of the court."

There were several reasons for this. First, the "default condition" changed. Before litigation, failure to achieve a negotiated settlement yielded simply a continuation of the status quo -- the pumping race. During litigation, failure to achieve a negotiated settlement meant going to trial and having the court decide the water rights of the parties. This was notably different. Litigants are typically risk averse, and there was considerable uncertainty about the possible judgment by the court. The court, for example, could rule that, once reasonable use on overlying lands had been accorded to overlying owners, then the remainder (up to the 21,900 acre-foot safe yield) would be allocated as surplus to some of the appropriators in order of seniority. Alternatively, the court could rule that the existence of the overdraft meant that there was no surplus. If the court took that approach, then it would have further to consider whether prescriptive rights had been established against the overlying owners. If prescriptive rights had indeed been established, then the court would further have to determine by whom and in what amounts. Thus, for the various Raymond Basin producers, the range of possible outcomes extended from a complete loss of rights to a complete protection of rights, and waiting upon the judge's decision was a risky venture.

Other matters also enhanced negotiating as a more attractive strategy in 1943. Having already expended over five years and considerable sums of money, the parties were aware that a trial of the issues and a determination of the rights of all the parties in an adversarial proceeding would involve time and difficulties, to say the least (33) . A negotiated settlement offered at least the possibility of minimizing additional expense. Furthermore, once in the midst of the litigation, with the draft Referee's Report in their possession recommending a reduction in pumping and estimating the safe yield of Raymond Basin to be 21,900 acre-feet, the parties had to contrast with the uncertainty of the court's decision a "prominent solution" (34).

In a group of 30 water producers producing slightly over 30,000 acre-feet per year in 1943 from a basin that could safely yield just under 22,000 acre-feet, the "prominent solution" was a 25 percent reduction in pumping for each producer.

Finally, but not least in importance, negotiation was facilitated by the presence of shared counsel. One attorney, Kenneth Wright of Los Angeles, was either Counsel or Special Counsel for sixteen of the parties. The existence of this extraordinary communication link among a majority of the parties enhanced the ability of entities with competing interests to reach a cooperative agreement with reasonable assurance. (35)

Between the issuance of the draft Report of Referee in March 1943 and September 1943, Pasadena and all but two of the other Raymond Basin parties negotiated a stipulated agreement, which they formalized and presented to the court in November 1943. The provisions of that stipulation were: (a) a statement of admission and assertion by each of the parties that their taking of water from Raymond Basin had been continuous, uninterrupted, open, notorious, and under claim of right, and adverse to the claims of all others, and thus satisfied the requirements for acquisition of a superior prescriptive right for each party as against all others; (b) an allocation of the safe yield of the Basin; (c) the declaration and protection of each party's right to its specific proportion of the safe yield of the Basin; and (d) an arrangement for the exchange of water pumping rights among the parties, to be supervised by some designated monitor. On November 24, 1943 Judge Collier signed an order requiring the stipulating parties to abide by the terms of the stipulation during the pendency of the litigation (36).

On November 26, 1943, Pasadena filed a motion to set the case for trial. After California-Michigan's attempt to block the trial failed, the trial was set for May 8, 1944. The trial actually began on May 18th. In the interim, one of the two non-stipulating parties, La Canada Irrigation District, joined the stipulation on April 28, 1944, leaving California-Michigan as the only holdout. Also in the interim, the Court on April 5, 1944 designated the Division of Water Resources of the Department of Public Works to serve as monitor, or Watermaster, for the agreement among the parties. Watermaster service began on July 1, 1944.

As the parties pursued strategies of holding out or settling, Judge Collier faced difficult issues. In light of the history and composition of use of the Raymond Basin, the parties involved, and the Referee's Report and the recommendations therein, Judge Collier had a number of possible choices, each of which contained legal or practical risks, or both. On one hand, if the Judge went along with the reasoning of the stipulation of the parties and declared that each had acquired prescriptive rights that could then be proportionately reduced to the safe yield of the Basin, he would be bringing forth a remarkable innovation -- indeed, a new doctrine -- in the field of water law. The pre-trial actions of the California-Michigan Land and Water Company made it apparent that such a decision would be appealed, and thus the Judge ran a distinct risk of having his decision reversed on appeal. The stipulation among the parties circumvented the long-standing legal definitions of different types of rights and of different priorities among rights by making all rights prescriptive and yet also correlative. Adoption of this point of view by Judge Collier risked not merely a reversal but ridicule, followed by the burden of a remand forcing him to try the case all over again.

On the other hand, clinging to the established principles of water law posed problems, too. There were arguable claims to overlying, appropriative, and prescriptive rights. The Basin was clearly overdrawn. To rule that there was a surplus would allow for a determination of rights among those claiming overlying rights and those claiming appropriative rights in accordance with settled principles of law, but would stretch the concept of "surplus" beyond any reasonable meaning and would likely mean the elimination altogether of the junior appropriators. As one observer put it: "In that action there was no conflict between the doctrine of 'correlative rights' and. the doctrine of 'appropriative rights to surplus water,' because there was no surplus water nor had there been for many years." (37) Yet to rule that there was no surplus, while it would allow for an adjudication of the correlative rights among those with overlying claims, would necessarily imply that there were no appropriative rights. "This the court just could not do. Cities and a large part of the economy of the area depended on the continued use of the appropriated water." (38) Moreover, ruling that there was no surplus still left the question of prescription, of whether there had been an invasion of rights through the taking of water.

Judge Collier thus faced a choice between adopting the stipulated agreement of the parties as the basis for his judgment and risking a reversal and remand, or following the established law that seemed inadequate for the circumstances and would lead to highly undesirable results. On December 23, 1944, the Judge signed his Judgment in the Raymond Basin case, revealing his decision. He adopted the stipulated agreement and proposed Judgment worked out by the parties, and accepted the risk of reversal. "The court must have felt that the rule of necessity dictated that the water be equitably apportioned to all users. Accordingly, the court adopted a new doctrine, that has since come to be known as the doctrine of ^mutual prescription'." (39)

"Mutual prescription" is the name given to the reasoning of the Raymond Basin Judgment. That reasoning, as described by Judge Collier and other observers, is: (a) that in an overdrawn basin there is no surplus water; (b) that the rights of users are per se invaded once an overdraft occurs, through the lowering of water levels; (c) that water withdrawn for non-overlying use, if it has been withdrawn continuously, openly, notoriously, and under claim of right for five years, is no longer water claimed under an appropriative right but water claimed by adverse use; (d) that as to overlying users, their use of an overdrawn basin constitutes an invasion of each other's right to reasonable use; (e) that thus all users who have been taking water under claim of right for a consecutive five-year period from an overdrawn basin are mutually prescripting against each other; (f) that a continuation of the situation would "result in an unreasonable depletion and the eventual destruction of the ground water as a source of supply," (40) and that protection of the resource requires limiting the amount taken to the safe yield of the basin; and (g) that the co-equal status of the users provides for this limiting through a proportional reduction in their rights to withdraw water.

The Judgment accepted the Referee's determination of a "present unadjusted right" for each party. The "present unadjusted right" was the highest amount of water continuously produced during a five-year period prior to the filing of the lawsuit, provided use had been continuous for at least five years thereafter. "The trial court concluded that each party owned this right 'by prescription,' and that the rights were of equal priority." (41) Judge Collier then defined a "decreed right" for each party, which represented the adjustment of that party's right downward by about one-third so that the sum of all parties' decreed rights matched the safe yield of the Raymond Basin.

The Raymond Basin Judgment entered December 23, 1944 contained the following provisions:

(1) each of the parties has the right to take water from Raymond Basin, and the rights of each are of equal priority and of the same legal force and effect;

(2) all parties are forever enjoined on or after July 1, 1944 from taking more water than their decreed rights, except California-Michigan Land and Water Company, which had not already joined in the stipulation, against whom this injunction takes effect July 1, 1945;

(3) each party is enjoined from taking more than 120 percent of its decreed right in any twelve-month period, unless the Watermaster indicates that an emergency justifies it, and in no event shall the amount taken by a party over a period of five years exceed five times the decreed right of that party;

(4) a watermaster, the Division of Water Resources of the Department of Public Works, is appointed to enforce the provisions of this Judgment, the Water Exchange Agreement among the parties, and the instructions and orders of the court, and an advisory board representing the parties is appointed to assist the watermaster, with representatives to be designated by the parties, and with its expenses to be paid by the parties;

(5) each party shall measure and keep records of all of its diversions of water from any source, of its imports of water, of the depth to ground water in its wells, and of its groundwater production, subject to the watermaster's approval as to measuring equipment and methods of recording;

(6) diversions by the parties of water from surface sources contributory to the Raymond Basin ground water supply are limited to the capacity of the existing works for such diversions at the time the lawsuit was initiated;

(7) whenever the water elevation at the City of Arcadia's Orange Grove wells falls below 500 feet above sea level, the annual extraction from the Eastern Unit of the Basin shall be reduced for the following season from 5,290 acre-feet to 3,261 acre-feet;

(8) administrative costs of enforcing and monitoring the Judgment are chargeable to the parties in proportion to their respective decreed rights;

(9) the Water Exchange Agreement of 1943 is incorporated and made part of this Judgment;

(10) the decreed rights of the parties may be leased, or sold outright, apart from the operation of the Water Exchange Agreement, with such transfers recorded by the Watermaster.

The Water Exchange Agreement of 1943, incorporated in the Judgment, was originally entered into by 25 of the parties as a way of offsetting individual parties' shortages with temporary surpluses of other parties. Under the Agreement, each party is required "to offer for exchange any water which is available to it in excess of its requirements at a price not to exceed the average cost of production of its entire supply" (42). Offers are submitted to the Watermaster prior to May 1 preceding the water year in which the exchange water is to be available. Also prior to May 1, parties whose pumping rights are inadequate to meet their needs submit requests. The Watermaster then allocates the offers among the requests with the lowest priced water allocated first, then the next lowest, and so on. Of course, it is not actual water that is allocated, but the right to extract specific quantities. The monies paid by those allocated exchange water are then distributed by the Watermaster to the offerors. The Water Exchange Agreement, or the "exchange pool," allows intra-basin transfers without actual leasing or sale of parties' decreed rights, or transactions between individual parties. Offers are pooled, requests met, and funds distributed through the Watermaster, so parties need not engage in multi-lateral transactions or "bidding wars" over available temporary surpluses.

B.3. Pasadena v. Alhambra II: The Raymond Basin Judgment on Appeal

As Judge Collier anticipated, his adoption of the stipulation of the parties and his judgment based on the idea of "mutual prescription" became the subject of an appeal. The California-Michigan Land and Water Company appealed from the Orders and Judgment of the trial court to the California District Court of Appeal for the Second District, Division 3, on February 23, 1945.

California-Michigan was a public service corporation, supplying water to its customers since 1913. When the Pasadena v. Alhambra litigation began, California-Michigan was withdrawing over 800 acre-feet from the Basin. Its withdrawals were from the Western Unit, where the total of the "present unadjusted rights" of the parties was 25,609 acre-feet and the safe yield was determined to be 18,000 acre-feet. As a result of the method of calculation of the "present unadjusted right," California-Michigan's "present unadjusted right" was 521 acre-feet. This yielded a "decreed right" of 359 acre-feet per year, less than half of what the Company was already using at the outset of the the litigation. California-Michigan claimed a right to its 1937 use level of over 800 acre-feet, alleging a "prior and paramount right to such water by reason of its ownership of various other water properties and water rights, which have been owned continuously and adversely from more than 40 years." (43) The Company appealed from an order for partial payment of referee's expenses, a final order determining and apportioning the referee's expenses, and the final judgment. These appeals were consolidated as one by the District Court of Appeal.

In the consolidated appeal, California-Michigan Land and Water Company raised procedural and factual challenges as well as a challenge to the determination of its right in the final judgment. California-Michigan argued the following errors of procedure: (a) that the wrong agency was chosen as Referee under the Court Reference Procedure; (b) that California-Michigan was denied adequate notice and opportunity to be heard on its objections to the Referee's Report; (c) that the trial court failed to dismiss the action for failure to prosecute when over five years passed between the initiation of the suit and commencement of the trial; and (d) that the trial court's judgment was improper since it determined the rights of the defendants as among themselves even though they had raised no issues against each other on the pleadings (44). Each of the allegations of error by California-Michigan was rejected by the District Court of Appeal.

The appeal also challenged two of the findings of fact made by the trial court. First, California-Michigan argued that the average annual supply of water to the Raymond Basin area by rainfall and runoff from the mountains was over 62,000 acre-feet. This challenge was quelled by the appellate court, which upheld Judge Collier's discretion to accept the findings of the Referee unless they were "clearly erroneous," which was not the case here. Second, the appeal alleged that Judge Collier had erroneously ruled the Raymond Basin to be "percolating water" rather than an underground stream. This was important to California-Michigan because the definition of Raymond Basin as an underground stream would undermine the "mutual prescription" doctrine, making surface water law apply to the Raymond Basin and rendering California-Michigan exposed only with respect to "downstream" users, it being impossible to establish an adverse use against an upstream user. The District Court of Appeal responded: "Since ground water is invisible, it is presumed to be percolating water and consequently the burden of proof is upon the party asserting the contrary . . . . Appellant did not supply this hiatus in proof." (45)

It was with respect to the reasoning underlying Judge Collier's determination of rights in the Raymond Basin case -- the "mutual prescription" doctrine -- that the District Court of Appeal sided with California-Michigan Land and Water Company. The appellate court first examined the argument that all of the other parties had gained prescriptive rights against California-Michigan. Two elements necessary for the establishment of a prescriptive right, said the Court, were the existence of adverse use and the running of the prescriptive period. The Court of Appeal did not question the running of the prescriptive period, but focused instead on the issue of whether there had been actual hostility in use. To the respondents in the appeal (i.e., the other parties) and to Judge Collier, the element of adverse use was present in this case through the existence of the overdraft. The appellate court gave a two-part response. First, the Court of Appeal stated that prescription depends on or implies a forfeiture of right to the adverse user, and such forfeiture cannot be made by one who is unaware of the adverse taking of his right. Overdraft alone is not a sufficient notice of an adverse taking if the owner of the right is unaware of the existence of the overdraft or if his own supply appears to him to be undiminished or not invaded. Second, California-Michigan's right was appropriative (or possibly prescriptive) and thus was a right to a specific amount of water. Invasion of such a right (unlike the case for an overlying or riparian right) may occur only by an interference that results in an actual diminution of the amount of water covered by the right. In this case, according to the District Court of Appeal, California-Michigan "has never suffered any involuntary diminution in its ground water production and has always had more water available than it use required. Consequently. . .the taking of ground water of the Area by the other parties has not been adverse to appellant's appropriative rights in the water supply." (46)

According to the District Court of Appeal, then, while it was certainly acceptable for the stipulating parties to agree that they had prescripted against each other and to treat their water rights as equal, nonetheless with respect to a non-stipulating party such as California-Michigan, it was incumbent upon them to establish their acquisition of a prescriptive right co-equal with California-Michigan's, and this had not been done merely through the existence of an overdraft condition in Raymond Basin. California-Michigan argued that its rights were in fact prior and paramount to those of the other parties. The District Court of Appeal stated that California-Michigan's water rights were "prior and paramount to those of <u>various of the other parties</u>." (47) What the

District Court of Appeal would not do was make a determination of the priority of California-Michigan's rights vis-a-vis the other parties. Rather, the Court of Appeal remanded the action to the trial court for a determination of "the exact priority of appellant's water rights in the common supply so that its water production may be restricted accordingly to the end of terminating the overdraft." (48) Thus, the appellate court did not reject Judge Collier's restriction of extractions by the parties to a level that would eliminate the overdraft, but it did reject the treatment of California-Michigan's water rights as equal to those of the stipulating parties since California-Michigan had not joined the stipulation. As to the allocation of water rights between and among the stipulating parties, the Court of Appeal upheld it, noting only that the sum of the rights would be adjusted to offset whatever adjustment would be made to California-Michigan's right. (49)

The decision of the District Court of Appeal reversing and remanding Pasadena v. Alhambra was appealed to the California Supreme Court. A hearing was held before the Supreme Court on October 8, 1947 and additional briefs were filed in November and December. The California Supreme Court announced its decision on June 3, 1949, overturning the Court of Appeal and affirming Judge Collier's original judgment. The Supreme Court majority first affirmed, as had the Court of Appeal, that the trial court had the authority to restrict the taking of ground water in order to protect the water supply and prevent "a permanent undue lowering of the water table." (50)

The question then arose of whether the rights of California-Michigan had been invaded in such a manner as to create a prescriptive right against the Company. The California Supreme Court rejected the ruling of the Court of Appeal that California-Michigan's appropriative right remained intact because it was still able to extract as much as it needed from the Basin. To sustain such a holding, according to the Supreme Court majority, would be to delay an action to preserve the basin until after it had been destroyed already, which would serve neither the ends of justice nor the policy of the State. The Court majority stated: "The proper time to act in preserving the supply is when the overdraft commences, and the aid of the courts would come too late and be entirely inadequate if . . . those who possess water rights could not commence legal proceedings until the supply was so greatly depleted that it actually became difficult or impossible to obtain water." (51) Thus, California-Michigan's continued extraction of its needed supply from an overdrawn basin did not leave it immune to the claims that it had invaded the rights of others and that others had invaded its right.

The Supreme Court turned then to the issue of remedy -- specifically, the remedy of proportionate reduction used by the trial court. "The main problems presented," wrote the Court, "are which of the parties should bear the burden of curtailing the total production of the unit to the safe yield and what proportion, if any, of the pumping by each particular party should be restricted." (52) The competing possibilities were allocation by priority of right, as advocated by the Court of Appeal, and proportionate reduction of right, as proposed by Judge Collier. The California Supreme Court relied on equity principles rather than strict interpretation of the law. It ruled that allocation by priority of right "does not appear to be justified where all of the parties have been producing water from the underground basin for many years, and none of them have acted to protect the supply or prevent invasion of their rights until this proceeding." (53) None of the parties had come to the court with entirely "clean hands." Each had to some extent "slept on his rights." The court was thus not obliged to show any of them favor.

In addition to this consideration weighing against allocation by priority of right, the Supreme Court recognized as a consideration weighing in favor of proportionate reduction the interests of the various publics served by the Raymond Basin water producers. Proportionate reduction by each of the producers, according to the Supreme Court, would be less disruptive of the local water economy than the complete elimination of rights for some. (54) The California Supreme Court, without explicitly endorsing Judge Collier's "mutual prescription" reasoning, sustained his result. This had the effect, intended or not, of introducing mutual prescription as a new doctrine in California water law.

The California-Michigan Land and Water Company, having lost in the highest state court, petitioned the United States Supreme Court for a writ of certiorari to review the California Supreme Court's ruling. On April 17, 1950, the United States Supreme Court denied California-Michigan's petition, refusing to review the case. (55) "After almost 13 years, the litigation was finally terminated." (56)

An examination of the effect of <u>Pasadena v. Alhambra</u> begins with a description of what it was <u>not</u>. Neither the trial court nor the California Supreme Court, in making and affirming the <u>Pasadena v. Alhambra</u> judgment, had overruled previous rulings in the California law of water rights. The Katz v. Walkinshaw scheme of allocating water rights to overlying owners, appropriators, and prescriptors in accordance with their priority of right remained in place. "Mutual prescription" had not been substituted for the old scheme, but instead allowed to develop alongside it. This was largely because the Raymond Basin Judgment was mainly based on a stipulation among the parties rather than on an adversary proceeding decided by a trial court. It was, therefore, possible in the immediate aftermath of Pasadena v. Alhambra to regard it as unique. Instead of clarifying the uncertainty of water right owners concerning their status, Pasadena v. Alhambra at a minimum left the area of California water rights law just as uncertain as it had been previously, and at most compounded that uncertainty.

The "mutual prescription" approach used in the Raymond Basin case was not without its detractors. In addition to criticisms of the expensive and time-consuming court reference procedure used in the adjudication of Raymond Basin (57), the approach has been criticized for its effect on the water right owner and his ability to know the status of, and to protect, his right. According to one critic, the doctrine of mutual prescription "means there are no longer 'water rights' in the conventional sense . . . . The paper right -- the water right created by deed -- means nothing." (58) Instead, a producer may find that owning overlying land does not protect him, and even pumping water continuously and putting it to beneficial use does not protect his right to that quantity of water, as the remedy of proportionate reduction leaves him "entitled to only a part of it." (59) In addition, the allocation of his right hangs upon a matter he cannot neither be aware of nor control. "No one knows the exact moment a basin becomes overdrawn. He may find out years later. Notwithstanding this his very rights depend on the later determination of that mythical moment when the basin becomes overdrawn." (60) Had "mutual prescription" become the prevailing doctrine in the California law of ground water rights, this situation would have confronted every producer in a basin that had not yet undergone adjudication. In a pre-adjudication basin, then, one unintended effect of the "mutual prescription" doctrine would be to encourage pumpers to maximize groundwater production in order to retain as large a right as possible after adjudication.

Pasadena v. Alhambra also left a considerable "hole" in the law of water rights, concerning the status of public entities and prescriptive rights. A longstanding common-law rule in California, formalized and incorporated into the California Civil Code in 1935, held that no use or possession of property (including water) owned by a public agency could ever ripen into a prescriptive right against that agency. (61) In the Raymond Basin case, cities and other public enterprises were parties, and the rulings of the trial court and the Supreme Court made no reference to this specific provision of the Civil Code. Instead, under the mutual prescription reasoning, prescriptive rights had in effect been gained against the various public corporations that produced water from the Basin. The cities and other public enterprises had entered into the stipulation rather than assert their rights to be free from prescription. Mutual prescription thus stood on shaky ground. Its application to other cases would depend upon the forbearance of whatever public water producers were involved in those cases; if they chose to assert their protection under the Civil Code, a mutual prescription solution would not work as a basin-wide means of allocating water rights.

What the Pasadena v. Alhambra approach did mean in the California law of water rights was that an alternative capacity for the resolution of a groundwater commons might be available to water producers. In addition to the traditional method of using the courts to adjudicate purely adversary proceedings among litigants and making allocations of water according to competing theories of priority of right, with all of the uncertainty about the court's decision the traditional method entails, producers after Pasadena v. Alhambra had another choice. If a community of water producers wished to work out their own settlement of an overdraft, they could approach the courts with the assurance (since Pasadena v. Alhambra had been affirmed by the highest state court) that the courts would formalize that settlement and place the authority of the state behind it. Such a means of resolution eliminated, because of the proportioned burden of reduction, the possibility of receiving one's best possible outcome -- a secure right to the full amount of water put to use -- but also eliminated the possibility of receiving one's worst possible outcome -- losing any and all rights to produce from the local supply. Pasadena v. Alhambra gave those producing water from an overdrafted basin the possibility of simultaneously securing at least part of their supply while also preserving the resource's ability to provide that supply into the future.

B.4. A Managed Basin: The Forty Years Since Pasadena v. Alhambra

The judgment in Pasadena v. Alhambra became effective as to all parties on July 1, 1945. During the forty years thereafter, the parties, the court, and the Watermaster have managed the Raymond Basin within the terms of that judgment, and on certain occasions modified the judgment itself. This review of the forty years of operation of the judgment will focus on the parties and non-parties to the judgment, the conditions of the groundwater supply in the Basin, actions taken by parties to enhance their water supply, and the mechanisms of management of the Basin.

a. The Parties and Non-Parties

There has been a concentration of the water industry in Raymond Basin since the initiation of the lawsuit in 1937. By the time of the issuance of the trial court judgment in 1945, only 25 of the original 31 parties were still producing water from the Basin under decreed rights. The others ceased production and transferred rights to some of the remaining parties. As Table 5-1 shows, during the years since 1945, the number of parties has further declined to the present seventeen. Of the seventeen active parties remaining, it is predominantly the public enterprises (four cities, one county water district, and two irrigation districts) and the private water supply companies (of which there are seven) that remain. Only three overlying landowners continue to produce groundwater as parties to the judgment. The others have sold their rights and become water consumers rather than water producers.

At the time of the judgment in 1945, four non-parties to the lawsuit were actively producing groundwater. An allowance was made

TABLE 5-1

Raymond Basin Parties' Decreed Rights, Groundwater Extractions, and Total Water Use Within Raymond Basin (in Acre-Feet), 1945-1985

Year	Number of Owners of Rights	Decreed Rights	Ground Water Pumped	Water Imported	Water Exported	Total Water Use In Basin
1945	25	21,451	20,109	N/A	N/A	N/A
1946	25	21,451	23,788	N/A	N/A	N/A
1947	25	21,451	19,954	N/A	N/A	N/A
1948	25	21,451	23,916	N/A	N/A	N/A
1949	25	21,451	22,308	N/A	N/A	N/A
1950	25	21,451	19,253	N/A	N/A	N/A
1951	25	21,451	23,377	N/A	N/A	N/A
1952	25	21,451	19,143	12,952	N/A	N/A
1953	24	21,451	23,314	20,163	N/A	N/A
1954	24	21,451	21,426	22,546	N/A	N/A
1955	24	30,622	23,731	21,187	N/A	N/A
1956	24	30,622	24,986	22,237	N/A	N/A
1957	24	30,622	30,015	20,655	N/A	N/A
1958	24	30,622	23,487	17,416	4,667	47,019
1959	24	30,622	33,205	23,885	8,420	54,241
1960	24	30,622	29,278	27,448	6,955	51,833
1961	23	30,622	29,279	29,941	8,392	52,306
1962	23	30,622	28,657	25,887	9,315	49,213
1963	22	30,622	30,434	26,362	9,598	50,654
1964	22	30,622	30,184	26,391	10,594	48,345
1965	21	30,622	28,731	26,341	8,850	49,031
1966	21	30,622	29,368	20,353	11,597	47,597
1967	21	30,622	25,705	18,103	9,444	47,626
1968	21	30,622	34,074	21,472	12,279	49,934
1969	21	30,622	28,398	20,461	10,594	46,565
1970	21	30,622	32,577	21,888	10,166	52,401
1971	21	30,622	30,990	26,843	11,273	51,701
1972	21	30,622	30,561	30,913	9,528	54,420
1973	21	30,622	32,434	23,027	10,504	49,655
1974	21	30,622	31,817	22,801	7,337	51,622
1975	18	30,622	31,810	24,130	10,290	48,931
1976	18	30,622	36,176	26,615	10,450	54,914
1977	18	30,622	32,861	22,282	6,155	51,145
1978	18	30,622	27,186	23,603	9,388	45,089
1979	18	30,622	31,661	23,042	7,868	51,851
1980	18	30,622	39,556*	15,391	8,291	51,104
1981	18	30,622	34,970*	25,558	12,674	52,419
1982	17	30,622	32,376*	22,489	6,474	52,089
1983	17	30,622	32,899*	20,062	9,082	48,840
1984	17	30,622	37,873*	22,426	11,041	55,319
1985	17	30,622	35,659	30,271	15,388	53,567

*-- In-lieu replenishment water counted as groundwater pumped.

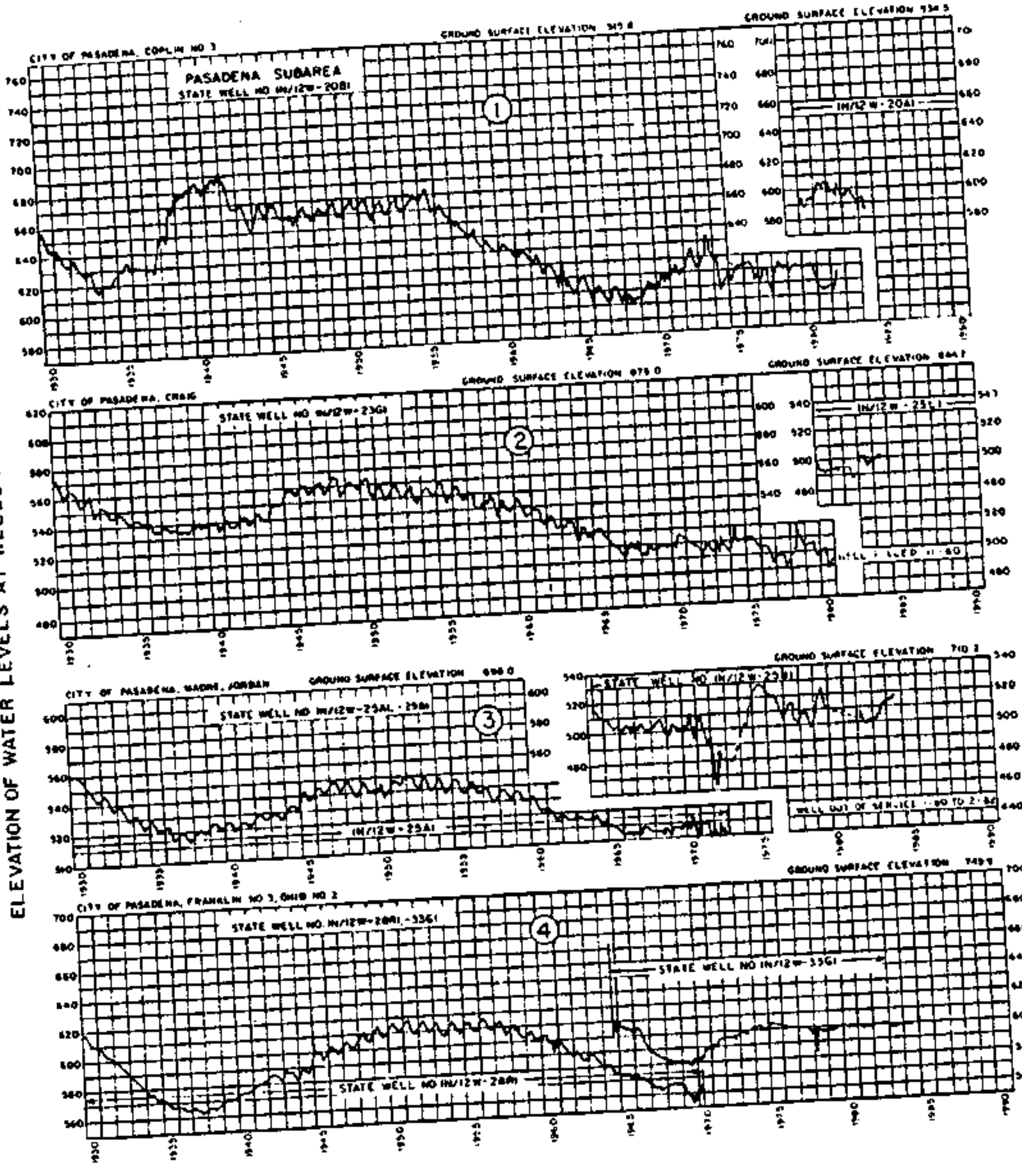
Source: Raymond Basin Watermaster Reports, 1945-1985 for their production: the safe yield of the Raymond Basin had been determined to be 21,900 acre-feet per year, but the total of the decreed rights of the parties was 21,451 acre-feet, leaving 449 acre-feet for the production of the four non-parties. The number of actively producing non-parties has since declined to two, who have extracted a combined average of 41 acre-feet per year over the past ten years.

The allowance made for the original non-parties has not, however been extended to newcomers. The Raymond Basin adjudication has been used to establish a boundary to exclude new producers. In 1960, the City of Pasadena brought suit against the East Pasadena Water Company to enjoin it from further pumping from the Basin. (62) This was done to keep that company from acquiring prescriptive rights in the Basin that might later force a downward adjustment in the rights of established right owners. Pasadena's suit against the East Pasadena Water Company was settled in 1965, largely because that Company acquired the water rights of an existing party and agreed to limit its extractions to those rights. (63) East Pasadena Water Company is now one of the seventeen parties to the Raymond Basin management system. The party whose rights East Pasadena acquired was the California-Michigan Land and Water Company, which fifteen years after its appeals of the Raymond Basin judgment ended, ceased producing ground water from Raymond Basin.

b. Ground Water Conditions in Raymond Basin

Improvements in underground water elevations in the Raymond Basin began during the pendency of the litigation. Six of the nine years from 1937 through 1945 were years of above-normal rainfall (see Fig. 5-1), and some of the parties restrained extractions during the period of the negotiation of the stipulated agreement. But the issuance of the judgment in Pasadena v. Alhambra in 1945 coincided with the beginning of a string of dry years. Sixteen of the next twenty years were characterized by below-normal rainfall -- the greatest "dry cycle" of recorded southern California history. Water levels at wells throughout the Raymond Basin continued to rise through 1950 and held steady through 1955 (see Fig. 5-2), despite the first ten years of drought and increased total water use. Remarking on this period, the 1954 Annual Report on Watermaster Service noted: "The effect upon the groundwater supply of the basin, that would have taken place if the court had not ordered the pumping limited to the safe yield, may readily be visualized." (64)

The increase in and stabilization of water levels in the Raymond Basin during the first ten years of drought, despite the fact that producers were withdrawing water each year at the historic safe yield of the basin while natural recharge to the basin was below normal, resulted in a redetermination of the safe yield of the Basin. Late in 1950, the City of Pasadena filed a motion with the Superior Court (which had retained jurisdiction of the Basin management program) for a review of the determination of the safe yield. The court granted the motion and the Department of Public Works was appointed to make the review. The Department filed its report with the court in October 1954, with the conclusion that the safe yield of the Basin was nearly 31,000 acre-feet, recommending (after a small allowance for active non-parties) that the decreed rights of the parties be increased to



[illegible] 5-2. Water Levels in Wells in Raymond Basin

[illegible]: Raymond Basin Watermaster Report, 1985

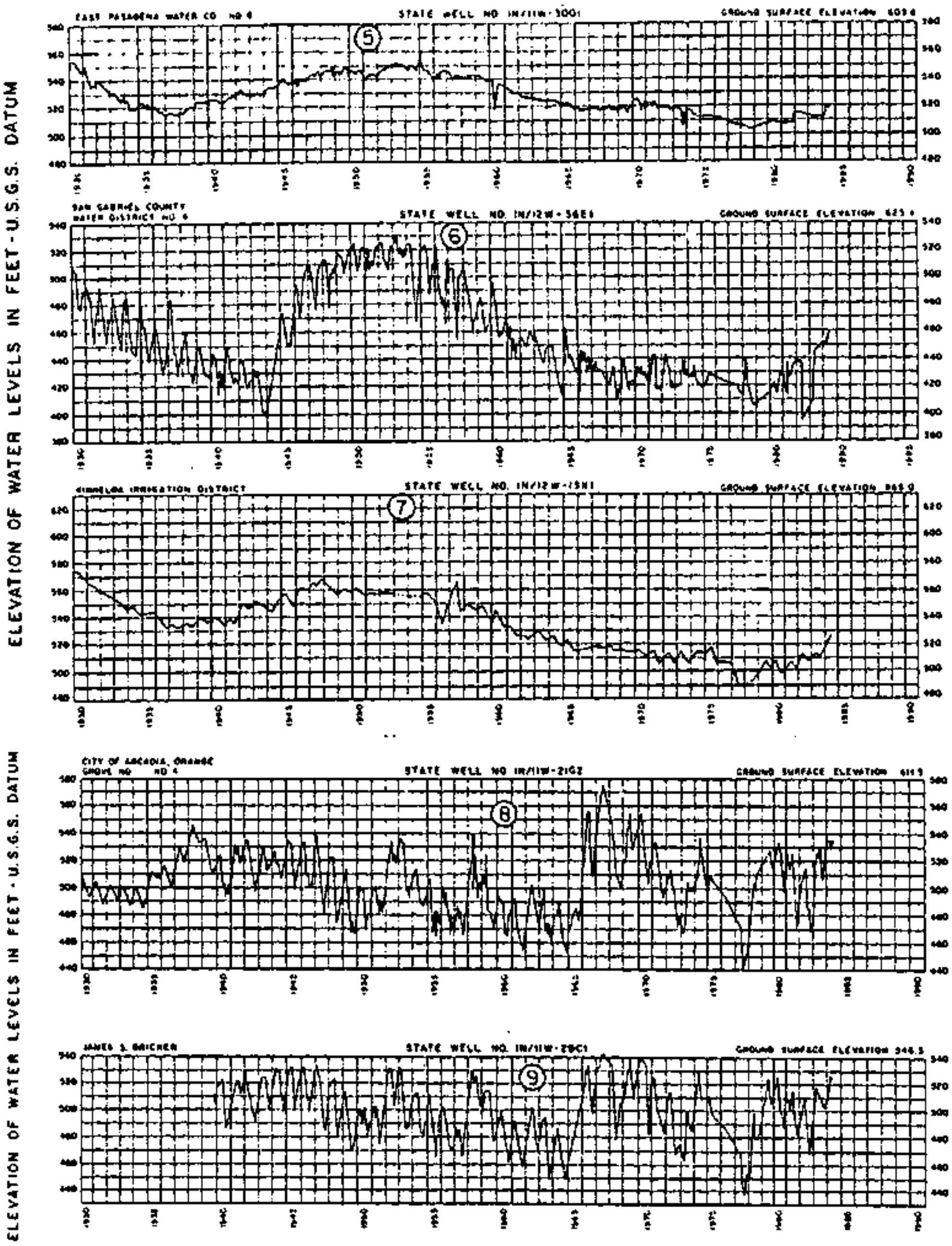


Figure 5-2 continued.

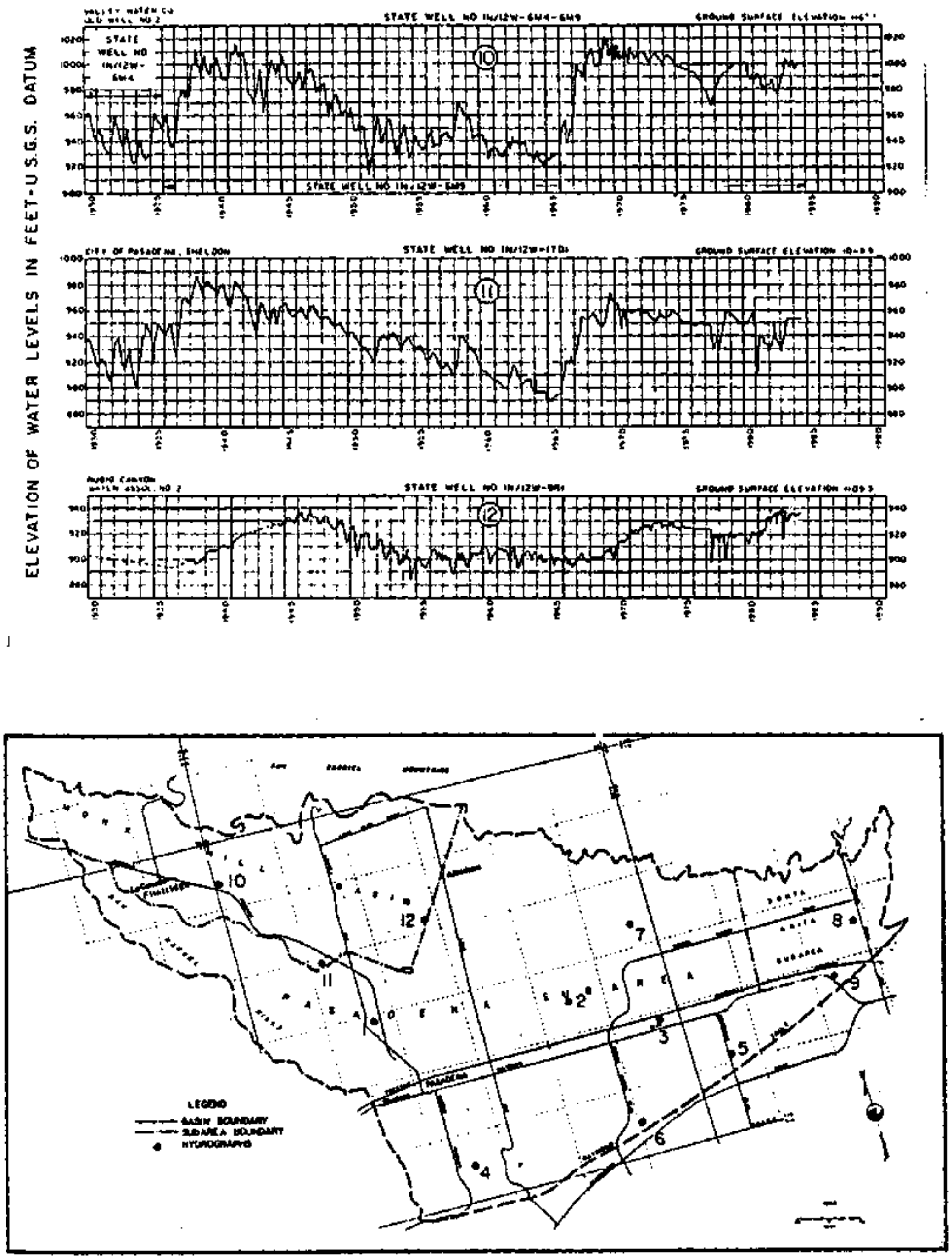


Figure 5-2 continued

30,622 acre-feet. On April 29, 1955, the Court issued a Modification of Judgment increasing the decreed rights of the parties proportionately to a total of 30,622 acre-feet.

As production increased to the new safe yield level and the drought continued, water levels in Raymond Basin declined gradually and eventually stabilized at a lower level than their 1950-1955 peak. Since 1960, the pattern of water levels throughout the Basin has remained consistent. Underground water elevations, like the ground surface, exhibit a downward slope from the foothills of the San Gabriel Mountains along the northern border of the Basin to the Raymond Fault at its southeast side. At the foothills, water elevations exceed 1,000 feet above sea level: along the Raymond Fault, water elevations stay between 400 and 500 feet above sea level.

Groundwater extractions have stayed extremely close to the determined safe yield of the Basin (see Table 5-1). In the first 40 years after the Judgment, and despite the 20-year drought, total groundwater extractions of the parties have exceeded the safe yield in 20 years and have been less than the safe yield in the other 20 years. The significance of this successful limitation of pumping was described by an observer during the second decade of drought: "The records will indicate that the total water used in the area has more than doubled during this period. Had this amount of water been drawn from the Raymond Basin without controls, as was done prior to 1944, there is very little doubt in any of our minds that water in the Raymond Basin would have been almost nonexistent." (65)

c. Enhancement of Supply

Surely, if the total water used in the area since 1945 has more than doubled and yet groundwater extractions have been successfully limited during that time, additional water has been supplied somehow. A shortage problem following the limitation on pumping first became acute in the Monk Hill area of the Basin. The water producers in the Monk Hill area relied upon ground water extractions and surface water diversions prior to the Pasadena v. Alhambra judgment. Following that judgment, their groundwater extractions were curtailed significantly, while the beginning of the long series of dry years reduced surface water availability. In the meantime, water demands in the Monk Hill sub-basin increased, and none of the producers in that sub-basin had access to imported water from the Metropolitan Water District of Southern California (MWD).

The City of Pasadena, as an original member agency of MWD, did have access to imported water through MWD. Under the terms of the stipulation among the parties to the Raymond Basin litigation, parties could exchange water in any given year through the administration of the Watermaster service. This involved one party pumping less than its "decreed right" while another pumped more than its "decreed right" and compensated the one party through the Watermaster. The City of Pasadena and the Monk Hill water companies used the Water Exchange Agreement in a cooperative fashion to give the Monk Hill parties a supplemental supply of water indirectly. Pasadena imported water from MWD, refrained from pumping its full decreed right, and offered the difference to the exchange "pool" from which the Monk Hill companies purchased it.

There was, however, a limit to Pasadena's ability to offer exchange water. Pasadena had its own demands to meet as a water supplier, and could purchase only a limited amount of imported water in any year from MWD. Pasadena's offers grew until they peaked in 1952 at 3,929 acre-feet per year, which the Monk Hill companies purchased (see Table 5-2). Yet the Monk Hill water companies were unable to meet their demands for water through the combination of ground water extractions under their decreed rights, ground water extractions under the Water Exchange Agreement, and surface water diversions. (66) During the 1950-51 water year, the parties in the Monk Hill sub-basin negotiated with MWD an agreement to make a temporary purchase of Colorado River water, premised upon their acting to form a municipal water district. That proposed municipal water district would then join the MWD and obtain a direct supply of imported water. In the interim, the Monk Hill water producers were also allowed to extract more than their allowed pumping from underground without being penalized; again, presuming that their actions would lead to the acquisition of needed additional supplies.

The proposed municipal water district for the Monk Hill area was formed in 1952, and was named the Foothill Municipal Water District. The District was annexed to MWD in 1953, and began to receive deliveries of Colorado River water in 1955. After 1955, water exchange purchases in the Monk Hill sub-basin declined (see Table 5-2), reaching zero by 1959. MWD imports to Monk Hill rose from 1,751 acre-feet in 1955 to 5,600 acre-feet in 1959, fully replacing the 3,929 acre-feet of exchange water, and allowing the City of Pasadena to return to pumping its decreed right.

.TABLE 5-2

Water Exchange Agreement Transactions in Raymond Basin, 1945-1985

	Quantity of Exchange Water Purchased, in Acre-Feet			
Year	Monk Hill Sub-Area	Pasadena Sub-Area	Santa Anita Sub-Area	Basin Total
1945	925	53	0	978
1946	550	82	600	1232
1947	2750	64	300	3114
1948	3150	142	0	3292
1949	3150	115	0	3265
1950	3782	160	300	4242
1951	3938	96	700	4734
1952	3929	100	0	4029
1953	3929	72	0	4001
1954	3929	67	0	3996
1955	3929	215	0	4144
1956	2850	41	0	2891
1957	1700	10	0	1710
1958	1050	0	0	1050
1959	0	70	0	70
1960	0	45	0	45
1961	0	25	0	25
1962	0	40	600	640
1963	0	25	0	25
1964	0	30	0	30
1965	0	35	200	235
1966	0	25	300	325
1967	0	0	0	0
1968	0	10	0	10
1969	0	40	0	40
1970	0	50	0	50
1971	0	40	0	40
1972	0	45	0	45
1973	0	45	0	45
1974	0	50	0	50
1975	0	50	0	50
1976	0	50	0	50
1977	0	50	0	50
1978	0	50	0	50
1979	0	0	0	0
1980	0	0	0	0
1981	0	0	0	0
1982	0	0	0	0
1983	0	0	0	0
1984	0	0	0	0
1985	0	0	0	0

Source: Raymond Basin Watermaster RepcDrts, 1945-1985

As Table 5-2 indicates, use of the exchange pool virtually dwindled to nothing after 1959, and has in fact been zero since 1973, while a look back at Table 5-1 indicates the significance of direct imports in Raymond Basin since the mid-1950s. Monk Hill water imports peaked in 1961 at 8,425 acre-feet and have remained between 5,000 and 8,000 acre-feet per year since. Pasadena is the only other direct importer of MWD water in the Raymond Basin. Pasadena's imports reached 21,516 acre-feet in 1961 and have fluctuated between 10,000 and 20,000 acre-feet since 1961. The MWD imports to Pasadena and to Foothill Municipal Water District, ranging between 20,000 and 30,000 acre-feet per year, have allowed the Raymond Basin water producers to meet the increase in water demand since 1945 while staying within the limitations on groundwater extractions.

Some enhancement of the amount of water supplied by the underground basin itself has been undertaken by the Raymond Basin water producers. This is accomplished by spreading water. "Areas are flooded with water that percolates into aquifers and supplements the natural supply." (67) In this way surface waters that might otherwise exit the Basin area are detained and allowed to recharge the basin. There is no program in the Raymond Basin to purchase and spread imported water; the waters that are diverted to spreading grounds are local supplies, run-off from the San Gabriel Mountains. To capture and control some of this runoff, the Los Angeles County Flood Control District operates three spreading grounds, one at each of the surface streams which traverse the Basin area -- the Arroyo Seco, the Eaton Wash, and and Santa Anita Creek. In addition to the operations of the Los Angeles County Flood Control District, some of the Raymond Basin parties -- the Kinneloa Irrigation District, the Las Flores Water Company, the Lincoln Avenue Water Company, the Rubio Canyon Land and Water Association, and the cities of Pasadena and Sierra Madre. Because spreading is done with local runoff, the amount of water spread from year to year varies greatly, depending on precipitation. The total amount of water spread has ranged from 1,200 to almost 19,000 acre-feet in a year.

By enhancing underground water elevations, the actions taken (and costs incurred) by those parties who engage in spreading benefit all Raymond Basin water producers. In order to provide these parties who engage in spreading with an incentive to do so, the Raymond Basin judgment was modified in 1974 upon motion of those parties to allow credit for spreading. Under the 1974 Modification of Judgment, the Watermaster makes in each year a determination of the amount of water diverted for spreading and the Los Angeles County Flood Control District provides the Watermaster with a determination of the amount of water actually spread. Each party engaged in spreading is then allowed in the following year to extract up to 80 percent of the amount credited to it, in addition to that party's decreed right under the judgment. (68) This extraction of the parties' spreading credits accounts in part for the fact that total groundwater extractions have exceeded total decreed rights in most of the years since 1974 (see Table 5-1).

d. The Management Mechanism for the Basin

The principal monitoring and basin-management activities of the first forty years after Pasadena v. Alhambra were conducted by the

Raymond Basin Watermaster, which was the Southern District office of the California Department of Water Resources. The Department of Water Resources as Watermaster monitored all water production within the Raymond Basin service area (including imports and surface diversions), kept a "water account" for each producer recording extractions made and annual decreed right remaining on a monthly basis, administered the Water Exchange Agreement, and prepared and submitted an annual report on basin activities and conditions to the Superior Court and to each of the parties.

The costs of these activities of the Raymond Basin Watermaster were shared by the State of California and by the parties to the Pasadena v. Alhambra judgment. As part of the State's commitment to preserving water resources, one-half of the costs incurred by the State Department of Water Resources acting as Watermaster were paid from the State budget. The other half was apportioned among the parties in accordance with their decreed rights. From fiscal year 1982 through fiscal year 1984, the State reduced its contribution to one-third, leaving two-thirds of the Watermaster Service costs to be paid by the parties. The total cost of the Raymond Basin Watermaster Service, and the costs charged to the parties, are shown in Table 5-3. As of 1985, the cost of Watermaster Service to the parties was approximately $3.50 per acre-foot of decreed right. An acre-foot of water in southern California in 1985 held an approximate value of $250.00, using the cost of replacing that acre-foot with MWD imported water, so the cost of Watermaster service was roughly a one and one-half percent cost for administration of the judgment.

TABLE 5-3

Total Cost of Raymond Basin Watermaster Service, and Amount Paid by Parties, Fiscal Years 1945-1985

Year	Total Cost	Cost to Parties
1945	$ 3,868.77	$ 1,934.38
1946	4,313.10	2,156.55
1947	6,200.22	3,100.11
1948	5,941.36	2,970.68
1949	5,496.00	2,798.00
1950	4,480.11	2,240.06
1951	6,548.91	3,274.46
1952	5,268.65	2,634.33
1953	4,511.64	2,255.82
1954	5,386.55	2,693.28
1955	8,749.02	4,374.51
1956	9,102.17	4,551.09
1957	9,112.84	4,556.42
1958	9,936.48	4,968.24
1959	10,548.82	5,274.41
1960	13,666.45	6,833.23
1961	16,498.68	8,249.34
1962	16,225.51	8,112.75
1963	17,414.00	8,707.00
1964	18,070.91	9,035.46
1965	23,005.89	8,090.94*
1966	24,842.56	10,189.71
1967	16,195.75	8,097.87
1968	21,209.47	10,604.73
1969	26,289.54	13,144.77
1970	24,080,38	12,040.09
1971	29,113.84	14,556.92
1972	26,739.87	13,369.94
1973	34,642.72	17,321.36
1974	35,671.48	17,835.74
1975	39,434.28	19,717.14
1976	44,460.88	22,230.44
1977	54,714.18	27,357.09
1978	57,997.73	28,998.86
1979	51,804.28	25,902.00
1980	58,082.24	29,041.04
1981	75,180.43	37,590.40
1982	94,906.08	62,925.47
1983	94,647.08	63,414.85
1984	106,662.81	71,108.55
1985	112,471.00	112,471.00

-.Special appropriation made by State Legislature

Source: Raymond Basin Watermaster Reports, 1945-1985

The Department of Water Resources was assisted by a Watermaster Advisory Board, made up of representatives of the parties. In 1968, the Advisory Board, the City of Pasadena, and the Department of Water Resources began a study to develop a mathematical model of the Basin, which could be used to simulate the behavior of the underground and surface supplies under various pumping and recharge plans. The study was completed in 1971, and analysis of its results led to some of the elements in the 1974 Modification of Judgment, such as the crediting for spreading. Another element was a program for the voluntary control of pumping patterns. No less than twice per year, the Watermaster is to study and report pumping patterns to the Advisory Board, with recommendations (based upon the model of the Basin) as to where more water should be pumped and where less water should be pumped. The Advisory Board then transmits its recommendations to the parties. The program is, however, entirely voluntary. No party can be stopped from pumping its full decreed right. Parties are simply encouraged to withhold or increase pumping for a certain period.

In 1984, the management mechanism for Raymond Basin was changed. Upon motion of the Raymond Basin Advisory Board, the Superior Court on March 16, 1984 replaced the Department of Water Resources as Raymond Basin Watermaster. The new Watermaster is the Raymond Basin Management Board, successor to the Raymond Basin Advisory Board.

The Management Board, which shares offices with the Foothill Municipal Water District in La Canada-Flintridge, is attempting a more finely-tuned management of the Basin. The ten-member Board, made up of Raymond Basin water producers, operates generally by consensus, with the continuing jurisdiction of the Court available for decisions

Raymond Basin producers, Pasadena was unwilling to reduce its own production enough to keep the Basin in balance while all other producers pumped all they desired from underground.

The rules of California water law encouraged Raymond Basin producers to pump all the water they desired from underground. A change in those rules was accomplished with the use of an available capacity, a California court. The "mutual prescription" approach of the Pasadena v. Alhambra Judgment recognized correlative rights not only among overlying landowners but among all established users. This made pumping reduction the equivalent responsibility of all those who had participated in the previous over-pumping of the Basin.

In addition to the proportionate reduction of groundwater extractions to the safe yield Raymond Basin, the Judgment based on the agreement among the parties also provided for the exchange of water rights, monitoring of use and sharing of information on an ongoing basis, the establishment of an Advisory Board made up of the producers' representatives, and the retention of jurisdiction by the Court. This continuing jurisdiction of the Court has been used to redetermine Raymond Basin's safe yield, to maintain a boundary against newcomers who attempt to use the Basin without first acquiring rights to do so, to give the parties who engage in recharge of the Basin credit for doing so, and to transform the Advisory Board into the Management Board. Other changes made outside the court by the producers secured for the rest of the Basin (i.e, outside Pasadena) a supply of supplemental water: those in the western part formed Foothill Municipal Water District, while those in the eastern part annexed to the Upper San Gabriel Valley Municipal Water District.

The Raymond Basin Judgment left some uncertainties in the California water law rules it changed. There was no explicit overruling of the scheme of overlying/appropriative/prescriptive rights, and the question of what to do about public agencies that asserted their right not to be prescripted against was left unanswered. And, in a way, Pasadena v. Alhambra aggravated the pre-litigation pumping race in other basins, since adjudicated rights were based on prior extractions.

But in the end, despite these shortcomings, the actions in Raymond Basin helped to preserve a groundwater supply that otherwise would have been destroyed by now. The approach of proportionate reduction of use via contingent stipulation eliminated for producers the possibilities of receiving their best possible outcome (unlimited pumping while others restrained themselves) or of their worst possible outcome (exercising restraint while others do not). Because of this effect on the incentive structure of their situation and because the water producers arrived at these arrangements themselves, compliance and cooperation have been very high, as total extractions have stayed quite close to the determined safe yield. The Raymond Basin example gave water users another option in their consideration of ways of addressing overdrawn groundwater supplies: the choice of working out their own settlement and having the Court place the authority of the State behind it, making it enforceable by each against all. That other option was used with increasing sophistication over the next two decades, especially in the West and Central Basins of Los Angeles County.

Notes to Chapter Five

1. State of California, Department of Water Resources, Annual Report on Watermaster Service in Raymond Basin [hereafter referred to as "Raymond Basin Watermaster Report"], 1958, p. 2; also, Raymond Basin Watermaster Report, 1968, p. 1.

2. Raymond Basin Watermaster Report, 1958, p. 3, and Blackburn (1961), p. 2.

3. Blackburn (1961), p. 2.

4. Pasadena v. Alhambra, 207 P. 2d 17 at 26.

5. Id. at 31.

6. Raymond Basin Watermaster Report, 1958, p. 3.

7. Raymond Basin Watermaster Report, 1966, p. 1.

8. Much of my understanding of California water rights law derives from the work of Vincent Ostrom, conversations with him, and access to years of notes and drafts prepared by him. Thus, in many instances, specific citations are not possible, though a general acknowledgement is in order. The reader is also referred to Vincent Ostrom's writings cited in the Bibliography.

9. Weschler (1968), p. 7.

10. Coe (1983), p. 3.

11. Goodcell (1961), p. 6.

12. 14 Cal. 116 (1902).

13. Id. at 140.

14. Goodcell (1961), p. 6; also, Carruthers and Stoner (1981), p. 38.

15. San Bernardino v. Riverside, 186 Cal. 7 (1921) at 14.

16. Krieger (1955), p. 1.

17. 141 Cal. 116 at 134.

18. Id. at 135.

19. Lux v. Haggin, 10 P. 674 (1886).

20. 186 Cal. 7.

21. E. Ostrom (1965), p. 191.

22. West's Ann. Cal. C. C. P. 22, defining "actions." Suits in equity are called "actions," Lux v. Haggin, 10 P. 674 (1886).

23. Quoted in Blackburn (1961), p. 2.

24. Ibid., p. 3.

25. Ibid., p. 8.

26. Ibid., p. 3.

27. Raymond Basin Watermaster Report, 1951, p. 1.

28. Raymond Basin Watermaster Report, 1958, p. 4.

29. Ibid.; also Blackburn (1961), pp. 3-4 and 180 P. 2d at 707 et seq.

30. Blackburn (1961), p. 5.

31. 207 P. 2d 17 at 26.

32. Id.

33. Raymond Basin Watermaster Report, 1958, p. 5.

34. Schelling (1968).

35. The presence of shared counsel among parties with competing claims must be regarded as unusual, at the very least, and should not be misread as being a normal procedure.

36. Blackburn, (1961), p. 6; Raymond Basin Watermaster Report, 1958, p. 5; 180 P. 2d 699 at 712.

37. Goodcell (1961), p. 6.

38. Ibid., p. 7.

39. Ibid.

40. 206 P.2d 17 at 27.

41. Id. at 26.

42. Raymond Basin Watermaster Report, 1945, p. 42.

43. Pasadena v. Alhambra, 170 P. 2d 499 (1946) at 501.

44. Pasadena v. Alhambra, 180 P. 2d 699 (1947) at 708 et seq.

45. Id. at 720.

46. Id. at 722.

47. Id. (emphasis added).

48. Id. at 723.

49. Id.

50. Pasadena v. Alhambra, 206 P. 2d 17 (1949) at 27.

51. Id. at 30.

52. Id. at 28.

53. Id. at 32.

54. Id.

55. 70 S. Ct. 671, 339 U. S. 937 (1950).

56. Blackburn (1961), p. 7.

57. Krieger (1955), p. 2; Goodcell (1961), p. 3.; Weschler (1968), p. 9.

58. Krieger (1955), p. 1-

59. Ibid.

60. Ibid., p. 2.

61. E. Ostrom (1965), p. 197.

62. Raymond Basin Watermaster Report, 1962, p. 6.

63. Raymond Basin Watermaster Report, 1965, p. 4.

64. Raymond Basin Watermaster Report, 1954, p. 1.

65. Blackburn (1961), p. 9.

66. Raymond Basin Watermaster Report, 1952, p. 8.

67. Raymond Basin Watermaster Report, 1975, p. 13.

68. Raymond Basin Watermaster Report, 1974, p. 31.

CHAPTER SIX

WEST BASIN: EXPOSURE ON THE CALIFORNIA COAST

CHAPTER SIX

WEST BASIN: EXPOSURE ON THE CALIFORNIA COAST

In some cases, users of a common-pool resource have only one problem to solve: restricting withdrawals from the resource to its "carrying capacity," or "safe yield." The Raymond Basin was such a case. Nonetheless, resolution of the Raymond Basin problem involved the passage of decades, the expenditure of considerable sums of money, and the creation of new institutional arrangements for supply enhancement, demand restriction, and monitoring. A preserved Raymond Basin is an extraordinarily valuable resource, but the process of preservation is fragile and costly, even when the problem is not too complicated.

Then there are cases like that of West Basin. West Basin presented water users with more than one problem to solve, in a less favorable setting. In West Basin, many more water producers were spread over a larger area. They faced not only a problem of restricting demand to supply, but also the problems of dwindling supply and contamination. West Basin users needed to work on several fronts and create several arrangements just to keep the groundwater supply from being completely destroyed, much less put to suboptimal use.

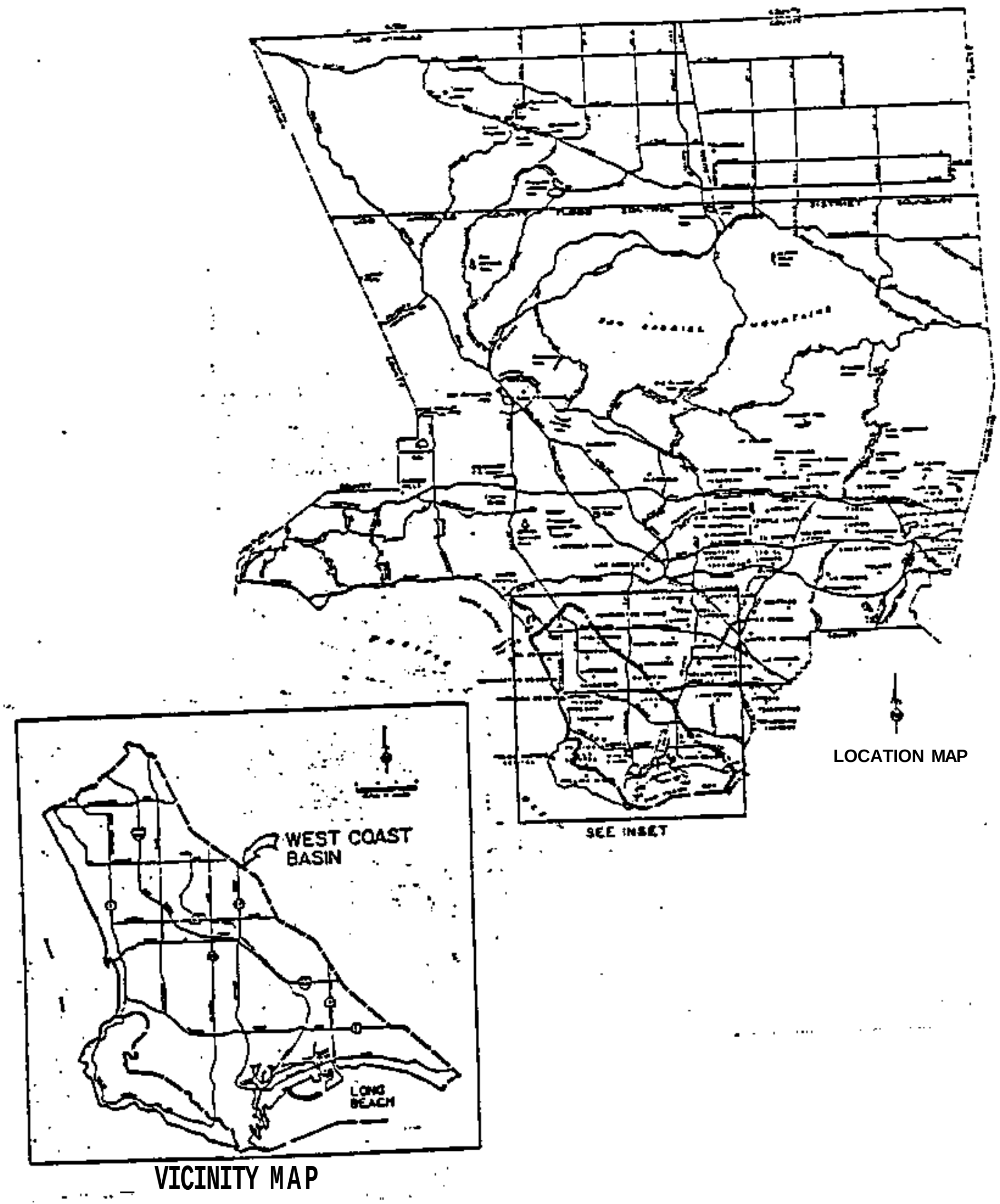
A. The Nature and the Problem of West Basin

Within the Los Angeles Basin lies the Coastal Plain of Los Angeles County. The Coastal Plain is the area from, the City of Los

Angeles south to the Pacific Ocean, an area of approximately 420 square miles. The Plain is bounded on the northwest by the Santa Monica Mountains, on the northeast by the Elysian, Repetto, Merced, Puente, and Coyote Hills, on the southeast by the Orange County line, and on the southwest by the Pacific Ocean. The Coastal Plain slopes gently to the south and east, toward the ocean and into Orange County.

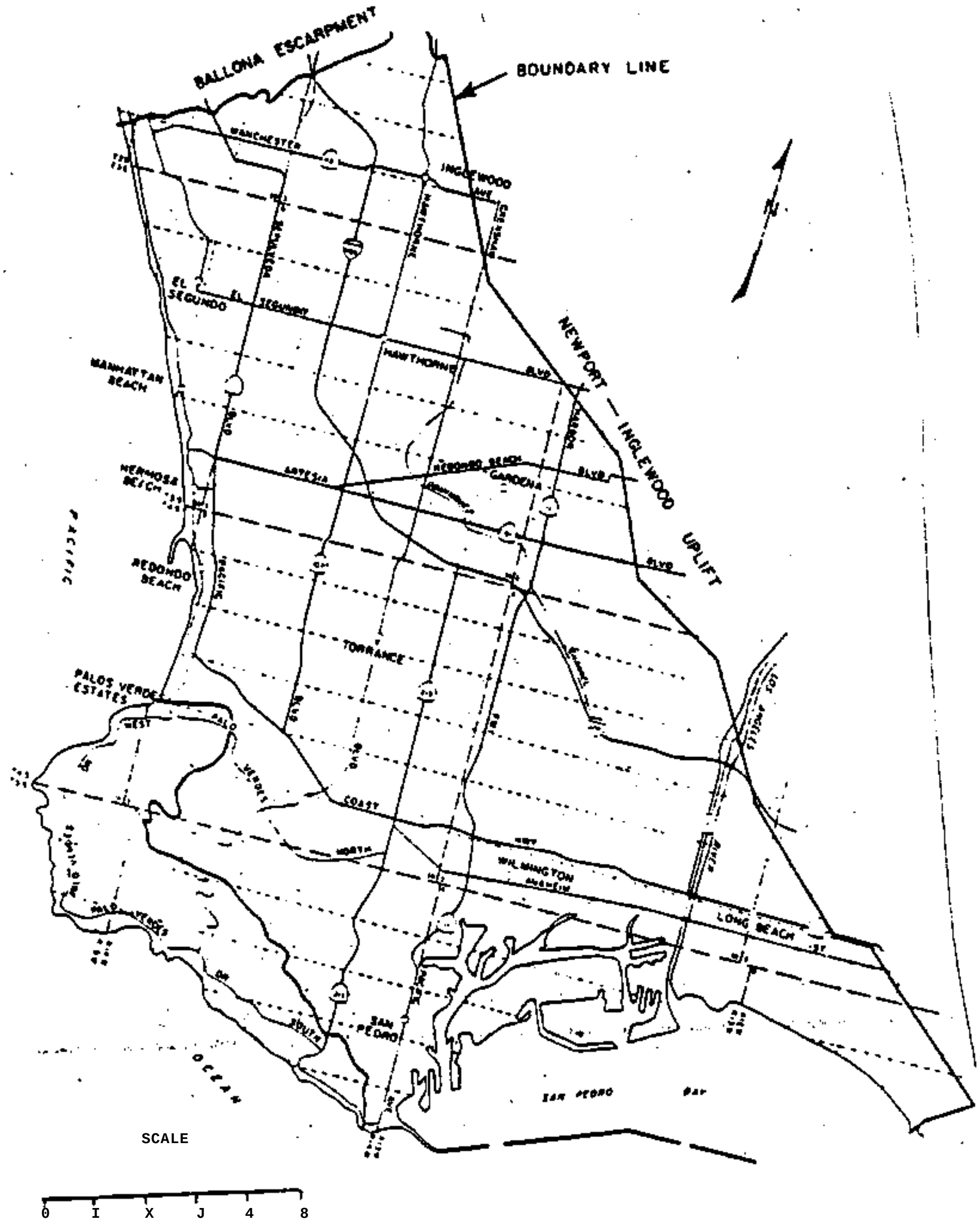
A significant disruption to this gradual sloping is a line of low hills bisecting the Coastal Plain from the northwest to the southeast, including the Baldwin, Rosecrans, Dominguez, and Signal Hills. This line of hills is the surface manifestation of the Newport-Inglewood Fault Zone, which extends from the northwest border of the Los Angeles County Coastal Plain into Orange County toward the area of Newport Beach. The Newport-Inglewood Fault Zone, also called the Newport-Inglewood Uplift, divides the underlying geologic and hydrologic structure of the Coastal Plain into two basins. The area northeast of the Uplift is the Central Basin (the focus of Chapter Seven); the area southwest of the Uplift is the West Coast Basin.

The West Coast Basin, known more commonly simply as "West Basin," is the southernmost toe of Los Angeles County (see Map 6-1). West Basin's length from northwest to southeast is 25 miles. Its average width is about seven miles. Its land area is approximately 170 square miles or 101,000 acres -- about four times the size of the Raymond Basin. The northern boundary of West Basin is along the crest of the Ballona Escarpment (see Map 6-2), which lies just south of and parallel to the Ballona Creek. The Ballona Escarpment is not a solid geologic disjuncture; rather, the historical lack of groundwater extractions along the escarpment has resulted in a ridge of high



Map 6-1. West Basin Within Los Angeles County

Source: LACFCD Evaluation of Barrier Project, 1983



Map 6-2. West Basin Boundaries

Source: West Basin Waterraaster Report, 1976 ground water levels forming a "ground water divide," from which water levels slope away to the north and south and across which ground water does not move. (1)

The Ballona escarpment reaches the Newport-Inglewood Uplift at the Baldwin Hills. The Newport-Inglewood Uplift forms the eastern boundary of West Basin from the Baldwin Hills to the Los Angeles-Orange County line near the City of Long Beach. The coast lines of San Pedro Bay (the location of the Los Angeles Harbor) and the Pacific Ocean form the southern and western boundaries of West Basin, respectively, with one exception. In the southwest corner of the basin, the drainage divide of the Palos Verdes Hills is treated as the boundary rather than the coast, because those hills are composed of non-water-bearing materials and waters on the seaward side of the divide do not influence West Basin. (2)

A.I. The Natural Physical System

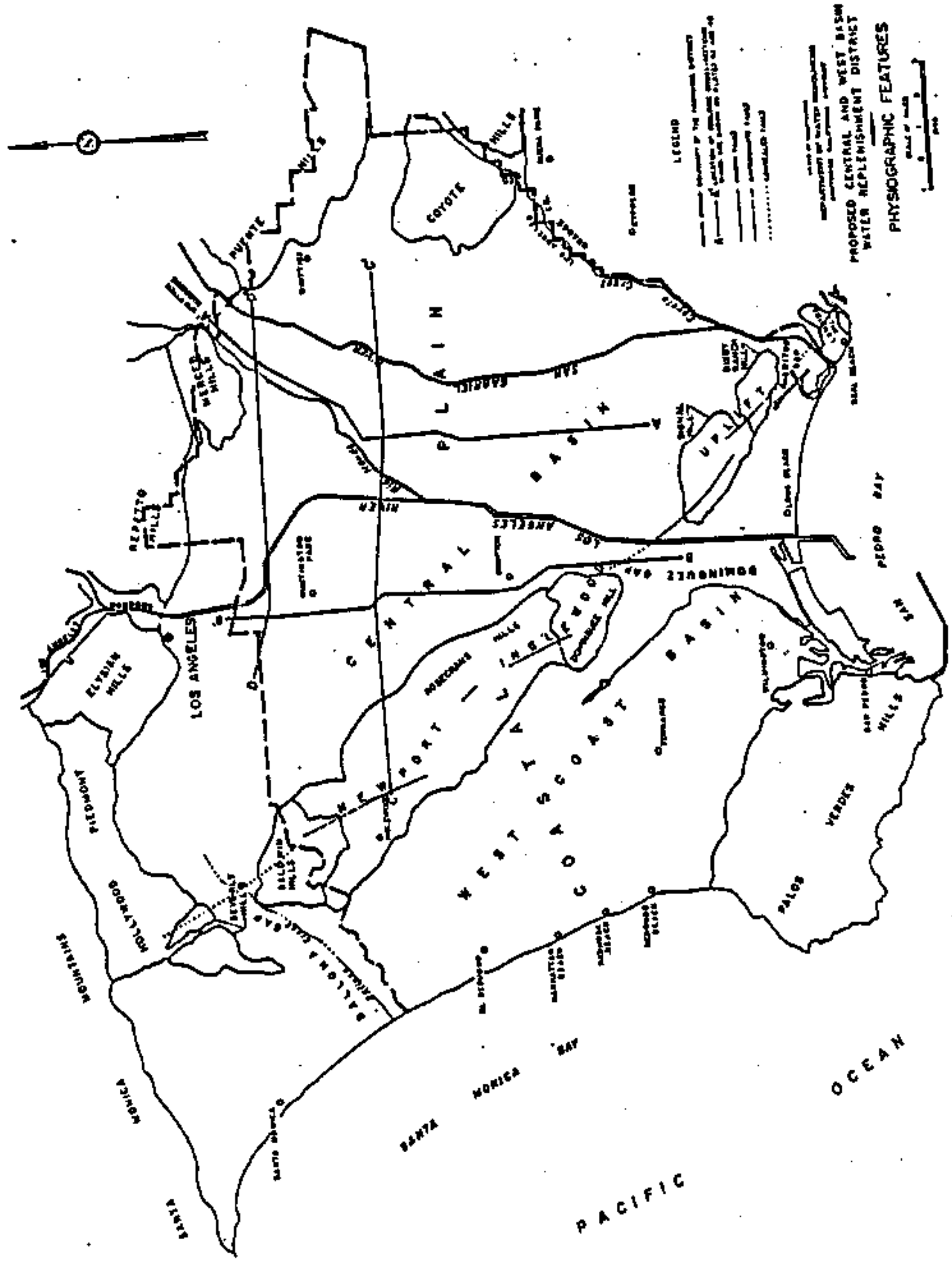
The Palos Verdes Hills were most likely an island at one time, and the current surface of West Basin was formerly a sea floor. During the Pleistocene and Recent periods of geologic formation, the Pacific Ocean moved in and out, alternately covering and exposing the Coastal Plain. These movements resulted in the depositing of layers of sediment upon the floor of the Plain. Coarser layers of gravel and sand were overlaid by finer layers of silt and clay, which were in turn overlaid by coarser layers, then finer layers, and so on. (3) During the times when the Coastal Plain floor was exposed, further deposits were laid down in channels of the ancestral Los Angeles and San Gabriel Rivers.

This process of formation resulted in the sandwiching of coarser materials, capable of transmitting and retaining water in their pore spaces, between finer, relatively impermeable materials, creating a "stacking" of aquifers beneath the floor of West Basin. (4) Fresh ground water is confined in these superimposed aquifers. The Silverado aquifer is the largest of these, covering over 80 percent of the area of the West Basin, and merging with other aquifers in the remainder of the Basin. The other, smaller aquifers are the Gardena, Gaspur, San Pedro, "200-foot sand," and "400-foot gravel" aquifers. The total groundwater in storage in this set of aquifers underlying West Basin is estimated at six and one-half million acre-feet, which, at current replacement prices, would be worth approximately $1.8 billion.

Overlying this set of aquifers, the last layer of soil deposits, is a relatively impervious layer of clay. This fact has crucial implications for the water supply system in West Basin. It means that there is very little recharge to West Basin from the average annual rainfall of 15 inches. Rainfall hitting the land surface in West Basin principally drains to stream channels that flow out to the Pacific. As a result, underground water levels in West Basin are unresponsive to weather conditions. In addition, virtually no capacity exists within West Basin for the recharge of the underground aquifers by spreading of water for percolation. (5)

How, then, does West Basin obtain its fresh groundwater supply? Invisibly, beneath the ground surface, water flows in from the Central Basin. West Basin is the last in a series of three interconnected groundwater basins. The next basin "upstream" is Central Basin, which in turn receives flows from the Upper San Gabriel Basin, which collects runoff from the mountains. (6) Since West Basin is unresponsive to local precipitation, its fresh water recharge comes from subsurface flow across the Newport-Inglewood Uplift from Central Basin. Under natural conditions, water gathers underground in Central Basin behind the Newport-Inglewood Fault, which acts as an underground dam. The underground water level is higher, then, in Central Basin than in West Basin, and the water spills over the fault from Central Basin into West Basin. The Uplift "resembles a ground water cascade," (7) and the rate of flow across the Uplift depends upon the difference in water levels between Central Basin and West Basin. The greater the difference between the higher water levels on one side of the Uplift and the lower water levels on the other side, the greater the volume flowing from the one side to the other. Since for "all practical purposes the sole source of continuing fresh water replenishment to the basin is the underflow across the Newport-Inglewood uplift. . . . the West Coast Basin is not a unique, independent hydrologic unit, but is dependent on adjoining areas for practically its entire ground water supply." (8)

The flow of water beneath the ground across the Newport-Inglewood Uplift is facilitated in certain locations by erosions of the fault discontinuities resulting from surface stream flows. The crossing of the Newport-Inglewood Uplift by surface streams has created narrow "gaps", backfilled with relatively more porous materials through which water more readily passes (see Map 6-3). Ballona Creek crosses the Uplift at Ballona Gap and then flows to the Pacific Ocean along the northern boundary of West Basin. The Los Angeles River crosses the



Map 6-3. West and Central Basins

Source: DWR Report on Proposed CWBWRD, 1959

Uplift through Dominguez Gap, which extends south between Dominguez Hill and Cherry Hill, following which the River empties into San Pedro Bay. The San Gabriel River crosses the Uplift very near to the Ocean at Alamitos Gap, situated between Bixby Hill in Los Angeles County and Landing Hill in Orange County. These stream channels serve as underground "avenues" through which water travels relatively easily.

Water is capable of entering West Basin along its eastern boundary from Central Basin. That is the principal source of fresh water supply. It is not, however, the source of all water supply. West Basin is also able to receive water along its western and southern boundaries, from the Pacific Ocean.

Because of the slow erosion of the clay covering of West Basin by the relentless movement of the Pacific Ocean, the aquifers underlying West Basin are in contact with the ocean floor, separated only by permeable material. (9) This exposure occurs along the eleven-mile western boundary between Ballona Creek and Palos Verdes Hills. The "gaps" referred to above, caused by the flows of the Los Angeles and San Gabriel Rivers also eroding the clay covering of the West Basin, further expose West Basin to the ocean (or San Pedro Bay, at least) along two four-mile sections of the southern boundary. (10) Along these exposed fronts, as described in Chapter One, what matters is the relative elevation of the underground water and the ocean. If the water confined under pressure in the aquifers remains above sea level, fresh water will flow out from the aquifers into the ocean. If the piezometric surface of the underground water declines below sea level, salt water from the ocean will invade the fresh water supply. (11) In a water-deficient area, neither of these alternatives is desirable:

water flowing out from underground into the ocean is waste, while salt water moving in from the ocean is contamination.

Altogether, then, West Basin is a highly valuable, but also highly exposed, water supply source. The ultimate source of fresh water to West Basin is miles away, in the rainfall and runoff of the San Gabriel mountain range; rainfall and stream flow on the surface of West Basin itself do not contribute to the ground water supply. This twenty-five mile long, seven-mile wide strip of land along the California coast can receive water below ground from the upstream basins to the north and east or from the ocean to the south and west. There, to the south and west, the Pacific Ocean ceaselessly laps against the shore line of West Basin: the intruder pressing at the gate, waiting to be let in.

A.2. Development of the Problems in West Basin

Today, West Basin is the location of twenty incorporated cities, standing wall to wall -- one long, undifferentiated urban mass. (12) There is a row of "beach cities", such as El Segundo, Manhattan Beach, Hermosa Beach, and Redondo Beach, and a row of "inland cities", such as Inglewood, Hawthorne, Gardena, Torrance, and Wilmington, plus parts of the Cities of Los Angeles and Long Beach. Three-quarters of a million people live on these 170 square miles, sharing it with a large industrial and commercial community, a major harbor facility, and one of the world's largest airports -- Los Angeles International, located just south of Ballona Creek.

Just over a hundred years ago, West Basin was a much less developed area. In the late 1800s, the West Basin area was principally agricultural, with a few small communities surrounded by orchards, truck farms, and grazing land. (13) At this time, ground water levels were very high, with heavy artesian flow from wells and swampy conditions in low-lying lands -- underground water elevations were over 100 feet above sea level in the vicinity of what is now the City of Hawthorne. (14) The Los Angeles and San Gabriel Rivers frequently overflowed their banks during winter storms and inundated the Coastal Plain. (15)

Around 1870, the West Basin communities of Inglewood and Long Beach began to tap artesian wells and springs in the area of the Newport-Inglewood Uplift. (16) Inglewood incorporated in 1887, a year that also saw the incorporation of Gardena and Redondo Beach. (17) Resort areas developed along the oceanfront -- beside Redondo Beach came Manhattan Beach, Hermosa Beach, and El Segundo in later years. As these resort towns grew, water supply enterprises developed to meet the demand for water. (18)

By the turn of the century, the area of artesian water flow had receded. Water suppliers began to drill shallow wells to reach the supply underground. A study of the area by the United States Geological Survey in 1904 reported a shrinkage of the artesian area in West Basin, lowered underground water levels, and the existence of over 100 producing wells. (19) Underground water levels were declining even though total groundwater extractions in 1904 were estimated to be only 10,000 acre-feet per year. (20) Nonetheless, West Basin still exhibited a seaward-sloping hydraulic gradient in 1904: the underground water was moving toward the ocean in all parts of the Basin.

Thus, the last two decades of the nineteenth century saw the beginnings of the development boom in West Basin. The first two decades of the twentieth century brought further acceleration in the population and economic growth of the area, with concomitant increases in the demands placed on the local water supply. Water levels that were above sea level throughout the basin (albeit declining) at the beginning of the century were below sea level at specific wells by 1920. (21)

The 1920s brought another large influx of population to the Los Angeles area, and the incorporation of more cities (Torrance in 1921, Hawthorne in 1922). Virtually all of the water supplied to this increasing populace came from underground. By the close of the decade, groundwater elevations over virtually the entire Basin south of the Ballona Creek area were below sea level.

As noted before, for all practical purposes, the entire supply of fresh water to West Basin comes by way of underground flow across the Newport-Inglewood Uplift. Increasing the differential between water levels on the West Basin, or "downstream", side and those on the Central Basin, or "upstream", side increases the flow across the Uplift from Central Basin into West Basin. As a result of this hydrologic phenomenon, West Basin water users actually increased their fresh-water supply during the early decades of the twentieth century by drawing down the water levels in West Basin, thus increasing the hydrostatic head across the Uplift and causing more water to flow out of Central Basin into West.

In the first two decades of the century, the average annual flow across the Uplift was approximately 10,000 acre-feet. Over the course of the 1920s, that annual flow from Central Basin to West Basin increased to over 20,000 acre-feet. (22) Thus, the producers in West Basin pulled more fresh water into the area by taking more water out. However, while fresh-water replenishment went from 10,000 acre-feet per year at the beginning of the century to 20,000 acre-feet in 1930, annual groundwater extractions quadrupled from 10,000 acre-feet to 40,000 acre-feet, leaving West Basin overdrawn by some 20,000 acre-feet per year.

Under other geologic circumstances, this overdraft would have resulted only in declining water levels. That result is dangerous enough, given the possibilities of compaction of sediments and land subsidence. But in West Basin, the same aquifers that were in contact with the fresh-water supplies coming across the Uplift were also in contact with the Pacific Ocean. Nature, it is often remarked, abhors a vaccuum, so when groundwater extractions were reaching 40,000 acre-feet per year and only 20,000 acre-feet per year were coming across the eastern boundary of West Basin, and with water levels throughout the Basin below sea level, nature began to fill the vaccuum from the western boundary, with sea water. West Basin began to make up its underground water shortage, not only with increased flows of fresh water from Central Basin, but with the invasion of salt water from the ocean.

The ocean came into West Basin early, and it came in fast. In 1912, the Southern California Edison Company abandoned a well at its Redondo Steam Plant due to excessive salinity of the water being produced there. (23) By 1920, other wells along Santa Monica Bay had been abandoned, (24) and in 1922 wells were shut down in the El

Segundo area because they were pulling salt water. (25) By 1932, waters underlying the Manhattan Beach area had reached chloride concentrations in excess of 100 parts per million; over the course of the next two decades those chloride concentrations reached 1,570 parts per million. (26) As of the early 1930s, the entire coastal area of West Basin from the Ballona Escarpment to Palos Verdes Hills was intruded by salt water. (27)

During the 1930s, the Depression slowed growth in West Basin only mildly. Water levels continued to fall, and the encroachment of salt water proceeded apace. It was during this decade that a group of oil companies acquired land and built refining operations in West Basin. They became major producers of water for their own use; by 1945, the oil companies alone were extracting over 27,000 acre-feet of ground water, nearly 36 percent of total groundwater production. (28) By the close of the 1930s, total groundwater production from West Basin had reached 50,000 acre-feet per year (see Table 6-1), while average annual fresh-water replenishment across the Uplift averaged about 24,000 acre-feet per year (29). The ocean continued to move in to make up the difference, threatening not only the coastal reaches but the rest of the Basin. (30)

During World War II, West Basin industrial concerns operated at full capacity, and groundwater pumping increased dramatically to support the wartime industrialization. (31) Underflow across the Newport-Inglewood Uplift increased to nearly 30,000 acre-feet per year, (32) but groundwater extractions increased during the decade to over 80,000 acre-feet per year. In addition, the concentration of

TABLE 6-1

West Basin Water Production and Total Water Use (in Acre-Feet), 1933-1985

Year	Groundwater Extractions	Imported Water	Exported Water	Total Water Use
1933	45,635	18,146	581	63,200
1934	49,985	17,915	600	67,300
1935	48,880	17,098	478	65,500
1936	47,152	27,758	610	74,300
1937	45,655	27,602	657	72,600
1938	46,054	27,014	668	72,400
1939	50,975	27,353	628	77,700
1940	52,024	26,953	111	78,200
1941	52,406	27,425	631	79,200
1942	52,929	31,349	678	83,600
1943	59,258	39,085	843	97,500
1944	68,062	42,379	1,041	109,400
1945	75,856	51,339	1,295	125,900
1946	75,847	52,033	1,880	126,000
1947	75,275	47,735	2,110	120,900
1948	82,138	51,455	2,193	131,400
1949	81,601	57,010	1,911	136,700
1950	81,626	60,652	1,578	140,700
1951	86,240	60,990	2,330	144,900
1952	87,490	63,150	2,600	148,040
1953	94,070	73,320	2,620	164,770
1954	86,970	84,580	2,670	168,880
1955	80,540	94,570	2,000	173,110
1956	67,650	112,870	2,214	189,086
1957	67,700	137,200	2,607	202,293
1958	67,000	135,000	3,053	198,947
1959	67,000	151,000	3,676	214,324
1960	67,000	152,000	4,089	214,911

TABLE 6-1 (continued)

Year	Groundwater Extractions	Imported Water	Exported Water	Total Water Use
1961	61,900	156,000	4,577	213,323
1962	58,624	165,918	7,542	215,975
1963	58,861	168,437	8,052	223,264
1964	60,842	188,877	8,873	240,846
1965	59,370	248,161	9,752	297,778
1966	60,759	237,237	10,618	287,378
1967	62,552	233,714	10,291	285,976
1968	61,554	243,184	11,445	293,293
1969	61,638	240,276	11,224	290,690
1970	62,447	257,012	13,700	305,759
1971	60,924	251,887	12,846	299,965
1972	64,733	262,633	12,868	314,498
1973	60,478	245,857	11,323	295,012
1974	54,966	251,931	12,056	294,841
1975	56,673	244,157	11,906	288,924
1976	59,407	256,846	13,225	303,028
1977	59,882	234,168	11,820	282,229
1978	58,300	257,535	10,461	305,374
1979	58,058	242,594	10,550	290,103
1980	57,085	264,379	11,783	309,681
1981	57,700	266,071	12,527	311,244
1982	62,664	251,393	11,728	302,329
1983	57,057	268,673	12,089	314,091
1984	53,341	282,569	12,230	323,680
1985	51,450	283,764	7,779	327,435

Sources: 1952 West Basin Referee Report; 1961 West Basin Referee Report; West Basin Watermaster Reports, 1956-1985 industrial and residential development in certain areas of the Basin meant that these accelerated withdrawals were not occurring uniformly across West Basin. Pumping "troughs" developed east of Hawthorne and in the Dominguez-Wilmington area, with extreme declines in those places causing accelerating production costs due to increased pumping lifts and the deepening of wells. (33) These troughs in turn changed the flow directions of the underground water, pulling water from surrounding areas toward these depressions and accelerating the inland movement of sea water. Inland water producers operating in the vicinity of these troughs were sucking the sea water directly toward the parts of the Basin on which they had become so heavily dependent.

After World War II, the Coastal Plain area generally, and West Basin in particular, continued its rapid urbanization and industrialization. Production of water for irrigation use in West Basin declined to 10 percent of total groundwater production by 1950; industrial use accounted for 48 percent and municipal use 42 percent. The urbanization and growth of population in the Basin as a whole is reflected in the population growth of some of the cities in West Basin through the postwar period. Redondo Beach, for example, had a population of 900 in the year 1900; by 1960, its population was 47,000. Manhattan Beach had 900 residents in 1920, 33,900 in 1960. Inglewood went from 3,300 in 1920 to 63,400 in 1960. Torrance, now the third largest city in Los Angeles County, had only 10,000 residents as late as 1940; by 1960, Torrance's population had increased tenfold, to 101,000. Long Beach, the County's second largest city, boomed from 2,300 residents at the beginning of the century to 344,200 in 1960, 150 times its turn-of-the-century figure.

Groundwater production continued to accelerate into the early 1950s, reaching 94,000 acre-feet in 1953. During that year, inflow across the Newport-Inglewood Uplift was 30,000 acre-feet, 52,000 acre-feet of salt water came in from the ocean, and there was a 12,000 acre-feet decline in ground water in storage. (34) Over the period from 1932 through 1953, it has been estimated that nearly 400,000 acre-feet of salt water entered West Basin. (35) The total accumulated overdraft through 1957 has been estimated at 832,000 acre-feet, with roughly half replaced by salt water and the other half accounted for by loss of ground water in storage, reflected in the lower water levels throughout the Basin. (36) Map 6-4 illustrates the declines in water levels throughout the Coastal Plain from 1934 through 1957. The areas that had at the beginning of the century shown underground water elevations of 100 feet above sea level by the late 1950s had underground water elevations of nearly 100 feet below sea level. (37)

With the ocean pouring into the Basin at upwards of 50,000 acre-feet per year by the 1950s, increasing amounts of the total area of West Basin became underlain by salt water. Throughout the beach cities, the grass in school and park lawns died as a result of being irrigated with ground water of high chloride content. (38) Along the western coastline, from 1950 to 1956, the line of underground water exhibiting chloride concentrations in excess of 100 parts per million moved inland at a rate of 1,100 feet per year, advancing nearly one and one-half miles in those seven years. (39) By 1957, nearly 12,000 acres of the western coastal area of the Basin was underlain by waters with chloride concentrations of over 500 parts per million. (40) All

Map 6-4. Lines of Equal Change in Ground Water Elevations, 1934-1957

Source: DWR Bulletin No. 104, Appendix B, 1968 of the aquifers in the Basin were affected. A second saline water front appeared along the southern coastline of West Basin, coming in from San Pedro Bay in the vicinity of the Dominguez and Alamitos Gaps. By the late 1950s, this second sea-water front had reached the Pacific Coast Highway near Wilmington, approximately two miles inland. (41)

With water levels down 200 feet in some places from their historic highs, an accumulated overdraft of over 800,000 acre-feet, 400,000 acre-feet of intruded salt water, advancing salt water fronts on both the west and the south, thousands of acres of land underlain by unusable contaminated ground water, and dozens of wells abandoned, West Basin water users were facing the imminent possibility of the destruction of their ground water supply. Water users in West Basin came close, in Elinor Ostrom's words, to "breaking the bank". (42) The California Department of Water Resources in 1959 referred to West Basin as "one of the most critically overdrawn ground water sources in southern California." (43) West Basin appeared to be a "tragedy of the commons" well on the way to its presumably inevitable conclusion. Disaster indeed seemed to be coming toward West Basin at a gallop: "one would predict from the theory of the commons that the basin would be destroyed by salt water intrusion <u>within a few years</u>." (44)

Today, though the development of the area has continued and total water used per year within West Basin is double what it was in 1953 (see Table 6-1), West Basin is a stable source of water supply as part of a conjunctive use system. The California Department of Water Resources no longer lists West Basin as in "critical overdraft" condition at all, much less as "one of the most critically overdrawn ground water sources in southern California". Underground water levels have stabilized, and have recovered in some places. The invasion by the ocean has been halted, along both the western and southern fronts. And these results have been accomplished without the imposition of either of the "solutions" regarded as necessary by much of the prevailing literature on commons problems: centralized management of the Basin as public property or placing the Basin under private ownership. The process was complicated, fragile, time-consuming, and expensive; it was, in fact, underway even as the Basin deteriorated to its most critical stages in the 1950s.

B. Responses to the Problems in West Basin

Water users in West Basin had multiple interrelated problems to confront and resolve in order to preserve and efficiently use their underground water supply. Over the course of four decades, they worked on these multiple problems, with action usually occurring on more than one front at any given time. This complicates the task of giving an account of the activities in West Basin. A strict chronological account causes one to jump from one focus of action to another. On the other hand, giving an account of activities by problem category -- e.g., supply enhancement, demand restriction, combatting sea-water intrusion --is also not simple, as it leaves one repeatedly doubling back on a time line, beginning the description of action on some problem just after completing the description of action on another problem and thus jumping back perhaps four decades to pick up at the start of the new story. In addition, the actions taken in response to one problem frequently carried ramifications (good or bad) for another problem. Because the problems of West Basin were (and are) interrelated, actions on problems cannot be cleanly separated.

Thus, having given the reasons why one should not organize the description of the responses to the problems of West Basin by problem categories, that organization is precisely the one to be followed here. It remains preferable to trying to describe multiple actions occurring simultaneously to address the various problems of the Basin. For the convenience of those readers interested in a strict chronological account, a West Basin Chronology has been included in the Appendix. We shall proceed through the discussion in this Section focusing on the following categories of problems confronting West Basin water users: (a) the securing of an additional supply of water, (b) the curtailment of demand upon the Basin's ground water supply, (c) the problem of upstream supply conditions and the replenishment of fresh water into the Basin, and (d) the battle with the underground invasion from the Pacific. But first, we shall discuss the setting for action in West Basin, and the very first steps of West Basin actors in recognizing their problems.

B.I. The Setting for Action: Obstacles and Advantages

The situation confronting water producers in West Basin as their problems became acute involved several obstacles to overcome in order to achieve successful collective action. The most obvious, in light of the theory of collective action (and in contrast with Raymond Basin), was the size of the user group. By the mid-1940s, approximately 700 persons owned wells in West Basin. Now, not all of those well owners were actively producing water from the Basin --

indeed, a majority of them were not. But each was at least a <u>potential</u> producer, one who could conceivably add to the demands placed upon the resource and who thus would somehow have to be accounted for if restrictions were to be placed upon demand. As for active producers, there were 279 of them in 1950, (45) nearly ten times as many as in the Raymond Basin case when litigation began there. The existence of a much larger group of users in West Basin meant that each of the steps they would have to take in resolving their problems would be more difficult, more expensive, or both.

In addition to the size of the user group there was the size of the resource. As noted earlier, West Basin is roughly four times the size of Raymond Basin. Users in the Inglewood area resided six cities and nearly an hour's drive away from users in Long Beach or Wilmington. The larger size of West Basin made it more likely that users at one end would fail or refuse to acknowledge that they even shared a water supply with users at the other end. Further, the size of the Basin made it more difficult and costly to gather information about the resource and use patterns.

This difficulty was compounded by the low visibility of the resource. Of course, all groundwater basins by definition suffer from low visibility. This general inclination was aggravated in the West Basin case by the fact that at each end of the Basin, boundary definitions become somewhat arbitrary, since neither the Ballona Escarpment nor the Orange County line is a firm hydrologic divide. In such a case, boundary definitions themselves can become sources of dispute among users.

West Basin water users, like those in the Raymond Basin, faced an obstacle to successful collective action in the institutional setting of their actions, as well as the physical setting. The institutional obstacle was the incentive structure built into California water law prior to 1950. Since the status and substance of the California law of water rights has been detailed at length in the previous chapter on Raymond Basin, only a few observations are needed here. Because of the definition of rights to the use of water established in California law, West Basin water users faced incentives to withdraw as much water as they could while also facing incentives to refrain as long as possible from engaging in a determination of their rights. Maximum possible withdrawal of water was the way to either protect an overlying or appropriative claim or to perfect a prescriptive claim. The senior water producers in the Basin -- the older private water companies and the cities -- were not induced to incur the costs of adjudication, since they reasoned that they had long since perfected rights to the water they were withdrawing. Adjudication would not bring them any more water, and would cost them considerably in time and finances. The newer water producers, such as the oil companies, plus those older producers who were increasing their production, actually faced an incentive to defer a determination of rights as long as possible in order to perfect claims to their new or expanded production. (46)

The West Basin situation also exhibited some characteristics favorable to collective action. While the structure of California water rights law was an obstacle to collective action, the availability of the California court system was an advantage, as it was in the Raymond Basin. The availability of the courts, especially with their equity powers, gave water users a capacity for engaging in information-gathering and sharing, making assignments of shares, and making those assignments enforceable.

But more to the point, the West Basin water users had an advantage that the Raymond Basin users did not have, at least with reference to water law and the use of the courts. The West Basin water users had the example of the Raymond Basin action to follow. Raymond Basin and West Basin are not physically interconnected, except in rather remote senses (streams that flow out of the Raymond Basin area eventually find their way into the Los Angeles and San Gabriel rivers, for instance, though these rivers do not directly recharge the West Basin). They were, however, sufficiently close that the news of what was happening in Raymond Basin was well attended to by West Basin actors, who did in fact pattern some of their own actions after the Raymond case. (47)

The West Basin situation had other favorable circumstances, as well. Though hardly a desirable state of affairs, the condition of the resource was a favorable spur to collective action in West Basin. As described in the previous Section, the problems of West Basin grew to be extreme and did so quickly. Water levels fell not by feet but by tens of feet in just a few years. Sea water flooded in by the thousands of acre-feet each year. The Pacific's invasion of West Basin nearly destroyed it, but it served also as "the stimulus which evoked the efforts of entrepeneurs to seek... solutions to their common problem." (48) West Basin was also a "downstream" resource, first to experience supply depletion and contamination and most exposed to the adverse consequences of others' actions, and thus more likely to be the locus of action.

Another favorable circumstance for West Basin water users was the distribution of interests within the user group. While the size of the user group was an obstacle, the distribution of interests was such that a relatively small number of major water producers accounted for a large proportion of the water produced from the Basin. West Basin was not in as advantageous position as Raymond Basin, with one clearly predominant individual producer. Nevertheless, in 1950, when there were 279 active producers in the Basin, 19 of these producers accounted for 68,601 acre-feet (84 percent) of all of the production from the Basin that year. (49) This smaller group, if they could control <u>their</u> actions, could effectively control the demands placed upon the resource. There was, in other words, a minimal effective set less than one-tenth the size of the entire group.

West Basin was also favored by the wealth and relative stability of its user group. After the introduction to the area of the oil companies, the set of major producers remained stable, even though use of the ground water supply continued to increase rapidly. This aided in the establishment of communication arenas, collective decision-making mechanisms, and monitoring of behavior (at least of the major producers). In addition, this set of major producers was composed of oil companies, large water service companies, and municipalities, each of which was relatively well positioned to bear some of the costs of information-gathering, communication, and decision-making involved in the process of resolving a commons problem. Indeed, it was their exploitation of this very resource that had brought the companies considerable wealth and the cities considerable revenue bases that they were then able to draw upon in remedying the effects of their past actions. (50)

B.2. Early Responses: Imports, Reports, and the First Meetings

On the basis of the above description of the setting for action in West Basin, one would expect that the cities, the major water service companies, and the larger industrial firms in the area would initiate the first responses to the problems in West Basin. That was indeed the case. The early steps of these actors were largely uncoordinated and self-seeking, but they became part of the groundwork on which later actions would be built.

By the 1920s, water producers in West Basin were aware that something was going on. They did not and could not know the extent of annual replenishment of the basin or the total volume of withdrawals, but they could see evidence of the beginning of overdraft conditions in the falling water levels of their own wells. (51) The industrial firms along the coast were among the first to become concerned, as water engineers in those firms observed not only water level declines, but the beginnings of salt-water intrusion. These engineers reported their concerns to management personnel, (52) but at that time there was little the industrial firms could do about water supply problems other than shut down brackish wells and construct new ones in other locations.

The cities were the first to take actions concerning the local water supply, as their personnel came to share the fears of the companies about the long-term prospects for Basin water. As we have already noted, the City of Los Angeles (small parts of which extend into West Basin) had constructed an aqueduct to the Owens River Valley to obtain for itself a supplemental source of water supply. Los Angeles' imports of Owens River water began in 1913.

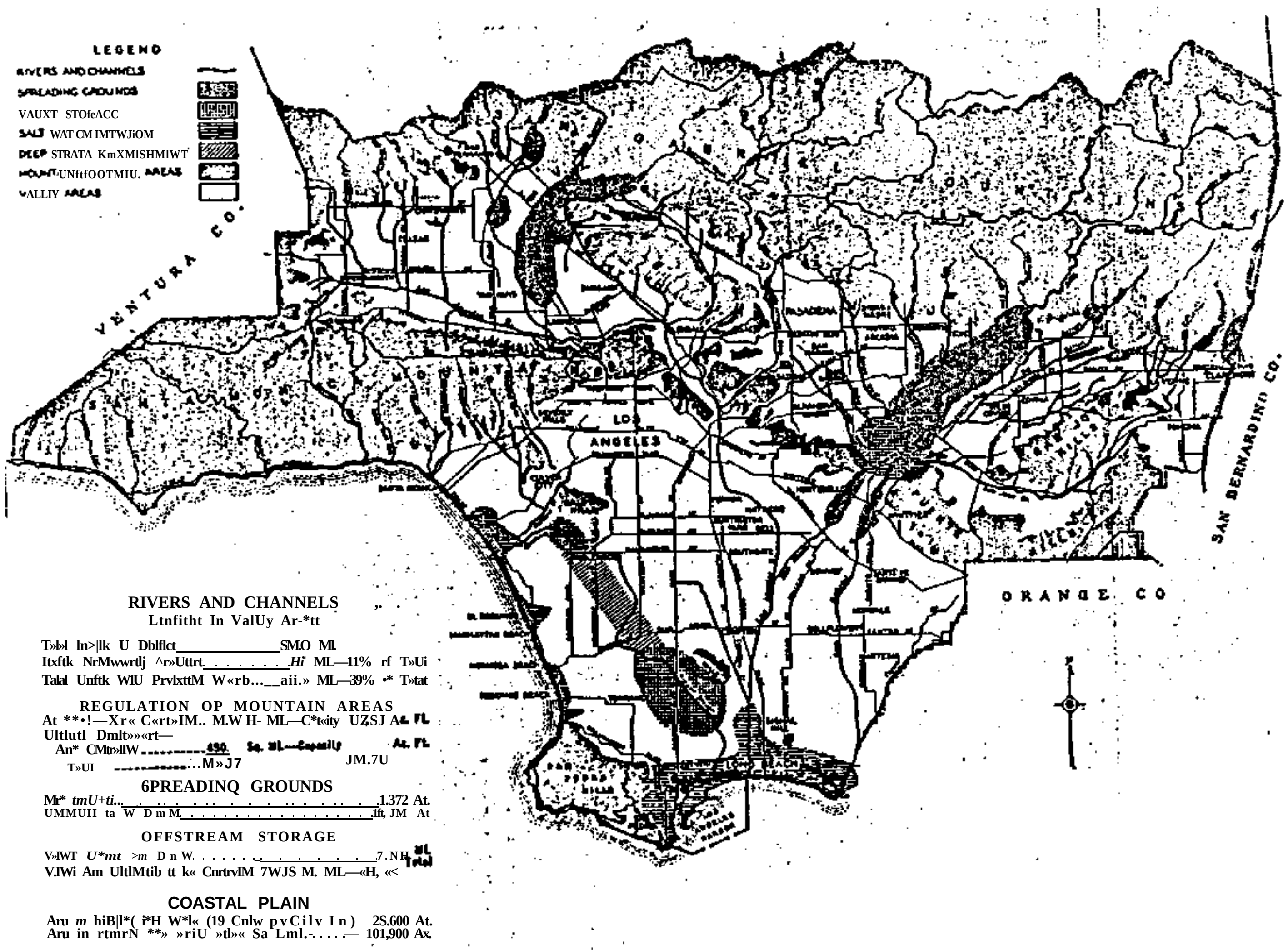
Then, Los Angeles and other cities in the area, led by Pasadena, organized to form the Metropolitan Water District of Southern California (MWD) in 1928. Also among the original member cities of MWD were some West Basin cities: Long Beach, Torrance, and Compton (which is mainly located in Central Basin, but produces water on both sides of the Uplift). As with the action of Pasadena in the Raymond Basin case, these cities did not tax themselves to obtain an imported supply through MWD for the benefit of West Basin generally, but for their own self-interest. Nonetheless, to the extent that their action in obtaining an additional water supply for themselves allowed them to later ease their demands on West Basin ground water, this action was part of the groundwork that aided later actions to preserve the Basin. The first deliveries of MWD imported water arrived in Los Angeles County in 1941.

One of the first activities of the newly-formed MWD was a study of the water supply conditions in the Los Angeles area. Water engineer H.P. Vail conducted the study and reported to MWD in 1929 on the issue of declining water levels and the deterioration of ground water quality, especially in the El Segundo area. He concluded that the source of the ground water contamination was indeed the Pacific Ocean, moving below ground into the aquifers of West Basin. (53) The City of Inglewood commissioned its own study of its water supply situation in 1931. Arthur Cory reported to the City that it faced serious long-term dangers from falling underground water levels and from the encroachment of deterioration in water quality. (54)

Another study of the Coastal Plain's water conditions was conducted by the State of California's Division of Water Resources of the Department of Public Works in 1930, with a report published in 1934. This report included, among other things, a map of the Coastal Plain area showing the extent of sea water intrusion at that time, plus the current and planned activities of the Los Angeles County Flood Control District (LACFCD) with regard to the Los Angeles and San Gabriel Rivers. That map is reproduced here as Map 6-5.

The Flood Control District, as one would guess, was principally charged with preventing the further flooding of the Coastal Plain area by these Rivers during the winter storms and wet years. As part of the flood control plan, the LACFCD was engaged in the process of straightening the Rivers' channels and lining them with concrete (which, of course, served largely to eliminate them as sources of replenishment to the Coastal Plain water basins). However, the LACFCD was also charged with maximum possible conservation of waters within the District, and so was concerned with problems of diminished local supplies. The District thus planned the construction of water spreading grounds along the sides of the River channels (see Map 6-5), into which storm flows would be diverted for percolation into the ground water system. Spreading of local flood waters.began in 1937. (55)

The concern of the Los Angeles County Flood Control District with the problems of local water supply continued through the end of the 1930s and into the early 1940s. In July 1942, The Chief Engineer of the LACFCD wrote a letter to the City Engineer of Manhattan Beach, Source: [redacted] Bulletin No. 32, 1930



indicating that there had been such an increase in the saline content of water produced at one of the wells in the Manhattan Beach area that the District was interested in investigating the cause. After their correspondence, these two men undertook contacts with other producers in the area. The LACFCD Chief Engineer wrote letters to several West Basin producers alerting them to the possibility of salt water contamination. The City Engineer for Manhattan Beach invited representatives from the other cities in West Basin to a meeting to discuss the possible problem. There was no interest and no attendance.

The LACFCD then sponsored a conference in March 1943 for all of the municipalities and the Chambers of Commerce in West Basin. This was sufficiently well attended, especially by city representatives, that a committee was formed to organize and fund an investigation of the problems of the area. This committee, the West Basin Survey Committee, arranged for the United States Geological Survey to conduct a study, financed by contributions from Inglewood, Redondo Beach, Manhattan Beach, El Segundo, Hawthorne, Culver City, Gardena, Hermosa Beach, and Palos Verdes Estates. (56) Only Torrance and Long Beach did not participate.

After the initial progress report of the United States Geological Survey, the West Basin Survey Committee sponsored a series of meetings throughout 1944 with representatives of the local industrial concerns and private and public water service companies. Representatives of the State Department of Water Reources and the County Flood Control District also attended. The involvement of the industrial users and the water service companies was formalized in the Spring of 1945 by the replacement of the West Basin Survey Committee with the broader-based West Basin Ground Water Conservation Group.

The West Basin Ground Water Conservation Group appointed a Ways and Means Committee to serve as a smaller investigatory body, to build upon the U.S. Geological Survey findings and produce a comprehensive report on the water supply and water quality problems for the Group. (57) The Ways and Means Committee met twice per month from March to September of 1945. The report it produced in September 1945 was distributed throughout the Basin, represented the views of local water producers while incorporating data from the federal, state, and county investigations that had preceded it, and contained alarming conclusions. The Ways and Means Report estimated the overdraft on West Basin at the time at 37,000 acre-feet per year, described the landward-sloping hydraulic gradient that had been created within the Basin, indicated that under such conditions ocean water could be expected to flow into the Basin in ever greater quantities to make up the overdraft, and warned that remedial measures would be costly in time, effort, and expense. (58) The Report also contained a map of West Basin, which provided producers with a shared picture of their resource and of who was "in" and who was "out" of the Basin.

With the exception of Torrance and Long Beach, which were securing their own imported supplies, all of the other West Basin water producers who received the Ways and Means Report were dependent upon the ground water to meet their needs. As of 1945, these producers faced the prospect that the water supply on which they depended was already threatened and getting worse fast. From September 1945 on, efforts proceeded on several fronts to address West Basin's problems.

The first of these was the effort to get some other source of water.

B.3. Securing an Additional Supply

By 1945, the Cities of Los Angeles, Torrance, and Long Beach were already importing water into West Basin from the Owens River and the Colorado River. In addition, a couple of the private water companies, Dominguez Water Corporation and Southern California Water Company, were "importing" water from Central Basin, conveying water pumped on the eastern side of the Uplift to the western side. (59) But the majority of water used in West Basin was still being produced from underground, and the majority of water producers in West Basin had no other source.

Among the conclusions of the Ways and Means Committee's report was that there was an immediate need for a supplemental supply of water to West Basin. Such a supplemental supply could come from reclaimed waste water or Colorado River water through the MWD, or both. The Committee Report recommended that a new organization of all West Basin water producers be formed, with a paid executive and the ability to assess dues from members, for the purpose of conducting the effort to address the overdraft problem.

On February 14, 1946, the last meeting of the Ways and Means Committee of the West Basin Ground Water Conservation Group was held, for the specific purpose of disbanding the Committee and the Group, to be superseded by the West Basin Water Association (WBWA). Articles of Association for the proposed WBWA had been drafted by attorney Kenneth Wright, whose services were retained by the California Water Service Company. (60) Mr. Wright, it may be recalled, was the attorney for several of the parties in the Raymond Basin litigation, judgment in which had just been rendered in accordance with the Stipulation among the parties that Mr. Wright had engineered.

The combination of the Ways and Means Committee Report with the apparently successful action in the Raymond Basin case prompted twenty charter members to sign the Articles of Association and form the West Basin Water Association. The beach cities, the oil companies, and the private water service companies were the principal charter members and the main motivating influences in the WBWA during its first two years. (61) Given their location, dependence on the resource, and exposure to the problems of the Basin, this composition is what we would expect. The inland cities of Inglewood, Hawthorne, and Torrance did not join WBWA at the outset.

The West Basin Water Association appointed an Executive Committee to conduct the ongoing affairs of the Association. The Executive Committee has nine members -- three from industry, three from the cities, and three from private water companies. The Association also created the paid position of Executive Secretary. This Executive Secretary and one part-time clerical staff member conducted the daily affairs of the WBWA out of a small office throughout the period of resolution of West Basin's problems.

The Association financed its activities through dues paid by the members. The arrangement for sharing the costs of the Association reflected the distribution of interests in the Basin among WBWA members. Members paid a share of the Association's budget based on their production of ground water. Members' statements of their own production were used intially for apportioning dues. The incentive in such a system to understate production was offset by the collective decision-making procedure adopted by the WBWA. Votes on Association concerns were also apportioned on the basis of stated ground water production. Instead of "one man, one vote", the WBWA used a weighted representation system, with members controlling a number of votes reflecting their proportion of total extractions. This voting rule built in a counter-incentive to overstate production. Thus, if members understated production, they lost votes; if they overstated production, they lost money.

The Association operated on two principles: decision-making by consensus, and the guiding criterion that all Association members should continue to derive some ongoing benefit from the Basin. (62) Throughout the forty years of its operation, this private Association "provided a means whereby people representing conflicting interests could discuss mutual problems and search for satisfactory solutions, [and] the Association has developed its own formal structure which insured the continuation of sustained negotiation and communication by all affected parties." (63)

For members of the Association, who had heavy investments in their location in West Basin and who anticipated a long future need for water, mining the Basin yielded a short-run payoff. A greater long-run advantage was to be gained if some other source of water could be used for a base supply while West Basin's ground water was preserved for peaking use. This would necessitate reduction in pumping from the Basin, of course, but that reduction was not necessarily the first step to be taken. Association members felt that securing the additional supply of water had to come first, since water producers would not likely cooperate, in reducing their withdrawals from the Basin until they had an alternative source of supply. (64) Of the possibilities for such an alternative source, "membership in the Metropolitan Water District with access to Colorado River water appeared to be the most feasible from technical, legal, and economic considerations." (65)

"Most feasible" is not the same thing as "easy". Acquisition of MWD imports would require annexation of territory in the Basin to the MWD, since MWD was and is partially financed by ad valorem property taxes. MWD was quite interested in having more consumers in West Basin. The construction and operation of the Colorado River Aqueduct was an extremely costly venture. MWD's territorial reach and water sales were not providing the District with sufficient revenues. MWD needed more taxpayers and more water buyers, not only to meet its financial obligations but also to perfect its claim to over a million acre-feet per year of Colorado River water. As of 1945, MWD was selling only about 32,000 acre-feet, less than 3 percent of its full claim. (66)

However, MWD was not interested in allowing the cities in West Basin to annex one at a time, even though it was possible for them to do so. Each member agency of MWD receives a weighted representation on the District's Board in proportion to its share of water sales. The MWD Directors were not interested in diluting the number of persons on the Board with members representing relatively tiny constituencies, though they were interested in having the West Basin area as a whole annex to MWD.

Annexing West Basin to MWD as a whole would require a three-step process. First, the area in West Basin to be annexed would have to be defined and a Municipal Water District created to cover that territory. The creation of such a District would be dependent upon a vote of the residents therein. Second, the area within the Municipal Water District would have to vote to annex to MWD. Third, MWD would have to vote to approve the annexation.

Voters within the various cities of West Basin would have to vote to tax themselves twice. They would have to vote for a municipal water district that would finance its operations and facilities for purchases of MWD imported water through a property tax. Then they would have to vote to be included within MWD's taxable territory, since MWD financed its construction and part of its operations through the property tax. Getting all of West Basin (except Torrance, Long Beach, and the parts of Los Angeles, of course, since they were already in MWD) to take these steps -- or, at least, a majority of the people in West Basin to do so -- would, in the view of the Association, be a delicate process, and would take some time, for consensus-building and voter education concerning the extent and gravity of West Basin's problems.

Such time was not forthcoming. A local politician, perhaps well-intentioned but also seeking to enhance his own recognition, seized upon the water issue as his vehicle for self-promotion. As the West Basin Water Association was getting underway, Los Angeles County Supervisor Raymond Darby organized the Southwest Water Fact-Finding Committee. That Committee issued a report of its findings in the summer of 1946, and proposed the creation of a municipal water district for the entire West Basin area, even as the WBWA was beginning to study the issue. By September of 1946, the Darby Committee had been reorganized and re-named the "West Basin Campaign Committee" and embarked upon the process of organizing a special election to form the West Basin Municipal Water District. (67)

Realizing that a Municipal Water District would have to be created for West Basin, the West Basin Water Association reluctantly agreed to support the Darby effort, even though the needed consensus had not been developed and the election seemed highly problematic. The inland communities, which had not yet been reached by the intruding sea water, were not yet ready to support a plan to be taxed for what they perceived as a benefit primarily to the coastal towns. Political leaders of inland cities, such as the Mayor and Council of the City of Inglewood, actively campaigned in opposition to the formation of the District. Nonetheless, enough petition signatures were collected to present to the Los Angeles County Board of Supervisors to warrant holding a special election on the issue, which was scheduled for January 14, 1947, less than a year after the WBWA had been formed. As expected, the inland communities voted against the proposed West Basin Municipal Water District. The beach communities voted for it. Overall, the "no" votes outweighed the "yes" votes, and the District was defeated. The election had divided West Basin against itself.

Recognizing the heavy support in the beach communities for the formation of a municipal water district, and with the need for a supplemental source growing more urgent all the time, the WBWA set to work on a new District and a new election. They drew up boundaries for a West Basin Municipal Water District that specifically excluded the inland communities of Inglewood, Hawthorne, Gardena, and the

Dominguez area. The new District included the cities of El Segundo, Manhattan Beach, Hermosa Beach, Redondo Beach, Palos Verdes Estates, and thirteen adjacent unincorporated areas. (68) Petitions were again circulated, signatures collected and presented to the County Board, and a second special election was scheduled for November 25, 1947. This time, the smaller District received overwhelming voter support; the vote was 8-to-l in favor of formation.

The newly-formed West Basin Municipal Water District (WBMWD) then began the twin processes of petitioning MWD for approval of annexation and organizing another special election within the District to obtain the voters' approval of annexation to MWD. MWD's Board unanimously voted to grant annexation on March 26, 1948, provided that voter approval within the District was secured by the end of the year. The special election within the West Basin Municipal Water District for annexation to Metropolitan was quickly organized and held on June 8, 1948. The vote among the residents to annex to MWD was also heavily favorable -- 15 voters supported annexation for each one who voted against it. Annexation proceedings were formally completed on July 23, 1948. Part of West Basin had secured its supplemental supply. Colorado River water deliveries began during 1949: MWD sold water to WBMWD, which retailed it to the component cities, water service companies, industrial users, etc.

Over the course of the next four years, the inland cities began to recognize more acutely their own need for an additional supply. The City of Gardena requested annexation to the WBMWD almost immediately, and annexed by special election on November 15, 1948. At the beginning of 1949, just six months after the formation of the smaller

WBMWD, the Mayor of Inglewood, who had campaigned against the formation of a District including his City, asked the WBMWD Board of Directors to annex Inglewood to the District so that the City could also have access to MWD water. Annexation of Inglewood was completed in June of 1952, and the City of Inglewood joined the West Basin Water Association at the same time. The Dominguez area annexed to WBMWD on October 16, 1952. And finally, the City of Hawthorne annexed to the West Basin Municipal Water District on October 23, 1953. By the end of 1953, the West Basin Municipal Water District included basically the same area as had originally been proposed in January 1947 in the election that had failed to carry. (69) Virtually all of West Basin had obtained access to a supplemental supply of water that would make it possible for them to rely less on the underground supply.

B.4. Curtailment of Demand: The West Basin Adjudication

The trial court judgment in the Raymond Basin case was issued in 1945 on the basis of the stipulation of the parties worked out over the previous two years. In West Basin, the Ways and Means Committee Report was issued in September of the same year. The Committee's Report reflected the sense of many members of the West Basin Ground Water Conservation Group that an adjudication of rights similar to that conducted in Raymond Basin would be necessary in West Basin for effective reduction of demand to occur. The Ways and Means Report detailed for the West Basin producers the procedure to be followed in pursuing such an adjudication. (70)

Just as with the securing of an imported supply, however, the process of curtailment of demand got off to a much quicker start than most of the West Basin producers anticipated. The California Water Service Company informed its attorney, Kenneth Wright, even before the issuance of the Ways and Means Committee Report that it was interested in initiating a Raymond-type litigation in West Basin. Mr. Wright, having observed the energy and finances expended by the City of Pasadena as the sole plaintiff in the Raymond Basin case, advised the Company not to go it alone. (71) This slowed the Company only slightly, as it found two other appropriators to join in as plaintiffs.

On October 24, 1945, just one month after the publication of the Ways and Means Committee Report, the California Water Service Company, along with the City of Torrance and the Palos Verdes Water Company, filed a complaint in the Superior Court of the State of California in and for the County of Los Angeles against 151 named defendants and several hundred unnamed defendants. The complaint sought an adjudication'of rights to the ground waters of West Basin. (72) Case Number 506806, California Water Service Company et al. v. City of Compton et al, occupied the Superior Court docket for the next sixteen years.

Thus, for a second time, before the West Basin Water Association was even off the ground, action had been initiated to which the Association then had to respond. In early 1946, the newly-formed Association organized an Engineering Advisory Committee to aid in data collection to support the adjudication. The Advisory Committee consisted of seventeen engineers representing water companies and utilities, industrial users, and the cities, plus one representative from the County of Los Angeles and one from the City of Los Angeles'

Department of Water and Power. (73) The Engineering Advisory Committee adopted the role of assisting the State of California Department of Public Works, Division of Water Resources, after Judge Arnold Praeger ordered that a reference be made in the case to the Division to act as Referee, as had been done in Pasadena v. Alhambra. This Order of Reference was made by Judge Praeger on July 26, 1946.

The Draft Report of the Division of Water Resources as Referee was not filed with the Court and presented to the parties until February of 1952. In the interim, based on preliminary findings reported by the Division to Judge Praeger, the Judge issued an order on November 9, 1949, that 340 additional named parties be added to the suit. This was accomplished by an amended complaint filed by the plaintiffs on December 5, 1949, which also supplied the contention that the rights and claims of each and every party were adverse to the rights and claims of each and every other party, (74) as this had become an issue raised in the appeal of the Raymond Basin case.

The Raymond Basin case was finally completed in 1950 when the California Supreme Court in essence upheld the trial court judgment of 1945. Kenneth Wright discussed the outcome of the case with the Executive Committee of the West Basin Water Association. "He said it could be relied upon in forecasting the probable decision with respect to the pending West Basin adjudication". (75)

What could not be forecast was the findings and recommendations of the Referee's Report, which was issued in draft form in February 1952 and in final form in September 1952. The Report contained 175 pages of text, plus 14 volumes of basic data. The Referee found that overdraft had commenced in earnest in 1920 and grown progressively worse thereafter, and that the Basin would suffer substantial and irreparable injury as a result. (76) The Referee reported that aggregate groundwater extractions had reached 90,000 acre-feet per year, while fresh-water replenishment to the Basin across the Uplift had averaged 24,400 acre-feet per year from 1930 through 1949.

Most striking was the recommendation concerning pumping limitations. The Referee Report recommended "that production in the basin should be initially limited to 30,000 acre-feet per year, and that changes in such quantity should be made from time to time as changes in conditions in the basin and in adjoining areas, or as data and information as to the effect of regulation of production may require." (77)

This recommendation, given that by 1952 pumping from West Basin had reached 90,000 acre-feet, represented a reduction of two-thirds by the water producers in the Basin. This was a much more drastic curtailment than the 25 percent cutback in the Raymond Basin case. Most of the large water producers were alarmed at the prospect of cutting back on their use of ground water by two-thirds. (78) They voiced their concerns within the West Basin Water Association. Subsequently the Association voted to form a legal settlement committee to try to find a negotiated settlement among the producers that would be more generally acceptable. The Referee Report "was a great motivator". (79) If the producers did not work out some other settlement, the judge might well adopt the Referee's recommendation and order a two-thirds reduction.

The Settlement Committee was established in November 1952, and consisted of five attorneys and five engineers. One of the attorneys was Kenneth Wright, who was the principal architect of the Raymond Basin stipulation. Shortly after the Settlement Committee began its work, Mr. Wright became ill. The work of the Committee proceeded, drafting a stipulation patterned after the one in the Raymond case, with Mr. Wright's occasional participation. A draft was completed in the fall of 1953, and at about that time Kenneth Wright died. (80) His assistant, attorney Ralph Helm, took over as the attorney for WBMWD, WBWA, and several of the parties to the litigation, so considerable continuity in the process was maintained.

The draft of the stipulation was circulated among the major water producers, but there was no new action on it until May 1954, at which time a revised draft was submitted. Discussion of this revised draft ensued, and at the meeting of the Settlement Committee on July 14, 1954, it was decided to submit the revised proposal to the parties as an Interim Agreement for the curtailment of pumping during the pendency of the litigation.

The Interim Agreement provided for a 25 percent cutback in extractions by the signatory parties, which would essentially split the difference between the 90,000 acre-feet then being pumped and the 30,000 acre-feet recommended in the Referee Report. The Agreement defined for each party to the litigation a "Prescriptive Right, 1949", which was "the highest continuous production of water by each user for beneficial use in any five-year period prior to October 1, 1949, as to which there was no cessation of use by it during any subsequent continuous five-year period prior to October 1, 1949." (81) For the 472 litigants, the proposed Agreement listed their "Prescriptive Right, 1949", which totalled 67,788.8 acre-feet.

The proposed Agreement then stated that each signator would agree to cut back production to the amount of its "Prescriptive Right, 1949", provided that the Agreement would only become effective against all signators once parties having 70 percent of the total "Prescriptive Right, 1949" had signed. The Interim Agreement was, in other words, a contingent contract. No one who signed it committed to a cutback unless there would be enough cutbacks to effectively improve conditions in the Basin.

Under those conditions, signatures were gained fairly rapidly. The willingness of parties to sign was further facilitated by an Amendment to the California Water Code passed in 1951, and supported by the WBWA, which provided that no ground water producer would forfeit ground water rights by reducing pumping and using an imported supply instead. (82) With these protections --no loss of right and no cutback unless enough others did so -- 46 producers with over 75 percent of the total "Prescriptive Right, 1949" had signed the proposed Interim Agreement by the beginning of 1955. (83) The Court was then petitioned to make an ex parte order approving the Interim Agreement and requiring the signators to abide thereby for the duration of the litigation. By the time of the judge's order on February 16, 1955, 50 parties with over 80 percent of the "Prescriptive Right, 1949" had signed the Agreement.

The Interim Agreement took effect on March 1, 1955. In addition to the cutback in production, the Agreement also followed the pattern of the Raymond Basin stipulation in naming the State's Division of Water Resources to act as Watermaster to monitor parties' water production and their compliance with the Agreement. In a governmental reorganization, the newly-established Department of Water Resources assumed the Watermaster responsibilities as successor to the Division in 1956. The Division established the West Coast Basin Watermaster Service Area effective March 1, 1955, and began to conduct the same activities it conducted as Watermaster in the Raymond Basin: maintenance of records, issuance of reports, testing of meters used to measure production, apportionment of costs among parties in accordance with their "Prescriptive Right, 1949", and administration of a Water Exchange Pool.

As in the Raymond Basin Judgment, the costs of the Watermaster Service for monitoring the Interim Agreement were paid one-half by the State of California and one-half by the parties. The half paid by the parties was apportioned among them on the basis of their "Prescriptive Right, 1949". The total budget and expenditures of the Watermaster for West Basin are shown in Table 6-2.

The Water Exchange Pool worked in the same way as the one established in Raymond Basin. Parties were required to offer for exchange the amount of water by which the parties' rights to ground water exceeded one-half the estimated total water use required by the party in the coming fiscal year, provided the party was able to replace that amount with some other source of supply. Water was to be offered at the replacement cost or less. In addition, parties may voluntarily offer more water than this to the pool at a cost not exceeding WBMWD's cost for imported water. Parties without connections to a supplemental supply, or whose needs exceed their rights plus the availability to them of imported supplies then request additional pumping rights through the Exchange Pool, and the

TABLE 6-2

West Basin Watermaster Annual Budget and Total Expenditures, 1956-1985

Year	Total Watermaster Budget	Total Watermaster Expenditures	Expenditures per Acre-Foot of Groundwater Extractions *	Expenditures per Acre-Foot of Total Water Use *
1956	$ 23,308	$ 19,722	$ 0.37	$ 0.12
1957	N/A	N/A	N/A	N/A
1958	22,378	17,114	0.33	0.09
1959	23,500	17,620	0.34	0.09
1960	29,694	16,507	0.31	0.08
1961	30,526	23,123	0.43	0.11
1962	30,196	34,180	0.58	0.16
1963	48,284	24,784	0.42	0.11
1964	40,326	25,403	0.42	0.11
1965	44,852	39,143	0.66	0.13
1966	42,875	39,707	0.65	0.14
1967	33,640	26,644	0.43	0.09
1968	39,234	39,620	0.64	0.14
1969	36,670	26,971	0.44	0.09
1970	41,342	34,810	0.56	0.11
1971	40,432	42,275	0.69	0.14
1972	44,843	47,547	0.73	0.15
1973	46,255	44,947	0.74	0.15
1974	48,122	45,406	0.83	0.15
1975	49,014	49,821	0.88	0.17
1976	52,500	61,819	1.04	0.20
1977	58,276	59,942	1.00	0.21
1978	65,086	68,038	1.17	0.24
1979	69,170	72,942	1.26	0.25
1980	88,095	79,032	1.38	0.26
1981	106,262	103,075	1.79	0.33
1982	123,240	118,998	2.07	0.39
1983	126,800	120,099	2.09	0.38
1984	131,882	127,794	2.40	0.39
1985	151,800	157,101	3.05	0.48

*-- By parties to Watermaster Service

Source: West Basin Watermaster Reports, 1956-1985

Watermaster allocates water offered among those requesting it, taking the least expensive water first. In this way, those with surface connections are reimbursed for their higher cost in taking imported water while those with insufficient or no access to imported water are able to meet their needs through ground water extractions in excess of their right. The operation of the Exchange Pool in West Basin since the fiscal year 1955-56 is illustrated in Table 6-3.

As the operation of the Interim Agreement was underway, new parties signed and came under the provisions of the Agreement, while others sold their rights to other signators. The total number of parties under Watermaster service declined overall during the operation of the Interim Agreement because of this consolidation. The parties to the Agreement consistently extracted less than their total "Prescriptive Right, 1949", so it would appear that the 25 percent reduction under the Agreement was not too difficult to meet. (84) There were a few overextractions, but only one signator overextracted in excess of the allowed 10 percent for more than one year without making up the debit in the following year. (85)

By the close of fiscal year 1957-58, there were 44 parties under Watermaster Service, whose total "Prescriptive Right, 1949" was 56,491 acre-feet, or 83 percent of the total calculated for all the West Basin litigants. (86) The reduction in total groundwater extractions brought about by their curtailment under the Interim Agreement may be readily observed by referring to Figure 6-1 or by a look back at Table 6-1. In the report of the Watermaster for the 1957-58 year, it was noted that water levels in the most damaged parts of the Basin (the south and southwest) had recovered five to ten feet since the first

TABLE 6-3

West Basin Water Exchange Pool, 1956-1985

Year	Exchange Water Offered	Exchange Water Received	Average Cost per Acre-Foot
1956	5,526	772	$22.30
1957	6,227	540	20.58
1958	3,905	654	21.90
1959	5,543	488	23.04
1960	3,922	310	21.90
1961	3,927	217	19.00
1962	[illegible],700	442	14.91
1963	3,050	467	13.16
1964	4,005	570	11.42
1965	4,034	847	11.92
1966	3,610	529	13.80
1967	2,836	335	13.97
1968	4,779	415	14.00
1969	3,047	529	13.28
1970	4,335	508	13.50
1971	1,832	551	14.22
1972	2,500	376	19.87
1973	2,238	434	23.31
1974	2,518	486	27.73
1975	4,424	504	34.60
1976	5,843	509	35.08
1977	7,057	402	33.76
1978	3,458	421	32.49
1979	3,768	367	33.48
1980	5,509	520	35.97
1981	5,328	250	36.17
1982	1,772	265	35.00
1983	2,270	64	40.00
1984	2,804	288	44.41
1985	2,381	477	69.54

Source: West Basin Watermaster Reports, 1956-1985

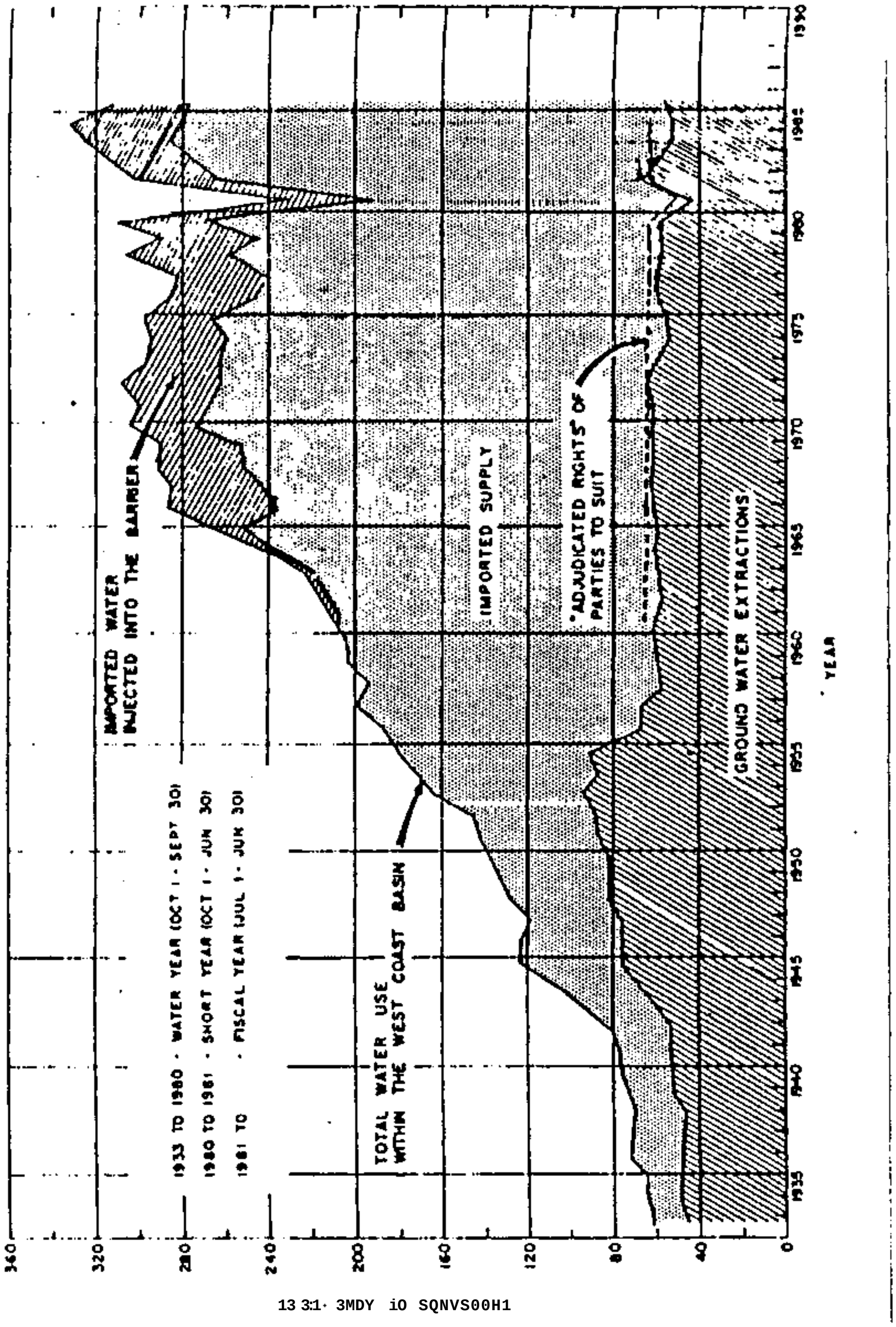


Figure 6-1. West Basin Groundwater Extractions and Total Water Use, 1933-1985

Source: West Basin Watermaster Report, 1985 year of operation under the Agreement (87). These improvements were realized even though southern California was in the middle of the 23-year drought cycle that lasted from 1945 through 1967.

In 1956, the investigation by the Referee was about six years old (data collection had ended with 1950), and parties had been operating under the Interim Agreement for one year. The West Basin adjudication was moving toward trial, apparently smoothly. A trial date was established for November 13, 1956. However, some of the parties were concerned about the increasing age of the Referee's Report, for three reasons. First, the Report was still the only comprehensive factual basis available to the Judge, and it contained that troublesome recommendation that pumping be curtailed to 30,000 acre-feet. Second, parties who had signed the Interim Agreement were concerned about the behavior of the non-signers since 1950; if their extractions had increased greatly and if the Judge chose some year other than 1949 as the benchmark for determination of rights, non-signers might have gained some benefit in the meantime. Third, parties were concerned about new pumpers, entities which had begun extracting water since the litigation was filed in 1945, and especially since the investigation period.

In the fall of 1956, as the trial date grew nearer, a majority of the major producers petitioned Judge Praeger to make a second Order of Reference. (88) This second reference was to extend and update the original reference, investigating the physical facts from October 1, 1950, through September 30, 1956. (89) The trial of the West Basin case was postponed, and on November 20, 1956, Judge Praeger signed an Order of Reference Continuance. The Reference was made to the

California State Water Rights Board, which had been made the statutory successor to the Division of Water Resources for court reference procedures at the same time that the Department of Water Resources had been made the successor to the Division's Watermaster functions. (90) However, in light of the experience and expertise of the Division's personnel with the Raymond and West Basin references and the fact that the Division's personnel were now largely the Department's personnel, the new State Water Rights Board executed a contract with the Department of Water Resources to perform the investigation, though the Board remained nominally the Referee for the reference continuance.

(91)

With the reference continuance, trial would probably be put off for a few years. As an interim move to prevent new pumpers from gaining prescriptive rights adverse to the interests of those who were already involved in the West Basin adjudication, the seven largest West Basin producers initiated a second lawsuit on October 31, 1956. (92) That action -- Dominguez Water Corporation et al. v. American Plant Growers Association et al., Case Number 668965 in the Superior Court of the State of California in and for the County of Los Angeles -- referred to more simply as "the American Plant Growers case", named 63 active producers who had not been included in California Water Service Co. v. City of Compton. Another 57 producers were added as the American Plant Growers case proceeded. For the most part, the defendants in this second West Basin suit were very small water producers. Those with connections to other water sources largely dropped out rather than incur the litigation costs involved in defending their right to one or two acre-feet per year of groundwater production. Indeed, by 1963, only twelve of the defendants remained as active groundwater producers and their total production amounted to only 300 acre-feet. (93) A settlement was reached and a stipulated judgment entered on March 24, 1966, ending the American Plant Growers case. (94)

With the initiation of the American Plant Growers case at the end of October 1956, the reference continuance ordered in mid-November 1956, and with a trouble-free first year of operation under the Interim Agreement behind them and a second year underway, the major West Basin water producers had reason to be pleased about the progress of the litigation as 1957 began. But in that year, the smooth operation of the litigation came to a sudden halt. Judge Arnold Praeger disqualified himself from the two West Basin suits upon discovering that he owned stock in one of the companies. This rendered void all of Judge Praeger's standing orders in the actions, including the order for Watermaster Service over the Interim Agreement and the order for the reference continuance. (95) All work halted while the two West Basin cases were without a judge and without valid orders.

The Judicial Council and the attorneys for the West Basin litigants began immediately to search for a new judge. In May 1958, they settled upon Judge George Francis of Alpine County, who took over the cases and reviewed Judge Praeger's orders. The Interim Agreement and the appointment of the Watermaster were reaffirmed on June 9, 1958. On July 28, 1958, Judge Francis reinstated all other previous orders, including the reference continuance. (96) Work on the second Referee Report resumed, as did the operation of the Interim Agreement, after this striking reminder of the fragility of the process.

The first draft of the second Referee Report was presented by the Department of Water Resources to the State Water Rights Board on June 2, 1959. The draft recommendations showed an important difference from the first Referee's Report. No longer did the Report recommend curtailment to 30,000 acre-feet; instead, the draft Report essentially ratified the provisions of the Interim Agreement, with curtailment to the pumping levels defined as the "Prescriptive Right, 1949". The issue of the safe yield of West Basin was thus avoided, which was the desire of the parties, (97) since precedent from the Raymond Basin case might encourage the Judge in the West Basin cases to restrict extractions to safe yield. The Department's draft report contained no estimate of the safe yield of West Basin, even though another Department publication later reported the Department's estimate of the 1957 safe yield of the Basin as 36,100 acre-feet per year. (98)

With the conclusion of the Department's investigation in 1959, work began in earnest on a final settlement to the West Basin Case, then fourteen years old. Again, the West Basin Water Association and its appointed Legal Settlement Committee were the focus of action. By the end of 1959, the Committee had made considerable progress in drafting a stipulated judgment. (99) The final draft of a proposed stipulation was presented to the Association at its February 1960 meeting. (100) This stipulation was to be effective as to the signators and presented to the Court once parties with 75 percent of the "Prescriptive Right, 1949" had signed. (101) By May, 20 parties with 33 percent of the rights had signed. (102) By February 1961, 30 parties with 65 percent of the rights had signed, and by June 1961, 56 parties with 82 percent of the total rights had signed the proposed stipulation, which was filed with the Court on July 21, 1961. (103)

In the meantime, the draft Report of the Referee had been circulated to the parties and presented to the Court in September 1960. The final Referee's Report was filed with the Court on June 8, 1961. (104) The final Report recommended that groundwater extractions be limited to the "Prescriptive Right, 1949" of the parties, that the Water Exchange Pool established under the Interim Agreement be continued and extended to all parties, that Watermaster Service be continued, and that the Court retain jurisdiction to make such adjustments and modifications to the Judgment as may from time to time be necessary. (105)

On July 21, 1961, a trial lasting only a few hours was held before Judge Francis. The Judge then signed the Findings of Fact, Conclusions of Law, and the Judgment in the case of California Water Service Company et al. v. City of Compton et al. on August 18, 1961. (106) The Judgment, which ratified in all particulars the stipulation among the parties, became effective on October 1, 1961, the beginning of the 1961-62 fiscal year. Of the 429 parties named in the Judgment, 99 were decreed to have non-zero Adjudicated Rights, and therefore came under Watermaster Service. (107) The total of those Adjudicated Rights was 64,064 acre-feet. Parties with Adjudicated Rights were also authorized, as the signators to the Interim Agreement had been, to produce, lease, or sell all or part of their Adjudicated Right. (108)

Before the first fiscal year under the Judgment had ended, seven parties had abandoned their rights, totaling 22 acre-feet. Further shifts ensued through the first several years under the Judgment. The Adjudicated Rights finally stabilized after the settlement of the American Plant Growers case (see Table 6-4).

There were three appeals from the final Judgment. The first was settled within a year by an upward adjustment in the "Prescriptive Right, 1949" calculated for Chandler's Palos Verdes Sand and Gravel Company. (109) Another appeal, by Edward Sidebotham, was settled in a similar fashion in 1964. (110) The most significant appeal was made by the City of Hawthorne, a major West Basin water producer.

The City of Hawthorne had refused to cooperate with the other West Basin producers in the formation of the WBMWD (though it did annex in 1953), in the negotiation of the Interim Agreement (which it never signed) and in the negotiation of the stipulated judgment (which it also did not sign). (Ill) The City had pursued a "holdout" strategy from 1945 through 1961. After the final Judgment became effective, Hawthorne filed its Notice of Appeal on October 18, 1961. The Judgment had given Hawthorne an Adjudicated Right of 1,882 acre-feet of water; during the 1960-61 year, Hawthorne had pumped 3,862 acre-feet. (112) Hawthorne, sufficiently far inland to be unaffected by sea-water intrusion, was willing to fight over the 2,000 acre-foot difference. Hawthorne's appeal was denied by the California District Court of Appeal, which affirmed Judge Francis' decision in the case by an order dated April 23, 1964. (113) When the California Supreme Court denied a motion to review the appellate court decision, (114) Hawthorne's appeal came to an end, closing the book on California Water Service Company v. City of Compton, nineteen years after it began.

TABLE 6-4

West Basin Parties to Watermaster Service, Adjudicated Rights, and Groundwater Production (in Acre-Feet), 1956-1985

Year	Parties to Watermaster Service*	Groundwater Rights*	Groundwater Production	Active Pumpers	Active Nonparties
1956	46	56,963	53,684	38	NA
1957	44	56,491	53,666	39	NA
1958	44	56,491	52,103	37	NA
1959	44	56,527	52,549	36	NA
1960	43	56,767	53,005	34	NA
1961	42	56,985	53,571	32	NA
1962	92	64,042	58,624	67	13
1963	95	64,138	58,861	64	12
1964	94	64,138	60,842	58	11
1965	95	64,138	59,370	55	10
1966	79	64,138	60,759	48	7
1967	88	64,469	62,552	54	5
1968	88	64,469	61,554	51	5
1969	82	64,468	61,638	49	4
1970	81	64,468	62,447	48	4
1971	80	64,468	60,924	48	4
1972	79	64,468	64,733	45	5
1973	77	64,468	60,478	43	5
1974	76	64,468	54,966	42	4
1975	76	64,468	56,673	40	4
1976	76	64,468	59,407	40	4
1977	76	64,468	59,882	40	4
1978	76	64,468	58,300	40	4
1979	76	64,468	58,058	40	4
1980	75	64,468	57,085	42	4
1981	74	64,468	57,700	35	3
1982	78	64,468	62,664	36	3
1983	76	64,468	57,507	36	2
1984	74	64,468	53,341	37	2
1985	74	64,468	51,450	37	

*-- under Interim Agreement, 1956-1961; under West Basin Judgment' 1962-1985

Source: West Basin Watermaster Reports, 1956-1985

The curtailment of demand that began during the negotiation of the 1955 Interim Agreement had an immediate effect on water levels in the Basin, as was noted before. At the end of the 1955-56 year, the Department of Water Resources reported five to fifteen foot increases in piezometric levels in the southern, southwestern, and southeastern parts of the Basin. (115) These improvements were sustained throughout the period of operation of the Interim Agreement. (116) The effect of the 1955 pumping reduction on water levels in wells can be seen in Figure 6-2, which presents hydrographs of two representative wells in West Basin.

By contrast, in the Hawthorne area, levels fell another nine feet from 1954 to 1959, and continued to fall through the period of the appeal, creating a "trough" in that part of the Basin that has never been erased (see Maps 6-6 and 6-7, which contrast the underground water elevations for 1950 and 1983). With its "holdout" strategy, the City of Hawthorne acquired some short-term benefits, in that during its "holdout" period the City obtained ground water at a lower cost than it would have paid for imported water. But over the twenty years since the end of the West Basin adjudication, Hawthorne has had to reduce its extractions and replace them with imported water anyway, and in the meantime experiences the longest pumping lifts in the Basin, making its groundwater production costs among the highest in the Basin as well.

From the beginning of the action in West Basin to obtain a curtailment of demand through an adjudication of water rights, many smaller producers have ceased groundwater production. The litigation costs involved in defending small claims, the availability of imported

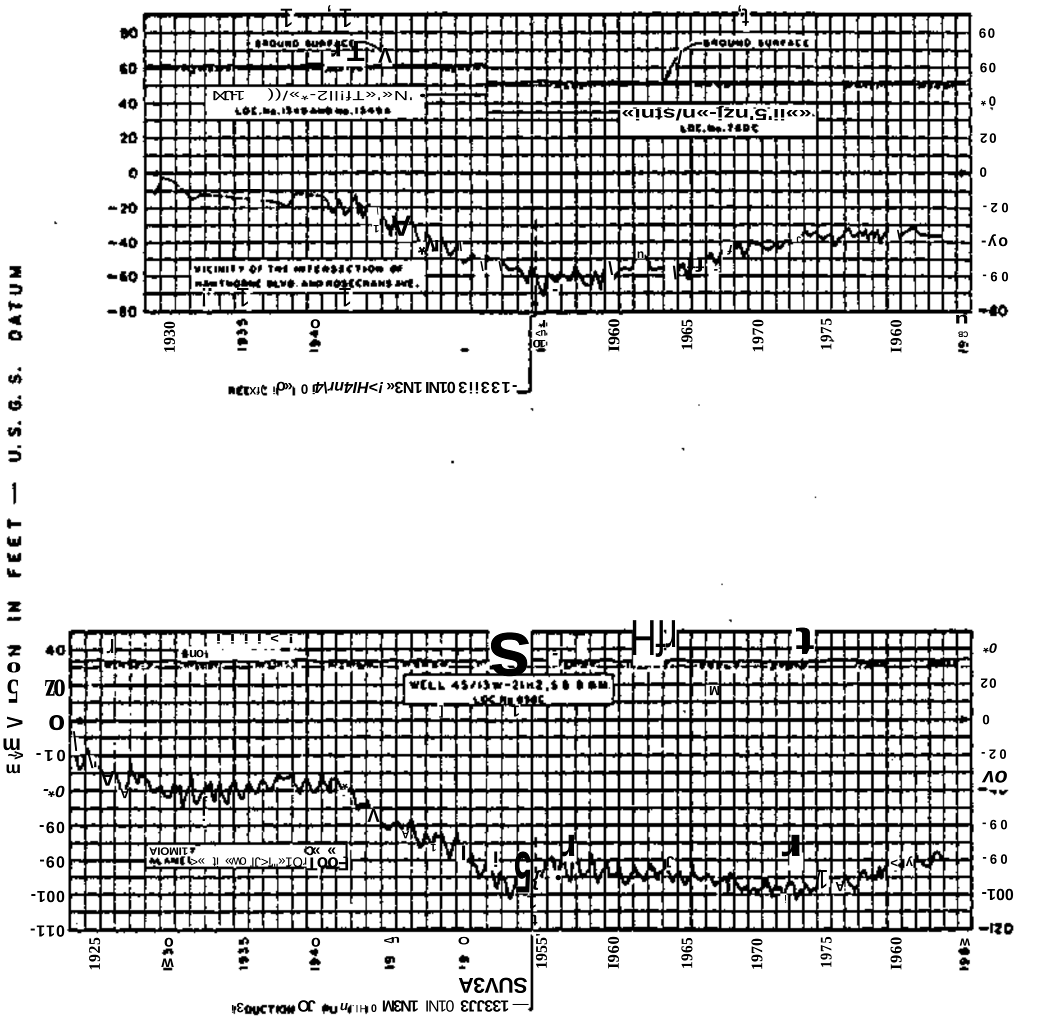
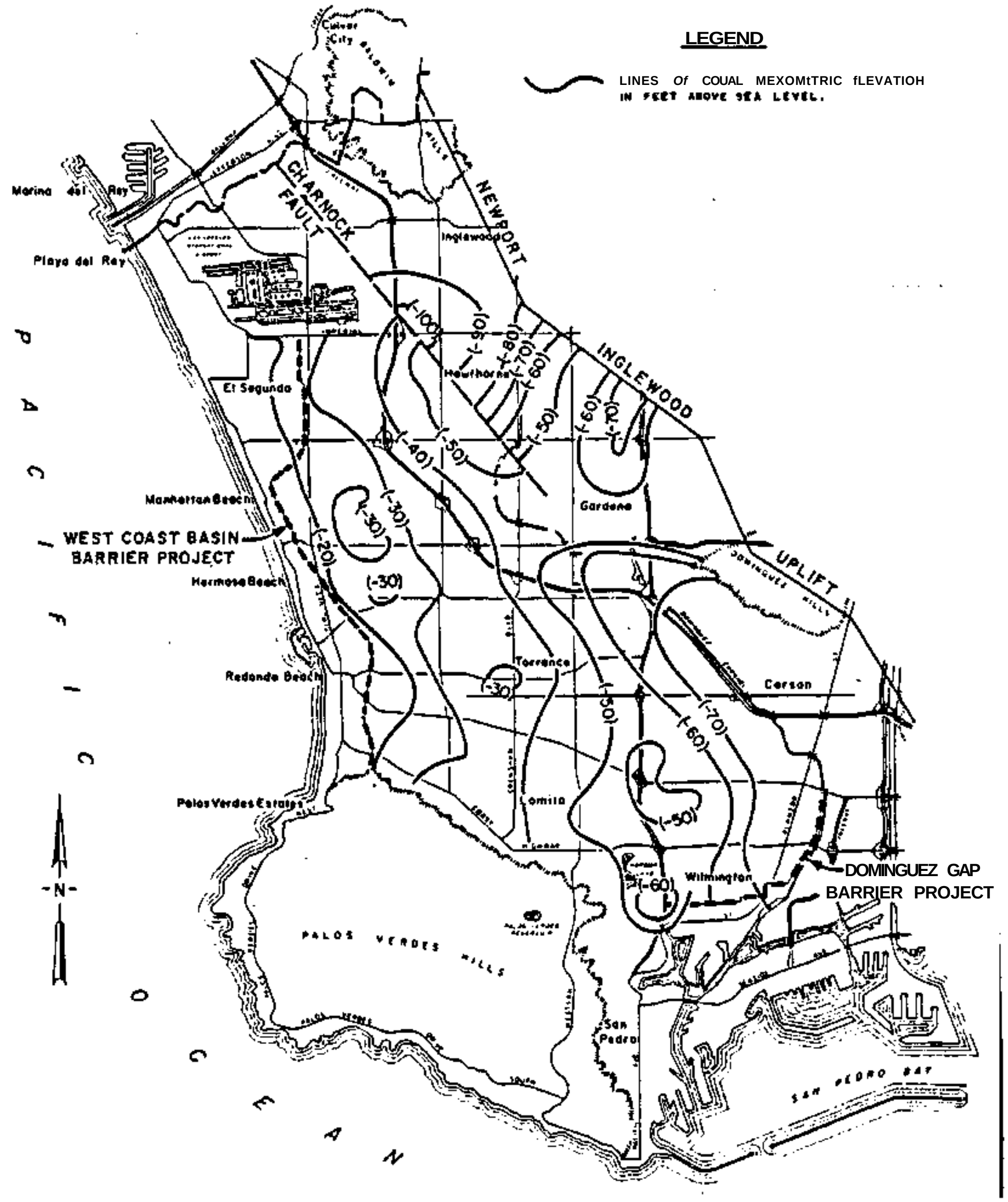


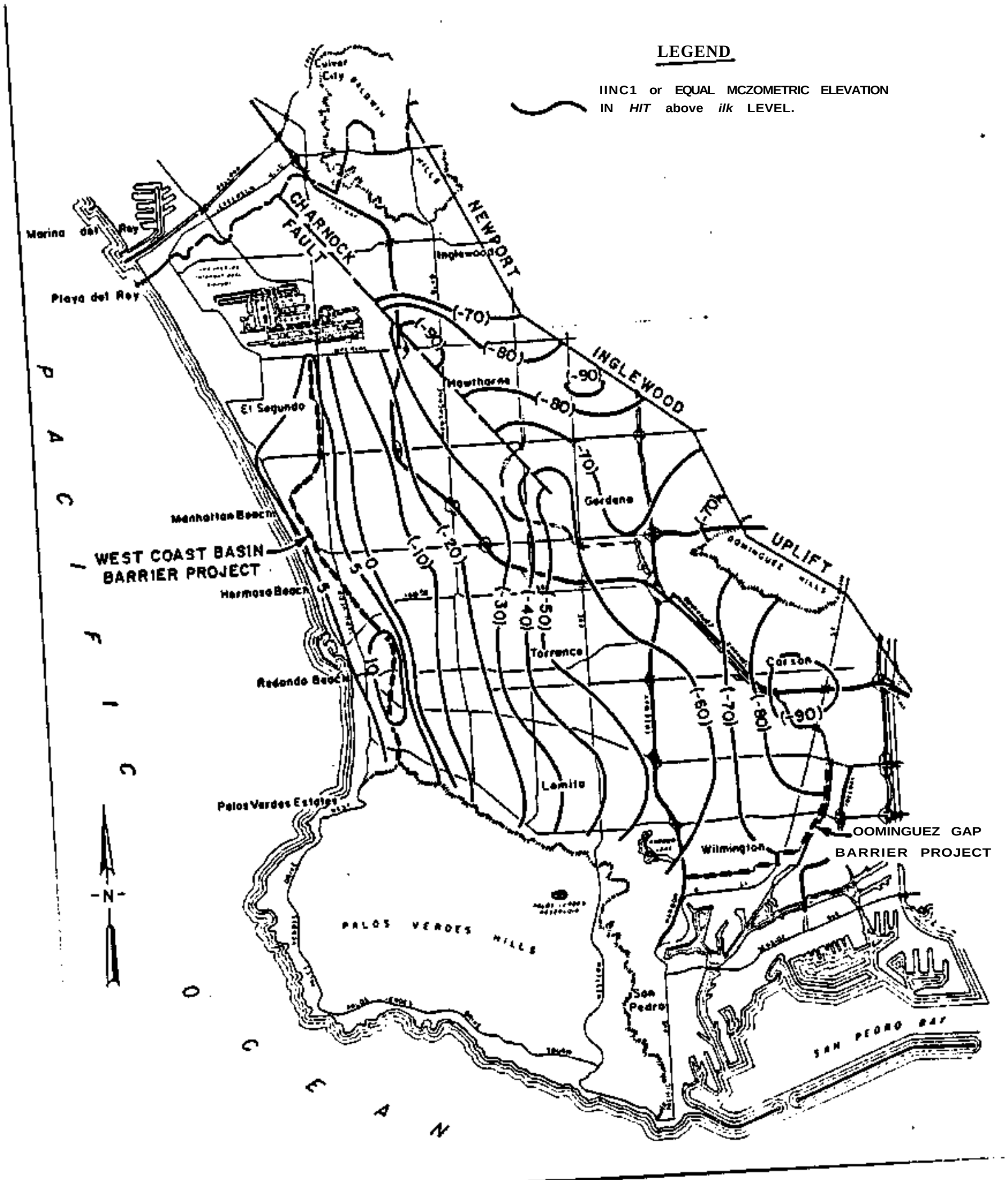
Figure 6-2. Water Levels in West Basin

Source: CWBWRD Annual Survey Report, 1984



Map 6-6. West Basin Ground Water Elevations, 1950

Source: CWBWRD Evaluation of Inland Saline Water, 1986



Map 6_7. West Basin Ground Water Elevations, 1983

Source: CWBWRD Evaluation of Inland Saline Water, 1986

water (despite its greater expense), and the burdens of reporting and paying monitoring costs and pump taxes (see below) have combined to reduce the number of active producers in West Basin from several hundred to a few dozen.

This reduction in the total number of producers has not resulted in a marked increase in the concentration of the West Basin water industry, however. The groundwater production from West Basin was highly concentrated to begin with, and remains so. Small producers -- i.e., those pumping 100 acre-feet per year or less -- totalled 232 in 1950, but accounted for only 5 percent of groundwater production. The nineteen large producers (1,000 acre-feet per year or more) extracted 84 percent of the ground water from West Basin in that year. In 1962, after the West Basin Judgment was entered, there were sixteen producers of 1,000 acre-feet or more, and they accounted for 87 percent of total groundwater production. As of 1985, there were fifteen such large producers, whose production represented 92 percent of the total extractions from West Basin. So, despite the large reduction in the number of active pumpers, the groundwater production industry in West Basin has concentrated from 19 producers accounting for 84 percent of production in 1950 to 15 producers accounting for 92 percent of production in 1985.

Changes in the distribution of production from West Basin have thus been primarily composed of abandonment of production at the small end rather than heavy consolidation at the large end of the production spectrum. Nevertheless, the experience of West Basin alerts us to the fact that the course of correcting a commons problem can be so costly that relatively small users are driven out, if their share of the benefits from the use of the resource is overwhelmed by their share of the costs of the resolution process.

The smaller (in terms of size of user group) West Basin water industry, like the small industry in Raymond Basin, now largely uses the Basin as part of a conjunctive-use water system. The cities, water districts, private water companies, and industrial users who account for the great majority of ground water use in the Basin now primarily use MWD imported water for their base supply and use ground water for peaking purposes. (117)

Ground water used for such peaking purposes is extremely valuable, as it supplants the need for costly surface storage systems and keeps to a minimum the capacity of surface distribution systems. Water demand at the peak hour of the peak day in the peak season can be as much as twenty times the average annual rate of use. (118) Construction of surface distribution systems with sufficient capacity to meet these peak-load demands is substantially less efficient than drawing upon ground water reserves to meet peak needs and building surface systems to accomodate base needs. The preservation of West Basin as such a valuable component of a conjunctive-use program, despite its expense, nonetheless represents a considerable saving over the alternative of destruction of the Basin and its complete replacement by a surface supply system. However, preservation of the Basin had not been guaranteed by the adjudication: the problems of fresh-water replenishment from upstream and salt-water contamination from the Ocean remained to be addressed.

B.5. Problems Upstream: Replenishment Lost and Regained

Under other circumstances, recoveries in underground water levels in an overdrawn basin would be an unmixed blessing. In West Basin, however, the curtailment of demand, which was a necessary step for the preservation of the resource, brought with it a new problem -- the loss of fresh water replenishment from Central Basin.

While water producers in West Basin had acquired a supplemental supply of water and curtailed their demands on the underground water, their upstream neighbors in Central Basin had continued to increase their production on the eastern side of the Newport-Inglewood Uplift. Underground water levels on the inland side of the Uplift continued to fall even as the water levels on the West Basin side began to recover. Thus, the differential in water levels across the Uplift grew smaller, which reduced the amount of fresh water flow from Central Basin into West Basin.

This prospect had been foreseen by the Division of Water Resources in its first Referee Report, which was one of the reasons the Division did not make a clear statement of the safe yield of West Basin. Recognizing West Basin's "Catch-22", that raising water levels to choke off the invasion from the sea would also reduce fresh water input from upstream as Central Basin water levels continued to decline, the Division declared itself "unable to specify a definite amount of water which may be _safely_ withdrawn or diverted annually from the West Coast Basin," (119) and concluded that a determination of such an amount would require years of observation.

Under the operation of the Interim Agreement in West Basin, this potential problem became manifest. In 1953-54, before the Interim

Agreement to reduce groundwater extractions had been signed by the major producers in West Basin, fresh water flow across the Uplift into West Basin had been 28,670 acre-feet. (120) By 1955-56, the first year of operation of the Interim Agreement, after water levels in West Basin had recovered five to ten feet and as water levels in Central Basin continued to decline, the estimated fresh-water replenishment to West Basin was down to 21,870 acre-feet. (121) By 1958, the Department of Water Resources noted in the 1957-58 Watermaster Report for West Basin that, in some places along the Uplift, the differential between Central and West Basin had been completely eliminated and even reversed. In various places along the Uplift, water levels in West Basin were actually higher than the water levels in Central Basin, so that ground water was moving inland across the Uplift, from West Basin into Central Basin. (122)

This problem was aggravated, not only by the ever-increasing pumping from Central Basin, but also by the loss of recharge capacity in Central Basin. Unlike West Basin, Central Basin is not completely covered by an impermeable clay upper stratum. The inland half of Central Basin is unconfined, with aquifers merging together and the coarse-grained materials through which water can readily percolate reaching all the way up to the ground surface. These permeable areas, which are capable of receiving large quantities of water and transmitting them underground, are called forebay areas. Central Basin contains two large forebay areas. The one to the northwest of the Basin is the Los Angeles Forebay Area, which coincides with the course of the Los Angeles River and underlies the City of Los Angeles and its immediate suburbs. In the northeast section of Central Basin is the Montebello Forebay Area, which coincides with the parallel courses of the Rio Hondo and the San Gabriel Rivers in the area where they pass through the Whittier Narrows. Water that percolates in these Forebays moves into the confined portion of Central Basin and, across the Uplift, into West Basin.

By the 1950s, much of the recharge capability of the unconfined portion of Central Basin had been lost. The paving over of the Los Angeles area and the lining of the the Los Angeles River as part of the County's flood control program had virtually eliminated the entire Los Angeles Forebay Area as a source of recharge to the aquifers in Central and West Basins. (123) Rainfall and runoff hitting the Los Angeles Forebay flowed into drainage channels that emptied into the "improved" Los Angeles River and headed for the Pacific. This left only the Montebello Forebay Area, which had not yet been paved over. Although the Rio Hondo and significant portions of the San Gabriel River channels had been lined, the Flood Control District had constructed spreading grounds for the capture and percolation of local runoff and flows from the San Gabriel River across the Whittier Narrows. In sum, even as the extractions from the aquifers underlying Central Basin were increasing, the area available for replenishment of the Central Basin had contracted. Central Basin was receiving less water, while Central Basin water producers were removing more.

This was an untenable situation for West Basin. Demand in West Basin had been restricted to around 60,000 acre-feet per year, but the replenishment from Central Basin had declined by the end of the 1950s to around 20,000 acre-feet or less. The 40,000 acre-foot overdraft would be made up by a combination of loss of storage (manifested in further declines in water levels) and inflow from the Pacific Ocean. West Basin water producers in the 1950s faced the worst of all possible worlds: they had reduced their reliance on the less expensive ground water underlying their lands, were purchasing more expensive, sediment-ridden Colorado River water to meet their needs, were paying taxes to WBMWD and MWD for the dubious privilege of doing so, and were paying for Watermaster service to monitor their demand curtailment, all while watching their groundwater situation continue to deteriorate because of actions by upstream users.

Once again, the West Basin Water Association was the focus of activity. Association members had come to realize that action within the boundaries of West Basin alone would be insufficient to resolve the Basin's problems. While they had no control over Central Basin, they did have two experiences on which to build: (1) a strong working relationship with the Los Angeles County Flood Control District, which operated the spreading facilities in the Montebello Forebay, and (2) observation of the activities of their neighbors in Orange County, who had begun a program of artificial replenishment of their underground water supply, supplementing their natural percolation with purchases of untreated imported water from MWD to be spread in the flood control grounds in Orange County. (124) The course of action that followed from these combined experiences was the pursuit of an artificial replenishment program in the Montebello Forebay, using imported water, and operated by LACFCD.

Spreading water in the Montebello Forebay was not an experimental concept; water had been spread there by the LACFCD since 1938. (125) However, especially in the midst of the 1945-1967 drought cycle, conservation of local runoff and storm flows was proving inadequate. The challenge was to devise a means of adding imported replenishment water to the process. The West Basin Water Association, in conjunction with the Flood Control District, pursued an amendment to the Los Angeles County Flood Control District Act to allow for the establishment of "conservation zones" within the LACFCD boundaries. These zones would be special taxing districts, the residents of which could be taxed for the financing of special projects that would be of benefit to the local residents but not necessarily to the entire area of the Flood Control District. Specifically, what the Association had in mind was a zone wherein residents would be taxed for the purchase of imported water to be spread at the Forebay to recharge Central, and eventually West, Basin.

In the spring of 1950, the California Legislature passed and the Governor signed legislation amending the Los Angeles County Flood Control District Act to authorize the creation of <u>temporary</u> "zones of benefit" within the District for the financing of special projects. (126) The first Conservation Zone was created by the Los Angeles County Board of Supervisors three years later, with an ad valorem tax rate of two cents per $100 of assessed valuation. The funds generated by this Zone were used for the purchase and spreading of imported water at the Montebello Forebay spreading grounds, beginning in 1954. (127) The water spread at Montebello Forebay recharged Central Basin and thus provided a benefit to Central Basin Water producers. Therefore much of Central Basin was included within the taxing zone, even though the creation of the zone had been at the instigation of West Basin producers, who also stood to benefit from the replenishment as it would help to maintain the differential across the Uplift.

The problem that remained was to obtain a permanent funding base for the replenishment operation. The LACFCD Zone was a temporary-funding source; it had a three-year time limit, following which the County Board of Supervisors would have to vote to renew the Zone for another three years. In addition, there was a distributional question raised by the use of property taxes to fund the spreading program; many of the residents of the Zone were by this time reliant primarily on imported water for which they were already being taxed. The funding of the replenishment program, which inured primarily to the benefit of the water producers in the area, through a tax on all property regardless of whether the property owner was using the underground water supply, was difficult (though not impossible) to justify to the Board of Supervisors as they faced votes to renew the Zone in 1957, 1960, and so on.

In 1953, the Orange County Water District switched the base of funding its artificial replenishment program to a "pump tax", or replenishment assessment. This taxing mechanism levied a fee on groundwater production --a "user tax" on the basin, in other words -- and used the proceeds to buy replenishment water for the spreading operation. Under such a scheme, those entities most directly benefiting from an ongoing replenishment program -- namely, the water producers themselves -- also most directly paid its costs.

The key difference between the situation in Central and West Basins and the one in Orange County was that Orange County already had, in the Orange County Water District, a permanent agency with boundaries that largely coincided with the underground water system, through which to operate the pump tax and the spreading operation. There was no such institutional facility in Central and West Basins. The LACFCD Zones were temporary, and were authorized only to levy an ad valorem tax. As long as another legislative change would be necessary to obtain authorization to tax groundwater production within Los Angeles County, the Association members felt that the legislative change may as well also authorize the creation of a permanent "special district" and an agency to operate the ongoing replenishment program.

As a result of the litigation in West Basin, groundwater producers there were already recording and reporting their extractions to the Division (later the Department) of Water Resources. Central Basin water producers were not doing so. Yet their water production would be taxed, too, under the unfolding scheme for a permanent artificial replenishment program financed by a pump tax. The West Basin Water Association and a drafting committee of twelve men representing various water producers, districts, and organizations worked on two fronts in the State Legislature in 1954 and 1955. (128) The first front was to secure legislation authorizing the creation of a special "water replenishment district". The second front was to obtain a legislative requirement that producers of ground water record their annual production.

The Water Recordation Act was promoted as a way of reducing the time and expense in future adjudications of ground water rights in southern California. As had been seen in the Raymond and West Basin litigations, much of the cost of these adjudications had been incurred in developing histories of ground water production for the various parties. The drafting Committee and the Association recommended to the Legislature that requiring recordation of ground water withdrawals for entities producing 25 acre-feet or more per year from underground in the four southern Counties of Los Angeles, Riverside, San Bernardino, and Ventura, and reporting of these withdrawals to the State Water Rights Board (which succeeded to the Court Reference duties of the Division of Water Resources) would expedite anticipated future adjudications without burdening the whole State and smaller groundwater producers. (129) The Water Recordation Act was passed by the California Legislature and signed by the Governor in June 1955.

Also in that month, the Legislature passed and the Governor signed the Water Replenishment District Act, the "second front" in the process of creation of a replenishment program for the Coastal Plain. The Water Replenishment District Act was confined to seven southern Counties (the ones included in the Recordation Act plus Kern, San Diego, and Imperial). (130) Replenishment Districts were empowered through the Act to raise funds through ad valorem property taxes, through pump taxes, and through the retailing of water to resident water users. (131) However, in an effort to overcome objections concerning possible duplication of effort and excessive taxation of local residents, two caveats were included in the Act that enhanced the Legislature's willingness to adopt it. First, boundary determinations would be checked by the State Engineer, who would investigate to ensure that those persons to be included within the boundaries of such a District would in fact be benefiting directly from the District's activities. (132) Second, the Act required any District established thereunder to explore and determine whether other existing agencies can do any part of its work. If so, then the

District must contract with that other agency to do that work, rather than establishing its own facilities or operations in addition to those already conducted by some other body. (133)

With the Recordation Act and the Water Replenishment District Act approved, the West Basin Water Association formed a new committee, the Relenishment District Boundary Committee, to work on the creation of a District. The newer Central Basin Water Association formed a similar Committee, and subsequently the two committees were combined into a Joint Committee on the Water Replenishment District. (134) The Joint Committee worked on the boundaries of a replenishment district, and arrived at a proposed District of about 420 square miles, encompassing all of West Basin and nearly all of Central Basin. It was proposed that the ad valorem tax of the LACFCD Conservation Zone be continued, and that the funds raised therefrom be devoted to purchasing enough replenishment water to make up the historically accumulated overdraft, based on reasoning that all property owners had benefited from the development of the area and that the development of the area had been in large part made possible by the overdrafting of West and Central Basins. The Replenishment District, then, would fund ongoing replenishment to offset continuing annual overdrafts through the pump tax, thereby making the water producers within the District bear the primary cost of keeping replenishment water flowing into the Basins, above and beyond that required to offset the accumulated overdraft. (135) Further, it was proposed that the Replenishment District not be annexed to the Metropolitan Water District, since the area within the proposed District was already annexed to MWD. The District could contract with resident MWD member agencies (such as the WBMWD and the

Central Basin Municipal Water District) for the purchase of untreated MWD water for replenishment. (136)

The Joint Committee, and the Water Associations in West Basin and Central Basin, embarked upon a petition drive after the Joint Committee's work was completed, to collect enough signatures within the proposed District to present to the County Board of Supervisors so that they would set a special election. The petition drive was completed, and over 100,000 signatures were presented to the Board of Supervisors on June 9, 1959. The Board forwarded the signatures to the Department of Water Resources and the State Engineer for the required determination regarding the appropriateness of the proposed boundaries. The Department held hearings on the issue on July 6, 1959, and presented its report endorsing the proposed boundaries on July 17. (137) The County Board of Supervisors then set November 17, 1959, as the date for a special election within the proposed boundaries on the question of whether the Central and West Basin Water Replenishment District (CWBWRD) should be formed.

The formation of the District received four-to-one support from the voters on November 17th. A five-member Board of Directors, each member representing a part of the District, was elected to govern the District, setting policy and establishing tax rates, with the Board appointing a General Manager to conduct the day-to-day operations of the District. For the 1960-61 fiscal year, the first year of District operations, the District's Board of Directors established a pump tax of $3.19 per acre-foot, the proceeds from which would be used to purchase 70,000 acre-feet of imported Colorado River water for spreading during the year. (138) The amount of the pump tax for each year and the MWD price per acre-foot of replenishment water are shown in Table 6-5. As the price of MWD replenishment water has escalated sharply in the past few years, so too has the CWBWRD pump tax.

In 1972, the Los Angeles County Board of Supervisors failed to renew the LACFCD Zone that had been used to finance replenishment water purchases for making up the accumulated overdraft. From fiscal year 1973 on, then, the Replenishment District has been the source of financing of the operation of the replenishment program. Still, the Replenishment District operates mainly as a financier of the replenishment program, not as a central manager of the basins. The District purchases MWD water, principally through the Central Basin Municipal Water District, which is conveyed by MWD to Whittier Narrows, where the County Flood Control District actually conducts the spreading operation, while the California Department of Water Resources conducts periodic engineering and geologic investigations of the area as well as providing Watermaster Service to monitor the operation of the Judgment.

One of the effects of the pump tax is to raise the cost of groundwater production to the groundwater producers in the Central and West Basins, to make them pay (at least partially) for their overdrafting of these ground water supplies. Even with the pump tax, ground water remains cheaper than treated MWD water. There is little doubt that without the curtailment of demand imposed by the Court through the West Basin adjudication, West Basin producers would rely much more heavily on the cheaper ground water than an imported water, at least in those areas of the Basin that are not underlain by sea water.

TABLE 6-5

Amount of CWBWRD Pump Tax and Price of MWD Replenishment Water (per Acre-Foot), 1961-1985

Year	CWBWRD Pump Tax	Cost of MWD Water for Replenishment
1961	$3.19	$ 12.75
1962	5.75	13.50
1963	6.63	14.25
1964	6.58	15.00
1965	7.36	15.25
1966	7.31	16.00
1967	6.20	17.00
1968	6.11	18.00
1969	6.00	19.00
1970	6.00	20.00
1971	6.00	22.00
1972	6.00	24.00
1973	9.00	27.00
1974	11.00	30.00
1975	14.00	30.00
1976	21.00	32.00/42.00*
1977	21.00	36.00/42.00*
1978	24.00	41.00
1979	24.00	48.00
1980	24.00	53.00
1981	16.00	53.00
1982	16.00	61.00
1983	16.00	79.00
1984	27.00	100.00/153.00**
1985	41.00	153.00

*-- Two-price system: higher price for State Project water

**-- MWD price changed in middle of fiscal year

Source: CWBWRD Annual Survey Reports, 1961-1985

Inducing ground water producers to use more imported water has been one of the objectives of the CWBWRD, which is concerned with the recharge of the basins, and of the MWD, which has been concerned with maxmizing imported water sales during periods when sufficient water is available. As a result, both the CWBWRD and the MWD have entered into arrangements with groundwater producers to use imported water in lieu of ground water. The CWBWRD began an in-lieu replenishment water program in 1965. Under this program, the District offers to reimburse groundwater producers for the difference in cost between pumping ground water and taking treated MWD water. (139) Through such an operation, the water producer receives imported water at the same cost per acre-foot as he incurs from pumping ground water, the CWBWRD keeps ground water in the ground at 100% replacement (which is more efficient than spreading, where losses occur due to evaporation) while paying only the difference between groundwater production and the treated imported water (which used to be a smaller amount than the price of untreated imported water), and the MWD sells more water at the higher, treated price than it would have if CWBWRD obtained the untreated water for spreading.

MWD has since instituted its own in-lieu replenishment programs, which are treated at greater length in the previous Chapter and in the subsequent Chapter on Orange County. These MWD programs make water available to groundwater producers at lowered prices during periods of surplus in exchange for restraint on pumping by those producers who are able to take the surplus imported water. (140)

Throughout its operation, the CWBWRD has had to balance two considerations: the adequacy of replenishment water supplies and the capability of the Forebay Area to receive those supplies. At times, for example, the District has reached and exceeded the maximum percolation rate in the Forebay. In 1963, spreading was actually stopped for a period due to the buildup of a fresh water mound in the area of the spreading grounds; the underlying structures were simply incapable to taking any more water. (141)

More frequently and more persistently, though, the concern has been with adequacy of supplies. With the threatened loss of Colorado River water due to the Arizona v. California litigation in the early 1960s, the Replenishment District Board and General Manager were alerted to the prospect that their replenishment program might well come to naught if MWD's allotment of the waters of the Colorado was severely reduced. This indeed came to pass after the decision of the U.S. Supreme Court in 1965. In response, MWD turned north and CWBWRD turned inward. The State Water Project became the source of additional water for MWD, bringing water from northern California in the early 1970s. CWBWRD, meanwhile, executed contracts with two waste water reclamation plants within the area to supply reclaimed water for spreading.

These responses have resulted in CWBWRD's purchases of replenishment water since the mid-1970s being composed of a varying mix of Colorado River water, State Project water, and reclaimed waste water, depending on their relative availability and cost. The locally-produced reclaimed waste water is the cheapest and most reliable source of supply. The Replenishment District generally uses all of the reclaimed waste water it can purchase each year. The District has been limited in the amount of reclaimed waste water it can spread by the Regional Water Quality Control Board and the State Health Department, which were imposing limits largely out of caution until the effects of spreading reclaimed water could be studied over a number of years. At the present time, the Regional Water Quality Control Board has approved a series of increases in the allowed amounts of reclaimed water for spreading. By 1990, the CWBWRD should be able to use up to 50,000 acre-feet per year of reclaimed waste water for spreading. Purchases of imported water for replenishment from MWD since 1974 have been a roughly even mix of Colorado River water and northern California water. In sum, the replenishment program of the CWBWRD is not heavily dependent upon the Colorado River, and has withstood the loss of availability of that water as Arizona has increasingly claimed its share.

Through the creation of the Central and West Basin Water Replenishment District, water producers on both sides of the Newport-Inglewood Uplift have regained their fresh water replenishment. There are no current estimates of the amount of flow across the Uplift into West Basin, but the recovery of water levels on the Central Basin side of the Uplift and the restoration of the water level differential between the Central Basin side and the West Basin side suggests that the amount of fresh water replenishment to West Basin has probably been restored to 1940s volumes, i.e., approximately 30,000 acre-feet per year.

B.6. Fighting Back the Sea

Re-filling West Basin, in light of the lowered water levels in Central Basin, was not a feasible alternative in the 1950s. (142)

Such a re-filling could not take place within West Basin because of the lack of spreading capability due to the covering of the Basin with an impermeable stratum of clay. Furthermore, even if such a re-filling were possible, it would simply have choked off the fresh-water replenishment across the Uplift. It became apparent by the early 1950s that, in order to maintain a sufficient hydrostatic head across the Uplift to maximize fresh-water recharge from Central Basin, water levels within West Basin would have to be maintained below sea level. This has remained true even with the operation of the replenishment program by the CWBWRD and the LACFCD. (143)

However, maintaining water levels within West Basin below sea level was also not compatible with the preservation of the Basin. The Ocean was flowing into West Basin and would continue to invade as long as the underground water levels remained below sea level. (144) There was, therefore, yet another challenge for the West Basin water industry-- how to maintain water levels sufficiently low within the Basin to maximize fresh-water input without simultaneously destroying the Basin through sea-water intrusion.

Ideas about how to keep the Ocean out of West Basin had circulated as early as during the life of the West Basin Ground Water Conservation Group in 1945. It was within that group that the idea of creating a fresh-water mound below the ground surface and parallel to the coast first emerged. (145) J.F. Poland of the U.S. Geological Survey, who had been engaged by the West Basin Survey Committee, supported the idea, as did the LACFCD engineers who had met with the Survey Committee and then the Ground Water Conservation Group. (146)

The Chairman of the Conservation Group was the City Engineer of

Manhattan Beach, O.A. Gierlach, who had worked with Paul Baumann, the Chief Engineer of LACFCD, in organizing the meetings that led to the formation of the Survey Committee. Gierlach and Baumann convinced the City and the LACFCD to try an experiment in Manhattan Beach. The LACFCD converted one of the City's seven abandoned wells to work in reverse. Fresh water was injected underground through this converted well. Measurements were taken at the other six wells, which were located 300 to 600 feet away. There was a noticeable rise in water level --a tiny fresh-water mound had appparently been created. (147)

The possibility of creating an underground mound of fresh water under pressure would be of benefit to other California coastal basins, as well as to West Basin in particular, so the West Basin Water Association appealed to the State of California to finance a one mile long prototype barrier in the Manhattan Beach *area.,* to continue and extend the experiment begun by the City and the LACFCD. An appropriation of $750,000 was passed by the Legislature and signed by the Governor on July 12, 1951. (148) The funds were appropriated for the use of the State Water Resources Board, which in turn entered into a contract with the LACFCD on October 1, 1951. The State Water Resources Board turned over $642,000 of the total appropriation to LACFCD for the installation and operation of the one-mile barrier. (149)

The Flood Control District began construction in January 1952, placing nine injection wells approximately 500 feet apart and parallel to the coast about 2,000 feet inland. In February 1953, the District began injecting treated Colorado River water imported from MWD via WBMWD into the series of wells. Again, the injection process worked

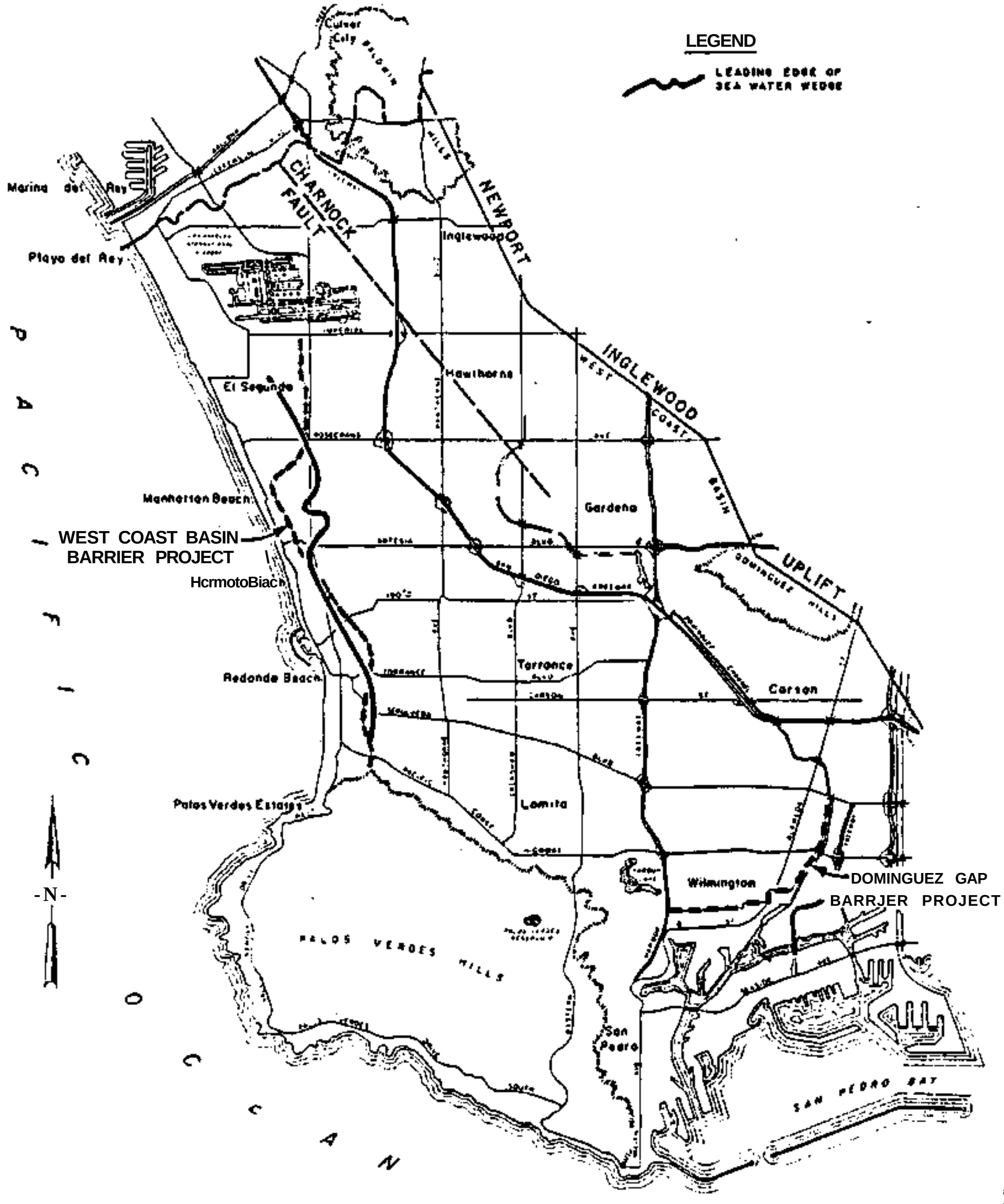
-- observation wells in the area showed a rise in water levels and a decline in salinity.

The State funds were exhausted by November. There remained ten miles of exposed coast line along which the Pacific continued to intrude. The LACFCD operated the prototype barrier with its own funds while the Association and the District sought a means of extending the barrier along the coast. The Association drafted an ordinance authorizing the creation of another Conservation Zone, known as Zone II, within the Flood Control District. The boundaries of Zone II coincided with the boundaries of West Basin. The Los Angeles County Board of Supervisors approved the creation of Zone II in January 1954, with an ad valorem tax rate of five cents per $100 of assessed valuation. (150)

This funding sufficed through 1959 for the maintenance of the prototype barrier and some extension, but it became clear that the cost of constructing a full barrier would greatly exceed the ability of the Zone II arrangement to generate revenue. Furthermore, Zone II had the same drawbacks as the Zone I financing of the artificial replenishment program: it was temporary, and it raised distributional questions about taxing all property in the area for a benefit that primarily went to water producers. Moreover, discussion had begun about constructing a similar barrier along San Pedro Bay to stop the intrusion of sea water along the southern boundary of the Basin, and there was no way that the Zone II arrangement could support that additional project.

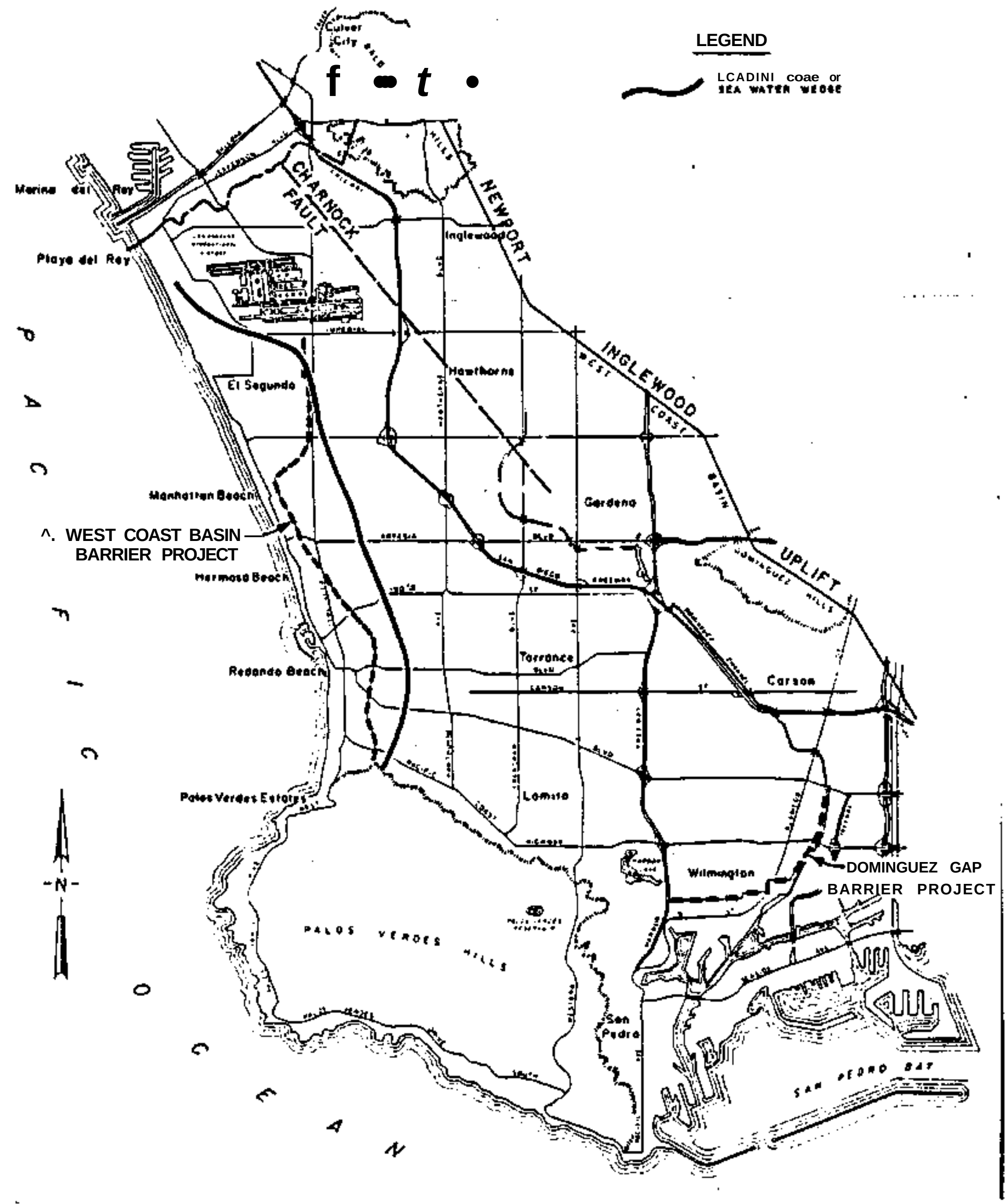
The financing of the barrier became another reason for the establishment of the Water Replenishment District with power to tax groundwater production. The District could raise money through the pump tax and could purchase water for the barrier at the same time that it purchased water for spreading. With the favorable vote on the formation of the CWBWRD in 1959, a new financing arrangement became possible, based on reasoning similar to that used in funding the spreading operation. The LACFCD Zone II funds would be used solely for construction of the barrier projects along the western and southern boundaries. The Replenishment District would raise the funds to operate and maintain the barriers once they were constructed. Thus, all property owners in West Basin would pay for the establishment of the fresh-water barriers, as all had benefited from the development of the area that had been based on exploitation of the ground water supply, but water producers would pay the costs from that point forward of maintaining the barrier from which they most directly benefited. (151)

This arrangement allowed for the completion of the barrier projects, following which Zone II was terminated by the County. CWBWRD now finances the barriers, with the actual operation and maintenance performed by the LACFCD engineers. Maps 6-8, 6-9, and 6-10 show the West Basin Barrier Project, which is the one along the Ocean, and the Dominguez Gap Barrier Project along San Pedro Bay. In addition, these maps indicate the location of the furthest inland intrusion of sea water in 1950, 1963, and 1985 along the West Basin Barrier Project. The West Basin Barrier Project now consists of 144 injection wells. The Dominguez Gap Barrier Project, which began operation in February 1971, consists of 40 injection wells. In addition to these two barriers, there is a smaller barrier project on



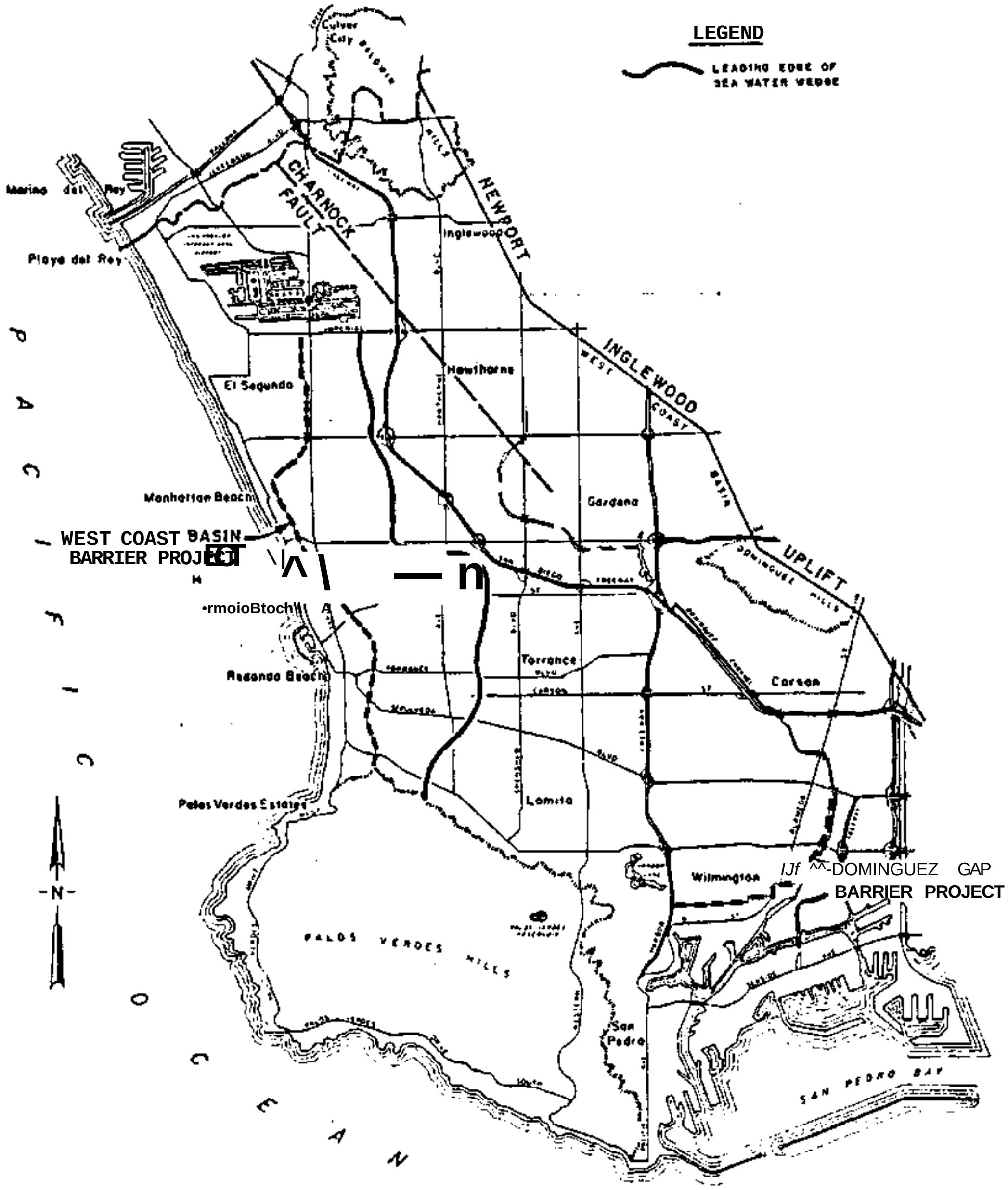
Map 6-8. West Basin Barrier Projects, and Inland Extent of Sea Water, 1950

Source: CWBWRD Evaluation of Inland Saline Water, 1986



Hap 6-9. West Basin Barrier Projects, and Inland Extent of Sea Water, 1963

Source: CWBWRD Evaluation of Inland Saline Water, 1986



Map 6-10. West Basin Barrier Projects, and Inland Extent of Sea Water, 1983

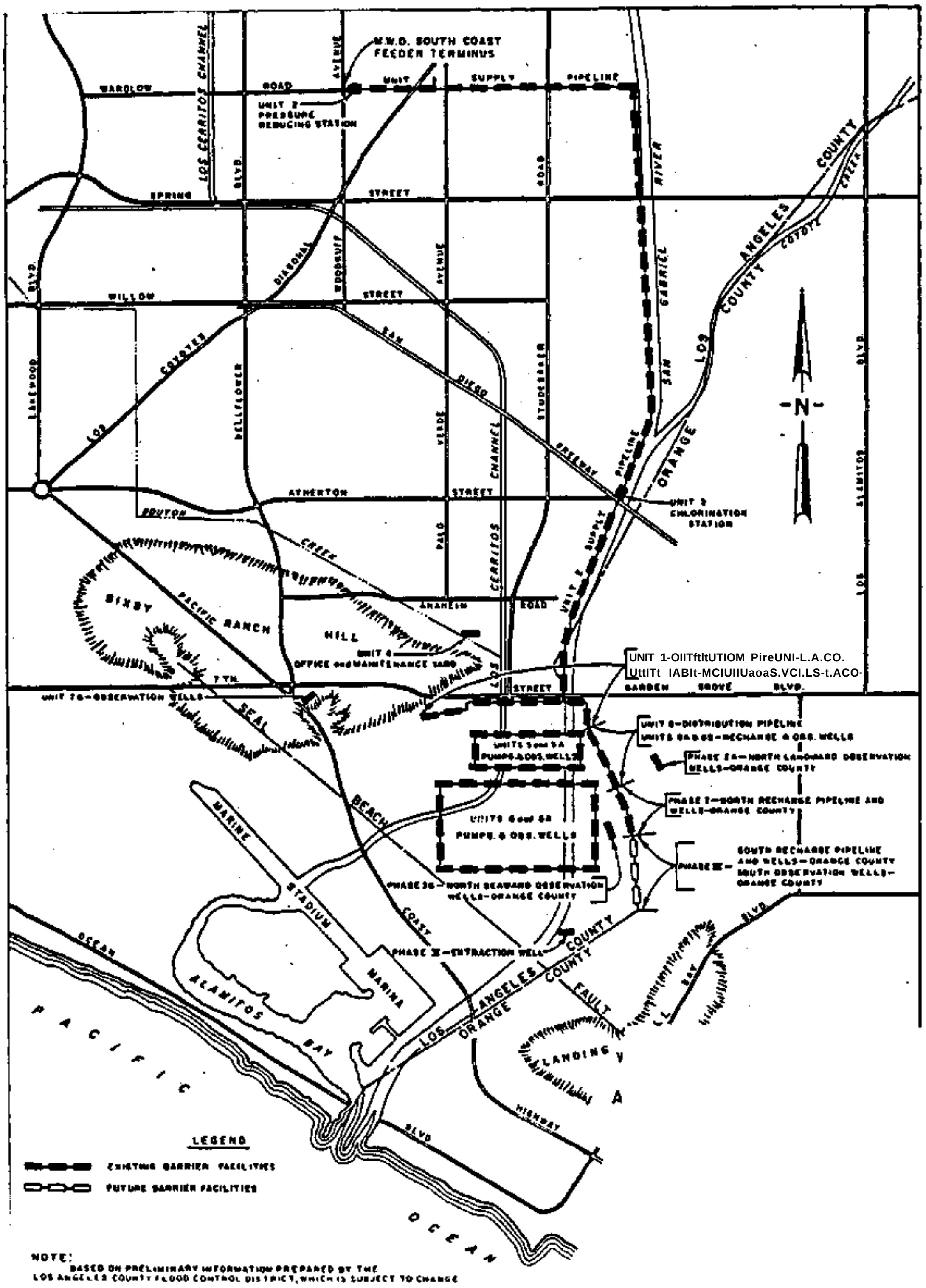
Source: CWBWRD Evaluation of Inland Saline Water, 1986

the boundary between Los Angeles and Orange Counties, called the Alamitos Gap Barrier Project, which is operated jointly by the LACFCD and the Orange County Water District (see Map 6-11).

These barriers have been successful in creating a wall against the Ocean so that underground water levels through the rest of West Basin could be maintained at low enough levels to maximize fresh-water flow across the Uplift from Central Basin. Water levels along the coast have been maintained at or slightly above sea level, which has been sufficient to keep additional sea water from entering the Basin. (152) Maps 6-8, 6-9, and 6-10 show the continual advance of salt water into the Basin, but this is showing the farthest inland movement of water degraded by concentrated salts and does not reflect new intrusion into the Basin.

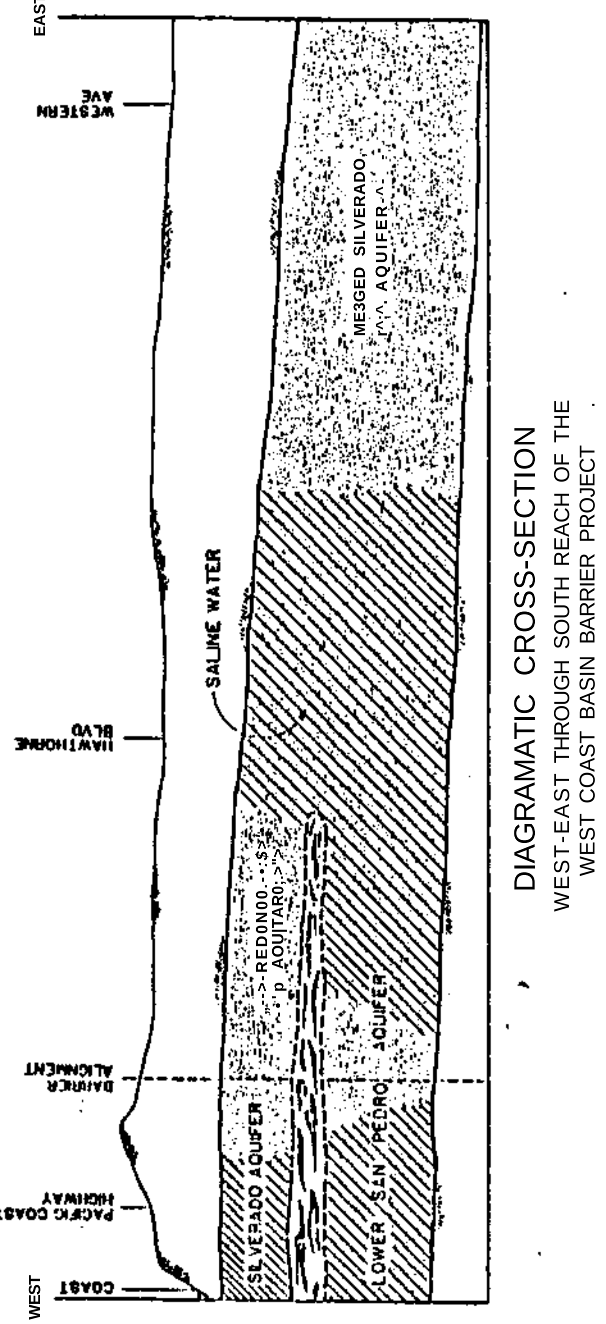
When the coastal barrier project was built and placed in operation, its course ran directly through the area of intruded sea water. As a result, when injection began and the fresh water mound formed along the coast about 2,000 feet inland, the sea water was divided, with a large area of salt water trapped on the inland side of the fresh water being injected underground, as can be seen in the cross-sectional view of the Basin presented in Figure 6-3.

This trapped inland sea water, known as the "severed toe" of sea water, amounts to about 600,000 acre-feet of water with chloride concentrations in excess of 500 ppm, which represents about 20 percent of the usable storage volume in the Basin. The area underlain by the severed toe of sea water totals about 10 square miles. As more fresh water is pushed underground by the coastal barrier project, this sea water wedge moves farther inland at a rate of about 300 feet per year.



Map 6-11. Aland.tos Barrier Project

Source: CWBWRD Annual Survey Report, 1984



DIAGRAMATIC CROSS-SECTION
WEST-EAST THROUGH SOUTH REACH OF THE WEST COAST BASIN BARRIER PROJECT

Figure I-3 • West Basin Cross-Section, Showing Intruded Sea Water

Source: LACFCD Evaluation of Barrier Project, 19[illegible]

(153) It has reached West Torrance, and will reach Torrance by 1995. The Replenishment District and the Flood Control District have each conducted recent studies of the inland sea water, and discussions sre underway within the West Basin water community about what (if anything) to do about the further encroachment of this saline water. Fresh water replenishment will, ever so slowly, dilute the saline water, but over that course of time many more wells would have to be abandoned as the area of concentrated salts continues its eastern movement. A program of intensive extraction and disposal of the saline water, another barrier project, adjustment of pumping patterns, and other ideas are under discussion at this time.

The inland movement of the severed toe of sea water reflects one unanticipated benefit of the barrier projects. The sea water wedge is being pushed to the east by the inland movement of a fresh water wedge coming from the barrier project. As was not generally understood at the time of the construction of the barriers, the injected water not only resists further sea water encroachment, but virtually all of the fresh water eventually moves inland into the Basin. (154) Thus, the barriers have become a second source of fresh-water replenishment to West Basin. The amounts were small at first, averaging only 3,000-4,000 acre-feet per year from 1953 through 1963. But with the expansion of the coastal barrier, injection reached nearly 48,000 acre-feet per year by 1966. Injection in the three barriers has averaged about 37,000 acre-feet per year in the 1980s. Table 6-6 shows the amounts injected at the barrier projects in West Basin.

TABLE 6-6

Water Injected at Barrier Projects (and Number of Injection Wells at Each), 1953-1985

Year	West Basin Barrier Project (Coastal)	Alamitos Gap Barrier	Dominguez Gap Barrier	Total
1953	1,140 (9)			1,140
1954	3,290 (9)			3,290
1955	2,740 (9)			2,740
1956	2,840 (9)			2,840
1957	3,590 (9)			3,590
1958	4,330 (12)			4,330
1959	3,700 (12)			3,700
1960	3,800 (12)			3,800
1961	4,480 (12)			4,480
1962	4,510 (12)			4,510
1963	4,200 (12)			4,200
1964	10,450 (28)			10,450
1965	33,020 (56)	2,760 (14)		35,780
1966	44,390 (59)	3,370 (17)		47,760
1967	43,060 (94)	3,390 (17)		46,450
1968	39,580 (94)	4,210 (17)		43,790
1969	36,420 (93)	4,310 (18)		40,730
1970	29,460 (93)	3,760 (18)		33,220
1971	29,870 (93)	3,310 (18)	2,200 (29)	35,380
1972	26,490 (92)	4,060 (18)	9,550 (29)	40,100
1973	28,150 (92)	4,300 (18)	8,470 (29)	40,920
1974	27,540 (92)	6,140 (18)	7,830 (29)	41,510
1975	26,430 (92)	4,440 (18)	5,160 (29)	36,030
1976	35,220 (120)	4,090 (18)	4,940 (29)	44,250
1977	34,260 (120)	4,890 (18)	9,280 (40)	48,430
1978	29,640 (120)	4,020 (20)	5,740 (40)	39,400
1979	23,720 (120)	4,220 (20)	5,660 (40)	33,600
1980	28,630 (120)	3,560 (20)	4,470 (40)	36,660
1981	26,350 (120)	3,940 (20)	3,550 (40)	33,840
1982	24,640 (120)	4,540 (20)	4,720 (40)	33,900
1983	33,950 (144)	3,270 (26)	6,020 (40)	43,240
1984	30,600 (144)	4,024 (26)	7,657 (40)	42,281
1985	27,350 (144)	4,274 (26)	7,387 (40)	39,011

Source: West Basin Watermaster Reports, 1956-1985

Operation of the barriers is expensive. Treated MWD water injected at the barriers costs $186.00 per acre-foot at present, so injection of 40,000 acre-feet of water at the three barriers each year costs $7,440,000. Nevertheless, studies undertaken by the Department of Water Resources and the LACFCD comparing various alternatives, such as mining West Basin and replacing it with a complete surface distribution and storage system, or trying to fill the Basin from upstream through an enlarged spreading program, have indicated that operation of these barrier projects is less expensive than other means of supplying the population and industry of West Basin with an adequate supply of water. (155) At the time of the expansion of the West Basin Barrier Project and the construction of the Alamitos Gap Barrier, for example, the LACFCD estimated that the average annual cost of building and maintaining surface storage facilities to match the underground aquifers' capacity for meeting peak demands was nearly three times greater than the average annual cost of building and operating the barrier projects. (156) Walling off West Basin from the Pacific Ocean is a formidable undertaking, from an economic as well as an engineering standpoint, but it appears thus far to be the least daunting alternative financially.

With the construction of the barrier projects, West Basin water users completed the set of responses to their problems. The barriers allow the water levels throughout the Basin to be maintained below sea level without the risk of additional sea-water intrusion. While much of the Basin remains underlain by salt water, the invasion of the Pacific has been turned back, and the remainder of the Basin is being replenished by fresh water from both the west and the east, instead of being filled with fresh water from one side and salt water from the other. While it is true that no fountain can both yield salt water and fresh, and indeed many of the "fountains" in West Basin were abandoned for just that reason, it appears to be also true that fountains that yielded salt water may be made to yield fresh water again.

C. Summary

West Basin presented water producers and the other residents of its several communities with multiple, interrelated problems in a setting less favorable to collective action. In this larger groundwater basin, there were fifteen times as many well owners and nine times as many active producers at the outset of activity than there were in the Raymond Basin. This greater number of producers faced problems that were connected in such a way that solution to one problem aggravated another problem. The reduction of pumping raised water levels and choked off fresh-water inflow from Central Basin, while keeping water levels low enough to increase fresh-water inflow accelerated the invasion of West Basin by the Pacific Ocean.

Addressing these problems and finding a package of solutions that struck the proper balance between water levels in the Basin and the inflow to the Basin from the east by fresh water and from the west by sea water required considerable institutional innovation, as well as the adaptation of ideas from other groundwater basins in the Los Angeles area. Certainly, the curtailment of pumping followed the example of Raymond Basin, and the use of the pump tax had begun in

Orange County six years before the establishment of the Replenishment District. But the adaptation of these devices to West Basin required some stitching and fitting, and beyond this there was original institutional design and implementation for West Basin's own problems. In the course of collective action in West Basin, water users created the West Basin Survey Committee, the West Basin Ground Water Conservation Group, the West Basin Water Association, the West Basin Municipal Water District, Flood Control District Conservation Zones I and II, and the Central and West Basin Water Replenishment District. Local producers took over the experimental barrier project after the initial appropriation from the State, and turned it into an ongoing operation along both exposed front funded locally through a tax on groundwater production. They also participated in the passage at the State level of the amendments to the Flood Control District Act and the drafting and adoption of the Water Recordation Act and the Water Replenishment District Act.

In West Basin, action was neither purely public nor purely private. Nor was action directed by any central public manager. Despite Carruthers and Stoner's assertion that innovation in basin management is virtually limited to the public sector, such essential innovations as the Recordation Act and the creation of a two-basin Replenishment District were designed and driven by the private associations of water producers. The participants themselves in West Basin, using a rich supporting institutional structure that enabled them to enter into contingent contracts and to create new political jurisdictions, were the major actors in designing and altering institutional arrangements to meet their needs. (157) And the polycentric management system created for West Basin fits neither of the established prescriptions for resource management in the extant commons literature. (158) Firm, tradeable rights to pumping have been created and a market in these rights has emerged, but West Basin has not been "privatized". Agencies have been created to import water, to monitor pumping, to fund the spreading and barrier projects, and to operate those projects, but in no meaningful sense can it be said that West Basin is under any form of central public management -- instead, specialized offices perform each of these functions in a coordinated and contractual rather than in a unified, directed fashion.

This is not to say that West Basin has been perfectly preserved and managed. Litigation dragged on for sixteen years and cost millions of dollars before a stipulated judgment was finally attained, and even that judgment was appealed. In the time that passed while collective action to curtail pumping and to fight back the sea was underway, lasting damage was done to the Basin. The trapped sea-water wedge presents the actors in West Basin with a new problem to solve. But, West Basin is no longer listed by the Department of Water Resources as critically overdrafted, new sea-water intrusion has effectively been halted, and the smaller water industry that operates in West Basin now is managing the Basin as part of conjunctive-use system, relying on the underground aquifers primarily for storage and peaking, which are their most valuable use. And those achievements must be regarded as a long step back from the brink in forty years.

Notes to Chapter Six

1. State of California Department of Water Resources (1959), Report on Proposed Central and West Basin Water Replenishment District [hereinafter referred to as "DWR Report on Proposed CWBWRD"], p. 27.

2. State of California Division of Water Resource (1952), Report of Referee-- West Coast Basin Reference [hereinafter referred to as "1952 West Basin Referee Report"], p. 119.

3. DWR Report on Proposed CWBWRD (1959), p. 18; also, 1952 West Basin Referee Report, p. 120.

4. DWR Report on Proposed CWBWRD (1959), p. 18; 1952 West Basin Referee Report, p. 120; State of California State Water Rights Board (1961) Report of Referee-- West Coast Basin Reference Continuance [hereinafter referred to as "1961 West Basin Referee Report"], p. 14.

5. 1961 West Basin Referee Report, pp. xi-xii.

6. E. Ostrom (1965), p. 10.

7. Jennings et al. (1963), p. 19.

8. 1952 West Basin Referee Report, p. 129.

9. Ibid.; also, p. 119.

10. E. Ostrom (1965), p. 37.

11. Central and West Basin Water Replenishment District (1986) Evaluation of Saline Water Inland of West Coast Basin Barrier [hereinafter referred to as "CWBWRD Report on Inland Saline Water"], p. 20.

12. Fossette (1986), pp. 6-7.

13. West Basin Watermaster Report, 1958, p. 13.

14. Ibid.

15. DWR Report on Proposed CWBWRD (1959), p. 7.

16. West Basin Watermaster Report, 1983, p. 47.

17. E. Ostrom (1965), p. 217.

18. Ibid., pp. 11-12.

19. 1952 West Basin Referee Report, p. 29; West Basin Watermaster Report, 1983, p. 47.

20. 1952 West Basin Referee Report, p. 66.

21. West Basin Watermaster Report, 1958, p. 3; Jennings et al. (1963), p. 12.

22. E. Ostrom (1965), p. 12 fn.

23. 1952 West Basin Referee Report, p. 26.

24. West Basin Watermaster Report, 1958, p. 3.

25. 1952 West Basin Referee Report, p. 26.

26. Ibid.

27. West Basin Watermaster Report, 1958, p. 3.

28. E. Ostrom (1965), p. 17.

29. 1952 West Basin Referee Report, p. 6.

30. E. Ostrom (1965), p. 13.

31. Fossette (1986), p. 6.

32. 1952 West Basin Referee Report, p. 129.

33. Ibid.

34. Fossette (1986), pp. 149-150.

35. Ibid.; E, Ostrom (1965), p. 14.

36. DWR Bulletin No. 104 (Appendix B) , p. 92; Jennings et al. (1963), p. 12.

37. 1961 West Basin Referee Report, p. 14; Coe (1983), p. 8.

38. E. Ostrom (1965), p. 14.

39. DWR Report on Proposed CWBWRD (1959), p. 39.

40. 1961 West Basin Referee Report, p. xi.

41. West Basin Watermaster Report, 1962, pp. 17-18.

42. E. Ostrom (1965), p. 126.

43. DWR Report on Proposed CWBWRD (1959), p. 1.

44. E. Ostrom (1986a), p. 12 (emphasis added).

45. 1952 West Basin Referee Report, p. 66.

46. E. Ostrom (1965), pp. 14-15.

47. Ibid., p. 306.

48. Ibid, p. xviii.

49. 1952 West Basin Referee Report, p. 66.

50. Central and West Basin Water Replenishment District (1966), Report on Renewal of Conservation Zones of the Los Angeles County Flood Control District [hereinafter referred to as "CWBWRD Report om LACFCD Zones"], p. 3.

51. E. Ostrom (1965), p. 14.

52. Ibid., p. 222.

53. 1952 West Basin Referee Report, p. 1.

54. Ibid.

55. E. Ostrom (1965), pp. 26-28.

56. Ibid.; also, Fossette (1986), p. 7.

57. 1952 West Basin Referee Report, pp. 2-3.

58. Fossette (1986), p. 11.

59. West Basin Watermaster Report, 1958, p. 24.

60. Fossette (1986), p. 12.

61. Ibid., pp. 15-16; E. Ostrom (1965), p. 236.

62. Fossette (1986), pp. 16-17; E. Ostrom (1965), p. 31.

63. E. Ostrom (1965), p. 80.

64. Ibid., pp. 30-32; also, Central and West Basin Water Replenishment District (1960), Report on Ground Water Replenishment and Basin Management in the Central and West Basin Water Replenishment District, p. 45.

65. E. Ostrom (1965), p. 32.

66. Ibid., pp. 24-25.

67. Fossette (1986), pp. 18-22.

68. Ibid., p. 31.

69. Ibid., p. 92; E. Ostrom (1965), p. 295.

70. Ibid., p. 306; Fossette (1986), pp. 205-206.

71. E. Ostrom (1965), p. 303.

72. Ibid., p. 307; Fossette (1986), pp. 12-13; West Basin Watermaster Report, 1958, p. 3.

73. Fossette (1986), pp. 49-50.

74. West Basin Watermaster Report, 1958, p. 4; 1961 West Basin Referee Report, p. v.

75. Fossette (1986), p. 81.

76. 1952 West Basin Referee Report, pp. 7-8.

77. Ibid., p 129.

78. E. Ostrom (1965), p. 33.

79. Fossette (1986), p. 95.

80. Ibid., p. 124.

81. West Basin Watermaster Report, 1958, p. 4.

82. Fossette (1986), p. 89.

83. E. Ostrom (1965), p. 34.

84. West Basin Watermaster Reports, 1956, 1957, and 1958.

85. West Basin Watermaster Report, 1958, p. 36.

86. Ibid., p. 1.

87. Ibid.

88. 1961 West Basin Referee Report, p. 3.

89. Ibid., p. 7.

90. Ibid., p. v.

91. Ibid., p. vi.

92. E. Ostrom (1965), p. 365; West Basin Watermaster Report, 1983, p. 48.

93. E. Ostrom (1965), p. 365.

94. West Basin Watermaster Report, 1965, pp. 3-4; West Basin Watermaster Report, 1983, p. 48.

95. E. Ostrom (1965), p. 350.

96. West Basin Watermaster Report, 1958, p. 5.

97. E. Ostrom (1965), p. 506.

98. DWR Bulletin No. 104 (Appendix B), p. 121.

99. West Basin Watermaster Report, 1959, p. 7.

100. E. Ostrom (1965), p. 360.

101. Jennings et al. (1963), p. 15.

102. West Basin Watermaster Report, 1960, p. 8.

103. E. Ostrom (1965), p. 360; West Basin Watermaster Report, 1961, p. 9; Jennings et al. (1963), p. 15.

104. 1961 West Basin Referee Report, p. vii; Jennings et al. (1963), p. 15.

105. 1961 West Basin Referee Report, p. 190.

106. Jennings et al. (1963), p. 15.

107. West Basin Watermaster Report, 1962, p. 1.

108. E. Ostrom (1965), p. 36.

109. West Basin Watermaster Report, 1963, p. 1.

110. West Basin Watermaster Report, 1964, p. 4.

111. Jennings et al. (1963), p. 15.

112. Ibid., p. 1.

113. Fossette (1986), p. 179.

114. E. Ostrom (1965), p. 35.

115. West Basin Watermaster Report, 1956, p. 1.

116. West Basin Watermaster Report, 1959, p. 2.

117. E. Ostrom (1965), p. 84.

118. E. Ostrom (1965), p. 15 fn.

119. 1952 West Basin Referee Report, p. 126.

120. 1961 West Basin Referee Report, p. xii.

121. Ibid.

122. West Basin Watermaster Report, 1958, p. 11; E. Ostrom (1965), p. 335.

123. DWR Report on Proposed CWBWRD (1959), p. 49.

124. Artificial replenishment began in Orange County in 1949; se Weschler (1968), p. 3, and the description of the Orange County experience in Chapter Eight below.

125. Fossette (1986), p. 129.

126. Ibid., p. 86.

127. DWR Report on Proposed CWBWRD (1959), p. 49.

128. Krieger (1955), p. 2.

129. Krieger (1961), p. 12.

130. Henley (1957), p. 667.

131. Krieger (1955), p. 3.

132. Ibid.

133. Ibid., p. 4.

134. West Basin Watermaster Report, 1959, p. 7.

135. CWBWRD Report on LACFCD Zones (1966), p. 14.

136. DWR Report on Proposed CWBWRD (1959), p. 76.

137. West Basin Watermaster Report, 1959, p. 7.

138. West Basin Watermaster Report, 1960, p. 9.

139. Central and West Basin Water Replenishment District (1966), Annual Survey Report on Ground Water Replenishment [hereinafter referred to as "CWBWRD Annual Survey Report"], p. 8.

140. CWBWRD Annual Survey Report, 1982, p. 20; also, 1983, p. 21.

141. West Basin Watermaster Report, 1963, p. 12.

142. DWR Bulletin No. 104, p. 17.

143. CWBWRD Annual Survey Report, 1983, p. 32.

144. West Basin Watermaster Report, 1960, pp. 19-20.

145. Fossette (1986), pp. 52-53.

146. Ibid.

147. Ibid., p. 85.

148. Ibid., pp. 88-89.

149. West Basin Watermaster Report, 1958, p. 15; 1961 West Basin Referee Report, pp. 42-43.

150. DWR Report on Proposed CWBWRD (1959), p. 55.

151. E. Ostrom (1965), pp. 44-45.

152. West Basin Watermaster Reports, 1958-1985; 1961 West Basin Referee Report, p. xi.

153. CWBWRD Evaluation of Inland Saline Water (1986), p. 42.

154. Fossette (1986), p. 145.

155. DWR Bulletin No. 104, esp. p. 4.

156. E. Ostrom (1965), p. 528.

157. E. Ostrom (1986a), p. 14.

158. Ibid., p. 25.

CHAPTER SEVEN

CENTRAL BASIN: A BASIN GETS DRAFTED

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CENTRAL BASIN: A BASIN GETS DRAFTED

As West Basin water users learned, West Basin and Central Basin are so closely interrelated physically that it is nearly impossible to address the problems of West Basin without involving Central Basin. That is also true of trying to describe and explain the actions undertaken in West Basin: in the course of addressing those actions, the description necessarily involves much of the story of Central Basin as well.

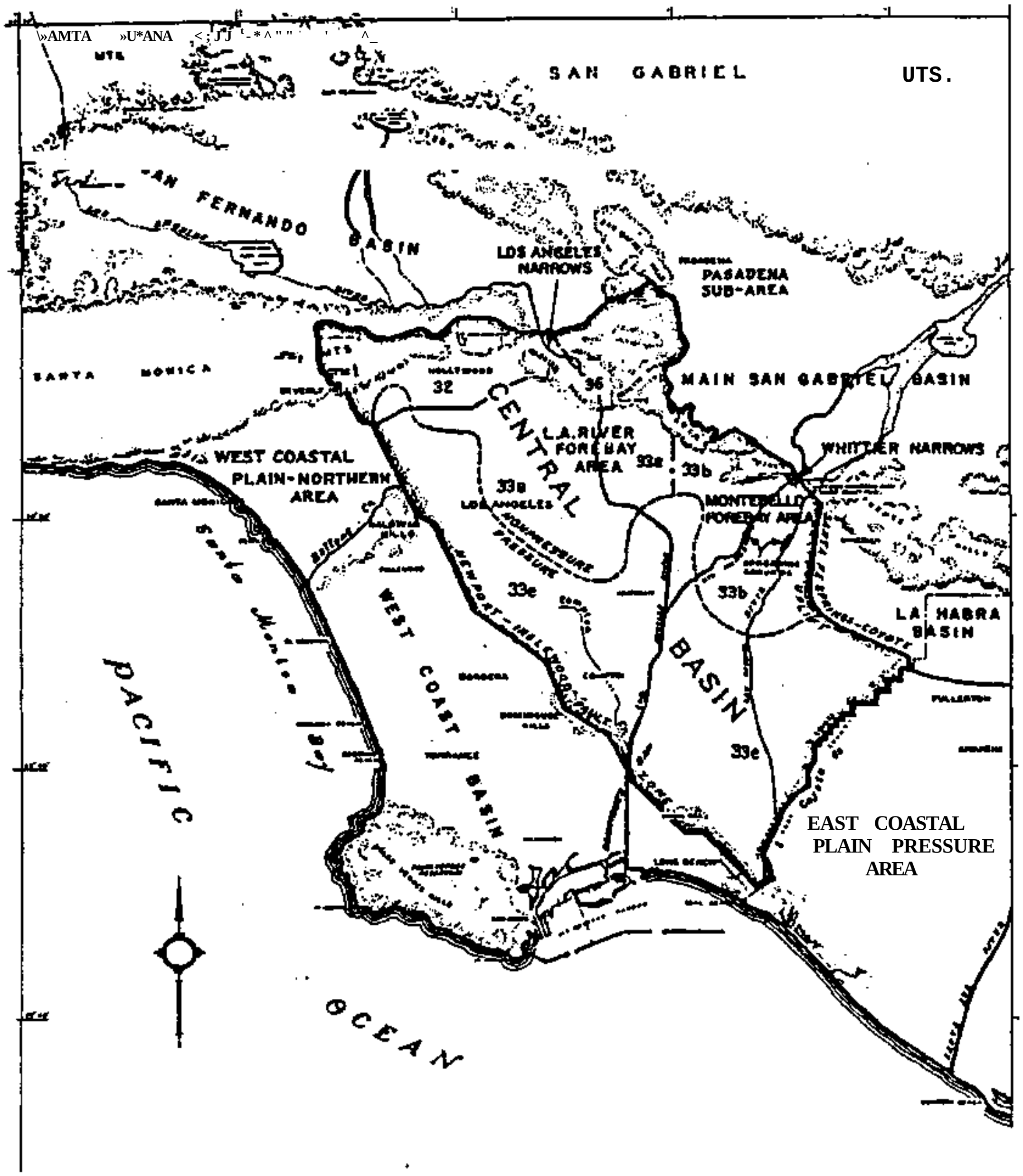
With as little repetition as possible, we will focus here on the actions of Central Basin water users to address their own problems, bearing in mind that many of the occurrences in Central Basin either were initiated by or were responses to the actions of producers in West Basin, and that there was significant overlap in the relevant actors. Several of the major producers in West Basin were also producers in Central Basin, and key personnel in agencies and groups involved in addressing West Basin problems held similar positions in agencies and groups involved in the resolution of the groundwater problems in Central Basin.

It is something of a cliche that water moves downstream and action moves upstream. As with all cliches, this one survives in part because it contains some truth. Central and West Basins are prime illustrations of the truth contained by this cliche. Some of the actions in Central were "voluntary", in the sense of being endogenous responses to Central Basin's own problems. In other important ways, most notably the adjudication of water rights, Central Basin was "drafted" by the actions of users in West Basin. Indeed, much of the impetus for organization of water users in Central Basin was the desire to avoid precisely what ended up occurring -- a basin-wide adjudication of rights to withdraw ground water. In the end, Central Basin water users were unable to fulfill their desire to avoid that step in the process of resolving their problems.

A. The Nature and the Problems of Central Basin

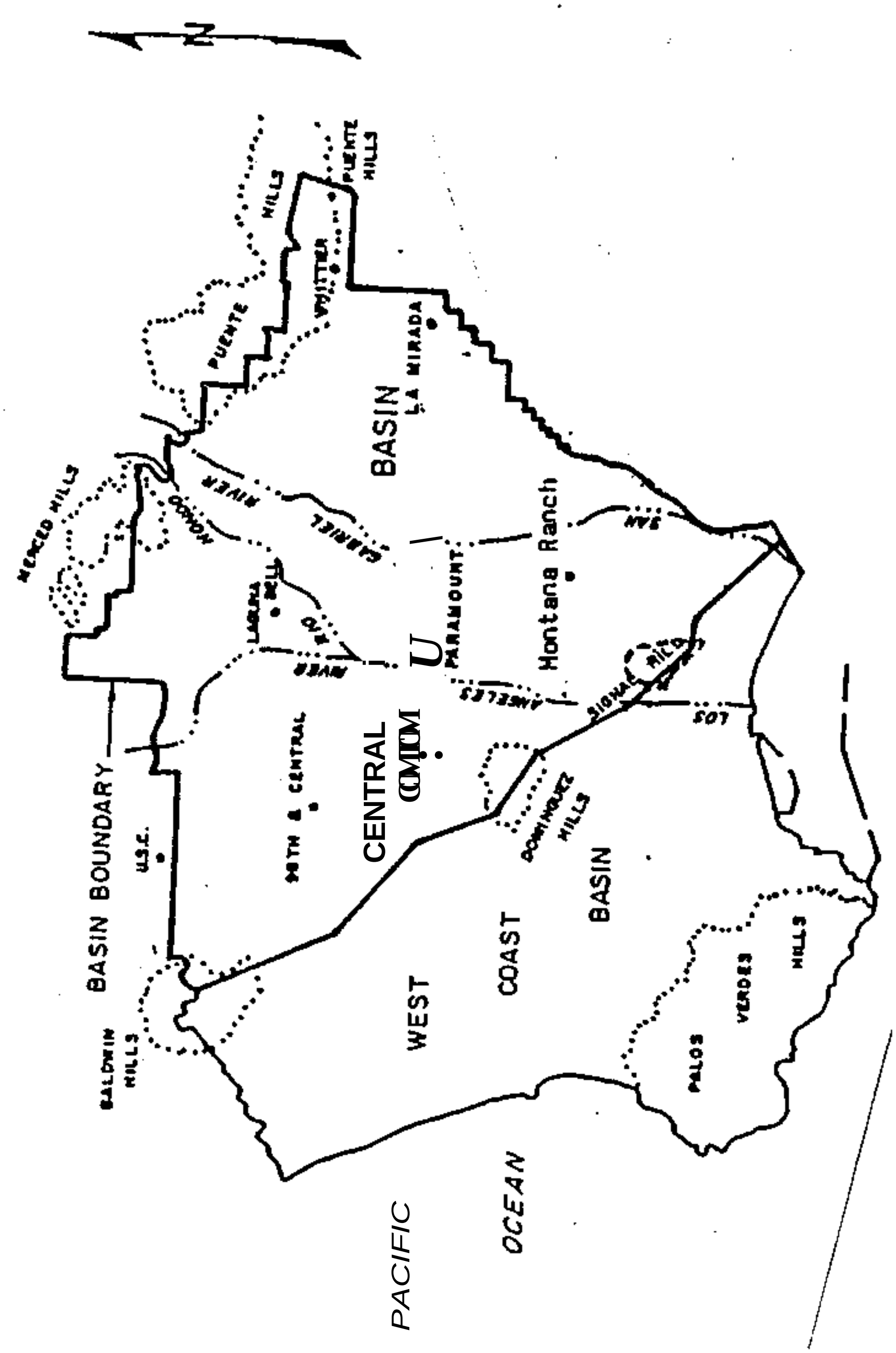
Of the three groundwater basins in the San Gabriel watershed -- the San Gabriel Basin, Central Basin, and West Basin -- Central Basin is the largest. Its location in the system can be seen by a look back at Map 1-2. Central Basin covers an area of 277 square miles, making it over 50 percent larger than West Basin. Like West Basin, Central Basin is now covered from border to border with cities, including a substantial portion of the City of Los Angeles at its north end and part of the City of Long Beach at its south end, which is very near to the Pacific Ocean. Within the boundaries of Central Basin are the cities of Bell, Bellflower, Compton, Downey, Huntington Park, Lakewood, Montebello, Norwalk, Paramount, South Gate, Vernon, Whittier, and parts of Inglewood and Signal Hill. (1)

Map 7-1 shows the boundaries of Central Basin as defined in an investigation conducted by the Division of Water Resources in 1952. Map 7-2 shows the boundaries of Central Basin as they are understood today, extending somewhat further to the northeast through Whittier and the Puente Hills, and extending somewhat less to the northwest than defined in the 1952 investigation. On its north, the Central



Map 7-1. Central Basin 1952

Source: State Water Resources Board, <u>Central Basin Investigation</u>, 1952



Map 1. Central Basin Boundaries, 1985

Source: Central Basin Watermaster Report, 1985

Basin is bounded by the Hollywood Basin, and that boundary runs through the City of Los Angeles. The remainder of the northern boundary of Central Basin extends along the Merced Hills, across Whittier Narrows, and then along Puente Hills. The northern Basin boundary terminates at the Orange County line, which forms the eastern boundary of the Central Basin. This boundary is a political and not a geologic one, and the aquifers in this area reach into the East Coastal Plain area of Orange County. The south-southwest boundary of the Central Basin is the Newport-Inglewood Uplift, separating Central and West Basins from Long Beach up to the Baldwin Hills just north of the City of Inglewood. (2)

A.I. The Natural Physical System

The Central Basin has the largest amount of underground water storage capacity in the Los Angeles Coastal Plain, estimated to be in excess of 13 million acre-feet. There are a number of shallow aquifers, and three deeper, major water-producing aquifers. These three aquifers -- Silverado, Sunnyside, and Lynwood -- are the source of three-fourths of the total groundwater production historically derived from Central Basin. (3)

The aquifers of Central Basin receive their water supply primarily from the surface and subsurface inflow of water from the San Gabriel Valley. The water originates as rainfall in the San Gabriel Mountains, the runoff from which is conveyed to the Los Angeles River, the Rio Hondo, and the San Gabriel River. The Los Angeles River enters Central Basin through the Los Angeles Narrows, crosses the Los Angeles Forebay Area, and proceeds south across Central Basin, exiting the Basin through the Dominguez Gap into West Basin (see Map 7-1). The Rio Hondo, a major tributary to the Los Angeles River, enters the Basin at Whittier Narrows parallel to the San Gabriel River, proceeds southwesterly across the Montebello Forebay Area and joins the Los Angeles River midway across the Basin. The San Gabriel River also enters Central Basin through the Whittier Narrows, crosses the Montebello Forebay, and runs south to the Pacific Ocean near Long Beach at the Orange County line.

As the Rio Hondo and San Gabriel Rivers flow through the Upper San Gabriel Valley toward Whittier Narrows, much of their flow disappears into the sand and gravel base of the Valley. This water crosses the Whittier Narrows and enters Central Basin as subsurface flow into the aquifers of Central Basin. (4) At the same time, the surface flows of the Rio Hondo and the San Gabriel River percolate downward into the aquifers of Central Basin in the Montebello Forebay. In the Forebay, the underground aquifers merge and are unconfined, and thus are capable of receiving large quantities of water from percolation through the sand and gravel surface of the Forebay Area.

The Los Angeles Forebay Area is similarly favorably situated for percolation from the flows of the Los Angeles River, but as described in Chapter Six, the Los Angeles Forebay has been largely eliminated as a source of fresh water replenishment to Central Basin, due to the lining of the Los Angeles River channel and the paving over of the Forebay Area. In the Montebello Forebay Area, by contrast, flood flows have been largely controlled through the construction of the Whittier Narrows Dam, and the river channels have not been lined in that Area, so percolation can still occur.

As Map 7-1 shows, the Central Basin is divided into a Non-Pressure Zone and a Pressure Zone. The Non-Pressure Zone is composed of the forebay areas, where the aquifers can receive water directly. The Pressure Zone is the area of Central Basin that is covered by the same impermeable layer of clay that covers all of West Basin. In this Area, rainfall and surface flows from the rivers do not recharge the underground supply. The Pressure Zone receives water only by the underground flow through the aquifers of the waters from the Non-Pressure Zone. Therefore, within the Pressure Zone, piezometric water levels are influenced only by the conditions upstream (i.e., the amount of water moving through and percolating in the forebay areas) and by the amount of water extracted.

At the southernmost tip of the Pressure Zone, the San Gabriel River approaches the Pacific Ocean at Alamitos Gap. In the Alamitos Gap, the clay covering of the Pressure Zone has been eroded, and the aquifers come in contact with the Ocean. Thus, even though Central Basin's boundaries do not extend all the way to the Pacific, the Basin is exposed to sea-water intrusion. If underground water levels in the Alamitos Gap decline below sea level, sea water can move up the Gap and into the Central Basin aquifers.

Central Basin is both an "upstream" basin and a "downstream" basin. It is not as highly exposed as is West Basin, especially to sea-water intrusion. Central Basin is, however, almost entirely dependent for its ground water supply on inflow from the upstream San Gabriel Basin. While the development of the Central Basin area certainly created problems for the downstream users in West Basin, Central Basin was not without problems of its own.

A.2. Development of the Problems in Central Basin

On the eastern side of the Newport-Inglewood Uplift, Central Basin ground water used to build up under pressure and emerge on the land surface as artesian water from flowing wells and springs. This artesian water was in use in Central Basin as early as 1870, during the early development of the Los Angeles area. (5)

As the use of the artesian water increased, its availability decreased. Central Basin water users began to drill shallow wells in the area to obtain enough water for continued development and growth. (6)

As in West Basin, growth in Central Basin was explosive. At the south end, Long Beach grew from a coastal village of 2,300 residents in 1900 to a major city of 344,200 at the close of the growth boom in 1960. At Central Basin's north end, the City of Los Angeles, which had already multiplied from 1,600 people in 1850 to 102,500 in 1900, boomed to 2,479,000 by 1960 and now contains 3,100,000 residents. In between Los Angeles and Long Beach, Whittier's population expanded from 1,600 at the turn of the century to 33,700 in 1960 (with another doubling to 72,900 in 1970), and Compton burst from a tiny 500-person spot on the map in 1920 to a city of 72,000 in I960, having doubled approximately every six years.

This development was in part made possible by the availability of the high-quality, relatively inexpensive ground water of the area, on which Central Basin water users became heavily dependent. Central Basin developed as the site of a groundwater production industry composed of ten cities, over fifty water companies and water districts, and hundreds of individual producers ranging from households to major industrial firms. (7)

These Central Basin water producers escalated their production of ground water as the area urbanized and grew. Figure 7-1 illustrates the swift rise in groundwater production over the 27 years from 1935 through 1961, from just over 150,000 acre-feet per year to nearly 300,000 acre-feet. Groundwater production increased each year, except when a year of exceptionally heavy rainfall would reduce demand.

The combination of increasing groundwater production with three other factors generated problems for Central Basin. The first of these other factors was the loss in local precipitation. As can be seen from Figure 7-1, seven of the ten years from 1935 through 1944 were years of above-average rainfall. Beginning with 1945, twelve of the next fifteen years were years of below-average rainfall. The drought cycle escalated water demand while reducing the natural replenishment to Central Basin. The second factor was the development of the San Gabriel Valley upstream from Central Basin. Water production and consumption in the Upper Valley increased, which reduced the amount of water flowing out of the Valley into Central Basin. The third factor was the paving over of the Los Angeles Forebay and the lining of the Los Angeles River channel, which eliminated for all practical purposes these sources of supply to the aquifers of Central Basin. (8)

The result of this combination of increased draft and diminished supply was the beginning of overdraft in Central Basin. Overdraft is estimated to have begun in 1942, (9) when total groundwater production passed the 200,000 acre-feet per year mark. The annual overdraft for

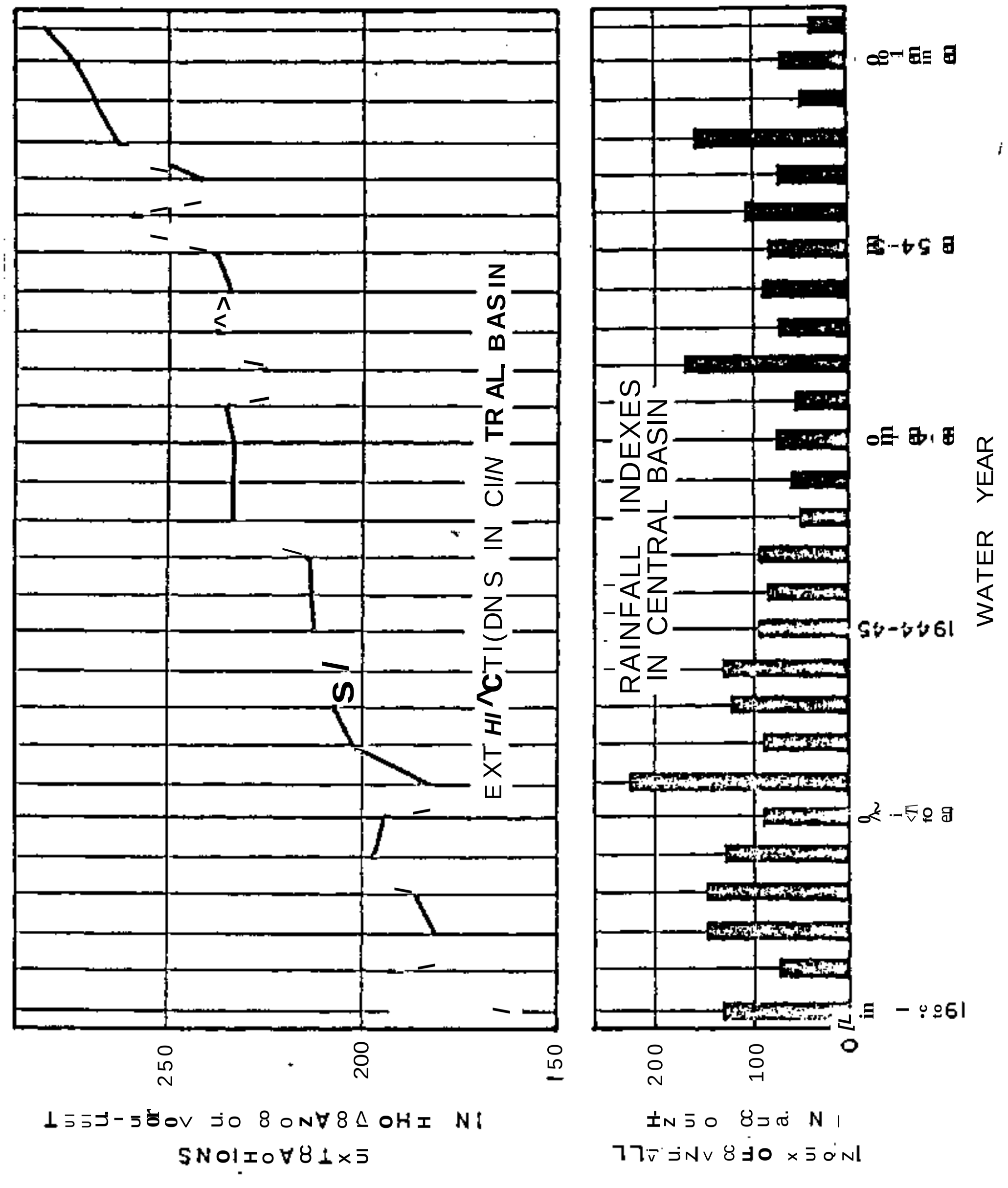


Figure 7-1. Groundwater Extractions in Central Basin, 1935-1961

Source: WRD Annual Survey Report, 1962

1945 was estimated at 12,270 acre-feet. By 1950, the annual overdraft was 77,000 acre-feet, and in 1960, it was 149,200 acre-feet. (10) By 1960, the accumulated overdraft in Central Basin totalled 1.3 million acre-feet, or 10 percent of the total ground water storage capacity. (ID

This accumulated overdraft manifested itself at individual wells in declines in water levels. In the forebay areas, the water table fell from 20 to 50 feet in the 1940s, (12) and another 50 feet in the 1950s. (13) In the Central Basin Pressure Area, water levels fell 100 feet from the beginning of the overdraft through the 1950s. (14) In 1960, ground water levels in the pressure area were as much as 109 feet below sea level. (15)

In the Alamitos Gap area, ground water elevations were down to 30 feet below sea level in 1950. Salt water had begun to flow up the Gap into Central Basin. (16) In the early 1960s, salt water intrusion had been detected in the shallow aquifers as far as two miles inland of the Uplift, and threatened to invade the major water-bearing Silverado and Sunnyside aquifers. (17)

Thus, through the period of intensive development of the Central Basin area, the ground water conditions in the Basin had deteriorated markedly. Water levels declined 100 feet (less in some areas, more in others). This imposed increased costs on water producers and consumers, as wells were either deepened or adandoned and re-drilled, and as pumping lifts in wells increased. At the same time, inflow to the Basin decreased, and along the Alamitos Gap, the Ocean threatened to move in to make up the difference as it had in West Basin. These two developments raised the prospect that Central Basin itself may be endangered as a source of high-quality, inexpensive water for a highly-developed, heavily populated area.

B. Responses to the Problems of Central Basin

Under these threats, Central Basin water producers began to respond to their problems of increasing demand, diminishing supply, and contamination. As we would anticipate, responses did not begin until conditions had worsened considerably. As an "upstream" basin, Central Basin took longer to reach this point. Central Basin has the shortest history of collective action of the four cases included here. In that shorter period, and with the combined assistance and prodding of their neighbors in West Basin, Central Basin actors also completed a process of securing an imported supply, addressing their loss of supply from upstream, curtailing demands placed on the Basin, and halting sea-water intrusion.

B.I. The Setting for Action: Obstacles and Advantages

The pumping race was on in Central Basin in the middle of this century, encouraged by factors that presented obstacles to collective actions to overcome the deteriorating ground water conditions there. At the same time, the Central Basin water situation contained some features that enhanced the prospects for the local producers to overcome those obstacles and successfully resolve their problems.

The principal obstacles faced by Central Basin users are by now familiar, as they were also present in the Raymond and West Basin cases. Central Basin presented an even greater "size problem" than did West Basin. It was estimated at the end of the 1950s that there were 750 or more owners of wells within Central Basin, about 50 percent more than at the peak of West Basin use. This is a very large number of actual and potential producers to involve in communication, decision-making, share assignments, cost-sharing, and monitoring. In addition, the physical extent of Central Basin and the low visibility of groundwater resources compunded the difficulties. When groundwater reserves range from Los Angeles to Long Beach, it is comparatively easier for users to fail to realize their interrelatedness, and comparatively harder to arrive at firm boundary definitions (as is evident from the differences in Maps 7-1 and 7-2). These factors make gathering information about the resource and arriving at agreements about adjusting use patterns more complex and difficult. As was the case in Raymond and West Basins, California water law further increased the incentives of Central Basin water producers to maximize production and avoid voluntary reduction of use. By the time Central Basin water users began to organize for some response to their problems, the trial court judgment had already been issued in Pasadena v. Alhambra. While the "mutual prescription" approach of that Raymond Basin judgment gave users in other basins a framework for resolution via proportionate reduction in demand, the prescriptive-rights aspect of that approach encouraged users in other basins to accelerate production in an effort to perfect a claim to as much ground water as possible in the event of a future adjudication. Thus, Pasadena v. Alhambra, though it became the key to demand reduction in both the West and Central Basins, had a perverse temporary effect of actually encouraging individualistic actions to maximize withdrawals from the ground water supply.

Nevertheless, the prospects for collective action in Central Basin were enhanced by the prior experiences of Raymond and West Basins, and, it should be added, of neighboring Orange County. Faced with considerable uncertainty regarding their resource and its use, Central Basin users did not have to invent processes of resolution as they went along. The actions of users in the other three basins gave Central Basin actors some points of departure and processes on which to build. At the same time, producers in Central Basin sought to avoid particular elements of previous actions in the other basins that had led to great expense and delay (in the cases of Raymond and West Basins) or to continued exposure to water supply conditions (in the case of Orange County). It may be said that in Central Basin, the "shadow of the court" loomed especially large, as much of the activity in Central was an effort to avoid the costly process of adjudication for as long as possible, and this avoidance was a direct result of the observation by producers in Central Basin of the occurrences in Raymond and West Basins.

In addition to the experiences of its neighbors, Central Basin had some other advantages. Its conditions and location (as both "upstream" and "downstream") left it in enough peril to spur action but also gave local users enough time to act before great lasting damage was done, as occurred with salt water intrusion in West Basin and Orange County. Further, Central Basin was benefitted by having a relatively stable and wealthy community of users who were able to sustain the costs and communication involved in collective action on this scale. It was a community that grew in financial resources in part as a result of its exploitation of its groundwater resources, and then was able to use the former to protect the latter.

Within that community of users, the distribution of interests also favored collective action. There was a relatively small efficacious subgroup of users with large stakes in the preservation of Central Basin and a large share of the production therefrom. In 1950, though there were hundreds of water producers in Central Basin, the majority of groundwater production was accounted for by fewer than twenty of these. These large producers were the cities and water companies, who had long time horizons and whose prosperity depended heavily on a secure supply of water. It was within this small band of water suppliers that the first efforts to organize responses to the problems of Central Basin began.

B.2. Early Responses: Getting Organized

Actions in Central Basin built upon West Basin experiences from the very beginning. As a water producer in both Central and West Basins and a defendant in the West Basin adjudication, the City of Compton invited representatives of the cities in the Central Basin area to a meeting in August 1949. To this meeting, Compton also invited the Chairman of the Executive Committee of the West Basin Water Association, the Executive Secretary of the WBWA, and attorney Kenneth Wright. (18) This meeting served as the first forum for discussion among some major Central Basin water producers concerning their problems of falling water levels and declining inflow into the Basin. Adjudication of water rights and acquisition of an imported water supply were among the possible actions discussed at this meeting, with the participants from West Basin adding their insights as "old hands at this sort of thing." (19)

Shortly after this meeting, the City of Long Beach first reported evidence of salt water in Central Basin, east of the Newport-Inglewood Uplift. This came as quite a shock to many Central Basin water users, who had thought themselves protected by the Fault from the sea. (20) Had this news surfaced before the August meeting in Compton, it might have prompted those present to organize. Instead, it took additional meetings and several more months, until June 1, 1950, for Central Basin water users to form the Central Basin Water Association (CBWA). (21)

The CBWA was formed with 17 producer-members who together accounted for about 87,000 acre-feet, or roughly half, of the total groundwater extractions from Central Basin. (22) The new Association hired as its Executive Secretary the same man who served as Executive Secretary of the West Basin Water Association. Carl Fossette continued to serve in both positions (and later as the first General Manager of the Replenishment District) for several years and, through his employment, "provided an essential communications link between the two associations." (23)

One of the first actions of the CBWA was to request the State Water Resources Board for an investigation and "an authoritative and unbiased statement of water conditions within Central Basin." (24) That report, published in 1952, indicated that ground water conditions were significantly worse even than those active in the CBWA had expected. The CBWA distributed copies of that Report to Central Basin water producers immediately. (25)

Also in 1952, the first Referee's Report in the West Basin adjudication appeared, and it was eagerly reviewed by producers in Central Basin. The Central Basin producers carried away from the Referee's Report three lessons. First, the Referee had recommended a two-thirds reduction in groundwater extractions. This recommendation for a severe curtailment alerted those in Central Basin that adjudication could result in outcomes much less mild than in the Raymond Basin case. Second, the Referee had begun its work in 1946 and issued its Report in 1952; a similarly detailed history of Central Basin could be expected to take even longer, given Central Basin's greater size and number of producers. Third, the entire cost of the investigation was being charged to the parties, adding potentially hundreds of thousands of dollars to the litigation costs. (26)

In light of the experiences of Raymond and West Basins, Central Basin water producers felt they had little to gain and much to lose from such expensive and time-consuming litigation. (27) The program of the Central Basin Water Association was to avoid the process of adjudication such as had taken place in Raymond Basin and was underway in West. It was anticipated that such a process in Central Basin would take even more time and would cost several million dollars, all to achieve a possible result of a drastic cutback in pumping. Instead, the CBWA pressed to acquire a supplemental supply of water through the organization of a water district. Through this action, the Association believed Central Basin would be able to avoid an adjuducation of water rights. (28)

B.3. Acquisition of an Imported Supply

In the early 1950s, it was the belief of the Central Basin Water Association that if producers in Central Basin had direct service connections to the Metropolitan Water District's imported water supply, those producers would reduce their pumping accordingly. (29) At the time, the Association members did not appreciate that the sequence of cause and effect ran in the opposite direction. In the Raymond and West Basin cases, it was the reduction of pumping that resulted in the increased use of the more expensive imported water, not the increased use of imports that resulted in the reduction of pumping.

Nevertheless, the Association members were correct in their presumption about the timing of these matters: acquisition of imported water supplies would have to precede any widespread reduction of pumping. In this presumption, they were supported by the State Water Resources Board investigation, which concluded that, at 1950 demand levels, alleviating the overdraft on Central Basin would require the importation for direct use within the area of up to 77,000 acre-feet of water per year, in addition to supplies already being imported. (30)

Water was already being imported to Central Basin by some of the major water producers. Los Angeles and Long Beach, as member agencies of MWD, had access to Colorado River water. In addition, Los Angeles imported water from its Owens River Aqueduct. The City of Inglewood was importing water from West Basin, and the City of Whittier and three of the largest water service companies were importing water from the San Gabriel Basin. (31)

Importing water from the neighboring basins was a questionable solution, though, since those basins were themselves subject to overdrafting. The acquisition of imported water on the scale needed in Central Basin would require access to MWD imports for the remainder of the Basin. As was the case in West Basin, the several cities in Central Basin technically could have annexed to MWD one at a time, but this was not satisfactory to MWD, which preferred annexation of the entire area so as not to further fragment the composition of its Board of Directors. Furthermore, the CBWA members realized that they could exert more influence on the MWD Board as a large single entity than as a number of small municipal representatives.

The plan of the Association, then, was to annex the entire Basin area (outside the Cities of Los Angeles and Long Beach) to Metropolitan. This would require the formation of a municipal water district, in the same fashion as had been followed in West Basin. With the participation and advice of the "old hands" from West Basin, the CBWA organized the petition drive to obtain signatures calling for the formation of the Central Basin Municipal Water District (CBMWD). (32)

The petition drive and the process of boundary definition of the proposed District occupied the Association through the summer of 1952. The required signatures were presented to the Los Angeles County Board of Supervisors in the Fall, and a special election on the question of formation of the District was set for December 15, 1952, five years after the successful election to form the West Basin Municipal Water District. In Central Basin, a high level of consensus had already been reached among the municipalities and other major producers on the need to form the District, and there was no organized opposition to the District by the time the election was held. As a result, the vote to form the CBMWD was 6-to-l in favor. (33)

The next step was annexation of the new District to MWD. After approval of the MWD Board of Directors was obtained, the issue once again had to be placed before the voters. Another petition drive was successful, and another special election was scheduled on the question of annexation to MWD. This second election was held on September 21, 1954, and the favorable votes prevailed by a 3-to-l margin. (34) Upon completion of annexation proceedings, the CBMWD became the second largest member of MWD, entitled to four directors on the 36-member Board. (35) MWD began work on extending service connections throughout Central Basin. Colorado River water began to flow to Central Basin water suppliers in 1955. (36)

Imported water was thus available to Central Basin in sufficient quantities to meet the demand for water, as a result of the CBWA's successful campaign. But conditions did not improve within the Basin, and groundwater production was not reduced. Instead, due to the actions taking place in West Basin, the continuation of the drought cycle that had begun in 1945, and the loss of inflow from the San Gabriel Basin, attention turned for the remainder of the decade to the ground water supply and to Central Basin's own "upstream" problem.

B.4. Improving Ground Water Supply Conditions

The concern of West Basin water producers with the loss of fresh water replenishment from Central Basin combined with other contemporaneous developments to produce the impetus for a program of artificial replenishment in Central Basin. The first of these other developments was the construction of the Whittier Narrows Dam and the LACFCD spreading grounds adjacent to the Rio Hondo and the San Gabriel Rivers in the Montebello Forebay. This generated the possibility of a program of controlled release of waters into the spreading areas of the Forebay for maximum percolation and minimum waste. Another important development was the initiation of a program of artificial replenishment using Colorado River water in neighboring Orange County in 1948, which provided Los Angeles County actors with an example to follow. A third factor was that conditions in Central Basin were ripe for such an undertaking. The extreme declines in underground water elevations in the farther reaches of the Central Basin Pressure Area had created a hydraulic gradient sufficiently severe that movement of ground water from the Forebay into the Pressure Area would be about as rapid as can be attained (given that water movement below ground never really approaches breath-taking speeds). (37)

As described in Chapter Six, the first step in undertaking a program of artificial replenishment in the Montebello Forebay was the creation of an instrument for fund-raising and operation of the replenishment program. Since the County Flood Control District already operated the spreading grounds for conservation of flood flows, the LACFCD was the clear choice for an operational instrument. There was at the beginning of the decade no matching instrument for raising the needed revenues, so a temporary program was instituted through the creation of Conservation Zone I within the LACFCD.

Zone I was created in January 1952, with *ad valorem* taxing powers to raise money for the purchase and spreading of Colorado River water.

Operation of the spreading program through Zone I actually commenced in 1954. Amounts of local runoff and purchased imported water spread by the LACFCD in Central Basin are shown in Table 7-1. From 1954 through 1965, LACFCD Zone I purchased and spread 575,433 acre-feet of imported water in the Montebello Forebay, using revenues of $9.3 million.

The temporary nature of the Zone I program, coupled with the prospect that artificial replenishment would be a very long-term program for the Central and West Basins, led members of the Central Basin Water Association and of the West Basin Water Association to search for a permanent instrument to conduct the replenishment program. In addition, as noted before, there were concerns about taxing all property owners in the area to pay for a replenishment program that primarily benefited the ground water producers. With the adoption by the State of the Water Replenishment District Act in 1955, the means existed for the creation of a special district that could match the boundaries of both Central and West Basins, could tax ground water production rather than real property to finance the ongoing replenishment program, and could persist over time without the continuing need for re-establishment by the County Board of Supervisors.

Thus, the CBWA created a special committee to study the possibility of the creation of a water replenishment district for Central Basin. This special committee joined with a similar one created by the WBWA, and devised the boundaries and constituent elements of such a district. (38) After another successful petition drive, a special election on November 17, 1959, secured voter approval

TABLE 7-1

Water Spreading at Montebello Forebay (in Acre-Feet), 1954-1985

Year	Local Runoff	Imported Water Purchased by LACFCD	Imported Water Purchased by CWBWRD	Reclaimed Water	"Make-Up" Water from San Gabriel	CBMWD	Total
1954	N/A	30,000					N/A
1955	N/A	24,800					N/A
1956	N/A	54,500					N/A
1957	N/A	50,000					N/A
1958	N/A	105,100					N/A
1959	N/A	54,400					N/A
1960	N/A	80,900					N/A
1961	N/A	80,800	66,400				N/A
1962	N/A	39,500	168,600	1,178			N/A
1963	4,520	4,800	75,800	12,405			97,525
1964	5,609	0	104,902	13,258			123,769
1965	8,301	75,456	84,672	14,548			182,977
1966	46,779	67,812	53,847	15,056	6,500		189,994
1967	60,971	74,060	10,180	16,224	0		161,435
1968	40,390	66,592	28,799	18,275	0		154,056
1969	104,222	12,529	5,251	13,877	0		135,879
1970	55,440	26,651	43,100	17,158	0		142,349
1971	41,781	46,714	25,420	19,495	0		133,410
1972	23,778	0	34,400	17,543	0		75,721
1973	44,835	0	71,900	21,949	0	20,000	158,684
1974	29,796	0	68,200	21,393	0	23,900	143,289
1975	29,665	0	71,900	21,884	0	0	123,449
1976	23,551	0	50,783	21,466	0	0	95,800
1977	26,309	0	9,300	22,863	14,500	6,900	79,872
1978	114,400	0	39,900	19,252	0	0	173,552
1979	68,600	0	66,351	22,457	0	0	157,408
1980	78,633	0	10,200	24,383	10,900	0	124,116
1981	35,120	3,300	28,700	26,109	31,500	0	121,759
1982	39,980	0	29,999	29,418	30,900	0	130,297
1983	102,713	0	39,751	17,035	8,900	0	168,399
1984	70,067	0	1,500	27,784	20,800	0	120,151
1985	47,310	0	40,600	26,998	0	0	114,908

Sources: Central Basin Watermaster Reports, 1963-1985; CWBWRD Annual Survey Reports, 1961-1985 for the formation of the Central and West Basin Water Replenishment District (CWBWRD).

The Replenishment District raises revenue through a replenishment assessment or "pump tax" on ground water production within its boundaries, and uses that money in the spreading program for the purchase (largely through CBMWD) of untreated imported water to address the annual overdrafting of the ground water supplies within the District. The Los Angeles County Board of Supervisors continued to re-authorize LACFCD Zone I through 1971 for the purpose of addressing the historically accumulated overdraft in the Central Basin. Thus, the property tax was used to offset the overdraft that had occurred in Central and West Basins over decades, and the pump tax was used to fund the ongoing replenishment activities to offset annual overdrafts created by the contemporary water producers within the District.

Concerns about the adequacy of imported supplies to sustain the artificial replenishment program of the CWBWRD have been present since shortly after its formation. The loss of entitlement to Colorado River water as a result of the Arizona v. California decision in 1965, and the failure of California voters to sustain funding for the completion of the State Water Project bringing water from the northern part of the State to the south, have at times made the supply sources for the replenishment program seem highly unstable and exposed. The completion of the Whittier Narrows Reclamation Plant in 1962 and of the San Jose Creek Reclamation Plant in 1967 has given the CWBWRD a base supply of locally-generated reclaimed waste water for spreading in the Forebay. By the end of the 1980s, the use of reclaimed water should provide a drought-free supply of about 50,000 acre-feet per year for the replenishment operation. By supplementing this local supply if replenishment water with in-lieu programs, whereby the CWBWRD and MWD reimburse pumpers for taking imported water for their direct use instead of ground water, reliance on annual provision of large quantities of MWD replenishment water has been reduced to the point where interruptions of MWD replenishment deliveries no longer threaten the long-term viability of the artificial replenishment program.

While reclaimed water provides an important source of local supply to the CWBWRD, by far the more important source of local supply is the native waters of the San Gabriel Valley flowing into Central Basin through Whittier Narrows from the Upper San Gabriel Basin. The loss of this source of supply would indeed seriously threaten the viability of Central Basin as a groundwater resource. Yet through the 1950s, the rapid development and growth of population in the upper portion of the San Gabriel Valley, with concomitant increases in the use of ground water there, lessened the inflow to Central Basin from its upstream neighbor. In order to protect the rights of the water users in the lower portion of the San Gabriel Valley -- i.e., Central Basin -- the Central Basin Municipal Water District, the City of Compton, and the City of Long Beach filed suit in Superior Court on May 12, 1959 against major water producers in the Upper San Gabriel Basin.

That suit, City of Long Beach et al. v. San Gabriel Valley Water Company et al, Case Number 722647 in the Superior Court of the State of California in and for the County of Los Angeles, lasted six years. Its purpose was to determine the rights of the lower Valley water users as against the upper Valley users. Negotiating committees were formed by the downstream plaintiffs and the upstream defendants in an effort to avoid a more protracted and expensive litigation. The committees appointed a Joint Engineering Reconnaissance Study to investigate the physical facts in lieu of a court-appointed reference.

Through intensive negotiations, the committees arrived at a statement of "Principles of Settlement" by September 1961. The basic principles included a provision that, depending on the outcome of the investigation of the physical facts, the lower Valley users would be entitled to some minimum base supply of water flowing from the Upper San Gabriel Basin into Central Basin through the Whittier Narrows. In years when this base supply was not forthcoming, the Upper San Gabriel Valley Municipal Water District would purchase imported water to be delivered to Whittier Narrows in quantities sufficient to make up the difference. Upon completion of the joint engineering study, it was concluded that the amount of the base supply to Central Basin should be 98,415 acre-feet per year. The negotiating committees agreed to a settlement incorporating these particulars on December 7, 1964.

With this amount settled and with the provisions of a settlement agreed, the downstream plaintiffs and the upstream defendants presented to Judge Edmund Moor of the Superior Court a Stipulation for Judgment in the suit. Among the provisions of that Stipulation was the creation of a three-member Watermaster Board to monitor the annual inflow across Whittier Narrows and make determinations of when the Upper San Gabriel Valley Municipal Water District should purchase additional water for Central Basin. One member of the Watermaster Board would represent Central Basin users, one would represent Upper

San Gabriel Basin users, and the third would represent both. Judge Moor approved the Stipulation and entered the Judgment in the suit on September 24, 1965, and appointed the Watermaster Board on November **12. (39)**

Since 1965, the Upper San Gabriel Valley Municipal Water District has had to purchase "make-up" water for delivery to Whittier Narrows in seven years. The amounts purchased and delivered for spreading are shown in Table 7-1.

With the creation of the replenishment program and the litigation against the upstream users of the waters of the San Gabriel Valley, Central Basin water users had secured a supply of water to recharge the aquifers of the Coastal Plain. In addition, Central Basin water users had imported water supplies available for their direct use through the creation of the CBMWD. These steps were vital for insuring the adequacy of water supplies within the Basin, but they did not produce the effect desired by the CBWA of curbing the pumping race. Instead, they made more ground water available to pumpers, who weighed the alternative costs of MWD imports for direct use and production of ground water for direct use and responded as would be expected, by continuing to increase their production of ground water. Ground water conditions in 1961 in Central Basin reached an all-time low, as the Association (through the CWBWRD) began the step it had originally organized in hopes of avoiding, an adjudication of the water rights in Central Basin.

B.5. Curtailment of Demand

The availability of imported water had not resulted in Central

Basin water producers reducing their demands upon the ground water supply. Indeed, the imported water for direct use went largely untouched. Although MWD direct-service water had been available within Central Basin since 1955, in January 1960, Central Basin water suppliers used only 3 percent of the capacity of their MWD connections, and in July 1960, only 14 percent. Meanwhile, groundwater extractions reached nearly 300,000 acre-feet in the 1959-60 fiscal year. (40)

The Central Basin Water Association members had realized by the close of the 1950s that acquisition of a supplemental supply of water and the institution of a replenishment program would not overcome the problem of overdraft in the Basin. Some enforceable reduction in groundwater extractions would be necessary to restore the Basin to a balance between inputs and withdrawals. Association members recognized that there could not be enough replenishment water to replace the overdraft, due not only to limited availability of water but also to the physical characteristics of the Basin -- aquifer transmissibility was simply too slow for spreading to keep up with the pace of extractions. (41) They further acknowledged that producers would be unwilling to reduce pumping prior to an adjudication of rights, not only because imported water was more expensive, but also because the law of water rights as modified by Pasadena v, Alhambra gave producers an incentive to pump as much water as they could in order to enlarge their rights. (42) Decreased reliance on ground water, and increased reliance on MWD imports, would have to follow an adjudication rather than prevent it. (43)

Therefore, the CBWA Executive Committee recommended to the CBWA

Board of Directors in 1961 a resolution expressing the support of the Association for an adjudication of the rights to extract ground water from Central Basin. (44) This resolution was adopted by the Board, reversing the Association's original commitment to avoid such an action.

The means for pursuing the Central Basin adjudication were present in the newly-formed Replenishment District. This had been anticipated during the process of formation of the District. (45) It was an assurance to West Basin actors that their supply of fresh water across the Uplift would be enhanced through the District's activities and not simply pumped out by Central Basin producers before it could reach West Basin. (46) The Replenishment District offered the possibility of using revenues collected by taxing ground water production to prosecute a legal action against all producers for a determination of rights to future production. Thus, the CWBWRD would initiate the suit as plaintiff and incur the costs of information-gathering and the negotiation of a stipulation.

The initiation of the lawsuit was delayed until a level of consensus could be reached that the adjudication was indeed necessary. It was anticipated that the development of such a consensus would speed the process of negotiating a curtailment of demand and reduce conflicts arising therein. The development of this consensus was facilitated by an initial report commissioned by the Replenishment District and performed by the District's consulting engineers. With the presentation of that report, titled "Control and Reduction of Ground Water Pumping in the Central Basin", in October 1961, and the adoption of the resolution of the CBWA endorsing the adjudication in

November, the requisite level of consensus was attained. On January 2, 1962, the Central and West Basin Water Replenishment District filed suit against 750 owners of wells in Central Basin. (47)

The case of Central and West Basin Water Replenishment District v. Charles E. Adams et al. -- Case Number 786656 in the Superior Court of the State of California in and for the County of Los Angeles -- was assigned to Judge Edmund Moor, who was also presiding over the litigation between the Central Basin producers and the Upper San Gabriel Basin producers. The complaint stated that as a result of the continued overdraft of the Basin, water levels had been lowered to the point that in approximately 80 percent of the area of Central Basin, water levels were below sea level. The complaint then alleged that this lowering of water levels had imposed damages upon the producers in the Basin in the form of increased costs and in the intrusion of sea water into the aquifers underlying the Basin. These occurrences were the result, according to the complaint, of the mutual prescripting of producers through their extraction of non-surplus waters from the Basin. (48) The relief requested was an adjudication of the respective claims of the defendants among themselves, a provision for the control and reduction of groundwater extractions, and the retention of jurisdiction by the Court for such modifications thereto as may become necessary.

Even as the action in Central Basin was being filed, negotiations for a settlement along the lines of the one reached in the West Basin case were underway. (4-9) The development of a settlement among the parties in Central Basin was facilitated by experience gained during the adjudication of rights in West Basin. (50) The passage of the

Recordation Act in 1955, requiring groundwater producers to record and report their groundwater production to the State Water Rights Board, aided in the swift compilation of a recent history of withdrawals from the Basin, from which the relative rights of the parties could be ascertained. (51) The CBWA sent out a questionnaire to all of its members requesting data on the quantity of water produced since 1950. (52) These data were compiled and verified by the District's consulting engineers, to form the sort of record that would otherwise have been compiled by a court-ordered reference. (53) As a result, the use of a court-appointed Referee was avoided altogether in the Central Basin case.

At the outset of the lawsuit, a settlement committee was appointed by the CBWA to draft an interim agreement for the reduction of pumping. The settlement committee worked with the Replenishment District's attorney and engineers to develop a formula for the calculation of the prescriptive rights acquired in the Basin. The committee met every month, and presented a draft of an interim agreement to the CBWA on May 3, 1962. Included as Exhibit "A" with the draft were the engineer's verifications of pumping records to date, which had already accounted for 93 percent of the production from the Basin. (54) Meetings with water producers to explain the interim agreement and encourage them to sign it began immediately thereafter.

Signators of the agreement would be required to reduce their groundwater production to 80 percent of their "assumed relative right" after October 31, 1962. The agreement listed the assumed relative rights of the parties as of 1961, based on their groundwater production and imports of water (which were preserved as rights to the extent that producers had substituted imported water for ground water). The 80-percent figure was termed the "agreed pumping allocation". The interim agreement would be presented to the Court when parties representing 75 percent of the total assumed relative rights had signed.

Signatures were collected much more quickly than in the West Basin case, in part because of the successful example of operation under the Interim Agreement there. The interim agreement in Central Basin was signed by 48 parties with approximately 78 percent of the assumed relative rights in Central Basin, and was presented to the Court on September 28, 1962. The Judge accepted the Central Basin Interim Agreement, appointed the Department of Water Resources to serve as Watermaster to oversee the operation of the Agreement, and issued an injunction ordering the signators to comply with the Interim Agreement. (55) The Agreement became effective on October 1, 1962, and thus 1962-63 became the first fiscal year of operation under the Agreement. Signators agreed to reduce their pumping to an aggregate of 166,917 acre-feet. The number of parties under Watermaster Service and the total of their Agreed Pumping Allocations are shown in Table 7-2, along with their actual groundwater extractions.

New parties joined the Interim Agreement after it went into effect. By the 1965-66 fiscal year, there were 91 signators, raising the agreed pumping allocation brought under Watermaster Service to 189,450 acre-feet.

In the meantime, as operation under the Interim Agreement began, the settlement committee of the CBWA and the attorney for the CWBWRD

TABLE 7-2

Central Basin Parties to Watermaster Service, Agreed Pumping Allocation, and Ground Water Production
1963-1985

Year	Parties to Watermaster Service*	Agreed Pumping Allocation*	Ground Water Extractions	Active Pumpers	Active Nonparties
1963	47	166,917	168,906	46	NA
1964	78	181,497	176,436	74	NA
1965	88	186,620	174,950	85	NA
1966	91	189,450	190,045	86	NA
1967	508	217,367	206,591	462	34
1968	488	217,367	219,945	437	38
1969	451	217,367	213,598	389	37
1970	402	217,367	221,998	368	30
1971	363	217,367	211,443	299	25
1972	327	217,367	216,100	269	20
1973	312	217,367	205,503	247	19
1974	292	217,367	211,274	228	19
1975	282	217,367	213,092	219	18
1976	279	217,367	215,979	202	17
1977	278	217,367	211,537	188	22
1978	257	217,367	196,532	169	14
1979	226	217,367	206,990	222	13
1980	220	217,367	209,513	173	14
1981	206	217,367	210,600	140	13
1982	198	217,367	205,576	135	12
1983	191	217,367	194,550	128	11
1984	181	217,367	194,079	124	10
1985	184	217,367	195,349	116	10

*Under Interim Agreement, 1963-1966; Under Central Basin Judgment, 1967-1985.

Source: Central Basin Watermaster Reports, 1963-1985

set to work on a stipulation for judgment in the Central Basin case. By the end of 1964, a draft of a stipulation had been completed. The Stipulation involved all of the defendants, from individual homeowners to the City of Los Angeles. It provided for a 20 percent reduction in pumping and a Water Exchange Pool, as did the Interim Agreement, plus provision for the continuing jurisdiction of the Court. The total of the assumed relative rights was stated to be 271,650 acre-feet, which resulted in a total agreed pumping allocation of 217,367 acre-feet. (56) As with the Interim Agreement, the Stipulation would be presented to the Court once signatures had been obtained from parties with 75 percent of the assumed relative rights.

The Stipulation was presented to Judge Moor at a formal hearing on May 7, 1965. Trial of the case was continued by Judge Moor to August 25, 1965, and was completed on the 27th. Judge Moor signed the Findings of Fact and Conclusions of Law and the Final Judgment, which incorporated all of the provisions of the Stipulation, on October 11, 1965. Judgment was formally entered in Central and West Basin Water Replenishment District v. Charles E. Adams et al. on October 18, 1965, to become effective at the beginning of the next fiscal year, on October 1, 1966. The Final Judgment covered 508 parties (many of the original 750 had dropped out of the case).

Some of the provisions of the Central Basin Judgment differed from those in the Raymond and West Basin cases. The calculation of Exchange Pool water prices, for example, followed a different formula, one which made Exchange Water prices in Central Basin (which are shown in Table 7-3) significantly higher than those in Raymond or West Basins. A result of this calculation of Exchange Water prices has been the emergence of a very active market in water right leases in Central Basin, as lease prices are

TABLE 7-3

Central Basin Exchange Water Pool Program, and Leasing, 1963-1985

Year	Exchange Water Offered	Exchange Water Received	Cost per Acre-foot	Number of Leases	Total Rights Leased
1963	16,185	7,285	$14.37	NA	NA
1964	16,428	16,428	$16.92	NA	NA
1965	17,899	15,145	$19.64	NA	NA
1966	19,455	5,059	$22.69	28	6,634
1967	22,721	11,625	$29.80	37	6,493
1968	51,226	16,536	$32.89	71	7,643
1969	25,418	13,010	$36.00	71	6,510
1970	26,131	7,154	$39.00	114	9,556
1971	25,866	7,584	$43.00	122	9,591
1972	25,963	7,055	$47.00	116	10,182
1973	27,662	5,067	$48.00	105	10,967
1974	28,398	2,255	$50.90	115	13,171
1975	28,595	545	$45.76	94	11,197
1976	32,167	223	$49.86	105	13,853
1977	30,883	494	$54.90	99	12,178
1978	31,383	190	$57.75	74	11,839
1979	31,357	88	$69.75	87	20,005
1980	27,484	516	$69.75	137	29,867
1981	21,841	136	$93.00	82	7,945
1982	24,472	725	$99.00	107	20,208
1983	26,950	1,055	$118.00	98	20,367
1984	28,502	708	$140.72	95	20,854
1985	27,876	1,800	$184.29	216	19,863

Source: Central Basin Watermaster Reports, 1963-1985

negotiated between lessor and lessee and are usually lower than Exchange Water prices. In 1985, the Central Basin Judgment was modified to change the method of calculation of Exchange Water prices, which should lower them considerably. That modification also directed the Watermaster to fill Exchange Pool requests from Voluntary Offers first, whereas in the original Judgment the Watermaster was instructed to fill Exchange Pool requests from Mandatory Offers first.

The allocation of the costs of Watermaster service (which are shown in Table 7-4) was also computed differently in the Central Basin case than in Raymond and West Basins. In those cases, the cost of Watermaster service is apportioned among the parties according to their groundwater rights, regardless of how small an amount this might represent. This has resulted in the Watermaster issuing invoices for and collecting very small amounts of money from some parties, to the point where the cost of billing the smaller parties exceeded the amount collected from them. In Central Basin, a minimum charge of $5.00 is assessed each party; the remainder of Watermaster service costs (if any) is then apportioned among parties according to their Agreed Pumping Allocation. If the total cost of Watermaster service works out to less than $5.00 per party, each party is assessed that lesser amount equally. (57)

A noteworthy similarity between the Central Basin and West Basin Judgments was their absence of a statement of the "safe yield" of the basins. As in West Basin, Central Basin users avoided the inclusion of a determination of safe yield so as to prevent a reduction of pumping to that level. An estimate of the safe yield of Central Basin in 1957 was made by the Department of Water Resources: it was 137,300

TABLE 7-4

Central Basin Watermaster Annual Budget and Total Expenditures, 1963-1985

Year	Total Watermaster Budget	Total Watermaster Expenditures	Expenditures per Acre-foot of Groundwater Extractions*	Expenditures per Acre-foot of Total Water Use*
1963	$46,438	$30,288.74	$0.18	$0.15
1964	$43,008	$45,585.58	$0.26	$0.20
1965	$45,736	$44,135.00	$0.25	$0.20
1966	$53,795	$62,976.24	$0.33	$0.25
1967	$44,024	$57,464.12	$0.28	$0.19
1968	$51,306	$45,123.24	$0.21	$0.14
1969	$64,270	$49,571.00	$0.23	$0.16
1970	$65,119	$66,943.37	$0.30	$0.20
1971	$65,781	$73,462.05	$0.35	$0.21
1972	$72,788	$58,288.52	$0.27	$0.15
1973	$73,896	$69,293.00	$0.34	$0.20
1974	$74,670	$80,895.00	$0.38	$0.22
1975	$77,532	$80,293.00	$0.38	$0.23
1976	$80,616	$84,311.43	$0.39	$0.24
1977	$92,466	$93,352.42	$0.44	$0.28
1978	$97,667	$104,391.00	$0.53	$0.34
1979	$103,795	$111,353.00	$0.54	$0.33
1980	$121,356	$118,695.00	$0.57	$0.35
1981	$138,500	$131,156.00	$0.62	$0.37
1982	$180,000	$181,111-37	$0.88	$0.53
1983	$193,500	$201,026.00	$1.03	$0.61
1984	$203,100	$186,074.00	$0.96	$0.57
1985	$227,100	$226,412.00	$1.16	$0.61

* by parties to Watermaster Service

Source: Central Basin Watermaster Reports, 1963-1985

acre-feet. (58) A reduction of annual groundwater extractions to safe yield would have required a 50 percent cut from the assumed relative rights in Central Basin, rather than the 20 percent decrease the parties negotiated. Parties in Central Basin were satisfied with the combination of a 20 percent reduction in groundwater extractions, the guaranteed minimum inflow from the Upper San Gabriel Basin, and the artificial replenishment program of the CWBWRD. With this combination, Central Basin actors felt that a successful maintenance of groundwater extractions at or about 217,000 acre-feet per year would overcome the problem of falling water levels and loss of ground water in storage.

Developments since the adoption of the Interim Agreement in 1962 and the entry of the Final Judgment in 1965 indicate that the Central Basin negotiators were correct. First, as a prerequisite to success, groundwater extractions were in fact successfully restrained. As Table 7-5 indicates, total groundwater extractions in Central Basin declined from 248,800 acre-feet in 1962 to 211,600 acre-feet in 1965, and thereafter remained below the total agreed pumping allocation in every year save two. Over this same period, total water use in Central Basin increased by over 100,000 acre-feet, from 267,713 acre-feet in 1962 to 370,625 acre-feet in 1985. The use of imported water accounted for the difference, escalating to the point where, in 1985, imported water use within Central Basin surpassed ground water withdrawals. Thus, despite the fact that imported water for direct use is more expensive than locally-produced ground water, Central Basin water producers have complied with the pumping reduction they negotiated throughout the period of operation of that agreement.

TABLE 7-5

Central Basin Water Production and Total Water Use (in Acre-Feet)
1962-1985

Year	Groundwater Extractions	Imported Water	Exported Water	Total Water Use
1962	248,800	52,392	33,479	267,713
1963	225,400	70,079	32,960	262,519
1964	219,100	87,919	31,308	275,711
1965	211,600	87,161	32,767	265,994
1966	222,800	124,414	32,986	314,228
1967	206,591	129,424	35,160	300,855
1968	219,945	140,362	37,011	323,296
1969	213,598	157,496	37,805	333,289
1970	221,998	173,599	40,509	355,088
1971	211,443	190,750	35,822	366,371
1972	215,913	196,619	35,400	377,162
1973	205,503	182,331	34,887	352,947
1974	211,274	187,430	33,853	364,851
1975	213,092	163,802	33,024	343,870
1976	215,979	175,843	33,231	358,591
1977	211,537	147,747	29,593	329,691
1978	196,532	160,392	48,743	308,181
1979	206,990	166,204	32,560	340,634
1980	209,513	168,678	40,081	338,110
1981	210,600	184,794	38,442	356,952
1982	205,576	174,597	38,705	341,467
1983	194,550	178,260	42,261	330,549
1984	194,079	176,150	43,109	327,120
1985	195,349	222,916	47,640	370,625

Source: Central Basin Watermaster Reports, 1963-1985

The successful maintenance of the reduction in ground water Withdrawals, combined with the spreading program and the guaranteed minimum inflow from upstream, resulted immediately in recovery of water levels in wells. Hydrographs of representative wells in the Los Angeles Forebay Area, the Montebello Forebay Area, and the Pressure Area are shown in Figures 7-2, 7-3, and 7-4, respectively. They illustrate clearly the rise in water levels that occurred following the adoption of the Interim Agreement at the end of 1962. Recovery was sufficiently rapid that by 1964 water levels in the Pressure Area had been restored to elevation comparable to those that existed in 1950, a rise of nearly 70 feet since 1961. (59) By 1966, water levels were approximately equivalent to those of the late 1940s, except in the Los Angeles Forebay which does not benefit directly from the replenishment program. Water levels in Central Basin have remained steady since 1966 (save for a dip in 1976 and 1977, when two extraordinarily dry years resulted in the loss of replenishment water as MWD devoted all of its supplies to direct use).

The loss of ground water in storage has not been completely eliminated in Central Basin by the combination of demand reduction and supply enhancement, but progress has been made in reducing the accumulated overdraft. That accumulated overdraft was estimated as high as 1.3 million acre-feet in 1961. By the time of the entry of the Final Judgment at the end of 1965, the accumulated overdraft had decreased to 719,000 acre-feet. (60) At the end of the 1979-80 fiscal year, the accumulated overdraft was down to 673,000 acre-feet, (61) and it had been further reduced to 632,200 acre-feet at the end of fiscal year 1985. (62) Thus, despite the fact that groundwater

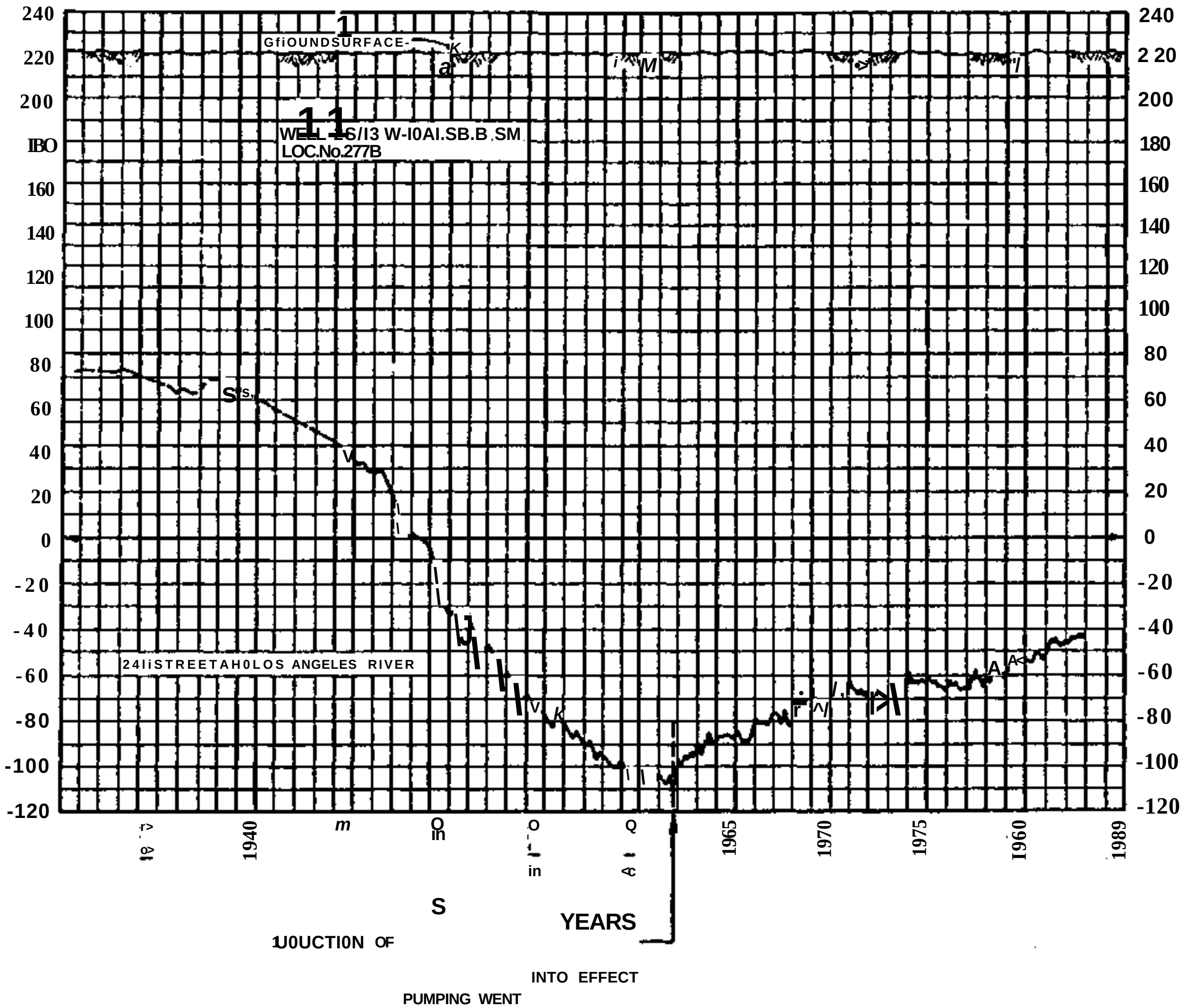


Figure 7-2. Water Levels at [illegible] Forebay

Source: [illegible]WRD Annual Survey Report, 1984

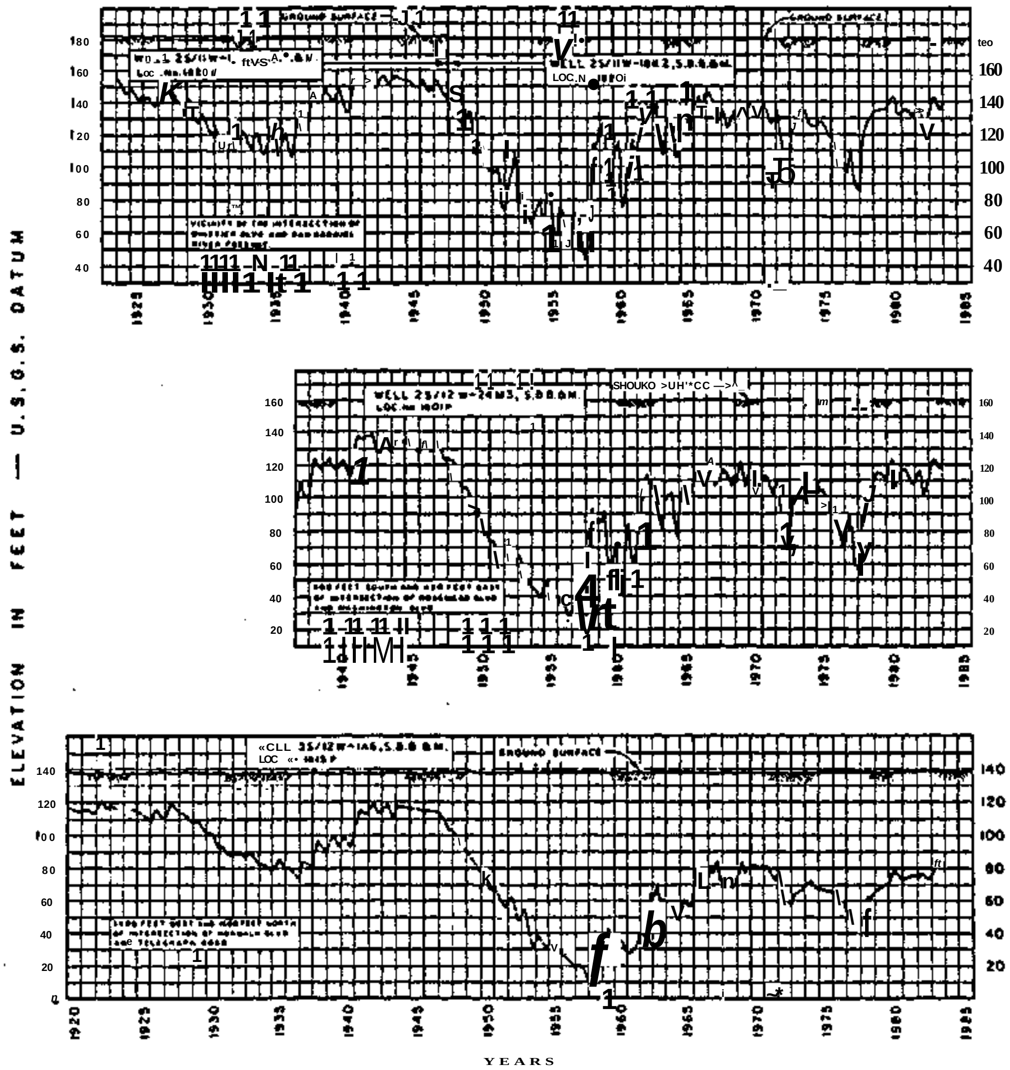


Figure 7-3. Water Level at Wells In Montebello Forebay

Source: CWBWRD Annual Survey Report, 1984

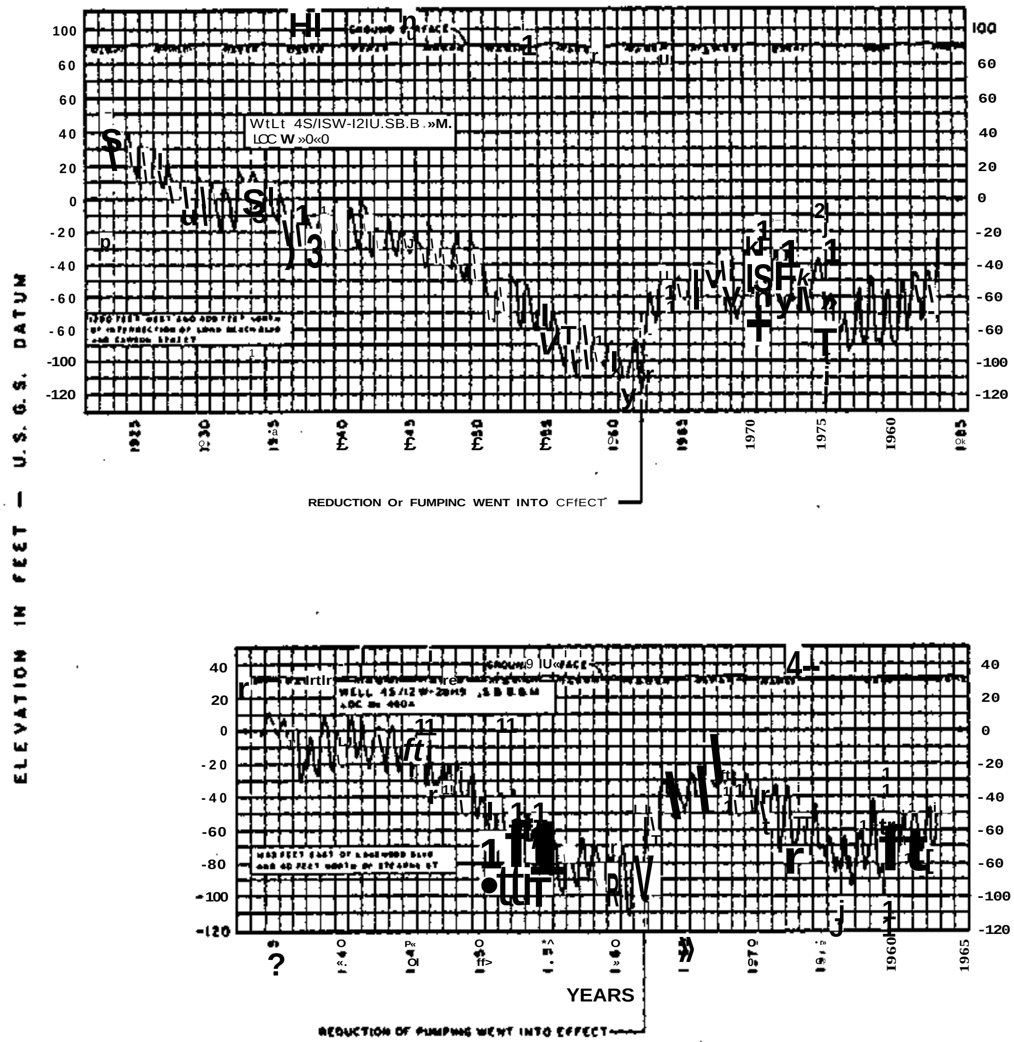


Figure 7-4. Water Levels at Wells in Central Basin Pressure Area

Source: CWBWRD Annual Survey Report, 1984

extractions in Central Basin were not reduced to the estimated natural safe yield of the Basin, the combination of the pumping reduction with the supply enhancement program has generated annual surpluses that have increased the amount of ground water in storage and cut the accumulated overdraft in Central Basin in half.

B.6. Halting Sea-Water Intrusion

As Figure 7-4 indicates, water levels in the Central Basin Pressure Area have recovered significantly, but remain below sea level. Water levels in the southern reaches of the Basin are deliberately retained below sea level in order to produce the maximum feasible hydraulic gradient between the Montebello Forebay and the Pressure Area. Maintenance of this gradient serves the purpose of maximizing the transmission of water from the spreading grounds through the aquifers to the Newport-Inglewood Uplift.

However, maintaining underground water elevations below sea level in the southern reaches of Central Basin leaves the ground water supply vulnerable to further salt-water encroachment up the Alamitos Gap. In order to take maximum advantage of the replenishment program, Central Basin water users would need to create their own wall against the Ocean so that water elevations on the inland side of the Uplift could be kept below sea level.

The institutional capacity for constructing a fresh-water injection barrier in the Alamitos Gap was developed in Central Basin by following the example of West Basin. In West Basin, Conservation Zone II of the Los Angeles County Flood Control District had been used to fund the extension and operation of the West Basin Barrier Project.

In Central Basin, Conservation Zone I had been established to begin the artificial replenishment program through spreading in the Montebeloo Forebay. With the establishment of the Replenishment District to take over the purchase of water for spreading to offset the annual overdrafts, LACFCD Zone I funds were devoted to purchases of relenishment water to offset the accumulated overdraft. In addition, Central Basin water producers seized upon Zone I as a source of funds for the construction of a barrier project in Alamitos Gap.

The Los Angeles County Board of Supervisors, in the process of re-authorizing Zone I in 1962, authorized the LACFCD to use its funds for construction of the Alamitos Barrier, in addition to continuing purchases of replenishment water. (63) The Flood Control District was authorized to negotiate with the Orange County Water District for joint construction and operation of the Alamitos Barrier, since the Barrier would be of benefit to Orange County as well. In addition, the LACFCD was directed to proceed with barrier design and construction alone while negotiations over coordination with the Orange County Water District were underway. During the 1962-63 and 1963-64 fiscal years, LACFCD Zone I spent $1.75 million on construction of the Alamitos Barrier.

Operation of the Alamitos Barrier began in 1965, with 14 injection wells. Since then, the Barrier has been expanded to 26 wells. An average of 4,000 acre-feet of treated MWD water has been injected at the Alamitos Barrier each year (unlike the West Basin Barrier Project, the Alamitos Barrier is no a significant source of fresh-water replenishment). Since the expiration of LACFCD Zone I in 1972, all of the purchases of water for injection at Alamitos have been made by the

Replenishment District and the Orange County Water District. The operation of the Barrier remains a joint project of the LACFCD and the Orange County Water District. The Alamitos Barrier has "effectively contained" the sea-water intrusion problem in Central Basin since 1965, (64) protecting the Basin from further contamination while allowing the replenishment program to recharge the aquifers in the Central Basin Pressure Area and in West Basin at the fastest rate attainable.

C. Summary

There are delicate balances to be maintained in Central Basin. Keeping the Ocean from flowing up the Alamitos Gap while keeping fresh water flowing out across the Uplift into West Basin, keeping the Montebello Forebay as full as possible while keeping elevations in the Pressure Area low enough to maintain a steep hydraulic gradient, accomplishing these flow directions without lowering water levels elsewhere in Central Basin. . . these actions require relatively sophisticated management and coordinated collective action. Yet Central Basin is even larger than West Basin, there were many more producers' actions to coordinate, and Central Basin lacked the extreme exposure and alarming deterioration that prompted action in West Basin.

Successful collective action in Central Basin was facilitated by the examples of its surrounding neighbors: Raymond Basin to the north, West Basin to the southwest, Orange County to the east. The adjudications in Raymond and West Basins originally appeared to

Central Basin producers as examples of action to be avoided, because of their expense and duration. In the end, the Central Basin Water Association recognized that water producers would not voluntarily switch from less expensive ground water to more expensive imported water in anywhere near the amounts needed to arrest the overdraft of Central Basin, so a curtailment of demand for ground water would be necessary. In pursuing this curtailment, however, the actors in Central Basin did not simply follow the exact path of the Raymond and West Basin adjudications. Instead, they demonstrated considerable learning, adapting the process of adjudication in ways that made it less expensive and the quickest of the basin adjudications.

In addition to this use of the examples of Raymond and West Basins, Central Basin water producers also adapted the experiences of Orange County to their own problems. The establishment of a large-scale water spreading program using imported water purchases was accomplished first through the creation of a special district (LACFCD Conservation Zone I) levying property taxes, later through the creation of a district with the power to tax groundwater production (the CWBWRD). This sequence followed the example of Orange County in its artificial replenishment program, conducted below Prado Dam a few miles to the east of the Montebello Forebay.

In addition to these examples, collective action in Central Basin was facilitated by its close physical connection to West Basin. As has been noted several times above, Central Basin is the only source of natural fresh-water replenishment to West Basin. Furthermore, some cities straddled the Newport-Inglewood Uplift, and they and other water producers pumped ground water on both sides of this divide. In order to resolve their own problems, West Basin water producers needed to extend their solutions into Central Basin. The overlapping producers, such as the City of Compton (which was a defendant in the West Basin adjudication and the first to convene a meeting of Central Basin cities), were the likely ones to initiate action in Central Basin. This initiation was accompanied by the inclusion of key personnel from West Basin. The most prominent example was the Executive Secretary of the West Basin Water Association, Carl Fossette, who became the Executive Secretary of the Central Basin Water Association and then the first General Manager of the Central and West Basin Water Association.

Their following of the examples of their neighbors and their inclusion as part of the solution of West Basin's problems should not be read to minimize accomplishments of the local actors in Central Basin. The fact that they found a way to adjudicate claims to a large groundwater basin at relatively low expense in just a few years has itself provided an example for subsequent groundwater basin adjudications. In addition, Central Basin actors created a forum for coiranunication and collective decision-making in the CBWA, taxed themselves for a replenishment program through the creation of LACFCD Zone I and the CWBWRD, established another barrier against the sea, sued upstream users to guarantee themselves a minimum annual fresh-water supply, and assisted in the drafting and passage of the Water Recordation Act and the Water Replenishment District Act. The short history of collective action in Central Basin has been eventful, and has resulted in the recovery of Central Basin from "critical overdraft" condition in 1960. In its current condition, Central Basin

U no Wer being overdrafted each year, and the overdraft accumulated from 1942 through 1961 has been reduced by about half.

Notes to Chapter Seven

1. Central Basin Watermaster Report, 1963, p. 3.

2. Ibid.

3. Ibid., p. 4.

4. Fossette (1986), pp. 130-131.

5. Central Basin Watermaster Report, 1986, p. 53.

6. Ibid.

7. State of California State Water Resources Board (1952) _Central Basin Investigation_ [hereinafter referred to as "SWRB Central Basin Investigation"], p. 13.

8. Ibid., p. 45.

9. CWBWRD Reportt on LACFCD Zones (1966), p. 3.

10. CWBWRD Report on Ground Water Replenishment (1960), p. 19.

11. CWBWRD Report on LACFCD Zones (1966), p. 3; also, CWBWRD Annual Survey Report, 1966, p. 46. It should be noted that the annual overdraft figures are calculated in the absence of artificial replenishment activities, and thus do not reflect the LACFCD's spreading of imported water from 1954 through 1960, which amounted to about 350,000 acre-feet, thus making the net reduction in ground water in storage a little less than one million acre-feet.

12. SWRB Central Basin Investigation (1952), p. 38.

13. DWR Bulletin No. 104 (1968).

14. Ibid.

15. CWBWRD Report on Ground Water Replenishment (1960), p. 18.

16. Fossette (1986), p. 125.

17. Central Basin Watermaster Report, 1986, p. 56.

18. Fossette (1986), p. 71.

19. Ibid.

20. Ibid., p. 72.

21. SWRB Central Basin Investigation (1952), p. 1.

22. Fossette (1986), p. 90.

23. E. Ostrom (1965), p. 43 fn.

24. Fossette (1986), p. 109.

25. Ibid.

26. Ibid., p. 107.

27. Lipson (1978), p. vi.

28. Fossette (1986), pp. 107-108.

29. Central Basin Water Association (1961), p. 4.

30. SWRB Central Basin Investigation (1952), p. 47.

31. Central Basin Watermaster Report, 1986, p. 10.

32. Ibid., p. 53.

33. Central Basin Watermaster Report, 1963, p. 5; Fossette (1986), pp. 133-135.

34. Central Basin Watermaster Report, 1963, p. 5; Fossette (1986), p. 135.

35. Ibid.

36. Central Basin Watermaster Report, 1986, p. 53.

37. CWBWRD Annual Survey Report, 1983, p. 37.

38. West Basin Watermaster Report, 1959, p. 7; Central Basin Water Association (1961), p. 1.

39. CWBWRD Annual Survey Report, 1966, p.22; CWBWRD Report on LACFCD Zones (1966), p. 18.

40. E. Ostrom (1965), p. 494.

41. Central Basin Water Association (1961), p. 2.

42. Ibid., p. 5.

43. Ibid., p. 6.

44. Ibid., p. 7.

45. DWR Report on Proposed CWBWRD (1959), p. 74.

46. Krieger (1961), p. 7.

47. CWBWRD Annual Survey Report, 1962, p. 10.

48. CWBWRD Annual Survey Report, 1963, p. 5.

49. E. Ostrom (1965), p. 496.

50. Lipson (1978), p. vi.

51. Krieger (1955), p. 4; Fossette (1986), p. 182.

52. CWBWRD Annual Survey Report, 1963, p. 6.

53. E. Ostrom (1965), p. 496.

54. CWBWRD Annual Survey Report, 1963, p. 7.

55. Ibid.

56. Fossette (1986), pp. 182-183.

57. Central Basin Watermaster Report, 1976, p. 59.

58. DWR Bulletin No. 104 (Appendix B), p. 121.

59. CWBWRD Annual Survey Report, 1964, p. 1.

60. CWBWRD Annual Survey Report, 1966, p. 46.

61. CWBWRD Annual Survey Report, 1980, p. 43.

62. CWBWRD Annual Survey Report, 1985, p. 42.

63. CWBWRD Report on LACFCD Zones (1966), p. 7.

64. Central Basin Watermaster Report, 1986, p. 57.

CHAPTER EIGHT

ORANGE COUNTY: SUPPLY-SIDE COMMONS MANAGEMENT

CHAPTER EIGHT

ORANGE COUNTY: SUPPLY-SIDE COMMONS MANAGEMENT

In the 1980s, the practice is known as "supply-side economics". In earlier decades, it was called "priming the pump". Either expression is appropriately descriptive of the approach taken to the groundwater economy of Orange County, California by its citizens and water producers. While purists of the supply-side doctrine would probably take issue with the description, in practice the approach has involved running a deficit to help make the economy grow to the point where it can afford the deficit that spurred the growth. Such a policy involves considerable borrowing -- borrowing from within the economy and borrowing from without -- and can be sustained as long as the sources from which one borrows can maintain the resource infusion.

While much of our thinking about commons problems, especially since Garrett Hardin's 1968 article, has been "era of limits" thinking focused on demand restriction, the experience of Orange County has for some fifty years been a story of boosting supply and placing no restrictions on demand. The community action in Orange County has taken the form of keeping the pumps primed, using the payoffs received by the participants in a well-watered local economy to support their demands with offsetting increases in supply.

A. Orange County: The Background and the Problem

Travelling southeast along the Pacific coast from Los Angeles County and the West and Central Basins, one crosses next into Orange

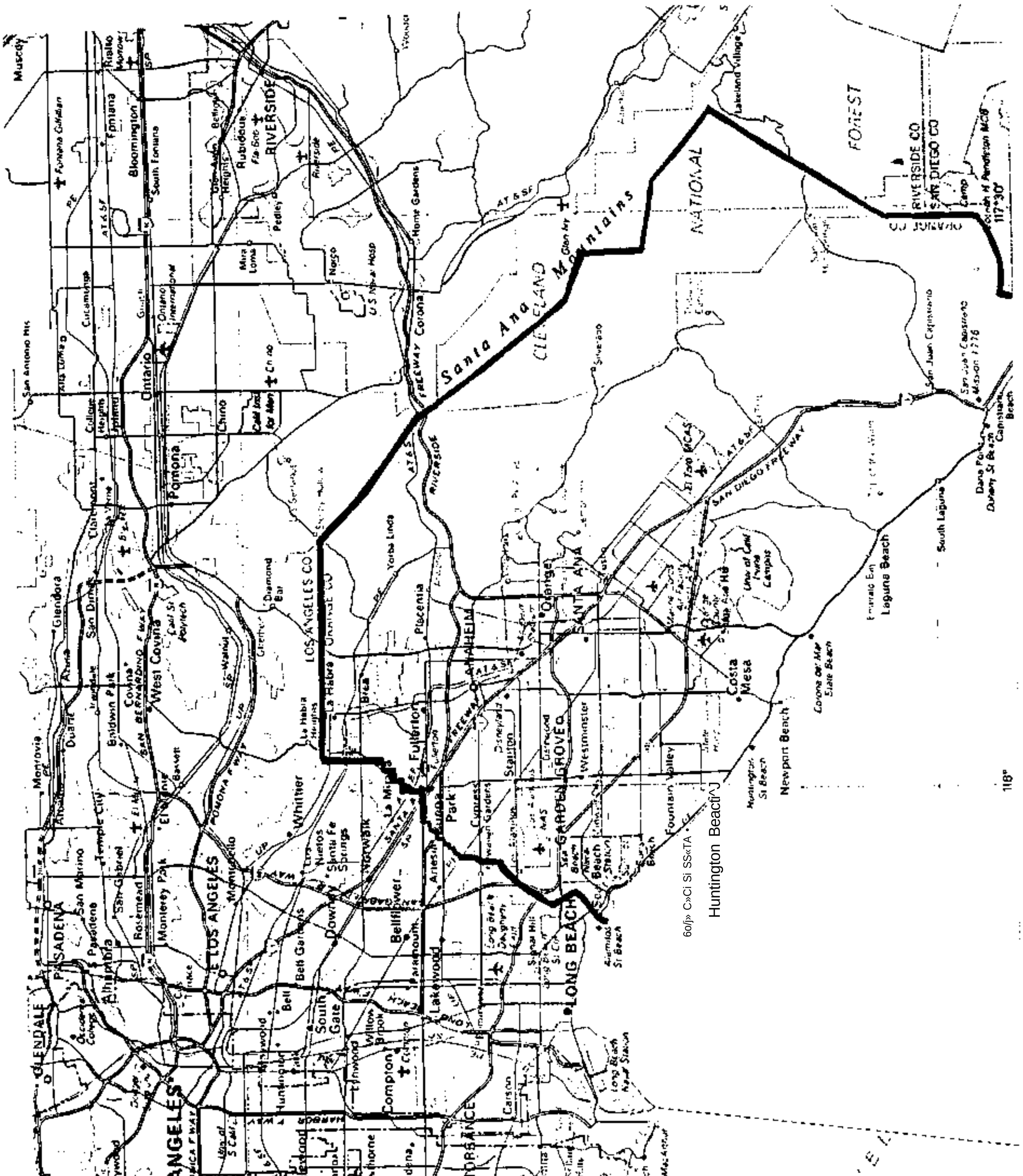
County. Orange County was once part of Los Angeles County, and became a separate county in 1889. Orange County is dwarfed by its neighbors, the Pacific Ocean, Los Angeles County, San Bernardino County, Riverside County, and San Diego County. Squeezed in among these giants are the 798 square miles, or approximately 500,000 acres, of Orange County. The inland border of the County is roughly coterminous with the Santa Ana Mountains. Within the boundaries of Orange County are the mission and town of San Juan Capistrano, the immense Irvine area, part of the Cleveland National Forest, and (among many others) the cities of Anaheim, Santa Ana, Fullerton, Orange, Garden Grove, Costa Mesa, and Huntington Beach (see Map 8-1).

A.I. The Natural Physical System

As is apparent from Map 8-1, the population and development of Orange County is concentrated in the northwesterly portion of the County, toward the Los Angeles area. This is to be expected, given the historical development of Orange County as originally part of Los Angeles County and subsequently as a suburban area of the City of Los Angeles (though Orange County has certainly developed an identity and economy of its own) . But it is also no mere coincidence that it is this populated portion of Orange County that is also supplied by a natural physical water system. This physical system consists of the lower portion of the Santa Ana River system and an underground water basin.

a. The Santa Ana River

The Santa Ana River is the largest coastal-area stream in southern

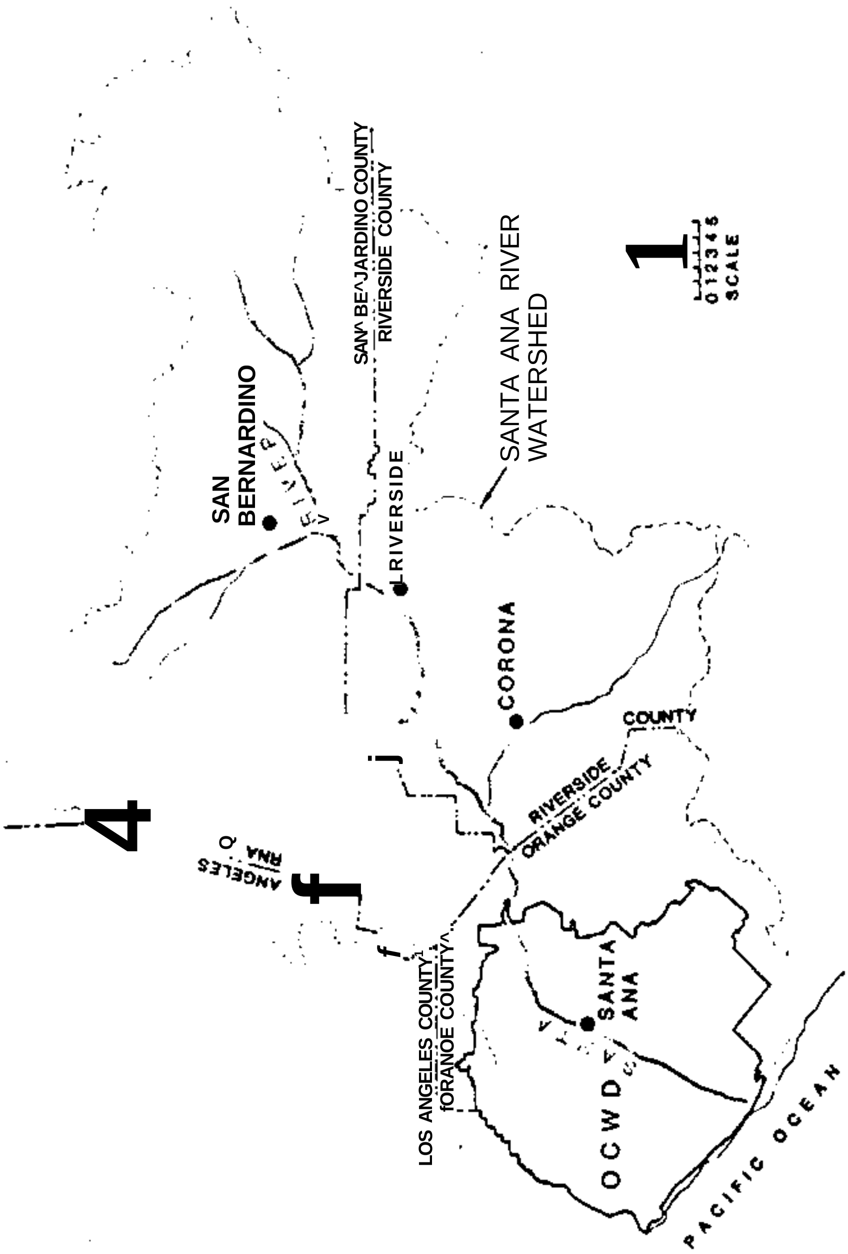


Map 8 1. Orange County ...

Source: Rand McNally ... United States, 1982

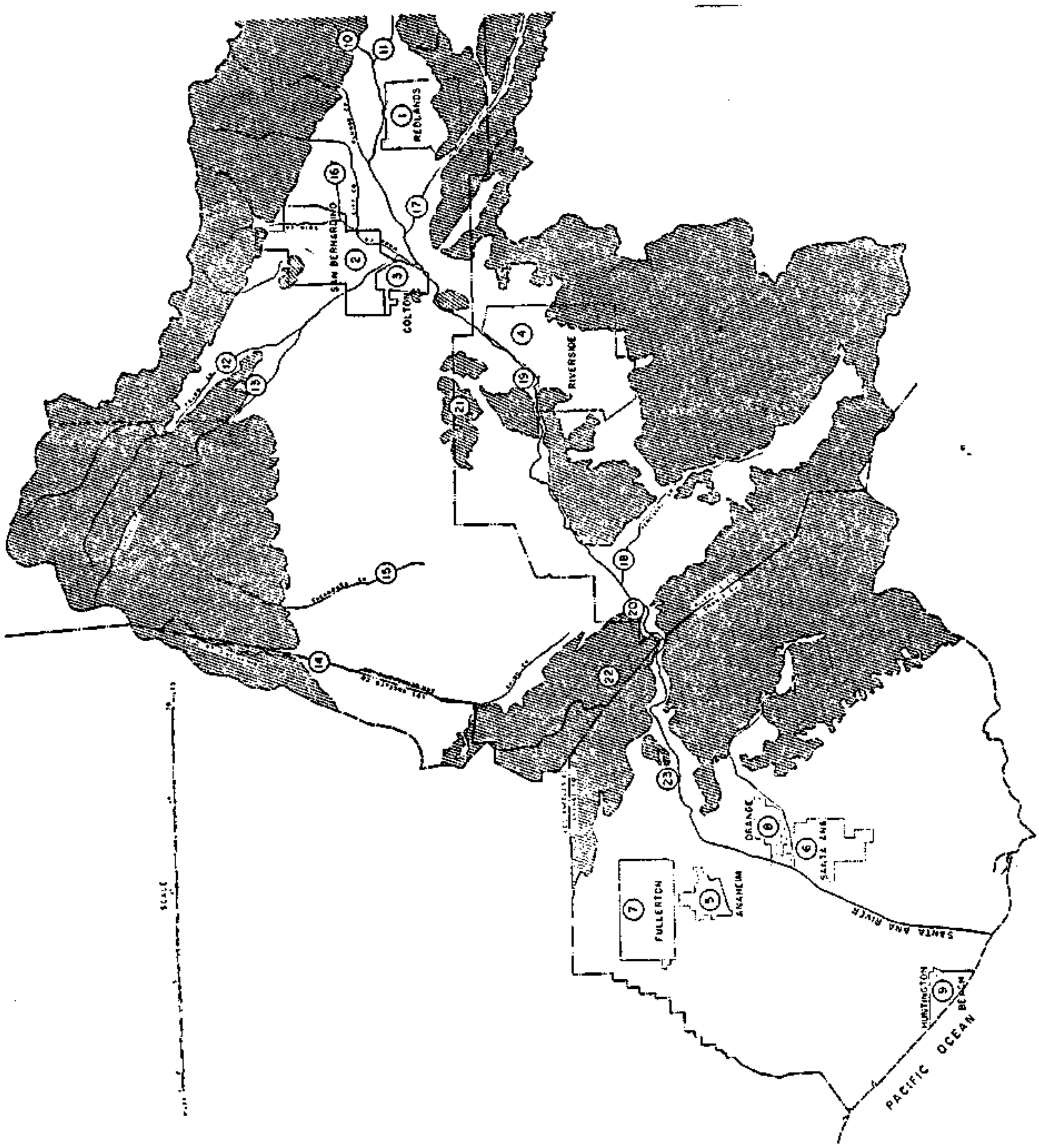
California. The total drainage area and tributary system of the Santa Ana River -- the Santa Ana River Watershed (see Map 8-2) -- covers over 2,000 square miles in the four southern California counties of San Bernardino, Riverside, Los Angeles, and Orange. The headwaters of the Santa Ana River are in the San Bernardino Mountains, 80 miles inland from the Pacific Ocean. The River originates in the confluence of a number of creeks that drain from the San Bernardino Mountains -- Mill Creek, Lytle Creek, Warm Creek, City Creek, Cajon Creek, Twin Creek, and Plunge Creek (see Map 8-3). From this confluence, the Santa Ana River flows in a generally southwesterly direction through the San Bernardino Valley and on through Riverside and Orange Counties to the Pacific Ocean.

In the headwaters or confluence area, the River and its tributaries flow through or adjacent to the Cities of Redlands, San Bernardino, and Colton. From there, the River travels through the Riverside Narrows and past the City of Riverside. Along the way, the River is additionally fed by Cucamonga Creek, Temescal Creek, San Antonio Creek, and Chino Creek. The River reaches the Santa Ana Canyon, between the Puente Hills and the Santa Ana Mountains, near the border of Riverside and Orange Counties. Below Bed Rock Crossing, an uprising of rock in the Santa Ana Canyon, the River opens out into the Coastal Plain of Orange County. There, the River flows past the Cities of Fullerton and Anaheim (which lie north and west of the River) and the Cities of Orange and Santa Ana (which lie east and south of the River). As the River passes the City of Santa Ana, it is joined by Santiago Creek, which drains from the Santa Ana Mountains. The River empties into the Pacific Ocean between Huntington Beach and



Map 8-2. Santa Ana River Watershed

Source: Orange County Water District Annual Report, 198[illegible]



Map 3-3. The Santa Ana River and Its Tributaries

Source: Appellants' Brief, Orange Count* Water District v. CJS of Riverside et al., 1957

Newport Beach.

The course and flow of the Santa Ana River have changed over time. Rainfall in the Santa Ana River Watershed is not only sparse on average, as one would expect (average annual rainfall in Orange County is 13.4 inches). Rainfall is also extremely unpredictable and varied, with possibilities of severe drought and over-abundance. Storm runoff in wet years can overrun the normal creekbeds draining the mountains and the riverbed flowing through the valley, the canyon, and the coastal plain. The Santa Ana River has repeatedly flooded (see Chronology, in Appendix), sometimes with disastrously destructive results. At times, then, the River has flowed wide and rapidly from the mountains to the ocean, and has sometimes settled into a new channel. At one time, for example, the River emptied into the Pacific Ocean near the boundary with Los Angeles County at the Alamitos Gap. The Santa Ana River now reaches the Pacific Ocean east of Huntington Beach at the Talbert Gap, and can now be expected to maintain this course since flood control measures are in place.

In addition to changes in the River's course, there has been considerable variation in the River's flow. In the late 1700s, for example, the journals of an early explorer recorded the Santa Ana River as being more than half an mile wide (1). On the other hand, only infrequently in 20th-century observation does the River actually flow above the ground over its entire 90-mile course from the mountains to the ocean. The River typically disappears at various points along its course, sinking underground and then surfacing again further downstream (2). As with most southern California streams, there are times and places where it is possible to "stand on the Santa

Ana River" without divine intervention or even wet soles.

b. The Underground Water Basin

As a natural physical water supply system, then, the Santa Ana River by itself would present considerable difficulties, alternating between destructive flooding and disappearance in drought. However, the River does not operate as a water supply system by itself, but rather as part of a conjunctive supply system along with underground reservoirs or groundwater basins.

The Santa Ana River's course crosses several underground barriers, such as fault lines. Water then collects upstream from these barriers, as it would with a surface dam, in underground reservoirs. Over the Santa Ana River's course, it supplies nine underground basins of this sort, starting with the Mill Creek Basin back at the headwaters, on through the San Bernardino, Colton, and Chino Basins, and finally to the last basin before the Pacific Ocean (3). This last basin is known variously as the Santa Ana Basin, the Coastal Basin, the Orange County Basin, or the District Basin, and is the one with which we are concerned in this Chapter.

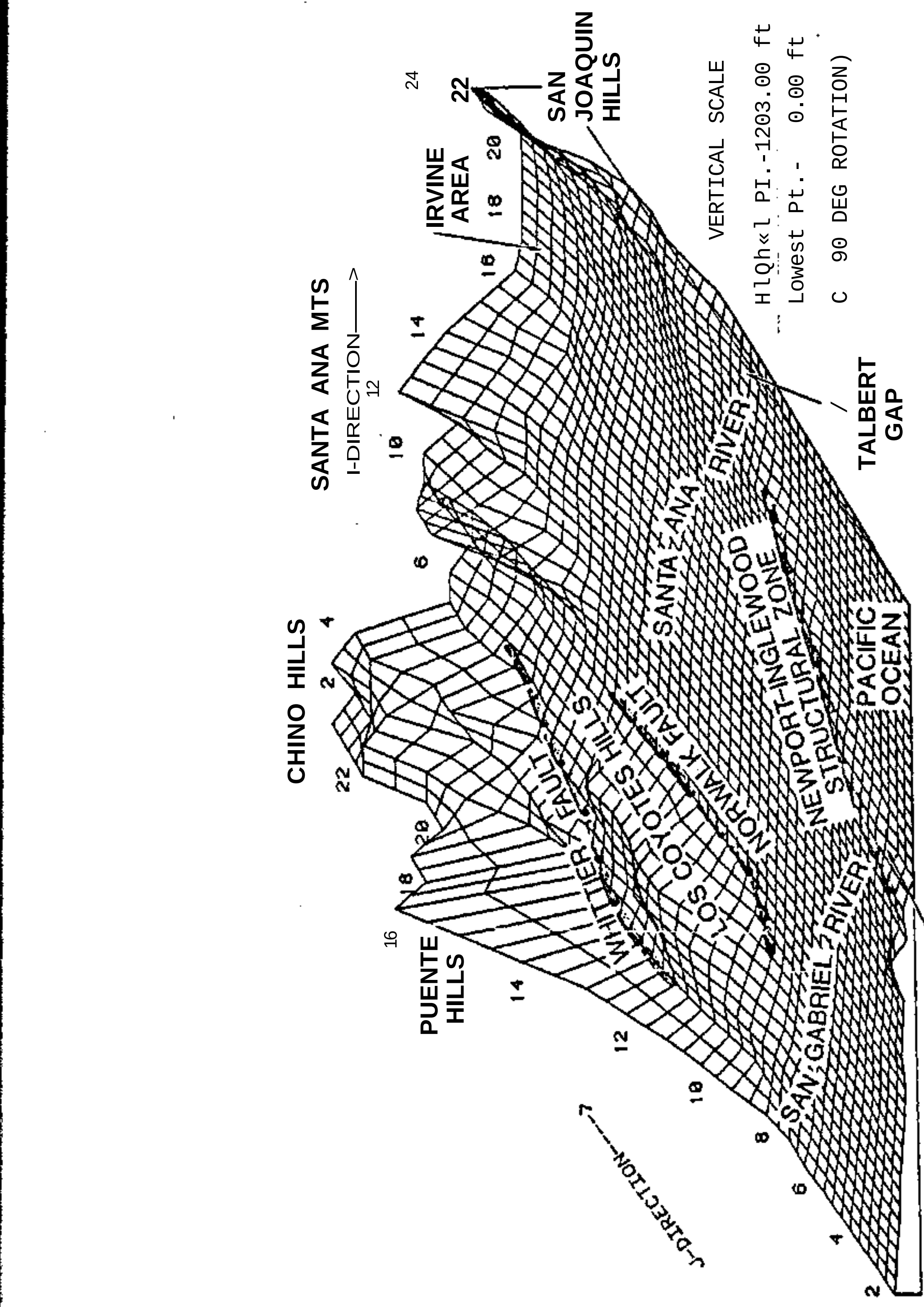
Each of these nine basins retains some River water and allows some through to the next basin in the series. As the last basin, the Orange County Basin's inflow is determined within the natural physical system by its geohydrologic characteristics, by the amount of water flowing in the watershed (due to rainfall and runoff), and by the extractions of water users from the eight upstream basins and the diversions of the surface flow of the Santa Ana River (where such surface flow occurs).

The physical boundaries of the Orange County basin are the Santa Ana Mountains to the east, the Chino and Puente Hills to the north, and the Pacific Ocean to the southwest (4) (see Map 8-4). The land area covered is about 300 square miles. The Santa Ana River cuts through the basin area and contributes an average (again, with wide variation) of about 50,000 acre-feet per year to the groundwater basin through percolation (5). The maximum fresh-water depth of the basin is approximately 4,000 feet in the Santa Ana and Garden Grove area, and the basin in total has a storage capacity of about 15 million acre-feet, with 10 percent or 1.5 million acre-feet of this in active, usable storage capacity.

Together with the Santa Ana River, the underground basin of the Coastal Plain of Orange County constitutes a conjunctive natural supply system, consisting of inflow and storage elements. The instability of the River's inputs to the local supply is offset by the capture and retention of the River flow by the underground basin. The fluctuation in River flow within the year and from year to year is countered by the basin's storage capacity, which makes water available in the Coastal Plain throughout the year and across years.

The basin contains three major aquifer systems, arrayed in layers. The upper aquifer system extends from very near the ground surface to a maximum depth of approximately 1,500 feet. The middle aquifer ranges from 1,300 to 2,600 feet deep. The lower aquifer contains poor quality confined water with a high level of dissolved solids, and ranges from 2,600 to 4,000 feet deep (6).

The water in the upper aquifer of the Coastal Basin is of very high quality, and can be extracted easily. Because the Coastal Plain



8-4. Orange County [illegible] Features

Source: OCWD Engineer's Report, 1983

is at a low elevation relative to sea level, and of course reaches sea level at the shore, the ground water in the upper aquifer comes sufficiently close to the land surface that artesian wells can supply the water. In fact, areas near the ocean in Orange County were historically swampy because of the presence of the subsurface flow so near to the land surface (7). Ground water elevations in the Coastal Plain area, in the absence of human intervention in the form of groundwater extractions, are maintained above sea level, so that as the overland terrain gradually declines to sea level, the ground water emerges above the land.

As the underground flow of the Coastal Basin approaches the Pacific Ocean, geohydrologic conditions separate the fresh water in the aquifer from the sea water in the Ocean. There is a geologic discontinuity between the Ocean and the Basin, caused by disjunctures beneath the land surface associated with the Newport-Inglewood Uplift (8). The Uplift runs parallel to the coast from the southeastern portion of the basin in Orange County on into Los Angeles County, and creates a sort of underground "wall" between the ocean and the basin. However, there are four points along the coast where this "wall" has been breached and a geologic continuity exists between the basin and the sea.

During the last ice age, when sea level was lower than its present elevation, the Santa Ana and San Gabriel Rivers flowing to the ocean carved out deep channels across the fault zone. Subsequently, as the river courses changed and as the sea level rose, these channels filled with sand and gravel, creating permeable "avenues" for the outflow of fresh underground water to the sea, or for the inflow of sea water into the underground basin (9). The four avenues, or "gaps", are the Alamitos Gap, the Bolsa-Chica Gap, the Bolsa-Sunset Gap, and the Talbert Gap. The Bolsa-Chica and Bolsa-Sunset Gaps appear to have subsequently been sealed from the ocean by later underground shifts, but the Alamitos and Talbert Gaps offer possibilities for water exchanges between the ocean and the basin (10). The Alamitos and Talbert Gaps are located at each end of the Newport-Inglewood Fault Zone (see Map 8-4).

A.2. Development of the Problem

The development and growth of Orange County took place principally on this Coastal Plain, on the land supplied with water by the natural physical system described above. A combination of the movement of population to Orange County, the movement of population to the upstream areas outside the County, the patterns of land use, and the law of water rights generated the commons problem in Orange County.

The recorded arrival of Spanish settlers in what was to become Orange County occurred in 1769 as part of the expedition of Father Serra north from the San Diego area. The expedition camped in the Santa Ana Valley on St. Anne's Day, July 28, 1769, and named the River and Valley in honor of St. Anne.

Subsequently, some of the explorers returned to the area and began settlements there. The first Spanish land grant in the area was issued in 1810 to Jose Antonio Yorba, who formed Rancho Santiago de Santa Ana in the area around the junction of Santiago Creek and the Santa Ana River, where the City of Santa Ana is located today. With the land grant was associated a riparian water right to the flows of the Santa Ana River adjacent to the land and to the underground water beneath the land.

Under Mexican administration in the first half of the 19th Century, private rancheros were developed on the remainder of the land in the Coastal Plain area. The rancheros irrigated the land for grain production and livestock raising. The flows of the Santa Ana River were sufficient for these pursuits. The rancheros' irrigation systems brought water from the streams onto the land to be cultivated mainly by use of flow patterns that relied on gravity (11).

With the transition from Mexican administration to U.S. statehood in the middle of the 19th Century, simultaneous with the "gold rush", westward migration to California increased, on the promise of possible riches and the availability of new lands. Lands were settled and developed along the Santa Ana River Watershed, including the upstream areas in San Bernardino and Riverside Counties. There also, the Santa Ana River provided the needed water supply for irrigating lands for livestock raising and crop production.

The large-scale ranchero holdings were devastated by the Great Drought of 1863-1864, which dried up the surface supply and resulted in the death of the ranchers' animals (12). Subsequently, smaller land holdings were developed and the crop patterns of the area changed from grain fields to vineyards and citrus groves. In response to the losses experienced by the rancheros in the Drought, the vineyard and grove proprietors began to develop artesian wells in the Coastal Plain, thereby securing water from the more stable underground basin supply rather than relying entirely on the more variable (and occasionally non-existent) surface flows of the Santa Ana River.

Towns were established in the Orange County area in the second half of the 19th Century. Anaheim was founded in 1857, Orange in 1868, Santa Ana in 1869. The earliest municipal water supply systems appeared in the 1870s. Also at this time, James Irvine began acquiring the land that eventually amounted to the vast Irvine Ranch holdings, ultimately covering approximately one-third of the area of what is now Orange County (13). Irvine Ranch developed an irrigation system drawing on both surface and underground supplies.

As the Coastal Plain area developed in the late 1800s and use of the water supply for irrigation increased, the water elevations in the basin lowered. The lowering of the basin water elevations caused dry lands to appear where there had previously been swamps (14). The presence of these additional dry lands increased the available acreage for cultivation. As growers developed the newly available lands, they in turn began to irrigate these former swamps, adding still more to the total water demand for irrigation in the Coastal Plain.

Increased demands placed on the physical system's storage capacity began to lower the underground water elevations at about the same time that upstream use and surface diversions began to diminish the inflow to the Basin. The upstream communities in the Santa Ana River system were developing, too, diverting the surface flows of the River for irrigation use and extracting water from the underground basins. Because the Coastal Plain area is the last one-third of the Santa Ana River's course, and because the Coastal Basin is the ninth in the series of nine underground basins in the Santa Ana River system, the Coastal Plain was (and is) highly exposed to the actions of upstream water users. The development of the upstream areas reduced the flow through Santa Ana Canyon and thus diminished both the surface flow of the Santa Ana River in Orange County and the replenishment by that River of the underground basin.

Orange County water users north of the River (i.e., in the Anaheim area) began to dispute with users south of the River (in the Santa Ana area) over rights to the increasingly scarce flow of the River. The northern interests attempted a pre-emptive move in the 1880s by taking action in a State court to establish a predominant right to the River water. The northern interests prevailed at the trial level, but the judgment was reversed by the California Supreme Court, which recognized and upheld the riparian right, dating back to 1810, of the Rancho Santiago de Santa Ana from its Spanish land grant (15). As a result, water users on both sides of the River in Orange County maintained rights to the flows of the River, and use of those flows continued apace.

By 1920, there were nearly 100,000 acres of irrigated agricultural land in Orange County, almost twice as much as in 1910. Groundwater extractions from the basin exceeded 180,000 acre-feet. This volume of extractions was greater than the safe annual yield of the Coastal Basin, which has been estimated to be 150,000 acre-feet. Representatives of local private and public water supplying companies and agencies were noticing receding water levels in wells. Along the coast, where the swampy areas near sea level were drained and cultivated, underground water levels declined to below sea level, reversing the direction of flow in the geologic "avenues" of the Alamitos and Talbert Gaps and thus beginning an inflow of sea water into the Basin.

With the exception of the attempted action of the Orange County water users on the north side of the River to secure their rights as against the south side users, no joint action or public concern over the adequacy of water supply was in evidence. Each proprietor developed his own supply based solely on calculations of his individually experienced costs and benefits, without regard for the effect of his extractions on other users. Indeed, over-supply of water in wet periods -- that is, the occasional flooding of the River during the winter storms -- received more widespread attention than the overall trend toward lowered water levels and diminshed natural inflow. Flooding, after all, caused immediate destruction and asset loss to those in the Coastal Plain, while the more gradual process of supply depletion posed a longer-term and less clearly perceptible threat to the economic welfare of landowners. "Until the 1920s, the main water problems of public concern were land drainage, storm water control and sewage discharge.... [while] pumpers, through basically uncoordinated activity, were mining the basin." (16)

In 1920, Orange County was poised on the brink of a population explosion and an economic transformation of proportions that are difficult to comprehend, even by the standards of the Industrial Revolution, the American economic "take-off" of the mid-1800s, or the rapid growth of American cities in the late 1800s. The economic base of Orange County changed from agriculture to oil production and distribution to industrial and commercial development. Although irrigation acreage had doubled in the previous ten years, in 1920 it had reached very near to its peak of 130,000 acres. As Table 8-1 illustrates, the population of Orange County roughly doubled in each decade from 1920 to 1970, with the exception of the Depression years of the 1930s, when population growth was a "mere" 10 percent. Orange

TABLE 8-1

Orange County Population During the Period of Water Resource Management, 1920-1980

Year	Total Population	Urban (%)	Non-Urban
1920	61,375	30,310 (49)	31,065
1930	118,674	63,933 (54)	54,741
1940	130,800	76,500 (59)	54,300
1950	216,224	146,251 (68)	69,973
1960	703,925	675,064 (96)	28,861
1970	1,420,386	1,403,341 (99)	17,045
1980	1,932,709	1,926,911 (99.7)	5,798

Source: World Almanac and Book of Facts, various years

County's population grew from 61,375 in 1920 to 1,932,709 in 1980, and the percentage of that population living in areas defined as "urban" escalated from 49 percent to 99.7 percent, a change that was reflected in the land use patterns of the Coastal Plain, where 90 percent of Orange County's people live. In the Orange County Coastal Plain in 1948, about 130,000 acres was devoted to irrigated agriculture and 28,000 acres to urban and suburban purposes. Fifteen years later, the distribution had been transformed, with 65,000 acres in irrigated agricultural use and 100,000 acres devoted to urban and suburban use.

Yet, in 1920, before this explosion and transformation, the basic structure of the common-pool problem in Orange County was already in place. Contributing to that problem were:

(1) the law of water rights, which made access to the common water supply an adjunct of land ownership, with no restrictions on access based on water consumption or supply conditions, and which was also the case in the Raymond, West, and Central Basins;

(2) the pattern of land use, which generated an early extensive use of the available water supply (such that an overdraft condition existed even when only 61,000 people resided in all of Orange County), and which was also the case in the Raymond and West Basins;

(3) the location of the natural water supply system as the downstream end of the surface and underground water series, creating an exposure to upstream activities similar to that of West Basin; and,

(4) the location of the underground water supply adjacent to the Pacific Ocean, with opportunities for sea water intrusion, as was the case in West and Central Basins.

Orange County was already experiencing a demand-supply imbalance, contributed to simultaneously by ongoing escalation in demand and the onset of diminution of supply. This pattern continued to operate without intervention into the 1920s, until supplies were threatened not only by diminution but also (as in West Basin) by contamination. Still, despite the similarities of this situation and the other cases, the responses to the commons problem in Orange County developed along a considerably different path.

B. Responses to the Problems in Orange County (17)

The path of collective action for water resource management in Orange County has had one consistent direction: the protection and enhancement of water supply. Along that path, there have been defineable stages: the early stage of information-gathering, communication, and upstream supplementation; the litigation and District-formation stage; the District-building stage; the basin-replenishment stage; and the conjunctive-use stage. Each of these stages has contained elements of design and use of institutional capacities, and attempts to alter the rules and conditions affecting the behavior of water users within and outside Orange County.

B.I. The Setting for Action: Obstacles and Advantages

There were, of course, some barriers to coordinated water management activities in Orange County in the 1920s. First, the nature of common-pool problems generates a tendency, because of the individualized appropriation of benefits and socialized diffusion of costs, toward competitive and self-interested action on the part of users. Second, a groundwater basin, as a particular type of common-pool resource, aggravates this basic problem by being a "hidden" resource and one in which use-units can be shifted about from one user's real property to another's. Third, the separation of Orange County in 1889 overlaid jurisdictional boundaries on the natural physical system in a way that divided the physical system still further among local units of public authority. The boundary line dividing Orange County from Los Angeles County, for instance, places some of the Santa Ana River Watershed and some of the underground Coastal Basin in Los Angeles County. With the establishment of Orange County, the Santa Ana River flowed through three counties, the Watershed reached into four counties, and the Coastal Basin underlaid two counties; no existing local public jurisdiction had boundaries that contained the major elements of the physical system supplying water to Orange County.

Yet, in addition to these barriers, Orange County had characteristics that were advantageous from the standpoint of potential collective action. First, the separation of Orange County from Los Angeles County, while it further complicated the boundary problem for actions with respect to the natural physical system as a whole, presented an advantage for collective action within Orange County itself. As of 1920, for instance, the independence of Orange County was barely three decades old. The independence was thus an event of some salience within the lifetimes of many County residents, and had occasioned a high degree of unity among the populace -- the 1889 vote to separate from Los Angeles had been a lopsided 3,004 to 499, or 6 to 1, in favor (18). Orange County experienced a strong sense of community, for a county, even if that sense of community was felt largely as a sense of independence that easily converted to an "us vs. them" mentality. Moreover, the extreme concentration of the County's population and developed property in the Coastal Plain area generated an identification of the Coastal Plain's water supply with the County's water supply and made the County an appropriate focal point of action in a way that Los Angeles County could not be in the Raymond, West, and Central Basin cases. The County of Orange, and its Board of Supervisors, was thus the locus of one of the first important actions taken with respect to the problem of water supply in the Coastal Basin.

Second, the development of Orange County up to 1920 had created fortunes and family dynasties. This was advantageous in three ways: (1) resident property owners lived throughout the Coastal Basin area who had considerable "stakes" in the water resources of the County, first from the standpoint of flood control and subsequently of supply maintenance; (2) there were resident property owners in the area with considerable assets, some of which might be devoted to activities for the preservation of the water resources of the County; (3) the number of prominent community leaders was relatively small because of the connections between extensive property holdings and the communities of Orange County, in that the Yorbas, Chapmans, Irvines, Spurgeons, and Tustins were not only extensive landowners and water users, they were also founders of towns and cities and leaders of local associations and local units of government (19). It bears repeating here that the Coastal Basin had reached overdraft conditions by 1920 when the 500,000 acres of Orange County still contained only some 61,000 persons. These prominent families, with their stakes and assets and connections to the County and its organized communities, were also focal points of early actions.

Third, the growth of Orange County had also generated a network of trade associations and public jurisdictions that provided a set of communication channels for discussion and dissemination of information about developments in the County. Because of the reliance of the County's economy on irrigated agriculture, local units of government were necessarily attuned and responsive to issues of water availability, once availability became recognized as a problem. Similarly, organizations such as the local chambers of commerce and the Orange County Farm Bureau established water committees that would report on water conditions and problems to their memberships. Members of the Farm Bureau, in turn, would be represented on local chambers of commerce, chamber memberships overlapped with local government council memberships, and so forth (20). Thus, some of the municipal governments and trade associations in Orange County initiated early activities.

B.2. Early Responses to the Supply Problem

By 1920, the Coastal Basin was being overdrawn, natural inflow had been curtailed by the activities of upstream users, and receding water levels in wells had been noticed by local water producers. The beginning of a series of drought years in 1923 spurred heightened discussion of water supply problems (21), and prompted the first series of actions within Orange County addressed to understanding and improving the supply conditions of the area.

The first step was gathering of information. The Orange County Board of Supervisors commissioned a study of the Santa Ana River and the Coastal Plain by Los Angeles-based engineer J.B. Lippincott. The Lippincott Report, delivered to the County in 1925, served four significant purposes. First, it formally confirmed what several water producers already knew, that the Coastal Plain was a water-deficient area, that the Coastal Basin was being overdrawn and the water table was declining sharply, and that the natural inflow from the Santa Ana River had been reduced to clearly insufficient levels. Second, the Report identified for the first time in Orange County the alarming news that signs of sea-water intrusion were already present along the Pacific coast, and warned that serious degradation of the groundwater supply would occur if some remedial measures were not taken. Third, the Report identified flood control measures that could be taken to protect property and conserve the occasional winter storm runoff. Fourth, as the Report's findings were disseminated through the communication network of local governments and associations, they provided for the water users of Orange County a shared picture of their situation with respect to water supply and prospects for future availability. In all, the Lippincott Report substantially altered the information conditions regarding the water problem of Orange County, a fact that helps in understanding why Orange County preceded the Los Angeles County basins in the initiation of collective action for water resource management.

The next two steps, to conserve and supplement natural inflow into the Coastal Plain, were taken at least partially in response to the Lippincott Report. First, the Orange County Board of Supervisors requested the formation of a special district from the California Legislature under the provisions of the Flood Control District Act (by which the Legislature also created the Los Angeles County Flood Control District). The Orange County Flood Control District was formed in 1927 to design and implement measures to control and conserve storm flows, for the dual purposes of protecting property in the Coastal Plain and retaining flood waters so that they might recharge the Coastal Basin (22). Second, representatives of Orange County joined with others in San Bernardino and Riverside Counties to form a Water Conservation Association for the purpose of developing a spreading program for the replenishment of the underground basins in the Santa Ana River Watershed. The Association obtained the approval of the United States Congress to use nearly 1,000 acres of federal land upstream from the Coastal Plain for water spreading (23). However, this first cooperative venture of Orange County with the upstream Counties also became the last cooperative venture between the downstream and upstream interests. The spreading program became a source of conflict as the upstream Counties began to put to their own use the waters collected for spreading, thus even further diminishing the inflow to Orange County (24).

Also in the late 1920s, three of the local units of government within Orange County took action to secure for themselves a supplemental supply of water. The nearly-complete diversion of Santa Ana River water had threatened the municipal supply systems of the Cities of Fullerton, Anaheim, and Santa Ana. These communities joined with others in the region to form the Metropolitan Water District of Southern California (MWD) in 1928. Their action insured a right of access for at least some of the population of Orange County to whatever supplemental sources of water MWD might ultimately acquire. Residents in these jurisdictions thus began paying ad valorem taxes to the MWD. While this action was undertaken by the Cities for themselves and on behalf of their residents, and thus should not be viewed as a "sucker" strategy or even necessarily as a "cooperative" move per se, this action did pave the way for these Cities to reduce their dependence on groundwater extractions and surface water diversions once their supplemental supplies through MWD became available, and so did inure to the long-run benefit of other Coastal Basin water users by making it possible to reduce total demand placed on the natural water supply system.

Information-gathering and communication activities undertaken in the 1920s, and the attempted supplementation and conservation of natural inflow, were early steps in the direction of collective action for water resource management, but throughout the drought-stricken decade from 1923 to 1933, water supply conditions in Orange County continued to deteriorate. The water levels declined still further, and well pumps near the ocean began to draw salt water. The next moves of Orange County water users to protect and improve the water supply conditions, which they knew from the Lippincott Report were highly vulnerable, were directed toward two strategies, the formation of another special district and the limitation of upstream diversions of inflow.

B.3. "Us vs. Them": Formation of the Orange County Water District

One of the most active associations of water user interests during the 1920s had been the Water Committee of the Orange County Farm Bureau. This is not surprising in light of the dominance of the local economy by irrigated agriculture. It was, after all, the 100,000 acres of irrigated ariculture, not the 100,000 persons, that was placing a 200,000 acre-feet per year demand on the Coastal Basin by 1930 (100,000 persons would normally be expected to consume about 20,000 acre-feet of water per year, one-tenth of the groundwater extractions in Orange County at that time). In April 1931, upon recommendation of the Water Committee, the Orange County Farm Bureau sent a letter to California State Senator N.T. Edwards and State Assemblyman Ted Craig. That letter requested the legislators to obtain the approval of the California Legislature for the formation of a special district within Orange County to be devoted to the problem of water supply, to "look out for the question of replenishing the Basin, conservation of the waste, and questions of that nature." (25) The legislators did not act on the recommendation with the introduction of a bill that year.

a. The Irvine Ranch Litigation: Orange County as Privileged Group

The next year, 1932, the concern about the increased upstream use of the Santa Ana River flows, and the building animosity over the spreading program that had been converted to the detriment of Orange County's water supply, turned into active conflict with the initiation of a lawsuit against upstream water producers. The lawsuit was not undertaken by the County of Orange or any of the local units of government or associations within Orange County, but by one water user -- one, huge water user.

The Irvine Company was "the dominant economic organization within the county." (26) The original land holdings of the Irvine Ranch extended over 172,000 of the 500,000 acres of Orange County -- in other words, one third of Orange County was once the Irvine Ranch, which extended from the Santa Ana Mountains to the Pacific Ocean (27). The Irvine Company had been formed to manage the considerable assets of the Irvine family, and was principally engaged in land development, in the course of which it sold off acreage. At the time of the initiation of the lawsuit, in 1932, the Irvine Company held approximately 92,000 acres (28). The lands possessed by the Irvine Company, which included some of the best farmland in the County, were watered by a combination of surface supplies and groundwater extractions. The Company had 80 wells in operation in 1932 (29).

In order to protect its water supply, which was dependent both on surface inflow and on basin recharge, the Irvine Company sued three upstream appropriators that were diverting water from Lytle Creek for spreading to recharge one of the upstream underground basins. The Company claimed that the upstream diversions of water that would have flowed through the Santa Ana Canyon and into the Coastal Plain were invading the Company's riparian right (30). The Company sought relief from the Court in the form of a declaration of the Company's right and an injunction restraining the upstream defendants from diverting quantities of water sufficient to damage its downstream right. The original action -- Irvine Co. v. Fontana Union Water Company et al. -- was expanded until it included twenty defendants, who were diverting water from Mill Creek and the Santa Ana River as well as Lytle Creek (31).

The actions of the Irvine Company were undertaken in order to protect its own water supply. Yet clearly, if the Company prevailed, the result would be an increase in the inflow to the Coastal Plain. Hence, all of the overlying users of the Coastal Basin stood to benefit, even if only the quantity of the Irvine Company's right were restored to the basin. The restoration of the Irvine Company's water might not (legally, at least) give the other water users in the Coastal Plain more water to withdraw, but it would raise the elevation in the basin and thus reduce pumping costs and sea water intrusion for the other users. That was the minimal benefit to other users from a judgment favoring the Company -- beyond that, a favorable judgment might actually result in increased water availability. Because of its own stake in the outcome of the case, the Irvine Company had undertaken an action from which several other users stood to benefit. The Irvine Ranch litigation presents a classic example of the provision of a collective benefit by and for a "privileged group" (32).

b. Sharing the Costs: Creation of the Orange County Water District

The Irvine lawsuit generated an additional rationale for the formation of the kind of special district for which the Farm Bureau had lobbied Senator Edwards and Assemblyman Craig in 1931. As the Irvine litigation grew, in number of defendants and scope, the prospective costs to be incurred by the Irvine Company escalated, as did the potential benefit to other downstream users if Mill Creek and Santa Ana River diversions were curtailed also. If a special district could be formed as a sort of "zone of benefit", encompassing lands that stood to gain from a successful prosecution of the suit, then funds raised by such a district could be used to defray the Irvine Company's costs in "going it alone", and could more equitably apportion the costs of the action with the potential benefits to be received from the action.

Another reason for creating such a district and then involving it in the litigation was to counterbalance the representation of the defendants. One of the defendants added to the suit was the San Bernardino Valley Water Conservation District, which had been incorporated in 1931 and could claim to represent the interests of all of the appropriators in the San Bernardino Valley (33). The Irvine attorneys perceived an advantage to be gained from being able to make a similar claim for the Orange County users, though the Irvine Company itself was not such a representative. If such a representative were to be employed, it would have to be created.

In April 1933, State Senator Edwards introduced Senate Bill 1201, which authorized the incorporation of the Orange County Water District. Senate Bill 1201, the Orange County Water District Act, was approved by the California Legislature on June 4, 1933. The Orange County Water District (OCWD) was specifically authorized in this enabling legislation "to represent the water users and landowners of the Coastal Plain in all litigation involving outsiders." (34) The OCWD subsequently entered the Irvine litigation as intervenor on behalf of the Irvine Company.

The initial idea in 1931 for the creation of a special water district in Orange County was directed to the more general purposes of conserving and replenishing the Coastal Basin. But it was the legal action in 1932 against the upstream appropriators, and the twin desires to have a representative party and a cost-sharing mechanism for the downstream users, which apparently provided the specific impetus for the creation of the Orange County Water District in 1933.

However, the Act authorizing the creation of the District did not stop at authorizing the District to pursue the litigation against the upstream interests. In addition, the District was charged to undertake: (a) management of the groundwater basin, (b) conservation of the quantity and quality of the groundwater in the basin, (c) reclamation of water for beneficial use, and (d) conservation and control of storm and floodwaters flowing into the District (35). Pursuant to these purposes, the District was granted powers: to import, sell, and store water; to conserve or replenish water within or outside the District; and to protect the water supply and water rights of Orange County users through any action or proceeding. The District may have been created to address the immediate concerns of Irvine litigation, but it is the District's use of these powers to implement the additional responsibilities, plus two subsequent uses of the power to pursue litigation, that have made the District the focal point of water resource management in Orange County. (36).

B.4. The District's Supply Management Program, 1933-1948

Different observers could choose to organize and analyze the half-century of the Orange County Water District's operation in different ways. One could choose, for example, to make divisions among different periods of the District's actions based on the different litigations initiated in 1933, 1951, and 1963. Alternatively, one could select the major changes in the District's taxing capacities in 1933, 1953, and 1968 as the dividing points among periods of District operations. The approach taken here is to organize the District's activities into three periods of dominant programmatic emphasis --a basin-protection period from 1933 to 1948, a basin-replenishment period from 1949 to 1964, and a conjunctive-use period from 1965 to 1985 -- because the other landmarks in the District's history, such as the litigation involving the District and changes in the District's powers, might best be understood within the context of the purposes being pursued during that time.

a. The Initial Situation of the Orange County Water District: The Source of the Supply-Side Policy, and Limitations on Management Capacity

While the Orange County Water District was created, at least in part, to aid in the prosecution of the Irvine Ranch litigation, and was further authorized to engage in any actions or proceedings on behalf of the local water users against those who might impair or diminish the water supply available to them, the District was not given the power to act with respect to the water consumption of users within its boundaries. The Orange County Water District Act of 1933 did not vest the power of undertaking an adjudication of water rights in the District or its Board of Directors. Indeed, the Act specifically prohibits the District from taking part in any action or proceeding against or between owners of land or water rights within the boundaries of the District (37).

In part as a result of this rule, and because of the actions of the District and other public water enterprises in Orange County, the water rights in Orange County to the flows of the Santa Ana River and to the groundwater of the Coastal Basin (now commonly called the District Basin) never have been adjudicated. This represents quite a different approach from that taken in the other cases in this study, where adjudication enabled users to place an enforceable upper limit on demand for groundwater. As one observer put it, "Only Orange County has elected to forego adjudicating the water rights in its own area." (38)

Orange County Water District acts much as a replenishment district, yet the contrast with the Central and West Basin Water Replenishment District is quite sharp in this regard. Whereas the two replenishment districts were formed to confront similar physical problems in neighboring areas, the Central and West Basin Water Replenishment District was created with a mandate to pursue adjudication of water rights within Central Basin, and the Orange County Water District was created with a prohibition on adjudicating water rights within the District Basin.

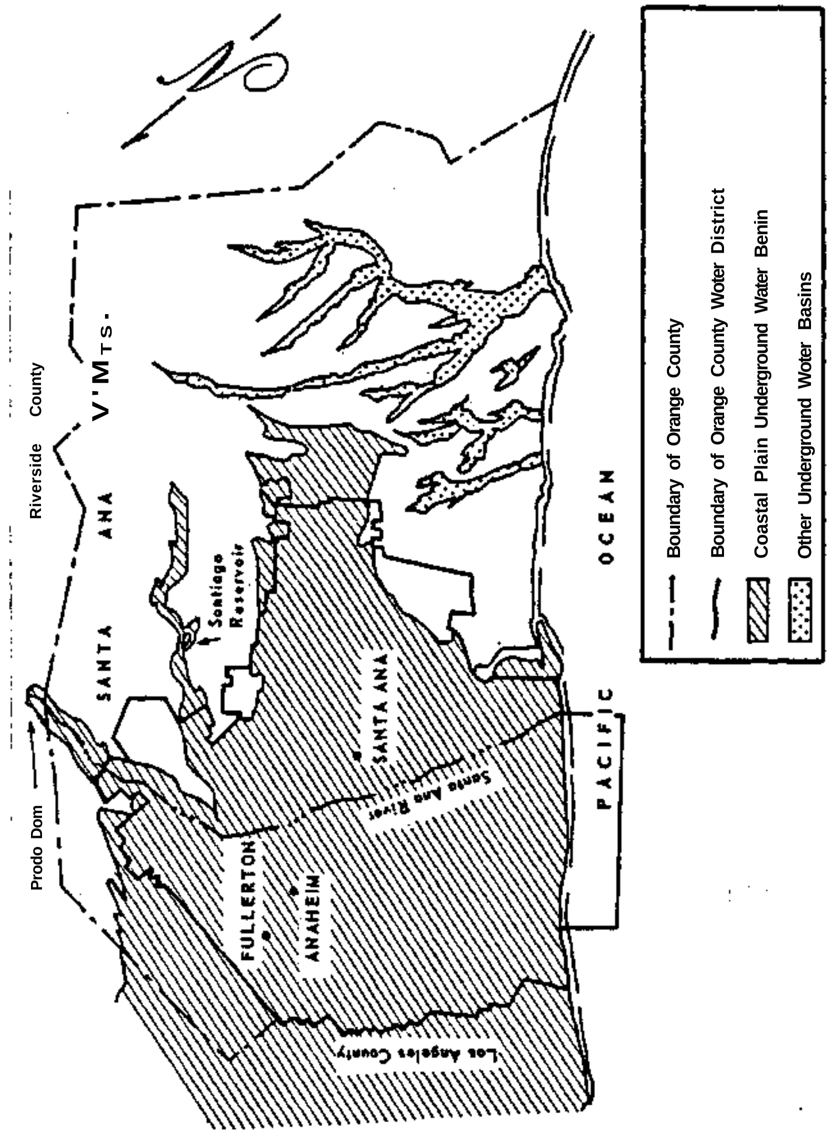
The rule barring Orange County Water District's participation in water rights adjudication in the District Basin is a reflection of an attribute of the Orange County community, an attribute the District's Board and staff have internalized as a fundamental policy commitment. The policy commitment, described as "inviolate," (39) is to the provision of a supply of water in Orange County that will be adequate to meet the demand for water in Orange County, regardless of growth, development, drought, etc. As part of a general "philosophy of plenty" in the County, the District's Board and staff, like other water policy leaders in Orange County, "feel that providing a full and plentiful supply of water is a superior policy to rationing a limited supply." (40)

In the rule prohibiting the District from engaging in an adjudication of water rights, and in the attitude of the community underlying it, lie the source of the "supply-side" approach to water resource management in Orange County. The District has thus been primarily engaged in the business of managing the supply of the ground water within the District boundaries, using taxing techniques to raise money to increase the yield of the basin, borrowing from within the natural physical system and from outside it, and taking actions to protect the basin's sources of recharge. Even when the Orange County Water District has acquired powers that could be used to discourage demand, these powers have primarily been used to enhance supply. Without an adjudication of water rights, and with its "inviolate" policy commitment, Orange County has chosen to manage only the supply side.

Some of the conditions of the establishment of the District placed limitations on its ability to manage the supply side in the absence of demand restrictions. Principal among these conditions was the original boundaries of the Orange County Water District. The District as formed in 1933 covered approximately 156,000 acres in the Orange County Coastal Plain, and so contained most of the overlying owners of the District Basin. However, significant by their exclusion were the Cities of Anaheim, Santa Ana, and Fullerton, and parts of the Irvine Ranch that lay over the basin. Thus, some of the significant users of ground water from the basin were not covered by the original jurisdictional boundaries of the District.

Moreover, as noted earlier, the imposition of political boundaries on the physical water system accentuated resource management difficulties. The Orange County Coastal, or District, Basin, extends into eastern Los Angeles County (see Map 8-5), where ground water producers were beyond the District's reach and yet whose extractions affected ground water levels within the District. (41) The result of this mismatch between the District's boundaries and the Basin's boundaries has been a pumping "hole" at the County border, where a sort of "no man's land" exists in which ground water producers on either side of the border apparently pursue maximum-extraction strategies, reasoning that failure to use the groundwater on one's own side of the border will result in its being used by producers on the other side of the border.

At the same time, the relationship of the District Basin to the Santa Ana River, its main source of natural recharge, places this source of supply beyond the County's and the District's boundaries and exposes those within the Orange County Water District to the upstream



Map 8-5. T[illegible] Coas[illegible] [illegible]
W[illegible]er Di[illegible]

[illegible]: Weschler (1968)

uses of the River, which can reduce inflow to a trickle. (42) The combination of these boundary limitations -- the extension of the Basin into Los Angeles County and the exposure to upstream uses of the River -- makes the Orange County Water District's supply-management problem analogous to that of trying to keep a bathtub full while the drain is stuck open and the water pressure at the faucet is low.

b. Winning A Battle and Losing the War: The District's Basin-Protection Activities Through 1948

The principal concern of the Orange County Water District from its formation in 1933 until 1942 was the prosecution of the Irvine Ranch litigation against the upstream water users. During this period, the District was mainly a taxing unit, coercing contributions from the potential beneficiaries for the provision of a collective benefit, and thus spreading the costs of the litigation. (43) In addition, the District served as a representative in the lawsuit of the interests of the water users in the Coastal Basin area.

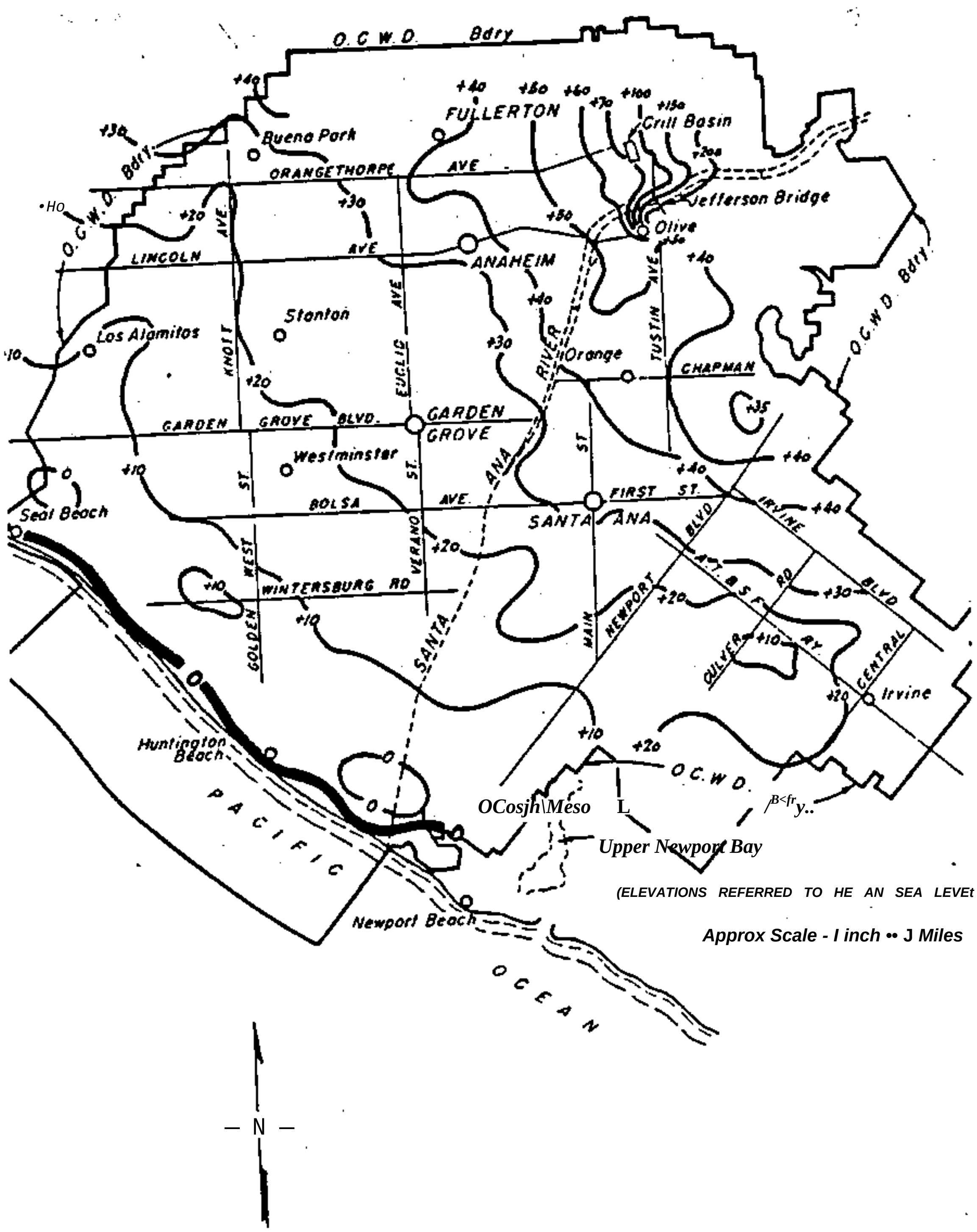
Three favorable judgments were obtained in the U.S. District Court for the Southern District of California in 1942. The judgments were entered upon three stipulations by the parties: the Mill Creek Judgment, the Lytle Creek Judgment, and the Santa Ana River Judgment. Each of these judgments reduced the amounts of water the upstream defendants could divert for spreading and set specific amounts per water year, specified the upstream spreading locations the defendants could use, and placed the administrative and monitoring responsibilities for making sure the amounts specified in the judgments were not being exceeded on the defendants. (44)

Over the same period that the litigation was being successfully pursued, the District and the water users within it found their basin conditions aided by occurrences beyond their control. First, the Depression slowed temporarily the pace of development in Orange County and thus reduced the rate of growth in water demand through the close of the 1930s. Second, the Hoover Dam was completed and dedicated in 1935, giving MWD a supply of water to deliver, and thus beginning the process of bringing a supplemental supply of water to the Cities of Anaheim, Santa Ana, and Fullerton. That process began to bear fruits after the completion of the Colorado River Aqueduct in 1941. Third, the period from 1938 to 1944 was a period of above-average rainfall, a cluster of "wet years" that improved basin supply conditions by increased natural inflow and percolation. This combination of events temporarily stalled the decline in ground water conditions during and after the successful prosecution of the Irvine lawsuit.

The other principal activities of the Orange County Water District during the litigation period were improvements of the recharge capacities of the basin. In cooperation with the Orange County Flood Control Distict, the OCWD engaged in rechanneling and improvements of stream beds to increase percolation of surface water into the District Basin, thereby improving the recharge potential of runoff and storm flows. (45) After a destructive flood in 1938, marking the beginning of the wet cycle, the Orange County Flood Control District and the U.S. Army Corps of Engineers undertook the construction of Prado Dam, at that point in the Santa Ana Canyon area where the Santa Ana River system narrows and flows from the upstream counties into Orange County. Prado Dam was completed in 1941, and has become a significant instrument for the Orange County Water District's supply management program, allowing for the conservation and controlled release of water into the Coastal Plain.

After the successful conclusion of the Irvine lawsuit and the resulting increase in inflow into the Coastal Plain, the improvements made in the recharge capabilities of the Basin, and the cycle of wet years in the late 1930s and early 1940s coupled with a reduction in growth of demand, groundwater conditions in the District Basin reached a level in the 1944 water year that has served ever since as a benchmark of desirable supply conditions. Map 8-6 shows the water level elevations within the District in 1944. Those water levels were sufficiently high to create economically favorable pumping lifts, and were at or above sea level along the Pacific coast, thereby effectively halting the sea water intrusion that had begun in the 1920s and continued in the 1930s. Even the water levels along the Los Angeles County border were favorable. This 1944 "profile" has continued to the present to be the desired state of affairs for the groundwater conditions in Orange County.

This successful point reached in 1944 turned out to be a precipice. The 1944 water conditions were subsequently revealed to be more the product of the uncontrolled, "fortunate" factors at work in the 1930s and early 1940s than the product of the actions of the District and Orange County water users. When the "good fortune" of slowed growth in demand and enhanced natural supply stopped after 1944, water levels went into a decline that was not arrested until 1956. Basin conditions changed so markedly that it is now conceded that 1944's profile is no longer an attainable goal despite its



Map 3-6. Orange County Ground Water Elevations, 1944

Source: Orange County Water District Annual Report, 1965

desirability.

As already noted in connection with the other cases, the 1944-45 water year marked the beginning of an extended period of dry years lasting until the late 1960s. At the same time, the close of World War II brought to an end the fifteen-year pause in the Orange County development boom. The postwar period's beginning was also the onset of a series of annual overdrafts of the District Basin akin to the situation during the 1923-1936 drought period. By 1948, annual ground water extractions had reached 250,000 acre-feet, an annual overdraft of approximately 100,000 acre-feet, a pace that would have completely eliminated the active usable storage capacity of the District Basin over 15 years. In the period from 1945 to 1948, the average elevation of ground water in the District Basin fell from 20 feet above sea level to 5 feet above sea level, with the levels near the ocean falling below sea level. Sea water intrusion began again, threatening the quality of water along the coast and spreading inland.

The supply-management program of the Orange County Water District from 1933 to 1948 had been oriented to protecting the Coastal Basin itself, with the presumption that the natural physical system might suffice to provide the "full and plentiful" supply of water for Orange County. The actions taken during this period were to restore natural inflow through the prosecution of the Irvine Ranch litigation against upstream diversions, to control flooding and conserve storm flows and improve the percolation of that inflow into the District Basin, and thus generally provide the conditions for the natural replenishment of the ground water supply.

However, as rapid development resumed, and as a cycle of years of above-average rainfall gave way to a cycle of years of below-average rainfall, it became apparent that, in the absence of an upper limit on demand, a supply-oriented resource management program based on natural replenishment could not ensure the desired water supply for Orange County and at the same time protect the ground water quality. The Irvine judgments were not sufficient to sustain the water supply of the County. Moreover, it also became clear that the amount of MWD water available to Anaheim, Santa Ana, and Fullerton would not be sufficient to keep them from continuing to use substantial amounts of ground water. (46) From 1944 to 1951, the average water levels in wells dropped 38 feet (see Figure 8-1). Wells along the coast began to be abandoned (47), as the line between fresh and brackish groundwater moved inland eight thousand feet in the five years from 1945 to 1950 (48). Despite the District's basin-protection measures, and the use of all available stream water for replenishment of the basin, the basin was facing serious deterioration as a valued resource, and the economic value of rights to use that resource was in jeopardy. Each District action during this period had been a success, yet the war -- the preservation of a valued resource -- was being lost.

B.5. The District's Supply Management Program, 1949-1964

Natural replenishment was insufficient; Orange County would require artificial replenishment. Artificial replenishment would require a source of imported water. Importing water would require (a) money, and (b) some source of access to that imported supply. These requirements, in turn, necessitated some institutional design, and

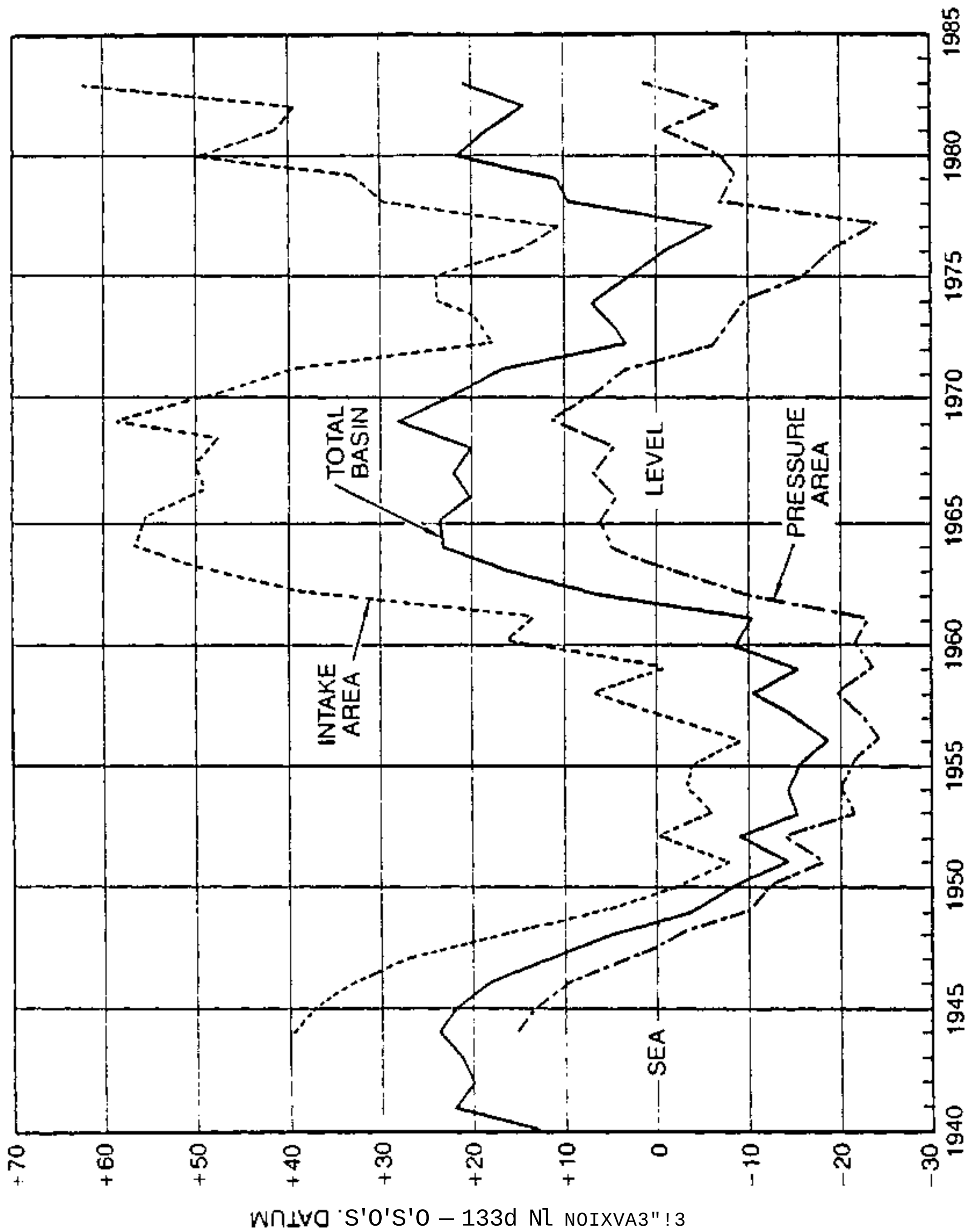


Figure 3-1. Average Water Levels in Orange County Basin.

Source: Orange County Water District Annual Report, 1933

re-design, in Orange County. That took time, time during which conditions of the District Basin continued to worsen. That compounded the replenishment task as the District pursued its principal supply-management orientation of this period: filling the basin.

a. Artificial Replenishment Begins, 1949-1953

When the Orange County Water District was created in 1933, it had been given by the California Legislature the power to tax the property owned within its boundaries. This ad valorem tax was the only fund-raising mechanism used by the District through the basin-protection period and on into the basin-replenishment period. The District had been authorized also to levy a special assessment against property if approved in a special election, and to issue bonds, but the District's Board of Directors had not sought to use either of these revenue powers, funding the District's operations entirely from the general ad valorem assessment. The Board of Directors continued this practice when they began to import water for artificial replenishment, funding the purchases from ad valorem revenues.

The District began its purchases of replenishment water with a special allotment of Colorado River water from MWD during the 1948-49 water year. The MWD water was directed into the Prado Reservoir behind the Prado Dam (actually outside of Orange County), and then released into the surface stream beds that the District had improved for percolation during the earlier joint operations with the Orange County Flood Control District. Because the Orange County Water District was not a member agency of MWD, MWD would not directly sell water to the Orange County Water District on a regular basis. Therefore, when replenishment purchases by OCWD continued in the 1949-50 and 1950-51 water years, they continued by going through the MWD member agencies within the County -- the Cities of Anaheim, Santa Ana, and Fullerton, and the Coastal Municipal Water District (which had been formed in 1942 in some coastal areas not originally included in OCWD, and which had annexed to Metropolitan, using the same process followed later by Foothill MWD, West Basin MWD and Central Basin MWD). In 1951, the Municipal Water District of Orange County was formed and annexed to MWD, taking into MWD more of the assessed valuation of Orange County. The Municipal Water District of Orange County became the principal pass-through for MWD replenishment water to the OCWD.

Thus, the Orange County Water District had secured the institutional infrastructure for its acquisition of imported Colorado River water from MWD for replenishment. MWD was still, at this stage, interested in securing purchases of its Colorado River water so as to perfect its right to the water in the event of future challenge, so availability of replenishment water was not a limitation on OCWD's replenishment activities as of 1951. The limitation OCWD faced was lack of adequate funding to purchase sufficient replenishment water from MWD.

Within the confines of its revenue-raising powers granted by the State Legislature, the Orange County Water District had only the option of increasing ad valorem tax revenues in order to purchase more water from MWD. Additional purchases were necessary because the amounts of replenishment water purchased in water years 1949-50 to 1952-53 averaged about 28,000 acre-feet per year, far insufficient to make up annual overdrafts approaching 100,000 acre-feet per year. By the end of June 1953, the average elevation of ground water throughout the District Basin had declined still further to 15 feet below sea level.

A special assessment, and the use of increased ad valorem revenues generally, was problematic for a variety of reasons. First, the special assessment would require a special election. This was a risky proposition, itself requiring the diversion of scarce District resources for an uncertain outcome, especially since the special assessment would have to be large in order to purchase enough replenishment water to stop the decline in water levels. Second, it was clear that additional replenishment purchases would have to be sustained for the foreseeable future and beyond; thus, no claim for the special assessment could be made that it was somehow "temporary," to meet some immediate emergency. Third, the ad valorem tax itself was questionable as a source of funding replenishment activities of the District. Those property owners already annexed to MWD were paying ad valorem taxes to MWD for the acquisition and transportation of the Colorado River water that they were then paying ad valorem taxes to OCWD to purchased from MWD; correctly or not, there was some perception of paying for the same water twice. Moreover, those property owners in areas annexed to MWD were paying this perceived "double tax" to benefit those property owners in areas of the OCWD that were not yet annexed to MWD and who were thus paying taxes only to OCWD for the replenishment water (49). In addition, use of the ad valorem tax drew revenue from non-pumping property owners to pay for replenishment activities that primarily benefited pumping property owners, and thus constituted a subsidy to ground water producers (50).

The alternative of not replenishing the basin with imported water, or of not replenishing it sufficiently to halt the decline in water levels and the spreading intrusion of sea water, was also undesirable. The spread of sea water into the basin threatened to render the considerable assets in wells and pumping equipment worthless, not to mention the assets in property watered by those wells and pumps. For the groundwater producers farther inland (and thus less immediately threatened by salt-water encroachment), a 38-foot decline in the underground water elevations increased pumping lifts and costs in those wells that could still reach groundwater, and rendered worthless those wells that could no longer reach groundwater at all. Depletion, if it continued apace, threatened reservoir compaction and possible land subsidence. Finally, a loss of the underground water supply would mean its replacement with a surface delivery system to provide direct supplies of imported water, and the construction of such a system of feeders and pipelines would be a massive financial undertaking that could be avoided if the system of groundwater use already in place were preserved. The option of a replenishment program that would use the basin itself as the system for storage and distribution of imported water was an economically preferable alternative. (51) The unresolved question was how to fund and implement the replenishment program.

b. Re-Designing the District, 1952-1953

This basic puzzle -- how to institute a replenishment program to preserve the District Basin and avoid constructing an entire surface-delivery and surface storage system, and how to fund that program -- was the subject of a joint meeting in 1952 of the Water Problems Committee of the Orange County Farm Bureau, the Water Committee of the Associated Chambers of Commerce, and the Board of Directors of the Orange County Water District. For intensive consideration of this puzzle, and development of a set of recommendations for a water resource management program for Orange County, a twelve-man Orange County Water Basin Conservation Committee was formed. (52)

The Orange County Water Basin Conservation Committee pursued the same basic policy commitment that has undergirded water resource management in Orange County throughout its history -- the commitment to a philosophy of plenty rather than scarcity. Thus, the Committee rejected two of three basic policy alternatives: one, centralized control over water consumption and distribution by some public agency empowered to enforce conservation; two, adjudication and limitation of water rights through the employment of the court-reference procedure (53) . To pursue replenishment of the basin without following either of these directions meant replenishing the basin while leaving pumpers basically free to pump. Funding a replenishment scheme subject to that constraint solely from ad valorem taxes was, as noted above, problematic in that pumpers were subsidized by non-pumpers, pumpers' incentives would aggravate the overdraft problem and the replenishment task, and non-MWD pumpers and non-pumpers would be taxed once for provision of MWD replenishment water for which MWD pumpers and non-pumpers would be taxed twice.

The Committee was, however, attracted to a proposal to fund replenishment by taxing pumping. Taxation of pumping to provide basin replenishment held the promise of raising the necessary funds, relating pumpers' taxation to their benefits received, relieving non-pumpers from paying for replenishment except to the extent that they purchased water from groundwater producers and thus benefited from improved basin conditions, and yet not inducing more pumping but indeed building in a conservation incentive without mandating conservation.

The Orange County Water District was already engaged in a basin replenishment program, but was not empowered to impose such a use tax. It would be necessary to gain such power for the OCWD by amending the Orange County Water District Act. Once this threshold was crossed, a package of amendments was assembled by the Committee of Twelve that amounted to a considerable re-design of the District as an institution for water resource management. Institution of a pump tax would require measurement and records of water production from the thousands of wells within the District. Every well would have to be recorded and monitored, just as is necessary with real property for the imposition of an *ad valorem* tax. Thus, an amendment was proposed requiring every producer of ground water within the District to register wells with the OCWD and to record and submit ground water production to the District twice per year. Such a change not only made possible the implementation of the pump tax, but also vastly enhanced the monitoring capacity of the OCWD.

The Committee also proposed an important enlargement of the territory of the District, with a related change in the District's Board of Directors. The Cities of Anaheim, Santa Ana, and Fullerton remained major producers of ground water from the District Basin, despite their access to MWD water imports. Their continued exclusion from the Orange County Water District could not be supported since they would receive considerable benefit from the OCWD's replenishment program. The Orange County Water District was enlarged to include the three cities, and the Board of Directors of the District was expanded from seven members to ten, allowing each of the three cities to appoint a Director to the District. Portions of the basin owned by the Anaheim Union Water Company and the Santa Ana Valley Irrigation Company near the Canyon were also to be added to the District.

Furthermore, the Committee proposed that an annual district engineer's report on basin conditions and groundwater production be submitted to the District and water producers. This provision would allow for monitoring of the effects of the replenishment program, and would also provide a shared picture on a regular basis of the condition of the basin, including the extent of sea water intrusion and the elevation of the water table.

A limited ad valorem tax provision was also made part of the Committee's recommendations. This was to help offset some of the overhead or administrative expenses involved in starting up the pump tax program. In addition, the ad valorem tax would be used to purchase some replenishment water. The amount of replenishment water to be purchased was up to 375,000 acre-feet, an amount equivalent to 1953 estimates of the accumulated overdraft of the basin. Since the accumulated overdraft had occurred during the three prior decades, the Committee decided it was appropriate to assess all property owners in the District to make up for the past overdraft conditions rather than just the current and future pumpers, especially in light of the territorial expansion of the Distict to include those who had previously been placing heavy demands on the basin without paying the

ad valorem tax. Nonetheless, the ad valorem general assessment was lowered from 15 cents to 8 cents per $100 of assessed valuation, and the provisions for a special assessment would be dropped from the District Act.

These recommendations of the Orange County Water Basin Conservation Committee were formulated as a bill to amend the Orange County Water District Act. Those amendments were introduced into the California Legislature and passed by it in 1953. With the required registration of wells, the use of ad valorem tax revenues to purchase replenishment water to replace the accumulated overdraft, and the availability of the pump tax (known formally as the "replenishment assessment") to fund the ongoing replenishment program, the Orange County Water District "now had the organizational and fiscal powers necessary to manage the ground water basin." (54) The District's Board of Directors first voted to levy a replenishment assessment as authorized by the amended Act on June 9, 1954.

The replenishment assessment -- the "pump tax" -- was formally challenged as unconstitutional in the Superior Court of the State of California in and for the County of Orange in 1954. The Superior Court upheld the 1953 Amendments. The judgment was appealed to the Fourth District Court of Appeal for the State of California, which affirmed the Superior Court judgment in January 1956. The case was not further appealed. Thus, a pump tax system, first used in California by the Orange County Water District, was adopted by the

California Legislature and withstood a constitutional challenge, and has "since become a popular way to deal with the common-pool problem, and is now used by several public water districts." (55)

The administration of the pump tax system relies heavily on self-monitoring by water users and minimally on monitoring by Orange County Water District staff. Each producer of ground water files a statement every six months with the OCWD, reporting the amount of ground water production as measured by a meter attached to each of the producer's registered wells. On the basis of the six-month statement, the District assesses the producer the appropriate sum, which is the product of the replenishment assessment (in dollars per acre-foot) and the quantity of water pumped (in acre-feet). The District engages a full-time employee in randomized meter readings. The ground water production statement, if questionable, may then be checked by a District inspector who forms an estimate of how much water was pumped at a well by checking the among of electrical power used at a particular pump during the six-month period. If a considerable discrepancy maintains, the District may investigate further. (56) There are penalties for operating a pump while failing to accurately report production. An offender may be fined $500 or be imprisoned for six months, and each day of operation in violation constitutes a separate offense. It has not been necessary to assess these penalties against any producer.

The pump tax in Orange County, unlike the pump tax in Central and West Basins, operates without a ceiling on water production. Individual water production is not restricted in Orange County, so the pump tax represented the only demand-side management tool of the

Orange County Water District after the 1953 Amendments. Because adjudication of ground water rights has not occurred in Orange County, each water producer may pump as much water as is desired, in light of that producer's own comparison of revenue and production costs. The pump tax enables the District to purchase water to sink underground to offset the extraction of that producer. As such, the pump tax adds to the production costs of the producer, and thus represents an effort to re-internalize some of the external costs of ground water production.

The effect of the pump tax thus could be to reduce ground water production if the tax were sufficiently high to reduce the differential between revenue and costs at the margin; that is, provided the producer cannot shift 100 percent of the tax onto consumers. For any producer who is producing for his own consumption alone, the pump tax will tend to reduce production; for producers who are retailing the water they produce, the solution is not determinate but depends on the competitive setting of the market and the likelihood of substitution by consumers.

On the other hand, if the use of the replenishment funds is to purchase sufficient water to replace in the basin the amount that a producer has extracted, and if pumping lifts are the principal component of groundwater production costs, then a pump tax used for replenishment purposes will also have the effect of keeping production costs lower than they otherwise would have been if pumping lifts had continued to increase. If the replenishment program funded with a pump tax, and operating without an enforced ceiling on demand, is of sufficient magnitude to fully replace the extractions of the producers, then the question becomes one of relative additions to production costs: if the amount per acre-foot of the replenishment assessment is lower than the additional cost per acre-foot of the greater pumping lift faced by the producer, the effect of the replenishment assessment is to lower production costs and thus to provide an incentive for greater groundwater production.

Groundwater producers will vary from one another in their relative efficiency of production, the production costs they incur, the pumping lifts they face, the extent to which they retail the water they produce, and the extent to which their customers (for those who do sell water) can be charged the amount of the pump tax. As a result, a pump tax and the replenishment program it finances will have different effects on different water producers -- for some, who can "pass along" the pump tax to their customers, while at the same time benefitting from restored water levels and smaller pumping lifts, there will be no disincentive effect on production of ground water. The pump tax is thus not a very precise tool of demand-side management. Only when set high enough to push the cost of water at the consumption stage beyond the value of that water to consumers will consumption, and hence production, be curtailed significantly. If the demand for water is inelastic over the relevant range (as there is reason to believe it would be in a semi-arid commercial-residential area with a high median income), the pump tax may have to be quite high indeed to accomplish a significant reduction in groundwater production.

In practice, the Orange County Water District has not set the replenishment assessment at such a high level. There are four reasons for this:

(1) the policy commitment of the District to providing a plentiful water supply rather than restricting consumption,

(2) the amount of the pump tax is bounded above by the Orange County Water District Act, and increases above that upper bound have required either amendment of the Act by the State Legislature or an extraordinary majority (8 of 10) of the District's Board of Directors;

(3) increases in the pump tax have been unpopular with ground water producers, who are the primary constituency of the OCWD, leading the Board to be wary of raising the assessment except in small annual increments; and

(4) the District is not allowed to be discriminatory in the amount of pump tax charged, so that a rate high enough to curtail pumping in certain troughs within the Basin would have to be levied on all producers within the Basin regardless of the elevation of the water table in their locales. (57)

Thus, for reasons related to the attributes of the community, the rules governing District decision-making and rules affecting the production behavior of users, this one potential demand-side management mechanism, imprecise though it may be, has not actually been employed as part of a demand-management policy by the OCWD. Each year, the pump tax has been set by the Board of Directors at whatever level was necessary to buy enough replenishment water to restore the average annual overdraft from the preceding five years plus one-tenth of the accumulated overdraft (58). Pump tax rates are shown in Table 8-2. The guiding considerations for the setting of the pump tax level have been supply needs rather than demand management. So, "the pump tax program of the OCWD does what most people in Orange County expect it to do: it provides a relatively steady supply of ground water." (59) The provision and protection of ground water supply remains the objective of the District, even though the 1953 Amendments gave the

TABLE 8-2

Orange County Water District Replenishment Assessment ("Pump Tax") per Acre-Foot, 1955-1985

Year	Replenishment Assessment	Year	Replenishment Assessment
1955	$3.50	1971	10.00/13.00
1956	3.50	1972	10.00/13.00
1957	3.90	1973	10.00/13.00
1958	3.90	1974	10.00/17.00
1959	3.90	1975	10.00/17.00
1960	4.30	1976	12.00/22.00
1961	5.50	1977	12.00/25.00
1962	6.00	1978	12.00/26.00
1963	8.00/11.00*	1979	12.00/30.00
1964	8.00/11.00	1980	17.00/30.00
1965	8.00/11.00	1981	17.00/30.00
1966	8.00/11.00	1982	15.00/21.00
1967	8.00/11.00	1983	14.00/21.00
1968	9.50/12.50	1984	23.00/32.00
1969	10.30/13.30	1985	23.00/32.00
1970	10.00/13.00		

*-- First rate is per acre-foot of water for irrigation, second rate is per acre-foot of water for non-irrigation use.

Source: Orange County Water District Annual Reports

District a potential demand-management mechanism in the pump tax.

c. Basin Protection II: Orange County Water District v. Riverside

The Orange County Water District had entered the Irvine litigation as intervenor following the District's creation in 1933. Eighteen years later, the District utilized its powers under the District Act to initiate a legal proceeding as plaintiff on behalf of the District Basin water users. In 1951, as the limitations of the District's ability to replenish the Basin were becoming obvious and just before the re-designing of the District's powers, the Orange County Water District sued upstream appropriators of the Santa Ana River flows. This time, the defendants were four upstream cities in the Santa Ana River Watershed -- Riverside, San Bernardino, Colton, and Redlands (for their various locations in the Watershed and relative to Orange County, refer back to Map 8-3).

This was the second downstream-upstream litigation in the Santa Ana River Watershed. The District was seeking to place a ceiling on production by these four large upstream users to protect the natural flow into Orange County (60). The use of surface and ground water by these cities had continued to increase, in part because of failure to annex to MWD and obtain supplies of supplemental water -- San Bernardino, for example, had just failed for the second time to obtain voter approval to annex to MWD. The complaint of the Orange County Water District filed in 1951 alleged that the four defendant cities had for years been taking water from the watershed, and that either they had no such right to the water or whatever right they had was subordinate to the District's rights. The relief requested in the complaint was a declaration of the water rights of each City, but not of the District, and an injunction prohibiting each City from taking water in excess of its declared right.

The case of Orange County Water District v. City of Riverside et al. did not reach trial until six years later, in 1957, after the 1953 Amendments had changed the District considerably. In the interim, the defendant cities had lost at virtually every stage of the pre-trial process. Their demurrers were overruled, then their motions for dismissal were denied, then their motion for judgment on the pleadings was denied. The defendants moved for a reference of the case to the State Water Rights Board, and this motion for reference was denied, too. The case proceeded to trial, which lasted for 114 days in 1957.

The judgment issued by the Superior Court after that trial clearly favored the Orange County Water District. The District's allegation that the Cities had no right to any of the waters of the Santa Ana River Watershed was not upheld by the court. The Court ruled that the defendants had indeed acquired and perfected prescriptive rights to some of the water by adverse possession. But the relevant period of adverse possession for the purpose of determining the declared rights was established as the five-year period prior to the initiation of the lawsuit, or the period from 1946 to 1951. And the declared right of each City was limited to the amount of its taking in the first year of that five-year period. Thus, each City in 1957 was enjoined from taking water from the Santa Ana River Watershed in excess of the amount it had taken in 1946. This meant for each City a reduction in use of the flows of the Santa Ana River System, and had the effect of forcing them into MWD in order to obtain supplemental water. For the

OCWD, inflow into the District Basin had once again been increased and protected, thus assisting in the program of replenishing the Basin.

The 1957 trial court judgment was appealed by the defendant cities twice. Each time, the District Court of Appeals upheld the judgment while ordering some modifications in the amounts of the declared rights of the defendant cities. After the second appeal came to the same end as the first, in 1961, the cities did not appeal again, and Round II of the upstream-downstream litigation battle ended ten years after it began.

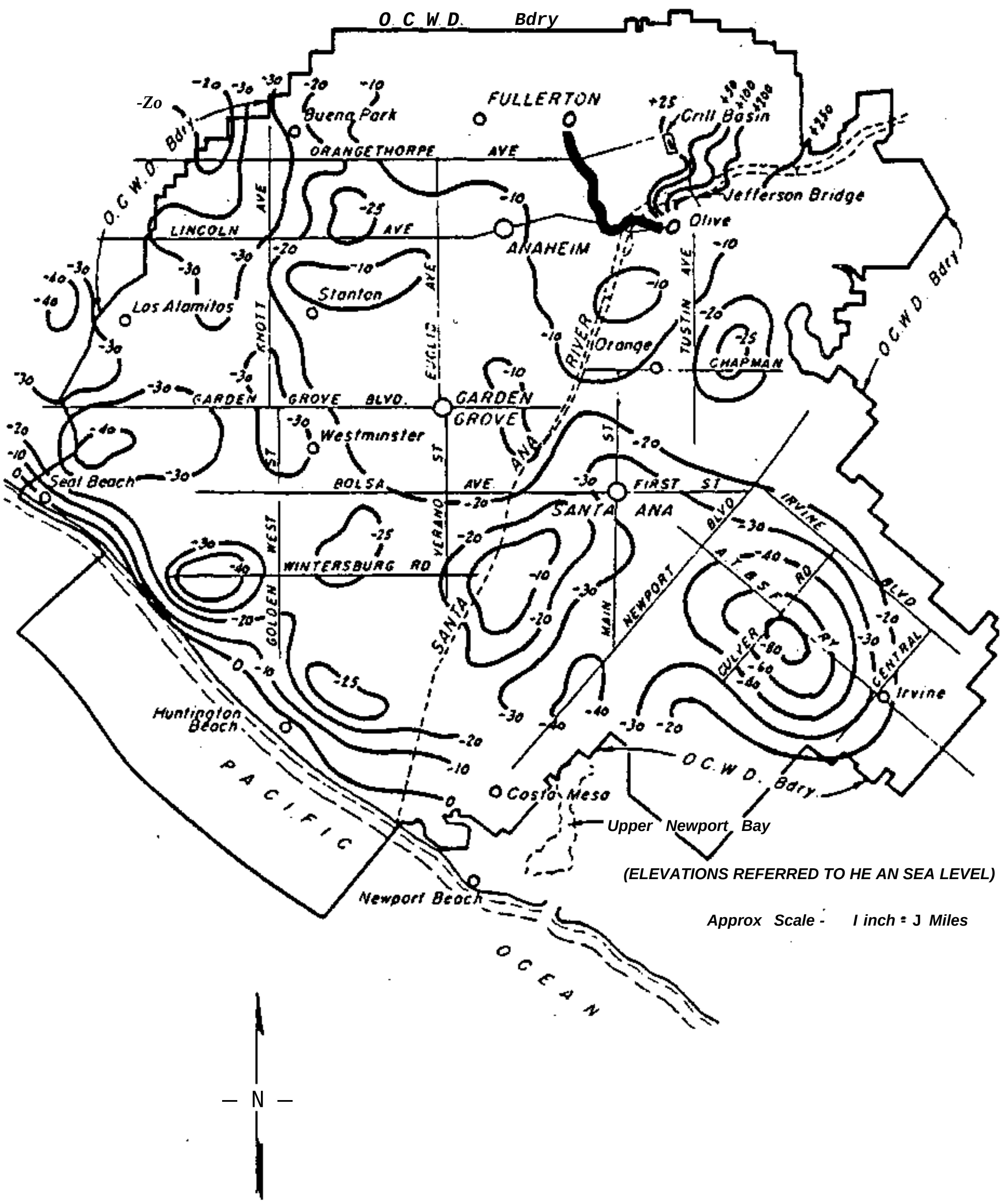
d. "Fill the Basin": 1954-1964

Of course, throughout the period of the litigation against the four upstream cities, the replenishment program of the District continued, and the 1953 Amendments gave the District the territory and taxing powers enabling it to pursue a much more intensive replenishment activity. Replenishment of the Basin was the principal programmatic emphasis of the OCWD from 1948 to 1964, but in the period after the 1953 Amendments that program was aggressively pursued, and has been referred to as the "fill-the-basin" policy (61).

The Orange County Water District was confronted in the 1940s and early 1950s with a period of drought, a falling water table, and increasing sea-water intrusion. The period of the "natural replenishment" program, from 1948 to 1953, had not brought appreciable improvement: water levels continued to fall, the accumulated overdraft of the basin continued to escalate, and sea water further invaded the basin. By 1954, the first year of operation after the 1953 Amendments, the accumulated overdraft was estimated to be 373,000 acre-feet (62).

At that point, with the combination of the ad valorem tax and the replenishment assessment or pump tax, the District began to purchase, through the five member agencies of MWD within Orange County, as much MWD water as it could for replenishment. The District faced a configuration of three limits on its purchases of MWD water: (a) how much it could afford; (b) how much it could store and spread; and (c) how much MWD had available to sell. Operating within those constraints, the District increased its purchases of replenishment water. The aim was to fill the basin as rapidly as possible to restore the 1944 water levels, for two reasons: first, the long-term future availability of MWD water was not certain; second, filling the basin and restoring the 1944 levels was the plan for halting sea water intrusion (63). The increase in purchases was rapid and large: in 1954, the five MWD member agencies in Orange County bought 48 percent of the water MWD delivered in southern California, though their combined entitlement was to 7 percent of the water (64).

The fill-the-basin program took a couple of years, even after the availability of the pump tax, to take hold and reverse the decline in water levels and sea-water intrusion. 1956 was the historic low point for the basin; 1956 is regarded with the same historic significance from a negative standpoint as is 1944 from a positive standpoint. Figure 8-1 shows the average water levels in the District Basin; by 1956, the average water level of the Basin as a whole was nearly 20 feet below sea level. As Map 8-7 indicates, water levels near the coast and along the Los Angeles County border were as much as 40 feet below sea level. In the Irvine Ranch area in the southeast part of



Map 8-7. Orange County Ground Water Elevations, 1956

Source: Orange County Water District Annual Report, 1965

the District, there was a pumping hole of 80 feet below sea level. The accumulated overdraft by 1956 has been variously estimated from 500,000 to 700,000 acre-feet, between one-third and one-half of the active usable storage capacity of the basin (65). Sea water had advanced three and one-half miles inland.

After 1956, the drought continued, and groundwater extractions continued to rise, but water levels in the Basin began to recover. Replenishment water purchases escalated to roughly 83,000 acre-feet in 1957, to 144,000 acre-feet in 1960, to 235,000 acre-feet in 1963 (see Table 8-3). Replenishment inputs exceeded natural inflow from the Santa Ana River each year from 1957 through 1964.

The District managers of the fill-the-basin policy sought during this period to relax some of the constraints under which the policy operated. They could not make more MWD water available; then, as before and as now, the District and the people of Orange County were dependent on a source of water over which they have no control. But they could, and did, increase the funds devoted to replenishment purchases, from $500,000 in 1954 to $830,000 in 1957 and $3,200,000 in 1964, devoting both replenishment assessment and *ad valorem* funds to this purpose (in spite of the "subsidy" issue). And they embarked on a program of constructing off-channel spreading facilities to supplement the recharge capabilities of the Santa Ana Riverbed and the improvements thereto in the previous two decades. In 1957, the District began purchasing land and excavating spreading basins. The first was the Crill Basin, now known popularly as "Anaheim Lake," an 80-acre spreading facility into which surplus water could be diverted for percolation. The Crill Basin is jointly operated by the District

TABLE 8-3

Orange County Replenishment Water Purchases and Costs, 1950-1982

Year	Colorado River Water	State Project Water	In-Lieu Program Water	Total Cost ($)
1950	22,726	0	0	181,805
1951	22,183	0	0	221,831
1952	39,177	0	0	391,774
1953	27,956	0	0	279,561
1954	50,000	0	0	500,000
1955	67,789	0	0	621,626
1956	20,916	0	0	209,159
1957	82,955	0	0	829,548
1958	77,145	0	0	925,738
1959	81,710	0	0	980,520
1960	144,471	0	0	1,733,657
1961	165,118	0	0	2,044,158
1962	174,916	0	0	2,294,895
1963	234,789	0	0	3,247,136
1964	185,439	0	0	2,712,971
1965	132,367	0	0	2,018,592
1966	116,820	0	0	1,869,115
1967	114,422	0	0	1,945,169
1968	92,452	0	0	1,664,127
1969	53,373	0	0	1,014,091
1970	85,664	0	0	1,713,282
1971	56,386	0	0	1,240,483
1972	35,325	0	0	847,805
1973	53,764	4,142	0	1,584,169
1974	49,412	42,795	0	3,161,047
1975	52,633	46,151	0	3,266,993
1976	14,914	73,802	0	3,578,648
1977	15,470	16,753	0	1,270,703
1978	35,714	93	48,290	2,206,894
1979	43,824	11,718	23,792	3,457,925
1980	21,765	21,765	25,180	2,325,729
1981	16,510	16,510	36,373	1,994,445
1982	16,440	16,440	0	2,002,488
1983	7,410	7,410	0	1,170,780
1984	7,907	7,907	0	4,089,755
1985	16,367	16,367	0	6,016,069

Source: Orange County Water District Annual Reports

as a spreading facility and by the City of Anaheim as a recreational facility. The City stocks the "Lake" with fish and raises the operating revenue of the facility from user fees charged to those who fish and boat there (66). With annual overdrafts running at roughly 100,000 acre-feet and an accumulated overdraft of 500,000 acre-feet or more to retire, the District's personnel worked to develop a system of spreading facilities capable of accommodating up to 200,000 acre-feet per year. By 1962-1963, they purchased and spread nearly 235,000 acre-feet of replenishment water.

The success in raising water levels through 1964 was aided by another phenomenon, a decline in groundwater production, both in absolute and relative terms. While total production rose 16 percent from 1954 to 1964, groundwater production declined 12 percent, and groundwater production as a percent of total water production declined from 92 percent to about 68 percent (see Table 8-4).

There were three principal reasons for this absolute and relative decline, even though the drought continued through this period. First, through this period an increasing amount of the area in Orange County was annexed to MWD (such that by 1960, 99% of the assessed valuation of Orange County was in the Metropolitan Water District), enabling users throughout the Basin who chose or were induced to obtain a supplemental water source to do so -- Figure 8-2 reflects the climb in imported direct service water from 1956 to 1964. Second, the Orange County Water District, while not employing an demand management program of its own, nonetheless formally encouraged those water producers who had access to imported water to use it, at least for half their supply during the fill-the-basin effort of the OCWD (67).

TABLE 8-4

Orange County Groundwater Production and Total Water Obtained (in Acre-Feet), 1953-1985

Year	Groundwater Production	Total Water Obtained	Groundwater Percentage
1953	213,800	230,386	92.8
1954	210,000	229,113	91.7
1955	148,224	173,281	85.5
1956	153,677	181,822	84.5
1957	186,025	233,290	79.7
1958	160,247	203,724	78.7
1959	208,572	260,587	80.0
1960	207,448	278,605	74.4
1961	226,025	309,188	73.1
1962	177,172	255,190	69.2
1963	186,093	273,285	68.0
1964	188,603	290,039	65.0
1965	179,798	283,278	63.5
1966	182,172	272,813	66.8
1967	169,375	264,295	64.1
1968	193,656	303,860	63.7
1969	178,798	288,413	62.0
1970	194,379	331,660	58.6
1971	203,923	337,763	60.4
1972	229,048	372,737	61.5
1973	214,983	332,960	64.6
1974	218,863	353,723	61.9
1975	225,597	356,256	63.3
1976	245,456	399,728	61.4
1977	243,511	392,919	62.0
1978	188,407	347,290	54.3
1979	213,290	376,797	56.6
1980	221,453	402,129	55.1
1981	228,943	445,308	51.4
1982	244,184	416,463	58.6
1983	249,548	392,480	63.6
1984	223,207	450,130	49.6
1985	252,070	414,000	60.9

Source: Orange County Water District Annual Reports

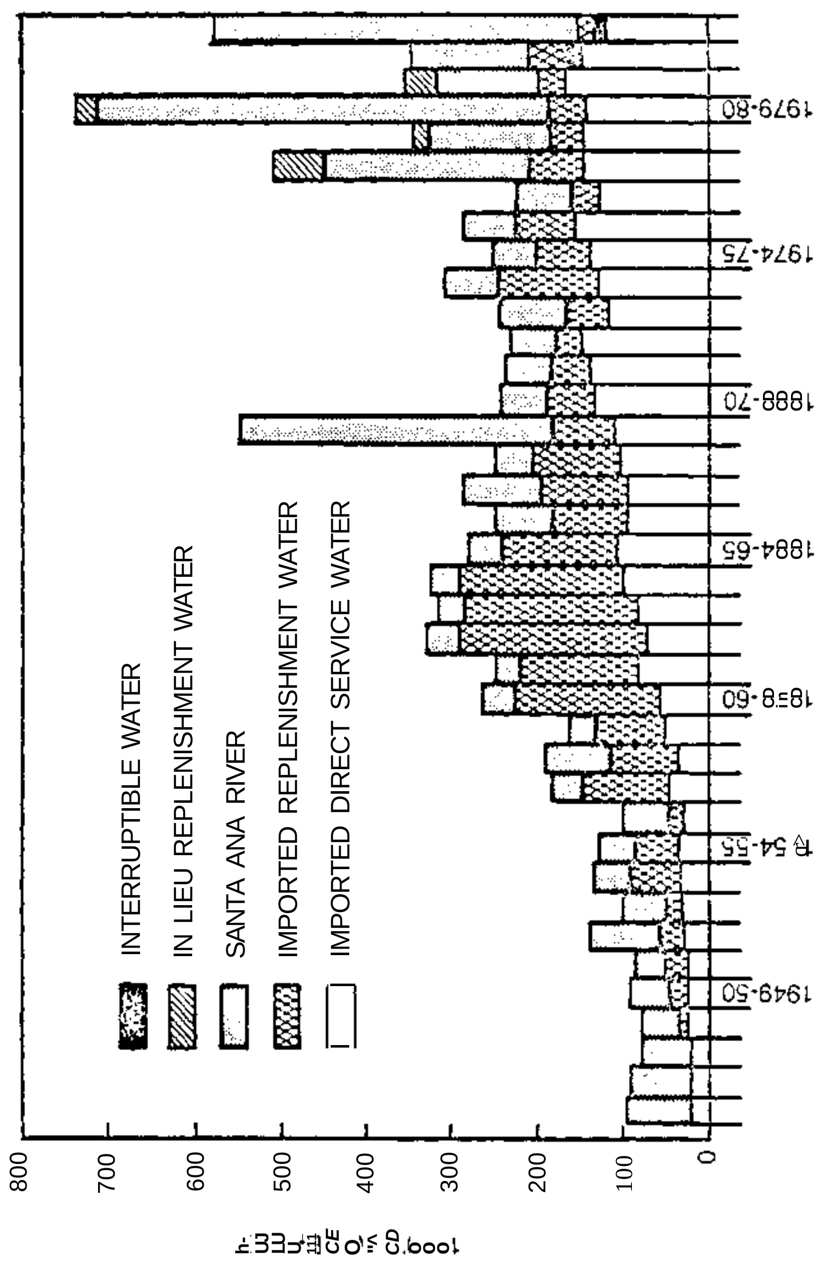


Figure 8-8. Non-Local Water Supply to the Orange County Water District

Source: Orange County Water District Annual Report, 1985

This was basically a "jawboning" effort by the District, carried on in an informal way with neither sanctions nor inducements. Third, this period, 1954-1964, was the period of most intensive urbanization of the area, as thousands of acres of agricultural land were redeveloped for residential and commercial use. Production of groundwater for irrigation use fell considerably from 1954 to 1964, and was cut almost in half in the three years from 1961 to 1964, as seen in Figure 8-3. Irrigation had placed a considerable demand on the basin supply since the early decades of the twentieth century, and in the 1960s irrigation demand abated rapidly just as replenishment activities were peaking.

Throughout the fill-the-basin period, Orange County became increasingly dependent upon imported water. The only source of that imported water was (and is) MWD. By 1960, the people of Orange County were using 59% more water than the District Basin could safely provide, yet they were drawing 75 percent of their supply from the Basin. In spite of this overdraft, basin water levels were not falling, but rising. The OCWD was pouring more MWD water into the basin than producers were pulling out. This intensive replenishment program peaked in the period 1961-1964, when an average of 190,000 acre-feet were purchased to be sunk underground each year. Having gone through the period of 1945-1956 by "borrowing from within," running huge annual deficits while the Orange County economy grew to the point where it could afford a large-scale replenishment program, the water users of Orange County shifted to "borrowing from without" for the period up to 1964, importing more than would normally be their share of the water from a source that was in danger of "drying up" at

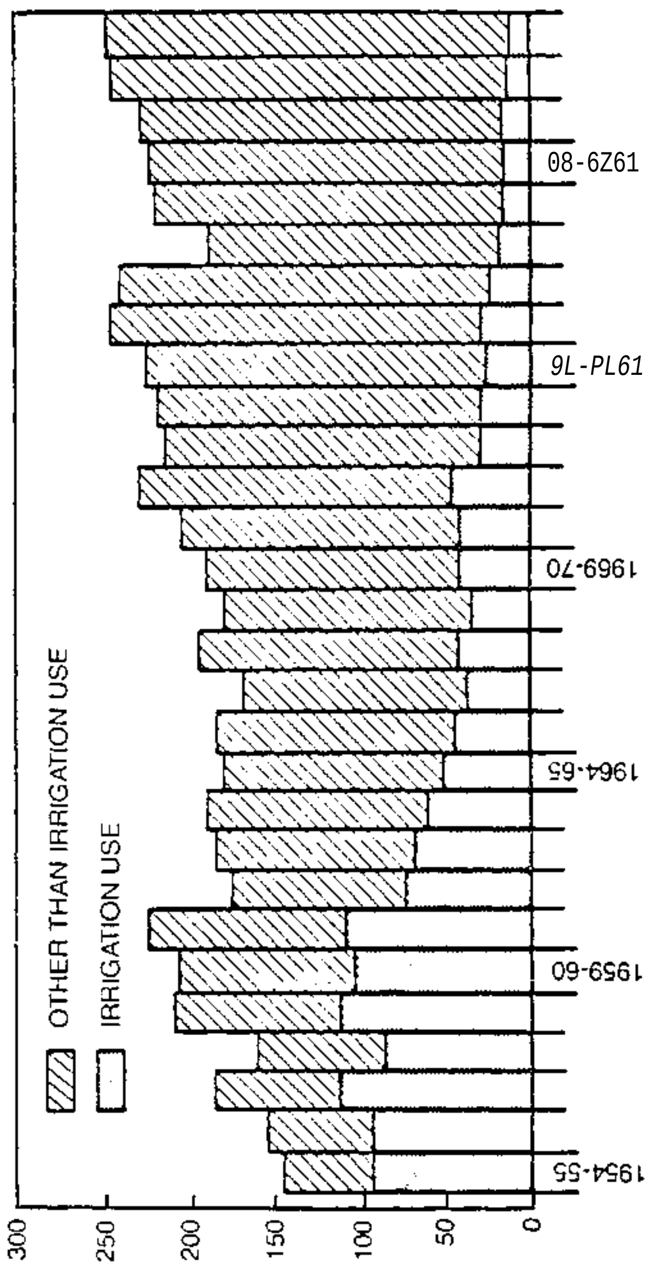


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Figure &-3. Groundwater Production in Orange County for Irrigation and Non-Jrrigation Use

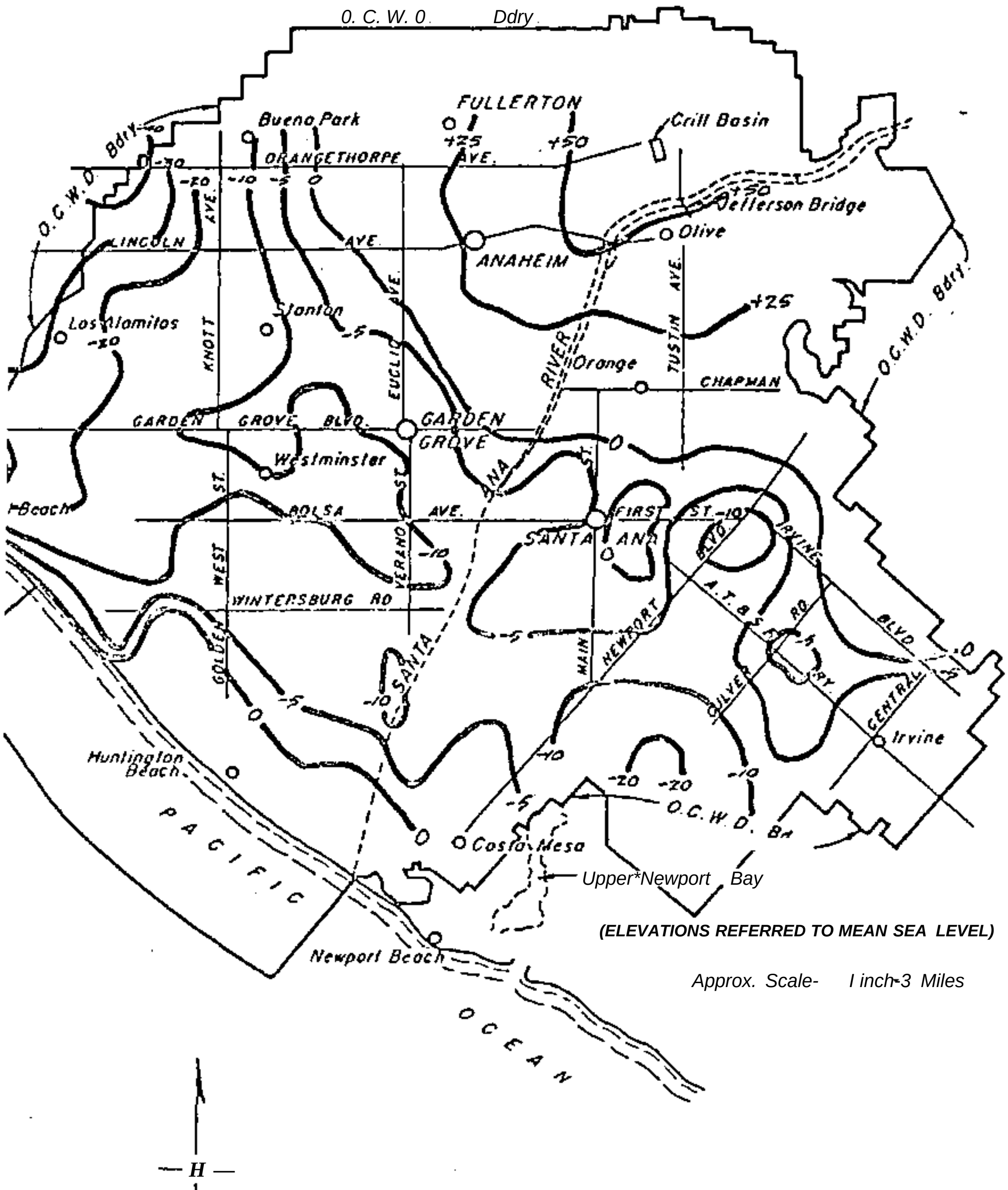
Source: Orange County Water District Annual Report, 1933

any time. And in 1964 the United States Supreme Court ruling in _Arizona v. California_ reduced MWD's entitlement to Colorado River water from 1,212,000 acre-feet per year to 550,000 acre-feet per year.

The fill-the-basin program was a success that failed. It was a successfully implemented program that suffered both from the inability of imperfect human beings to make accurate predictions of the future and from defects of institutional design. A look back at Figure 8-1 shows the extraordinary recovery of water levels in the basin. In 1964, the average water levels for the basin as a whole were 24 feet _above_ sea level, up from 20 feet _below_ sea level in 1956 and equalling the average water level in the landmark year of 1944. This was accomplished despite the fact that throughout the period dry year followed dry year, Orange County's population doubled, and total water use grew. Over the fill-the-basin period, the District had developed the financial and physical capacity to handle 200,000 acre-feet of replenishment water in a year -- a remarkable accomplishment in itself. Yet after 1964, the fill-the-basin program was abandoned by the Orange County Water District, not because it had accomplished its objectives, but because it had failed to do so.

The 1964 water levels for the basin as a whole had equalled those of 1944, but, in ways not anticipated at the outset of the fill-the-basin program, the basin had changed. The distribution of water in the aquifers had been altered by pumping patterns, the large overdraft accumulated during the period of "borrowing from within," and the gradual and never-ending natural process of movement below the surface of the earth. The implementation of the replenishment program itself had concentrated all the spreading facilities in the upper portion of the basin, in the "forebay" area. As a result of these factors, while the average water level in the basin equalled the 1944 level, the 1964 levels were far above the 1944 levels in the inland portions of the basin and far below the 1944 levels along the Pacific coast and the Los Angeles county border (see Map 8-8). Exposure to salt water intrusion continued along the coast and in the Seal Beach area.

The different distribution of water in the basin meant that: (a) raising the water levels along the coast of their 1944 levels would involve raising water levels in the upper portion of the basin (already 50 feet above 1944 levels) even higher; (b) raising the water levels along the coast now would likely bring back the swampy conditions that existed earlier in the century. Neither outcome was satisfactory. The OCWD had been pouring water into the basin in the upper area, where sea water intrusion was not an immediate problem and where the users of supplemental water from MWD were concentrated, while toward the coast groundwater extractions were more heavily relied upon and sea water kept encroaching. Without the ability either to limit extractions or to discriminate in pump tax charges, the Orange County Water District was raising a "tilted" water table. By the end of the fill-the-basin period, over 500,000 acres of the District were underlain by sea water, and over 50 wells had been abandoned (68). The accumulated overdraft had been considerably reduced, but remained at 140,000 acre-feet (69). Thus, sea water intrusion had not been stopped, and the accumulated overdraft had not been eliminated, and these had been the two main objectives of the fill-the-basin program.



Map 8-8. Changes in Orange County Ground Water Elevations, 1944-1964

Source: Orange County Water District Annual Report, 1965.

Reviewing the operations of the previous ten years, the OCWD Engineer wrote in the annual report on the 1965-1966 water year:

> ... it now appears certain that spreading in the forebay cannot entirely eliminate sea water intrusion without also causing undesirably high water levels in some of the coastal portions of the basin. It is also apparent that under future water supply and demand conditions, it would be unwise to rely solely on ground water replenishment in the forebay area to prevent sea water intrusion...

B.6. The District's Supply Management Program, 1965-1985

Beginning in 1965, the Orange County Water District moved away from the fill-the-basin policy and began to generate the necessary elements of managing the basin as part of a conjunctive-use program. Conjunctive-use is an essential part of the management programs that are in place for Central and West Basins, where extractions are limited. In Orange County, where extractions from the District Basin are not limited, the conjunctive-use program is an attempt to alter use patterns so as to minimize reliance on the basin as a source of supply for daily needs, thereby preserving the basin's capacity to provide water supplies during emergency and peaking periods.

As part of a conjunctive-use system, the basin is treated more as a storage reservoir, to be filled when supplies are plentiful and mined when supplies are scarce. This is a more valuable use of the basin than its use as a source and distribution system for daily water supply. If the basin and the water it provides are evaluated on the basis of the alternatives available for their replacement, replacing the basin's storage capacity with surface storage tanks would be a more substantial drain on the residents of Orange County than would shifting their reliance for base supply needs to surface and imported water. When Orange County was making the transition to the conjunctive-use program, construction of equivalent surface water storage capacity would have cost nearly 2 billion dollars (70). Moreover, if the basin were preserved as a storage facility, the construction of surface distribution systems for direct service water could be minimized, since those systems would not have to be built for peak demands if the basin could be used for meeting peak water requirements. Finally, a practical constraint favored treating the basin primarily as a storage reservoir: using the basin for base supply needs and relying upon surface and imported water as needed to supplement the base supply would place Orange County's reliance for emergency and peaking supplies on precisely those water sources <u>least</u> likely to be available during seasonal peaking or under drought conditions.

Experience during the fill-the-basin period favored a move to conjunctive-use management. Since the fill-the-basin activities had not halted sea-water intrusion, the people living in the 5,000 coastal acres underlain with sea water had been forced to develop alternative supply systems anyway, and those living just further inland remained threatened by the sea. Further, pouring water into the basin each year to meet the daily demands of water users required annual purchases of as much as 200,000 acre-feet of replenishment water, since the absence of a restriction on water extractions meant natural inflows would not come close to maintaining water levels. Not only did trying to keep the basin full require purchases of 200,000 acre-feet of replenishment water, but such purchases could be made only if 200,000 acre-feet of replenishment water were <u>available</u>. The period of "borrowing from within" had been followed by a period of "borrowing from without" during the fill-the-basin period, but the possibility had arisen that the sources from which to borrow might dry up. Consequently, the District and the residents of Orange County faced the problem of how to pursue a supply-side management program without a clear, stable source of supply.

a. The Instability of Water Supply: The Colorado River, the State Project, Basin Protection III, and the Rain

By 1965, total water use in the Orange County Water District was approaching 300,000 acre-feet per year and ground water production was approaching 200,000 acre-feet per year (see Table 8-3). During the five-year period from 1961 through 1965, inflows into the District from the Santa Ana River averaged roughly 30,000 acre-feet per year, or about one-tenth of total water use (see Figure 8-2). Water imported from MWD for direct service requirements of water users had grown to approximately 90,000 acre-feet in 1965. Thus, the water users in the Orange County Water District had an incoming water supply of about 120,000 acre-feet to meet a demand of nearly 300,000 acre-feet. The remainder was being pumped from the basin, and had been being replaced by the District's replenishment activities, financed by the pump tax.

As the use of imported MWD water for direct service, or base supply, was growing toward 100,000 acre-feeet per year in Orange County alone, with water users in Los Angeles and other southern California counties also relying heavily on those imports, the reduction of MWD's right to Colorado River water to 550,000 acre-feet per year in the Arizona v. California decision posed a serious threat to the OCWD's ability to acquire up to 200,000 acre-feet per year of MWD water for replenishment. The District Engineer wrote in 1967 that water levels had begun to decline and would likely continue to decline as Colorado River water availability was reduced by increasing direct service requirements and the anticipation of the loss of water to Arizona (71). MWD was no longer pursuing a strategy of seeking ever more customers making ever greater purchases; its concern had become the allocation among competing users of a supply that would take a sharp drop at some point in the future. Orange County began to do what everyone else in southern California did after Arizona v. California and as the twenty-year drought continued: try to hang on until the State Project brought northern California water to the Southland.

Beginning with the 1964-1965 water year, Orange County Water District's purchases of MWD replenishment water declined sharply. In the 1963-1964 year, OCWD had purchased over 185,000 acre-feet of Colorado River Water for replenishment. By the end of the decade, replenishment water purchases were down to just over 50,000 acre-feet. MWD's price had risen from $15.00 per acre-foot to $19.00 per acre-foot over this period, but this did not account for the precipitous decline in replenishment purchases, especially since OMWD raised its replenishment assessment from $11.00 to $13.30 per acre-foot for non-irrigation production over the same period and the number of acre-feet produced (and hence taxed) per year remained constant. Indeed, total expenditures for replenishment water declined from the 1962-1963 peak of $3,247,136 to $1,014,091 for the 1968-1969 water year. The problem was availability of replenishment water, not funding or price.

The Orange County Water District turned once again to the Santa Ana River. Diminution of inflows from the Santa Ana River prompted initiation of another court action against upstream water producers in 1963. In this action, the District acted on behalf of Orange County water users against water districts that represented upstream water users -- the Western Municipal Water District of Riverside County, the Chino Basin Municipal Water District, and the San Bernardino Valley Municipal Water District. The District sought an adjudication of rights to the waters flowing to and behind the Prado Dam in the Santa Ana River Watershed. In this adjudication, the District's aim was to establish a <u>minimum</u> right, a guaranteed amount of river flow each year. Negotiating in the shadow of the court, the District settled with the upstream districts on an arrangement that:

(a) guaranteed the OCWD 42,000 acre-feet of Santa Ana River flows per year;

(b) gave the District a protected right to store water behind Prado Dam for controlled release;

(c) established a Santa Ana River Watermaster, to monitor the Santa Ana River flows and the storage of water (including imported MWD water) behind Prado Dam, with a five-member Watermaster Board of which two members would be appointed by the Orange County Water District's Board of Directors;

(d) formed the Santa Ana Watershed Planning Agency, a joint-powers agency of the four Districts.

This settlement, reached in 1968, approved by the court in 1969, and taking effect in 1970, secured a stable, minimum inflow of Santa Ana River water. Previous actions had limited upstream appropriators, but this left Orange County exposed continually to dry periods (when use of their right by upstream appropriators might leave little or nothing for the downstream area) and to new upstream appropriators. Just as importantly, the OCWD obtained rights to use Prado Reservoir for storage of water without danger of its stored water being converted to others' use. This was vital to the District's supply management program in two ways. First, a conjunctive-use basin management system would require storage of storm flows for maximum recharge, if a wet year or a series of wet years would ever come. Second, the Prado Reservoir provided a delivery point for the anticipated northern California water coming upon completion of the State Project, and the Santa Ana River Watermaster would monitor these imports and their storage behind Prado Dam so as to assure Orange County of its rights to the imported water despite its being delivered outside the County (72).

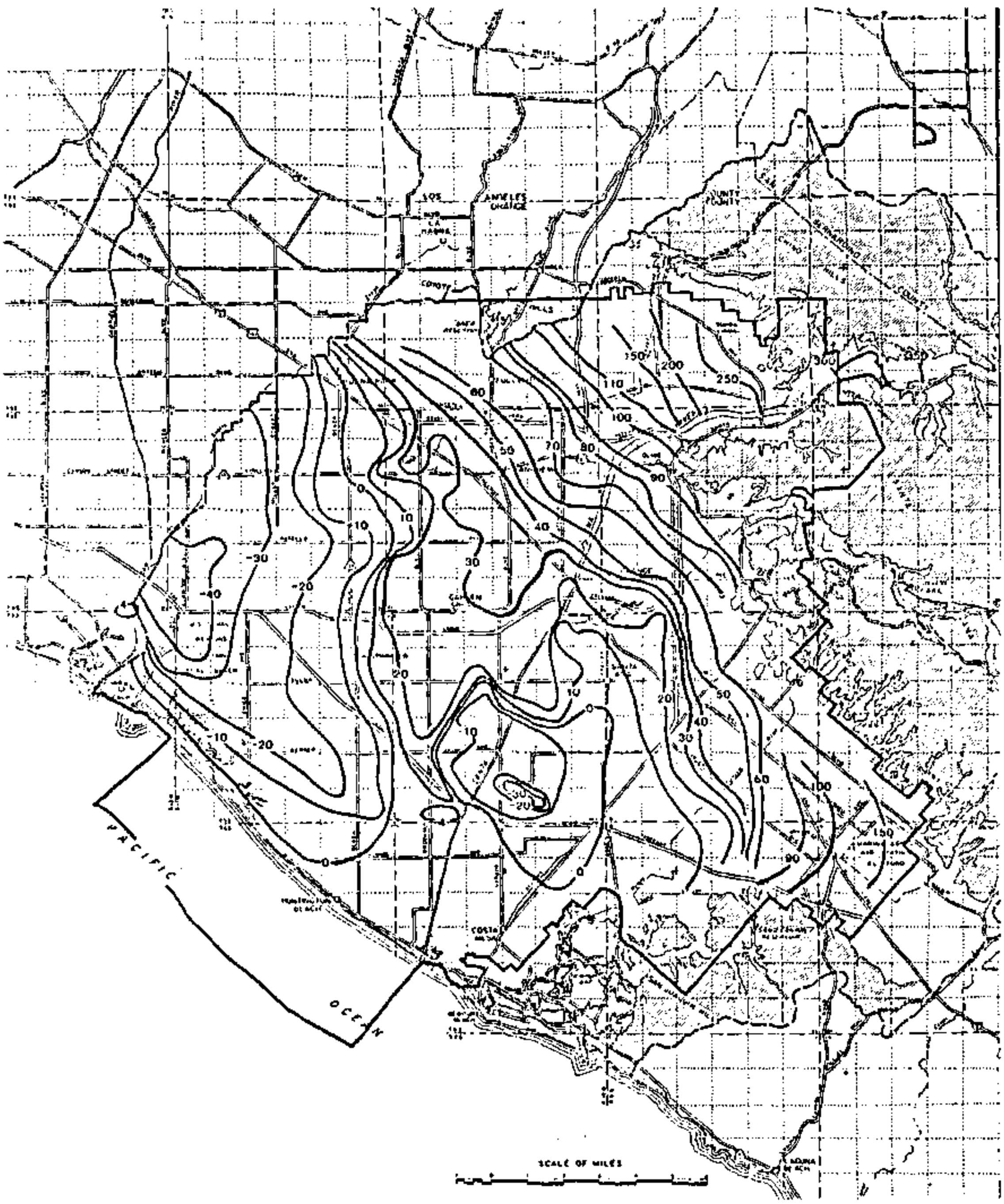
The State Project water from northern California, upon which many program plans for water management were based in southern California in the 1960s, did not arrive in the quantities anticipated in those plans. Deliveries of State Project water finally began during the 1972-1973 water year, peaked in 1975, and averaged 25,000 acre-feet per year for replenishment purposes during the first ten years of operation (see Table 8-2). State Project water did not become available in Orange County for direct service needs until the 1974-1975 water year.

By this time, the mid 1970s, the improved availability of water imports on which the OCWD and other Southland providers had waited was snatched away by a compounding factor. Water availability, especially for replenishment (replenishment water having a lower priority than direct service water supplied by MWD), had always been limited by ecological factors, such as rainfall and runoff, but now was also limited by energy scarcity. The State Project water and the "energy crisis" arrived at the same time. MWD curtailed water deliveries beyond direct service requirements in order to economize on energy use and production costs. MWD's prices rose 50 percent from 1973 to 1978. Availability of both Colorado River water and State Project water was constrained over that same period. Then, in the early 1980s, the failure to fully complete the State Project further clouded the outlook for import availability in light of the loss of Colorado River water.

Of course, higher energy costs become a "fact of life" to which people adjust, and have adjusted, after a time. The adjustments to the first round of price shocks had fairly well been made by the 1975-1976 and 1976-1977 water years, just in time for the two driest consecutive years in the history of California. Colorado River water was made unavailable for replenishment after March 1977, and State Project water was unavailable altogether after March 1977, even for direct service use. Groundwater production in these two water years was 245,456 acre-feet (a record) and 243,511 acre-feet respectively, and by the end of the 1976-1977 water year, the average elevation of water in wells in the District Basin was back down to 6.3 feet <u>below</u> sea level.

The long-term drought had abated, however, and in the years since 1969 southern California experienced a "feast or famine" pattern of rainfall. The two year drought of 1976-1977 was followed by 29.3 inches of rainfall in 1978, 219% of the long term mean, by 18.9 inches of rainfall in 1979, 141% of the long term mean, and in 1980 by 23.2 inches of rainfall, 173% of the long term mean. In the 1977-1978 water year, total natural inflow into the District was 253,591 acre-feet, and the average elevation of water in wells in the District Basin was up 16.1 feet to 9.8 feet above sea level. By the close of the 1979-1980 water year, the average elevation of the underground water was 18.3 feet, close to the 1964 levels at the end of the fill-the-basin program and the 1944 levels still treated as a standard (see Figure 8-1), though the distribution of water levels remained uneven (see Map 8-9). In the 1983 water year, rainfall was 27.85 inches, 208% of the longterm mean, and basin water levels were up to 20.4 feet above sea level, with a total natural inflow into the District of 426,300 acre-feet; still, water levels remained 20 to 40 feet below sea level in places.

The instability of water supply to Orange County was a principal reason for the development of a conjunctive-use program to replace the fill-the-basin policy. Since there had been, and would be, no attempt to restrict water use in the County, provision of an adequate supply was the sole available policy alternative. The fill-the-basin approach, replacing annual extractions with annual purchases of replenishment water, had been pursued on "borrowed time," using Colorado River water to which Arizona would eventually press its claim. Colorado River water purchases for replenishment continued, but in greatly reduced amounts. The State Project water was a source of continual uncertainty and instability. And the natural water supply, which depended on rainfall, alternated between flood and drought. The District's conjunctive-use program would require more



Map 3-9. Orange County Ground Water Elevations, 1930

Source: Orange County Water District Annual Report, 1983

activities than the acquisition of a minimum right to 42,000 acre-feet per year from the Santa Ana River secured through Basin Protection III. To make conjunctive-use work to secure a more stable water supply and deal with the ongoing problem of sea-water intrusion meant altering the characteristics of the basin itself.

b. Catching the Rain: Building Maximum Recharge Capacity

Previously, the Orange County Water District had acquired and developed 750 acres of the Santa Ana Riverbed for recharge of the basin using the flows of the River. Channels and low-lying barriers were constructed within the River to allow for ponding of water to increase percolation and reduce the amounts wasting to the ocean during times of above-normal flow. In addition, the acquisition and development of the Crill Basin, or "Anaheim Lake", provided a spreading facility for replenishment water. The beginning of the conjunctive-use program in 1965 triggered a new program of building maximum recharge capacity, adding considerable capacity to that available through the riverbed and Anaheim Lake. The instability of water supply, especially natural inflows, necessitated taking the greatest possible advantage of wet years and heavy River flows in order to store water in the Basin for use during dry periods.

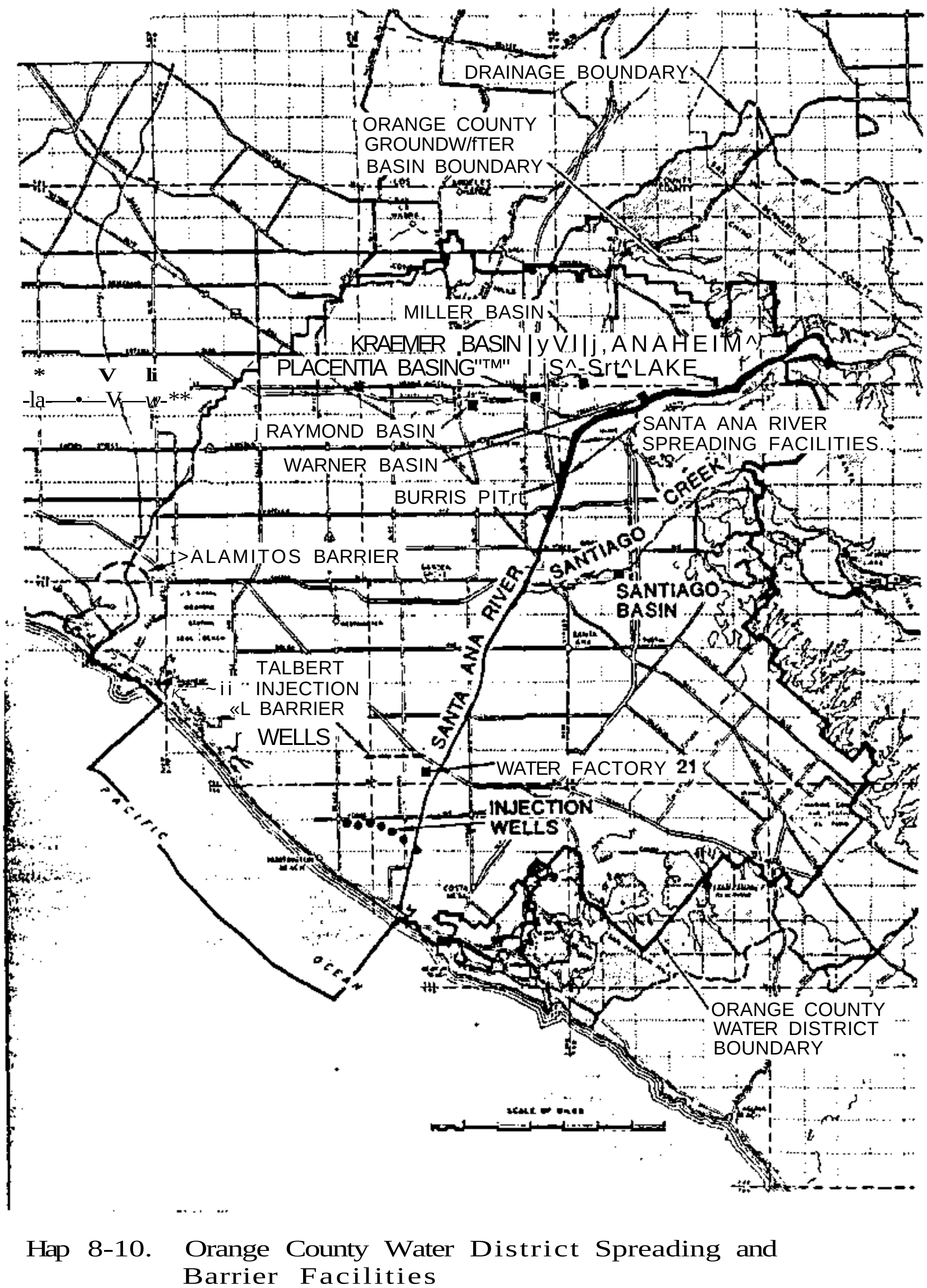
In 1966, the Orange County Water District purchased 95 acres on the north side of the Santa Ana River. The area was excavated to a depth of about 50 feet, and was named the Willis H. Warner Water Spreading Facility -- the "Warner Basin," for short -- after the first Chairman of the OCWD Board of Directors. Warner Basin, like Anaheim Lake, was used for storage of imported replenishment water and Santa

Ana River water. In addition, Warner Basin is made available for recreational activities, an idea successfully tested at Anaheim Lake.

In 1967, in anticipation of the settlement of the litigation against the upstream water districts, the Orange County Water District purchased the water rights of the Santa Ana Valley Irrigation Company, and acquired as part of the sale 2,140 acres of low-lying land behind the Prado Dam in Riverside and San Bernardino Counties. This acreage, in the Prado Flood Control Basin, is under the Prado Reservoir, allowing the District to store water behind Prado Dam, permitting controlled releases into the District's downstream recharge facilities. Thus, after three lawsuits against the upstream appropriators in San Bernardino and Riverside Counties, the Orange County Water District itself actually became an upstream owner of land and water rights in those Counties.

In 1976, the District made two more acquisitions. Near Anaheim Lake, and adjacent to the Miller Storm Retarding Basin owned and operated by the Orange County Flood Control District, the OCWD purchased 45 acres that it developed into the Kraemer Basin. In addition to its use as a recharge facility, Kraemer Basin's location next to the Miller Basin allowed for exchange of water between the facilities to ensure maximum storage in each. Downstream, along the Santa Ana River, the District acquired the Burris Pit, which it enlarged to 200 acres for conservation and recharge of storm flows. The complete set of Orange County storage and recharge facilities can be seen in Map 8-10.

In addition to these facilities, the Orange County Water District has been considering the acquisition of some property still further



Hap 8-10. Orange County Water District Spreading and Barrier Facilities

Source: Orange County Water District, 1933 downstream, below the confluence of Santiago Creek with the Santa Ana River. Santiago Creek drains from the Santa Ana Mountains and, as seen in Map 8-10, empties into the Santa Ana River downstream of all of the District's recharge facilities. As a result, during wet years, much of the flow of Santiago Creek not taken by surface diversions of water users is lost to the ocean.

In all, the Orange County Water District owns 3,400 acres of land primarily used for conservation and basin recharge. 2,140 acres are outside the County in Prado Reservoir, and 1,260 acres are inside the County in the Riverbed and the recharge basins. The District's conservation and recharge activities over the 30 years from 1949 through 1978 entailed the purchase and spreading of over 2.3 million acre-feet of imported water, and retained and percolated approximately 1.8 million acre-feet of Santa Ana River water.

The District's master plan for conservation and recharge aims for a recharge capacity of 300,000 acre-feet per year to accommodate the base flow of the Santa Ana River, storm flows, and imports (73). However, completion of this plan requires acquisition of more recharge capacity, and this has become difficult in light of the economic development of Orange County. The "intense competition for land in the Anaheim Forebay area for industrial, commercial, and urban development...has resulted in a rapid escalation of property values," thereby making it "extremely costly to acquire suitable sites for groundwater replenishment use" (74). Yet, without such additional sites, the somber assessment of the District's 1975-1976 annual report was that "recharge needs for the next 25 years will exceed the present physical capacity of the District to capture and conserve water supplies, which could result in the loss of substantial amounts of water" (75).

Despite these concerns about the future, the District's recharge-capacity component of its conjunctive use program has considerably improved the ability to replenish the basin beyond its natural capability. In years of above-normal rainfall and River flow, such as 1969, 1978, 1979, 1980, and 1983, despite groundwater production of 180,000 acre-feet or more and total water use of 300,000 acre-feet or more, the amount of groundwater in storage in the basin increased by 50,000 to 200,000 acre feet. The District remains short of its goal of 300,000 acre-foot annual recharge capacity, but its ability to catch the rain when it does fall has increased markedly, and the essential supply-side component of the conjuctive-use program -- the ability to refill the basin when water is plentiful -- is largely in place.

c. Walling Off the Basin

The opposite side of the conjunctive-use coin is the ability to draw down the basin when water is scarce. In a different geologic circumstance, this might be unproblematic. But in a coastal basin like the District Basin in Orange County, drawing down the basin in dry years does present a problem. If one conceives of the groundwater basin in a conjunctive-use program as a storage facility, a basin such as the District Basin is a storage facility with a leaking side, allowing for the intrusion of sea water.

As noted before, the formation of the District Basin left two geologic avenues for the inflow of sea water, the Alamitos Gap and the

Talbert Gap. As also noted before, the fill-the-basin program had not succeeded in halting the salt-water by the early 1960s, despite the recovery of underground water levels, and the threat of further intrusion continued for water producers as far as four miles inland. As long as water levels remained below sea levels in certain "pockets" and "troughs" of the basin, sea water would continue to find its way into those areas.

With the advent of the conjunctive-use program, the problem loomed larger than one of "pockets" and "troughs". Refilling the basin in wet years and mining it in dry years meant raising and lowering the whole water table in such a manner that in the dry years the average water level in the basin might fall below sea level. Such an occurrence would prompt far more extensive contamination of the underground supply. Yet, in light of the characteristics and history of the Basin, one could not reasonably expect that a conjunctive-use management system would not bring average elevations below sea level. The District Basin had shown its ability to drop from 10 feet above sea level to 10 feet below sea level in 3 years (1947-1950) and to rise from 10 feet below to 20 feet above in just two years (1961-1963). Clearly, the prospect of mining the basin for as little as two or three consecutive dry years would bring back the possibility of an underground flood of ocean water spreading though the Basin. Yet the conjunctive-use policy implied just such a prospect of mining the basin in dry periods. In the words of the District's Annual Report for the 1974-1975 water year, "To increase the usable storage capacity of the groundwater basin it is desirable to have the capability of drawing water levels below sea levels without deterioration of the basin by sea water." (76)

To this end, the Orange County Water District undertook two coastal barrier projects, one in each of the underground avenues, the Alamitos Gap and the Talbert Gap. The Alamitos Gap Barrier Project was constructed as a joint project with the Los Angeles County Flood Control District, and is located near the border of Los Angeles and Orange Counties, near the mouth of the San Gabriel River (see Map 8-10). This project is a sea-water intrusion barrier using a mound of fresh water injected below the ground surface. The pressure mound of fresh water acts as a wall against the incoming sea water, and some of the fresh water seeps into the basin, as well. Approximately 4,000 acre-feet per year has been injected at Alamitos since it became operational in 1965, about 80 percent by the Los Angeles County Flood Control District and 20 percent by the Orange County Water District.

More extensive sea water intrusion into the Orange County basin had occurred along the Talbert Gap between Huntington Beach and Newport Beach. Here the Orange County Water District constructed the Orange County Coastal Barrier Project. This barrier involved a larger scale of operation and a more complex method. The barrier facilities needed to effectively "wall-off" the basin at this point were designed to accommodate 20,000 to 25,000 acre-feet of injected fresh water per year. In addition to the possibility that this might still not suffice to hold back the sea entirely, this project raised two new problems. First, injections of that magnitude would likely raise the underground water levels to or above the level of the ground surface in that area, creating (or re-creating) swampy conditions. Second, there was no guaranteed supply of additional 20,000 to 25,000 acre-feet of water to feed those injection wells each year, in light of the anticipated reductions in MWD water and MWD's own exposure to dry periods, when whole years might come and go without MWD having supplies available beyond those committed to direct service needs.

OCWD's response was to make the Talbert Gap barrier project a two-stage barrier project. Approximately 4 miles inland lies a series of 23 multi-point injection wells that create a fresh water mound against the sea similar to, but on a larger scale than, the Alamitos Barrier. But between these injection wells and the shore, about 2 miles inland, is a series of extraction wells. These seven extraction wells pull brackish water as it seeps inland and return it to the ocean over the ground surface through open channels. This serves two purposes: to intercept and remove some of the contaminated water before the injection-well barrier; and, to lower the underground water levels so the 20,000 to 25,000 acre-feet per year could be injected to create a large undergound wall of water that stayed underground. The construction of the Talbert Gap project began in 1967 and the first units became operational in 1969.

In addition, the Orange County Water District acted to secure for the Coastal Barrier Project a drought-free, lawsuit-free supply of fresh water for the injection wells. Adjacent to the injection wells at Talbert Gap, the District constructed Water Factory 21, a facility for the production of fresh, high-quality water from reclaimed waste water, and for experimental work on demineralization of sea water. Water Factory 21 produces purified waste water that is injected at the barrier project. Additional water injected there is pumped from a deeper aquifer not affected by sea water intrusion and from which other water producers do not extract ground water.

Through the operation of the Alamitos Barrier and the Talbert Gap Barrier, the Orange County Water District has attempted to complete the wall along the ocean to protect the basin as a storage reservoir. The District Engineer reported in 1970 that, with the favorable status of ground water levels and with the barrier projects operating, "if necessary to meet future demands, substantial amounts can be withdrawn from the ground water reserves without causing sea water intrusion." (77)

d. A New Attempt at Demand Management: Penalties and Rewards

One of the problems noted with the replenishment assessment, or pump tax, was its uniformity. It raised the final cost of producing ground water, but did so evenly on all producers without regard to where in the basin they were producing and the status of water levels in their area of the basin. Moreover, the District had since 1948 been encouraging all producers with access to MWD imported water to adopt a fifty-fifty proportioning in their water supply -- half from MWD, half from the basin. Some producers cooperated with the OCWD request and purchased MWD water while reducing their proportion of production from the basin, even though MWD water for non-irrigation use was up to 50 percent more expensive than groundwater production for non-irrigation use. Other producers went on producing most or all of their water by pumping from the basin, thereby keeping their total water cost to a lower level. Thus, all producers were being taxed at the same rate while those who cooperated with the District's requests paid higher unit costs than those who did not cooperate.

In 1968, the Orange County Water District sought and obtained another amendment to the Orange County Water District Act by the State Legislature. This amendment authorized the District's Board of Directors to establish a "basin production percentage," a proportion of total water production that should be produced by ground water withdrawals from the basin. This basin production percentage would be applied to ground water production by those entities producing over 25 acre-feet per year for non-irrigation use. Irrigation use had already fallen so greatly, and MWD irrigation water costs were below average groundwater production costs for irrigation use, that irrigation water was exempted. And the small producers' aggregate water use was extremely small, relative to production for the large producers, so they too were not covered by the Amendments.

For those producers covered by the basin production percentage, the Board of Directors was further authorized to set a "basin equity assessment." This assessment is levied on each acre-foot of water produced in excess of the basin production percentage. If, for example, the established basin production percentage were 70 percent, and a producer of water for non-irrigation use produced 80 of its total 100 acre-feet of water production by pumping groundwater, that producer would pay the District the amount of the basin equity assessment multiplied by the 10 acre-feet produced in excess of the 70% target. The basin equity assessment monies collected by the District are held in a Basin Equity Fund, against which reimbursement claims may be made by producers who are requested by the District to produce less than the basin production percentage of their total production. Thus, if a different producer were requested by the

District to produce 60 of its 100 acre-feet of total production from the basin, and did so, and if the basin production percentage were set at 70 percent, that producer could claim a reimbursment equal to the amount of the basin equity assessment multiplied by the 10 acre-foot difference between the 70% target and the 60% requested and achieved.

The aim of the basin equity assessment is to even the water costs of producers in the District, so that those cooperating by producing less from groundwater are compensated for their higher costs of procuring MWD water, and those attempting to benefit by producing a greater share of their total production from the basin are taxed. The basin production percentage and the amount of the basin equity assessment are established by the OCWD Board of Directors at its regular monthly meeting in April of each year for the coming water year, which begins July 1. Among the factors considered by the Board are the conditions of the Basin, the availability of MWD water for direct service and for replenishment, and the distribution of that availability of MWD water in various areas of the basin (78). In light of this information, the Board adopts a basin production percentage for the coming year that will, in the Board's prospective view, maximize productive use of the groundwater basin without encouraging overdrafting of the basin.

The basin equity assessment is then set, with primary consideration given to the cost differential between pumping groundwater and importing MWD water. Thus, if that differential is estimated to be $20.00 per acre-foot, the producer in our example above who produced 80 acre-feet from groundwater instead of the target 70 acre-feet would pay an additional $200.00 to the District and the producer who met the 60 acre-foot request of the District could claim and receive $200.00 from the District. The $200.00 would represent the amount of money the first producer was attempting to save by producing 80% from ground water and the amount of additional cost incurred by the second producer in cooperating with the District's request. In some years, the basin equity assessment has been set lower than the estimated cost differential; for example, during the drought years of 1975-1976 and 1976-1977, the Board lowered the basin equity assessment and raised the basin production percentage, since the drought had severely curtailed MWD's available water supply and producers in Orange County responded (in accordance with the policies of MWD and OCWD) by drawing down groundwater reserves.

Two additional items are worth noting about the basin equity assessment program. First, it should be underscored that the basin equity assessment is levied <u>on top of</u> the replenishment assessment already charged on each acre-foot of pumped groundwater. Thus, those producers subject to the basin equity assessment charges in, say, 1975 paid $17.00 for each acre-foot of water they produced <u>plus</u> $23.00 for each acre-foot of groundwater in excess of 70% (the production percentage for that year) of their total production, for a total tax of $41.00 on each acre-foot of production in excess of the basin production percentage. This would have made the estimated cost of production of those additional acre-feet $67.50 per acre-foot, and MWD's price that year for direct service non-irrigation water was $67.00 per acre-foot. Second, it should also be understood that the basin equity assessment program is a demand-management tool, but is purely an incentive device and does not bind Orange County water producers in any way. For example, any producer requested to produce less than the basin production percentage may choose not to do so, and by so choosing simply forfeits any reimbursements from the Basin Equity Fund. By the same token, producers willing to pay the basin equity assessment on top of their replenishment assessment may produce in excess of the basin production percentage with impunity. This might be a rational strategy for producers who are so efficient as to face groundwater production costs below the District's estimated average, and thus for whom the cost differential between groundwater and MWD water is greater than the basin equity assessment.

Two other incentive programs aimed at regulating the demand-side conditions in a conjunctive-use policy toward managing the basin have been introduced by the Metropolitan Water District with the cooperation of the OCWD. The first is the in-lieu replenishment program, operated by MWD from 1978 through 1981. The second, which began n 1982, is the new water pricing program of MWD with interruptible, non-interruptible, and emergency classes of service and rates.

The in-lieu program was initiated by MWD when the wet year of 1977-1978 followed the two-year drought of 1975-1977. Suddenly, with large amounts of rainfall and surface runoff and with the underground basins of southern California being recharged naturally, MWD had more water available than it could sell. As a result, the Metropolitan Water District offered water at its lower replenishment price directly to groundwater producers, as an inducement to them to take more MWD water and produce less from underground than they normally would. Since this program coincided with the objectives of the OCWD's conjunctive-use program -- specifically, with the objective of filling the basin as full as possible during wet periods for later use during dry periods -- the OCWD cooperated with and participated in MWD's in-lieu program. In fact, the OCWD's Board of Directors voted to further subsidize the in-lieu water program by paying part of the lowered MWD price, thereby making the in-lieu water even more attractive. The OCWD used monies collected from the replenishment assessment to pay $15.00 per acre-foot of MWD's already lower price of $58.00 per acre foot, thus making the cost of in-lieu water to Orange County producers $43.00 per acre-foot in the 1977-1978 water year, significantly less than the estimated cost of $65.00 per acre-foot of producing the water from underground. As a result, Orange County water producers purchased 48,290 acre-feet of in-lieu water in 1978, and total groundwater extractions fell from 243,511 acre-feet in the previous year to 188,407 acre-feet. In the 1979, 1980, and 1981 water years, the MWD in-lieu rate per acre-foot was $74.00, $78.00, and $85.00, of which the District paid $23.00, $23.00, and $30.00, making the cost to water users $51.00, $55.00, and $55.00, respectively. The District policy-makers were clearly pleased with the in-lieu program, describing it in the District's Annual Report as "an excellent method of indirectly recharging the basin "through curtailment of extractions" (79).

After 1981, the MWD institutionalized the in-lieu program and made it a reciprocal relationship between the MWD and the individual groundwater producer. Different classes of water use were characterized as "interruptible" and "non-interruptible." Most of MWD's direct-service water deliveries were classified as "non-interruptible," meaning the recipient and MWD contracted for an assured water supply that MWD was obliged to deliver. The non-interruptible water price was the equivalent of the old direct-service price -- $96.00 per acre-foot, untreated, at the beginning of the program in the 1982 water year. However, for certain groundwater producers who were capable of switching back and forth between MWD imports when they were plentiful and groundwater extractions when imports were scarce, MWD set an "interruptible" water rate much lower than the non-interruptible rate -- $61.00 per acre-foot, untreated, for the 1982 water year. The $35.00 per acre-foot difference was an inducement from MWD to the water producer to purchase more imported water and pump less groundwater when supplies were plentiful. At the same time, however, the producer taking advantage of the interruptible price was exposed to a shut-off of this supply at any time (hence, "interruptible") by MWD whenever it ceased to have a surplus of water available, and that producer would be obliged to switch to using groundwater reserves instead during those periods of scarcity. Thus, MWD became a conjunctive-use management participant through its direct relationship with water producers as part of the new water pricing program.

The in-lieu and interruptible-water programs of MWD made surplus imported water more attractive to Orange County water producers, while the basin equity assessment program gave OCWD a selective taxing tool (on top of the uniform pump tax) for making excessive reliance in groundwater supplies less attractive. While the OCWD does not control the MWD programs, between the basin equity tax and the MWD programs, the District does have more of a demand-side component to its conjunctive-use program now. At present, then, the District has implemented its conjunctive-use system through four major steps: (a) as established guaranteed minimum inflow from the Santa Ana River; (b) an increased recharge capacity for filling the basin during periods of more abundant supply; (c) "walling off" the basin on the ocean side, allowing basin levels to be run up or drawn down without increased intrusion of sea water; and (d) a system of penalties for those who rely too heavily on groundwater production and rewards for those who cooperate with District requests for restraint.

C. Summary

Physically, water resource management in Orange County resembles management of Central and West Basins combined. There are areas capable of significant recharge south of Prado Dam, similar to the Montebello Forebay Area in Central Basin. There is also a pressure area in Orange County not suited to percolation, as in the lower reaches of Central Basin and in West Basin. The Newport-Inglewood Uplift runs through Orange County. In the areas below the Uplift, Orange County is significantly exposed to the invasion of salt water along its coastal boundary, as is West Basin. Also like West Basin, the District Basin in Orange County lies at the downstream end of a watershed, highly exposed to the actions of upstream water users.

As has been the case in the Raymond, West, and Central Basins, the District Basin in Orange County has been turned away from critical overdraft and destruction. Moreover, the underground system is now relied upon for storage and distribution of the imported water the

Orange County Water District purchases from MWD. This District program takes advantage of a groundwater basin's most valuable feature in conjunction with surface and imported supplies: its provision of low-cost storage and distribution as an alternative to the construction and maintenance of equivalent systems.

The avoidance of destruction and the transition to more highly-valued use in Orange County has occurred in a very different fashion than in the companion cases in Los Angeles County. In Orange County, the emphasis of the basin-management program has continually been on the enhancement of supply rather than the curtailment of demand. In each of the Los Angeles County cases, curtailment of demand through assignment of shares was a cornerstone of the process of resolution.

In Orange County, the active water concerns deliberately excluded assignment of shares from their process of resolution. Since the Orange County Water District is the principal actor on the water management scene, the prohibition of the District from engaging in an intra-basin adjudication of water rights has effectively operated as a general ban on such an action.

In the absence of an assignment of shares, the water-management approach in Orange County has been one of accommodating unlimited groundwater production. This necessity has mothered considerable invention. The creation of the OCWD itself, as a special district the boundaries of which are supposed to conform to the boundaries of the resource, preceded any such district creation in the Los Angeles County cases. Artificial replenishment through spreading of imported water, and the use of the pump tax, also originated in Orange County.

The Orange County Water District has also been an innovator in the acquisition of spreading facilities to be used jointly as recreational facilities financed in part by user fees. Only in the creation of barriers against sea-water intrusion did Orange County water managers exchange their role of innovator for that of follower. Even there, with the construction of Water Factory 21 to provide a supply of purified waste water for injection into the barrier wells, they added their own dimension to barrier operation.

All of this innovation, made necessary by the decision not to assign shares to the groundwater supply and curtail groundwater extractions, has come at a price. The Water District's operations are dependent upon availability of imported water for replenishment, and thus are significantly exposed to decisions by MWD to reduce replenishment water availability in times of drought. Another drought cycle is inevitable in Orange County; when it comes, surface supplies will dry up, replenishment water will be cut back, and groundwater extractions (being unlimited) will undoubtedly accelerate. If the drought cycle lasts half as long as the most recent one lasted, the District Basin could quickly return to 1956 elevations. Absent an assignment of shares, Orange County has brought its basin back from that brink of destruction, but has done so in a way that is fragile.

Notes to Chapter Eight

1. Orange County Water District Annual Report, June 1983.

2. Appellants' brief, Orange County Water District v. City of Riverside et al., p. 6.

3. Ibid.

4. Orange County Water District Annual Report, March 1975; also Crooke and Toups (1961), pp. 1-2.

5. Coe (1986), p. 19.

6. Orange County Water District Annual Report, March 1975.

7. Orange County Water District Annual Report, June 1983.

8. Orange County Water District Annual Report, April 1979.

9. Ibid.

10. Orange County Water District Annual Report, March 1975.

11. Orange County Water District Annual Report, June 1983.

12. Ibid.

13. Ibid.

14. Ibid.

15. Ibid.

16. Lou Weschler, Water Resources Management: The Orange County Experience (1968), p. 6.

17. Although specific citations will be made throughout this section, a general citation is in order to the work of Louis Weschler, whose study of community action in water management in Orange County from the 1930s to the 1960s provided a baseline for this section. Interested readers should definitely consult Weschler's Water Resources Management: The Orange County Experience for an extensive history of the formation and activities of the Orange County Water District and an evaluation of its performance up to 1968.

18. Orange County Water District Annual Report, April 1979.

19. Orange County Water District Annual Report, June 1983.

20. Weschler (1968), p. 13.

Notes to Chapter Eight (continued)

21. Ibid.

22. Ibid., p. 14.

23. Orange County Water District Annual Report, June 1983.

24. Ibid.

25. Quoted in Ibid., p. 16.

26. Weschler (1968), p. 13.

27. Lamb (1974), p. 21.

28. Weschler (1968), p. 13 fn.

29. Orange County Water District Annual Report, June 1983.

30. Ibid.; also Weschler (1968), p. 13.

31. Weschler (1968), p. 13.

32. Ibid., pp. 12-15.

33. Ibid., pp. 13-14.

34. Ibid., p. 14.

35. Orange County Water District Annual Reports, March 1975 and June 1983.

36. Weschler (1968), p. 1.

37. See, for example, Krieger (1961), p. 8.

38. Ibid.

39. Weschler (1968), p. 28.

40. Ibid.

41. Ibid., p. 3.

42. Ibid.

43. Ibid., p. 14.

44. Ibid.

45. Ibid.

46. Ibid.

Notes to Chapter Eight (continued)

47. Crooke and Toups (1961), p. 11.

48. Weschler (1968), p. 15.

49. I am indebted for this insight to Vincent Ostom and his studies of the California water industry.

50. Weschler (1968), pp. 24-25.

51. Ibid., p. 29; also, Orange County Water District Annual Report, April 1977: "Maximum utilization of the groundwater basin reduces the cost of water to citizens within the cities of Orange County. Savings are achieved by reduction in surface conveyance facilities, minimum treatment facilities, and reduction in seasonal and daily surface storage reservoirs."

52. Weschler (1968), p. 16; Crooke and Toups (1961), p. 5-6.

53. Weschler (1968), p. 8 and p. 17; Coe (1986), p. 19.

54. Weschler (1968), p. 17.

55. Ibid., p. 9.

56. Weschler (1968), p. 10.

57. Ibid., pp. 22-23 and 43-44.

58. Orange County Water District Annual Reports, all years; see also Coe (1986), p. 20: "To secure funds for imported water and other expenses, a pumping assessment was levied uniformly among well users..."

59. Weschler (1968), p. 59.

60. Crooke and Toups (1961), p. 4; Krieger (1961), p. 7.

61. Weschler (1968), p. 30.

62. Ibid.

63. Ibid.

64. Ibid.

65. Orange County Water District Annual Reports; also, Coe (1986), p. 19.

66. Orange County Water District Annual Report, 1973.

67. Weschler (1968), pp. 43-44.

Notes to Chapter Eight (continued)

68. Crooke and Toups (1961), p. 11.

69. Weschler (1968), p. 33.

70. Ibid., p. 54.

71. Engineer's Report on Ground Water Conditions, for 1966-1967.

72. Orange County Water District Annual Report, May 1980.

73. Orange County Water District Annual Report, March 1975.

74. Orange County Water District Annual Report, April 1977.

75. Ibid.

76. Orange County Water District Annual Report, April 1976.

77. Engineer's Report on Water Supply and Basin Utilization for 1968-1969, February 1970.

78. Orange County Water District Annual Report, March 1975.

79. Orange County Water District Annual Report, May 1980.

CHAPTER NINE

COMPARISONS AND CONCLUSIONS, AND SUMMARY

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COMPARISONS AND CONCLUSIONS, AND SUMMARY

In the last four chapters, extensive histories of four of the groundwater basins in the Los Angeles area have been presented. They are histories of collective action that have brought each of these basins back from conditions of extreme overuse and imminent destruction to relatively stable conditions. The stakes were high, the problems complex, and the processes of restoration were fragile and laced with potential for failure. Scholars holding the traditional views of commons problems would have predicted that these valuable resources would be destroyed, unless they were either privatized or turned over to a central public manager. The alternative view, which occupied Chapters Three and Four, presented the possibility that these resources might not be destroyed, indeed that they might even be preserved and put to more valued uses, without resort to either of the two prevailing policy prescriptions.

The final chapter will connect the histories of the four basins to each other and to the alternative approach of Chapters Three and Four. The purposes here are to consider whether and to what extent the alternative view can be used to make sense of the processes that occurred in the four cases, to compare what happened in these cases, to evaluate the results in each case with respect to cost, distributional consequences, compliance, and exposure, and to summarize these explorations with a reference back to the traditional views and policy presciptions for commons problems.

A. Comparisons of the Cases

The four cases presented in the previous chapters shared several similarities in the variables affecting their situations and in the actions taken in the processes of resolving their problems. As stated at the close of Chapter One, these cases were quite deliberately chosen because of their similarities. Each is a groundwater basin within the Los Angeles Basin area. This saves us the complications involved in comparing a groundwater basin with a fishery with a forest, and so on. Such cross-resource comparisons should be on the agenda for additional research, as we press the alternative views presented here into other areas to explore their general applicability. To reduce the complexity of presentation to a minimum, comparing groundwater basins with groundwater basins has been the approach selected here. Choosing all four groundwater basins in the same general location serves a similar purpose, as it saves comparing California water law with that of Indiana or some other state, or the process of creating special districts in California with that in Maine, or even comparing southern California's water situation with that of northern California.

No claim is made here that these four groundwater basins are representative examples of all commons situations wherever in the world they occur. As a result, no inference should be drawn that the analysis of these cases "proves" that all common-pool resources will be saved from overuse and deterioration and devoted to higher-valued use. The cases are too similar, too localized, and indeed too favorably situated, for such sweeping conclusions to be drawn. It is important to underscore that there are also cases consistent with the predictions of traditional approaches, where common resources have been destroyed.

Rather, as stated at the close of Chapter Four, these cases serve a different purpose. They demonstrate quite plainly that common-pool resources (a) do not have to be destroyed simply because multiple individuals or firms have claims to their use, (b) do not have to be converted from common property arrangements to some other form of property arrangements in order for destruction to be averted, and (c) do not have to be managed by a central government manager or converted to individually-held private property in order to be devoted to a higher-valued use. Despite the fact that no claim is made for their representativeness, these cases do at least show that it is possible for commons problems to be resolved by the users themselves. They refute each of the alternative contentions in the literature, i.e., that overall governmental control is "required" that privatization of natural resources is "the only way" to ensure optimal use. Finally, the cases support the recommendation of the National Academy of Sciences Panel on Common Property Resource Management that policymakers should first investigate whether management arrangements have been established by local users before the imposition of one of the "package" solutions of the literature on commons situations. (1)

While the cases presented here share a number of similarities, they are not "clones". They differ on some of the variables affecting their situations and in some of the actions taken in the process of resolving their problems. These differences also highlight the alternative view set forth in Chapters Three and Four, which stressed the variability of commons situations and emphasized that variety, rather than uniformity, is to be expected when local users address their own resource-management challenges. Even with the similarity of resource type and location, and the extent of learning and adapting by users in the basins from each other, there are differences among them that are relevant to the likelihood of collective action, the forms that action took, and the outcomes attained.

A.I. Variables Making Resolution More or Less Likely

In Chapter Four, a series of variables concerning the resource, the community of users, and the institutional setting, was presented and their relation to the likelihood of successful resolution posited. These variables were drawn from various sources, including the theory of collective action, the work of several scholars on commons problems, and the conditions in the "cold fish war." In Figure 9-1, these variables are reiterated with brief summaries of the status of the four basins with respect to each of the variables.

A review of the variables readily yields two previously discussed observations. The four basins were favorably situated for collective action in a number of respects, and the four basins were quite similar on a number of counts.

Each of the four basins exhibits a low rate of renewability, either because natural recharge (safe yield) is low relative to total basin storage capacity or because the basin is poorly suited to artificial recharge (or, in the case of West Basin, both). This makes each of the basins vulnerable to rapid deterioration under conditions of overuse, yet makes recovery possible if the demand-supply imbalance

FIGURE 9-1

Comparison of the Variables in the Four Basins

Variable	Raymond Basin	West Basin	Central Basin	Orange County
Rate of Renewability of the Resource	Low--Small Capacity; Safe Yield 31,000 acre-feet; poorly suited for artificial recharge	Low--Large Capacity; Safe Yield 36,000 acre-feet; poorly suited for artificial recharge	Low--Large Capacity; Safe Yield 157,000 acre-feet; well suited for artificial recharge	Low--Large Capacity; Safe Yield 150,000 acre-feet; well suited for artificial recharge
Condition of the Resource	Overdraft began 1913; Annual overdraft, 1913-35, 7,000 af.; 1936-43, 8,500 af. Water levels dropped 30-50 ft. 1930-37 No salt-water intrusion.	Overdraft began 1920; Annual overdraft, in 1920s, 20,000 af.; in 1930s, 25,000 af.; in 1940s, 40,000 af.; 1950-53, 60,000 af. Water levels in Hawthorne area down 200 feet; Accum. overdraft, 832,000 acre-feet in 1957; 400,000 acre-feet of salt water came in, 1932-53	Overdraft began 1942; Annual overdraft, in 1950, 77,000 af.; in 1960, 149,000 Water levels dropped 100 feet; Accum. overdraft, 1.3 million acre-feet in 1960; Salt-water intrusion 2 miles inland of Uplift	Overdraft began by 1920; Annual overdraft, nearly 100,000 af. by 1950; <u>average</u> water level below sea level by 1949; Accum. overdraft, 500,000-700,000 acre-feet in 1956; Salt-water intrusion 3 1/2 miles inland

Figure 9-1 (cont'd)

Variable	Raymond Basin	West Basin	Central Basin	Orange County
Location of the Resource	Self-contained; not exposed to salt-water contamination	Extreme downstream; highly exposed to salt-water contamination	Upstream and downstream; limited exposure to salt-water contamination	Extreme downstream; highly exposed to salt-water contamination
Size of the Resource	Small-- 40 sq.mi.	Larger-- 170 sq.mi.	Large-- 277 sq.mi.	Large-- 300 sq.mi.
Visibility of the Resource	Poor-- as with all ground water basins	Poor-- with unclear bounds at north & south ends	Poor-- with unclear bounds at north & south ends	Poor-- with unclear bounds at west end
Size of the Group	Small-- 31 in 1937, 17 now	Large-- over 700 well owners, 491 parties and 279 active producers in 1950, 37 active pumpers now	Large-- 750 well owners, 508 parties with rights in 1967, 187 now	Large-- over 1,000 producers as late as 1970, over 300 now
Distribution of Interests	Nearly privileged as City of Pasadena accounted for half of total production	Concentrated industry: in 1950, 19 parties accounted for 84% of total production	Concentrated industry: in 1950, 17 parties accounted for half of total production	Concentrated industry: cities, large agricultural holdings, water service companies; Irvine Ranch especially significant

Figure 9-1 (cont'd)

Variable	Raymond Basin	West Basin	Central Basin	Orange County
Homogeneity of the Group	No salient cleavages	Division between inland and beach cities; no other salient cleavages	No salient cleavages	No salient cleavages
Wealth and Income of the Group	Prosperous community: cities & major private producers had funds & personnel to devote to process	Prosperous community: cities & major private producers had funds & personnel to devote to process	Prosperous community: cities & major private producers had funds & personnel to devote to process	Prosperous community: cities & major private producers had funds & personnel to devote to process
Extent of Other Interactions Among Users	Cities had contacts with each other; water service companies did also	Cities had contacts with each other; water service companies did also; industrial users also	Cities had contacts with each other; water service companies did also; industrial users also	Cities had contacts with each other; water service companies did also; industrial & agricultural users also
Stability of Group and Use	Group of producers remained stable; use grew steadily	Group of producers stabilized after WWII; use grew rapidly until 1950s	Group of producers stabilized after WWII; use grew rapidly until 1960s	Group of producers stabilized after WWII; use grew rapidly until 1970s

Figure 9-1 (cont'd)

Variable	Raymond Basin	West Basin	Central Basin	Orange County
Time Horizon of Users	Cities & water service companies committed to area and basin use indefinitely	Cities & water service companies committed to area and basin use indefinitely; industrial users had large capital investments to protect	Cities & water service companies committed to area and basin use indefinitely; industrial users had large capital investments to protect	Cities & water service companies committed to area and basin use indefinitely; industrial users had large capital investments to protect
Availability of an Alternative Supply	Yes, through MWD, but costs higher & quality poorer	Yes, through MWD, but costs higher & quality poorer	Yes, through MWD, but costs higher & quality poorer	Yes, through MWD, but costs higher & quality poorer
Degree of Real Control Users Can Have	Home rule; State accomodating of local control; access to courts; ability to establish limited-purpose special districts	Home rule; State accomodating of local control; access to courts; ability to establish limited-purpose special districts	Home rule; State accomodating of local control; access to courts; ability to establish limited-purpose special districts	Home rule; State accomodating of local control; access to courts; ability to establish limited-purpose special districts

Figure 9-1 (cont'd)

Variable	Raymond Basin	West Basin	Central Basin	Orange County
Availability of Information-Gathering Facilities	Extensive: Courts, State Agencies, USGS Surveys, Local Agencies (e.g., LACFCD Engineers)	Extensive: Courts, State Agencies, USGS Surveys, Local Agencies (e.g., LACFCD Engineers)	Extensive: Courts, State Agencies, USGS Surveys, Local Agencies (e.g., LACFCD Engineers)	Extensive: Courts, State Agencies, USGS Surveys Local Agencies (e.g., OCFCD Engineers)
Ability to Make and Sustain Enforceable Agreements	Yes--Common-law tradition; Civil court procedures	Yes--Common-law tradition; Civil court procedures	Yes--Common-law tradition; Civil court procedures	Yes--Common-law tradition; Civil court procedures
Presence of a Single Institution With Several Needed Capacities	Yes--courts	Yes--courts	Yes--courts	Yes--courts

is redressed (i.e., these are not totally occluded basins where all use takes the form of "mining").

All four basins were in considerably endangered condition prior to and during the process of resolution. As was noted in Chapter Four, this is vital to spur users to undertake the costs of organization and altering use patterns. We would not anticipate that resource users would take actions until they were experiencing problems. While all four basins were endangered, there were differences of degree among them, with West Basin in the most extreme condition of overuse and contamination.

As is the case with groundwater basins generally, the four basins exhibited low visibility. The boundaries of the resources, and thus the extent of the user community, were not readily apparent to the local users. This presents a barrier to successful collective action, and indeed was a prime reason why so much of the inital action in each case focused on the gathering of information about the boundaries of the resource, the capacity and yield of the resource, the conditions of the resource, and the identification of the users. Visibility is one of the variables on which the four basins were <u>not</u> favorably situated for successful collective action. In the case of three of the basins, the usual poor visibility of groundwater basins was compounded by the fact that the acknowledged boundaries of the basins were not all well-defined hydrologic divides.

The number of water producers in all but Raymond Basin was relatively large, but the distribution of interests among the users was concentrated, though to differing degrees. Central Basin was the least concentrated, Raymond Basin the most. Raymond Basin and Orange

County each approached the status of "privileged groups," as the City of Pasadena in the former and the Irvine Company in the latter each took actions at the outset despite the fact that their actions ultimately benefitted all users. The concentrated distribution of interests in each case was favorable to collective action, as relatively small groups of users were able to affect large shares of total groundwater production.

Each user community was relatively homogeneous, being undivided by language, culture, or other differences that would impair communication and the possibilities for trust among the users in working out agreements concerning use. Only West Basin exhibited a division among the users, and this was temporary, as the inland cities that were originally unaffected by sea-water intrusion were reluctant to join with the beach cities in taxing themselves to acquire imported water.

In each basin, there was at the outset of collective action a prosperous community of users capable of bearing costs in addressing their water problems. The development of the Los Angeles area yielded booming cities and a thriving commercial community. That development was itself facilitated by the use of the ground water supplies of the area, and in each of the basins some of the proceeds of that prosperity were able to be redirected to the restoration and preservation of those water supplies.

Each of the basins had a relatively stable community of users with a long time horizon, and with partial networks of interconnection upon which to build more inclusive instruments of collective decision-making. The cities, in particular, were long-term users to whom preservation of a stable and adequate water supply into the future was important. Unlike other types of users, cities are unable to come to an area, exploit its resources, and then pick up and move elsewhere. Similarly, while they are not as immobile as cities, the water service companies, industrial firms, and (in Orange County in particular) large agricultural concerns had considerable stakes in the preservation of an adequate local water supply well into the future. And, within the basins, neighboring cities and neighboring water service companies had extensive other interactions with each other, and industrial and agricultural concerns had connections with one another through such organizations as area Chambers of Commerce and the Orange County Farm Bureau. The task that remained was to build connections among different types of users, so that cities communicated with industrial producers and water service companies, etc., concerning the problems they all faced. The major users of these basins were neither transients nor total strangers, and this more favorably situated them for successful collective action.

In each of the basins, there became available an alternative, though less preferred, source of water. This made curtailment of demand upon the ground water supply, though costly, less difficult than it would have been otherwise, while underscoring for the local users the value of the less expensive, high-quality, and more stable ground water supplies.

The institutional setting for each of the basins was similar and quite favorable to local collective action. In each basin, users had access to expert information-gathering capabilities, the ability to make and sustain enforceable agreements, the ability to devise local institutions with powers to tax and enforce compliance with whatever arrangements users established, and access to courts where information-gathering, communication, collective decision-making, cost-sharing, share assignments, sanctioning of behavior, and monitoring could occur or be established. Not all of the available capacities were used in each basin, most notably in Orange County where the use of the courts for intra-basin share assignments was eschewed. The point here is simply that the capacities were indeed available for local users if they chose to incorporate them to facilitate their resolution process.

There were, of course, variables on which the basins differed. Resource location was one of these. Raymond Basin was not directly connected to other basins, and was not exposed to salt-water contamination, and as a result users in that Basin needed only to address their own demand-supply imbalance. Both West Basin and Orange County were located at the extreme downstream ends of their respective watersheds, and were thus highly exposed to the actions of upstream users. Each of these two was also a coastal groundwater basin, highly exposed to salt-water contamination. Central Basin had a more limited exposure to salt-water contamination, being vulnerable in the Alamitos Gap area. Central Basin was also in the position of being both an upstream basin (with respect to West Basin) and a downstream basin with respect to the Upper San Gabriel Valley, and so was also exposed to the actions of upstream users.

The basins also differ in size, from Raymond Basin's 40 square miles to Orange County's 300 square miles. The smaller size of Raymond Basin was beneficial to the prospects of successful collective action there, as information-gathering and the other necessary steps in the resolution process are likely, other things being equal, to be less difficult and costly than they would be when they involve a larger resource.

Raymond Basin also stands out from the others with respect to group size. Each of the other three basins was being used by hundreds of producers prior to and during the period of collective action. In Raymond Basin, where there are only 17 active producers now, there were just 31 fifty years ago at the outset of the Pasadena v. Alhambra litigation. Information-gathering, communication, collective decision-making, and monitoring are each substantially simpler and less costly when total group size is 31 as opposed to 500 or 1,000.

If one were to take the set of variables as a whole, and look across the four basins in an attempt to predict where successful collective action was most likely to occur and where it was most likely to occur first, one could make some tentative observations. Given its favorable disposition with respect to all of the variables except visibility, its clear difference in resource and group size, and a distribution of interests that approached "privileged group" status, one would anticipate collective action to occur first and be most likely to succeed in Raymond Basin. It would be more difficult to predict a second most likely case: Orange County had a more favorable distribution of interests, homogeneity of user community, and extent of other interactions of users than West Basin but had a larger resource, large group of producers, and was in less extreme conditions (at least at first) than West Basin. Central Basin, with its large size, less concentrated distribution of interests, and more limited exposure, would be the basin one would anticipate to be last to exhibit collective action and least likely to be successful, other things being equal. In terms of a strict chronology, the predictions based on the variables alone would be incorrect, as the order of initiation of collective action was in fact Orange, Raymond, West, Central. (Raymond Basin was, however, first to complete the seven steps in the process of resolution.) The variables are not strict conditions, however, as was indicated when they were presented in Chapter Four. They are indicators of likelihood, and the actual course of resolution is a course of human action and not easily subject to deterministic or mechanistic accounts.

A.2. Steps in the Process of Resolution

In Chapter Four, the process of resolution of commons problems was described as involving seven steps: information-gathering, communication, collective decision-making, cost-sharing, assignment of shares, establishment of sanctions, and monitoring. Figures 9-2 through 9-8 present brief summaries of these seven steps in each of the four basins, focused on the initial (i.e., First, the Figures are largely self-explanatory; they are not quite as condensed as Figure 9-1. Second, the specific actions taken and the actors involved were the subjects of extensive presentations in Chapters Five through Eight, and little would be gained from recapitulation in further prose here.

As with the variables affecting the situations in the four basins, there are considerable similarities and also some differences among the basins. Some points are worth underscoring briefly. First, there was no uniform pattern to the actions taken in the four basins, though they started from very similar initial conditions. It cannot be inferred that the initial conditions in the basins "determined" in any meaningful sense the activities therein, as they proceeded along different paths from similar starting places. West and Central Basins come closest to following the same path, which is not surprising in light of their close physical connection and the overlap among the actors there.

Second, in each of the four basins there is a mix of private and public action and leadership, though the mix differs from one basin to another. In Orange County, for instance, collective action originated in private and public arenas, and subsequently the Orange County Water District became the principal locus of activity. By contrast, action in Raymond began primarily in public arenas, and has over time evolved to where the producers' own representative Board has largely taken over management of the Basin. In West Basin, the West Basin Water Association was a principal locus of communication and collective decision-making before, during, and after the period of most intensive activity.

FIGURE 9-2

Step One: Information-Gathering

	Raymond Basin	West Basin	Central Basin	Orange County
Initial Condition	Boundaries and Users Unknown; Users know only their own use & water levels	Boundaries and Users Unknown; Users know only their own use & water levels	Boundaries and Users Unknown; Users know only their own use & water levels	Boundaries and Users Unknown; Users know only their own use & water levels
Local Leadership	City of Pasadena	West Basin Survey Committee; West Basin Conserva-tion Group; LACFCD	Central Basin Water Ass'n.	Orange County Board of Supervisors
Other Capacities Engaged	USGS, DWR as Referee	USGS, DWR as Referee	SWRB	
Actions Taken and Subsequent Conditions	Lawsuit yields analysis of Basin conditions and use patterns; after suit, Watermaster Reports continually apprise users of Basin conditions and use patterns	Early actions of local users provide shared picture of Basin and its dangers; lawsuit yields analysis of Basin conditions and use patterns; annual Watermaster Reports thereafter	SWRB Report shows that Basin is in worse condition than supposed; CWBWRD compiles histories of use prior to lawsuit; after suit, Watermaster Reports update Basin conditions and use	County Supervisors commission Lippincott Report indicating severity of Basin problems; after 1953, annual Engineer's Reports update Basin conditions and give some use data

FIGURE 9-3

Step Two: Communication

	Raymond Basin	West Basin	Central Basin	Orange County
Initial Condition	Cities & water service companies had contact	Cities & water service companies had contact	Cities & water service companies had contact	Informal network of local govt's and trade associations
Local Leadership	Pasadena intiated meetings & lawsuit	LACFCD & City of Manhattan Beach initiated meetings	Compton intiated meetings leading to CBWA	Farm Bureau, Chambers of Commerce, County Board of Supervisors
Other Capacities Engaged	Court	Court	Court	
Actions Taken and Subsequent Conditions	Lawsuit prompted negotia-tion among parties, leading to formation of Raymond Basin Advisory Board, which becomes Management Board	West Basin Survey Committee becomes West Basin Water Association which is permanent forum for discussion of Basin problems & possible actions; Settlement Committee organizes negotiated reduction in pumping	Central Basin Water Association serves as permanent forum for discussion of Basin problems & possible actions; Settlement Committee organizes negotiated reduction in pumping	OCWD formed with represen-tation by area, becomes focus of information gathering and dissemination

FIGURE 9-4

Step Three: Collective Decision-Making

	Raymond Basin	West Basin	Central Basin	Orange County
Initial Condition	No collective decision-making mechanism	No collective decision-making mechanism	No collective decision-making mechanism	Orange County Board of Supervisors, but it does not match Basin boundaries
Local Leadership	City of Pasadena initiates lawsuit	Cities & major companies form WBWA	Cities & major companies form CBWA	County Board & Farm Bureau, Irvine Ranch
Other Capacities Engaged	Court	Court	Court	
Actions Taken and Subsequent Condition	Through lawsuit, pumpers negotiate reductions in pumping which are approved by Court; afterward, Raymond Basin Management Board becomes decision-making mechanism for the Basin	WBWA aids in conduct of lawsuit, and then organizes CWBWRD. Reduction in pumping and ways of replenishing Basin & halting sea-water intrusion along with CWBWRD. Much inter-agency decision-making--e.g., WBWA with CWBWRD, LACFCD, WBMWD, MWD, etc.	CBWA organizes CWBWRD, which conducts lawsuit resulting in pumping reduction. CBWA also serves as mechanism for making decisions about recharge & barriers along with CWBWRD. Much inter-agency decision-making--e.g., CBWA with CWBWRD, LACFCD, CBMWD, MWD, etc.	Through Irvine Ranch lawsuit, OCWD is formed as agency through which decisions about basin management are made

FIGURE 9-5

Step Four: Cost-Sharing Arrangements

	Raymond Basin	West Basin	Central Basin	Orange County
Initial Condition	Producers pay only direct production costs; actions benefitting the Basin paid by the actor	Producers pay only direct production costs; actions benefitting the Basin paid by the actor	Producers pay only direct production costs; actions benefitting the Basin paid by the actor	Producers pay only direct production costs; actions benefitting the Basin paid by the actor
Local Leadership	City of Pasadena initiated lawsuit	Cities form WB Survey Committee & later org's.	17 original CBWA members	County Board & Farm Bureau
Other Capacities Engaged	Court	Court, Legislature & County Board	Court, Legislature & County Board	State Legislature
Actions Taken and Subsequent Conditions	During lawsuit, Court appor- tioned costs on basis of pumping rights; this becomes basis for support for Watermaster Service & Management Board	Within WBWA, dues assessed on ground water production and this formula is used to pay for CWBWRD programs; property tax used for early recharge & barrier programs & to make up accum. overdraft	Within CBWA, dues assessed on ground water production and this formula is used to pay for CWBWRD programs; property tax used for early recharge & barrier programs 6c to make up accum. overdraft	Early OCWD formed to spread costs of Irvine litigation through property tax; later, this tax is supple- mented by tax on ground water pro- duction to pay for artificial recharge 6c barrier programs

FIGURE 9-6

Step Five: Assignment of Shares

	Raymond Basin	West Basin	Central Basin	Orange County
Initial Condition	Rights to unlimited production through ownership of land; rights to specific amounts through use	Rights to unlimited production through ownership of land; rights to specific amounts through use	Rights to unlimited production through ownership of land; rights to specific amounts through use	Rights to unlimited production through ownership of land; rights to specific amounts through use
Local Leadership	City of Pasadena	Plaintiffs in suit, WBWA	CWBWRD & CBWA	
Other Capacities Engaged	Court, DWR as Referee	Court, DWR as Referee	Court	
Actions Taken and Subsequent Conditions	Through stipulation of parties based on DWR study, and "mutual prescription", rights to ground water production defined based on historical use, separated from land ownership, and made tradeable	Through stipulation of parties based on DWR study and "mutual prescription", rights to ground water production defined based on historical use, separated from land ownership, and made tradeable	Through stipulation of parties and "mutual prescription", rights to ground water production defined based on historical use, separated from land ownership, and made tradeable	OCWD forbidden from acting to define rights to ground water among Orange County producers; initial conditions prevail

FIGURE 9-7

Step Six: Establishment of Sanctions

	Raymond Basin	West Basin	Central Basin	Orange County
Initial Condition	No sanctions	No sanctions	No sanctions	No sanctions
Local Leadership	City of Pasadena	Plaintiffs in suit, WBWA, CWBWRD	CBWA, CWBWRD	OCWD Board
Other Capacities Engaged	Court, State Legis-lature, DWR as Watermaster	Court, State Legis-lature, DWR as Watermaster	Court, State Legis-lature. DWR as Watermaster	State Legislature
Actions Taken and Subsequent Conditions	Production in excess of right results in fine & possible loss of right; failure to report production results in fine & possible loss of right; failure to pay pump tax can result in fine & possible imprison-ment	Production in excess of right results in fine & possible loss of right; failure to report production results in fine & possible loss of right; failure to pay pump tax can result in fine & possible inprison-ment	Production in excess of right results in fine & possible loss of right; failure to report production results in fine & possible loss of right; failure to pay pump tax can result in fine & possible imprison-ment	Failure to report production results in fine & possible imprison-ment; failure to pay pump tax results in possible fine & possible imprison-ment; production in excess of basin production percentage by covered producers subjects them to basin equity assessment

FIGURE 9-8

Step Seven: Monitoring

	Raymond Basin	West Basin	Central Basin	Orange County
Initial Condition	No monitoring	No monitoring	No monitoring	No monitoring
Local Leadership	City of Pasadena	WBWA Settlement Committee	CBWA Settlement Committee	OCWD Board
Other Capacities Engaged	Court, State Legis-lature, DWR	Court, State Legis-lature, DWR	Court, State Legis-lature DWR	State Legislature
Actions Taken and Subsequent Conditions	Court, adopting parties' agreement, appoints DWR as Watermaster to monitor parties' production	Court, adopting parties' agreement, appoints DWR as Watermaster to monitor parties' production, CWBWRD also monitors in order to assess pump tax	Court, adopting parties' agreement, appoints DWR as Watermaster to monitor parties' production, CWBWRD also monitors in order to assess pump tax	Amendments to OCWD Act require reporting of ground water production, annual Engineer's Reports

Of course, the most striking difference among the basins, after review of Figures 9-2 through 9-8 as it was after Chapters Five through Eight, is the difference between Orange County and the other three basins. In Orange County, because of the closer relationship of the boundaries and population of the County with the boundaries of the basin, the Orange County Board of Supervisors was more actively involved in local leadership than was the Los Angeles County Board of Supervisors. There was in Orange County much less use, especially with the establishment of the Orange County Water District, of other institutional capacities such as the courts and state agencies than in the other basins.

But it is in the assignment of shares (Figure 9-6) that the contrast is most stark. In Orange County there has been no assignment of shares to the groundwater supply. The initial condition regarding rights to use of the Orange County basin still prevails today. In the other three basins, firm, tradeable rights based on historical use and limited in aggregate to sustainable levels were established through adjudication. The difference in Orange County does not represent an oversight on the part of water producers there. As noted in Chapter Eight, those who formed the Orange County Water District placed an explicit prohibition upon the District, forbidding it to engage in an intra-basin determination of rights.

This raises an important issue for us, in light of the proposition in Chapter Four that a <u>successful</u> resolution of a commons problem would involve action in each of the seven steps. Does the absence of action to assign shares in Orange County mean that Orange County represents an <u>un</u>successful resolution of a commons problem? After all, water levels have recovered from their 1956 lows and sea-water intrusion has been halted in Orange County. In what respects could this be considered unsuccessful? The response to the question lies in the remaining comparisons, on issues of exposure, cost, and efficiency.

Before proceeding to those other comparisons, we turn to the issue of rule changes in the four basins. As described in Chapter Three, the underlying structure of situations is affected by a set of rules. By identifying the rules, one can compare across situations and find essential similarities that may underlie apparent differences and essential differences that may underlie apparent similarities. In Figure 9-9, rule changes that were made in the process of resolution in the four basins are compared. Position rules are denoted by "P", boundary rules by "B", authority rules by "A", information rules by "I", aggregation rules by "G", and payoff rules by "C". The rules are stated in such a way that they can be indicated by a "yes" (Y) or a "no" (N) in each basin, before and after the process of resolution.

The comparisons of the "rule strings" before and after action in each of the basins indicates the differences in the underlying structure of the situations as a result of the steps taken. The underlying structures of the situations in each of the basins are substantially different after the period of collective action from what they were before. Thus, as stated in Chapter Three, even within the general category of common-pool resources (which each of these basins was before action and remains after action) there can be marked differences in the structure of the situation in which users act. The differences between the "before" and "after" columns reflect the

FIGURE 9-9

Rule Changes in the Four Basins

Rule	Raymond Basin Before	Raymond Basin After	West Basin Before	West Basin After	Central Basin Before	Central Basin After	Orange County Before	Orange County After
Pro-position of "monitor" exists	N	Y	N	Y	N	Y	N	Y
P.2.-- "Large" v. "Small" Producers Defined	N	N	N	N	N	N	N	Y
P.3.-- Position of "decision-maker" (e.g., Board member) exists	N	Y	N	Y	N	Y	N	Y
B.l.-- Access denied to those who do not acquire rights	N	Y	N	Y	N	Y	N	N
A.l.-- Quantity of use restricted	N	Y	N	Y	N	Y	N	N
A.2.-- Can sell or lease rights to groundwater production	N	Y	N	Y	N	Y	N	N

FIGURE 9-9 (continued)

Rule	Raymond Basin Before	Raymond Basin After	West Basin Before	West Basin After	Central Basin Before	Central Basin After	Orange County Before	Orange County After
I.I.--Reporting required	N	Y	N	Y	N	Y	N	Y
G.I.--Decision-making about quantity withdrawn made by individuals in isolation	Y	N	Y	N	Y	N	Y	Y
C.I.--Sanctioning available on use patterns	N	Y	N	Y	N	Y	N	Y
C.2--Payments assessed on quantity of use	N	Y	N	Y	N	Y	N	Y
C.3.--Payments assessed on rights	N	Y	N	Y	N	Y	N	N

differences between endangered, open-access common-pool resources and managed, common-property resources.

The comparisons of the "after" columns across the four basins indicate the underlying similarity of the results obtained in Raymond, West, and Central Basins, despite differences in the steps taken in those three basins. In each of those basins, the same basic rule changes were made, albeit in slightly different ways and at different times, resulting in the same incentive structure facing each user in those basins. Comparing the "after" columns in Figure 9-9 also reveals differences between the rule changes made in the three Los Angeles County basins and in Orange County. Several of the rule changes are similar (P.I., P.3., I.I., C.I., and C.2.), but others are different (P.2., B.I., A.I., A.2., G.I., and C.3.). This is further evidence for us that the situation in Orange County is in significant ways different from those in the other three cases. The implications of those differences become more clear in the remaining comparisons among the basins, to which we now turn.

A.3. Comparisons of the Four Basins on Four Criteria

Preserving a valuable resource and organizing its use so as to increase the value it provides for those who rely upon it are substantial achievements. They may, however, be attained in such a way as to make these achievements only temporary and highly vulnerable. Such achievements are also always bought at a price. That price may be measured in terms of the financial costs incurred in the process of resolution, and also in terms of the distributional consequences of the management activities. Here, we shall briefly explore the actions that have occurred in the four basins in terms of their continued exposure to depletion and contamination, the financial costs incurred by the users, the comparative benefit of preserving the basins relative to the alternative of destroying and replacing them, and the effect of the basin management programs on the distribution of access and use among the population.

a. Exposure in the Four Basins

The discussion at the beginning of this study of the water supply problems of the Los Angeles Basin indicated that water supply is inadequate and unpredictable. To the extent that the achievements in the four basins have lessened their vulnerability to the inadequacy and unpredictability of water supply, then we can say that a lasting resolution has been attained. Otherwise, temporary improvements have been made that may vanish with the next extended period of drought.

The first form of exposure to consider is loss of supplies. In the Raymond Basin, which is self-contained (being neither an upstream nor a downstream basin), natural local supply is received directly, in the form of runoff from the mountains. Raymond Basin water users can do nothing to regulate the rainfall, but they can attempt to make maximum use of it when it is plentiful. As has been noted, the Basin is poorly suited to artificial replenishment, but various parties in Raymond Basin have operated local spreading grounds in conjunction with the Los Angeles County Flood Control District to capture the natural runoff in the streams that traverse the Basin and allow it to percolate into the underground reservoir rather than flow out of the Basin. This action raises underground water levels during wet periods, which can then be drawn down during dry periods. By restricting total groundwater extractions to the long-term safe yield of 30,622 acre-feet, the Raymond Basin producers have insured that, over long periods, recharge to the Basin and withdrawals therefrom will be equal, and long dry cycles can be withstood.

In West Basin, the entire source of natural fresh-water replenishment is from Central Basin. The reduction of groundwater withdrawals in Central Basin as a result of the adjudication initiated by the Replenishment District, the spreading of local runoff, reclaimed water, and imported water in the Montebello Forebay, and the maintenance of a sufficient hydrostatic head across the Newport-Inglewood Uplift have ensured to West Basin a relatively steady supply of fresh water. This supply would be highly exposed to the actions of users in Central Basin were it not for the management scheme adopted for the two basins. The fact that the replenishment activities are financed by the Central and West Basin Water Replenishment District gives West Basin producers a voice in decisions regarding their water supply. They also pay to support the supply program even though most of the activity occurs in Central Basin. This fact, combined with the reduction of groundwater extractions in West Basin to 1949 levels and the reduction in reliance upon Colorado River water for replenishment, leaves West Basin well able to withstand extended dry cycles.

Central Basin's natural water supply comes from upstream, in the Upper San Gabriel Valley. The actions of Central Basin water producers in securing a guaranteed minimum inflow across Whittier Narrows into the Montebello Forebay has markedly reduced their exposure to irregularities in rainfall and to withdrawals upstream. The inflow from the Upper San Gabriel Valley is supplemented by the spreading of local runoff by the LACFCD during wet periods, by the spreading of reclaimed waste water produced at the Whittier Narrows and San Jose Creek Reclamation Plants, and by the spreading of imported water from northern California and the Colorado River. The imported water supplies have been the most vulnerable, and the Replenishment District has sought to minimize reliance upon them. With the reduction in groundwater extractions in Central Basin to the agreed pumping allocation of 217,367 acre-feet, with the long-term safe yield of the Basin at roughly 157,000 acre-feet and with the increase in use of reclaimed waste water for spreading to 50,000 acre-feet, Central Basin is also positioned to withstand the long cycles of dry years that southern California experiences.

Orange County has, like Central Basin, secured for itself a guaranteed minimum inflow from upstream, which has stabilized its ground water supply conditions to some degree. But in Orange County, as we have noted several times, there has been no limitation on groundwater withdrawals. Each year, the Orange County Water District attempts to purchase and spread sufficient amounts of imported water to offset the overdraft caused by groundwater extractions in excess of the basin's 150,000 acre-foot safe yield.

Imported replenishment water is the first form of imported water cut back by MWD during dry periods; imported water used for direct service needs receives the higher priority. Orange County water users have not been induced to switch their base supply from ground water to imported direct service water to the degree that users in Central and

West Basins (which are similarly situated physically) have been. Instead, they have relied for most of their total water use on ground water while purchasing replenishment water to make up the overdraft. This has worked so far, for two reasons. First, during the second half of the last extended drought cycle, imported Colorado River water was available in sufficient amounts and at sufficiently low cost to allow the Water District to purchase enough each year to offset the annual overdraft and even to reduce part of the accumulated overdraft. Second, when the availability of imported replenishment water became constrained after California's loss of much of its claimed rights to Colorado River water, the most recent long-term drought cycle abated.

The question that remains for Orange County is what will happen when the next extended drought begins. There is no question that another dry cycle will come. The only question is when it will start. Because agriculture still represents a larger share of land use in Orange County than it does in the three Los Angeles County basins, Orange County was already more exposed to variability in precipitation, since water demand for agricultural use escalates more rapidly in dry periods than does water demand for residential and commercial uses. With no limitation on groundwater extractions, with ground water being less expensive than imported water for direct service use, and with availability of imported water for replenishment reduced and its cost significantly higher than in the late 1950s and early 1960s, Orange County is highly exposed to depletion of its ground water supply when the next dry cycle occurs. The current favorable conditions in the Orange County basin must be regarded as transitory and vulnerable.

A second form of exposure to consider is exposure to contamination. This is not a problem in Raymond Basin, which is not exposed to the ocean or to upstream polluters. Any contamination of the groundwater supply in Raymond Basin would come from indigenous pollution sources, and ground water quality is assiduously monitored in this Basin as well as the others for such contaminants. In each of the other basins, the primary threat to ground water quality has been from the ocean, and in each case that threat has been largely eliminated through the construction and operation of the barrier projects. In West and Central Basins, the barrier projects are operated using treated imported water (which is equivalent to direct service water, in priority and in price). In Orange County, the barrier project is operated using purified waste water from the Water District's Water Factory 21, which assures a supply of water for the barrier there regardless of precipitation conditions. The Central and West Basin Water Replenishment District is exploring the possibility of using purified waste water in the barrier projects in those basins, thus further ensuring the supply of barrier water in the future.

In all, then, the four basins may be regarded as not exposed to contamination threats (unless pollution problems grow in the future). Three of the four basins may also be regarded as not exposed to the extreme variations in precipitation that are characteristic of the Los Angeles area. Because of its reliance on imported replenishment water and the absence of assignment of shares to the ground water supply, Orange County remains highly exposed to cyclic fluctuations in local water supply.

b. Basin Management Costs

Basin management costs consist of: watermaster service expenditures (where applicable), water replenishment expenditures (where applicable), and adjudication costs (where applicable). Since all of the area of the four basins is now annexed to MWD and part of some MWD member agency (i.e., either a city or a municipal water district), inclusion of the property taxes paid to MWD and the member agencies (which are retailers of imported MWD water to direct service users) would serve no purpose in comparing the costs incurred in the four basins, despite the fact that acquisition of imported supplies was vital to the process of resolution in each basin. Also excluded from consideration are the costs of spreading of local runoff by the Los Angeles County and Orange County Flood Control Districts, as this activity would probably have been undertaken as part of flood control anyway. One further note: expenditures cited below are all for 1985, except of course for the adjudication costs, which were incurred earlier.

Arriving at watermaster expenditures for Raymond, West, and Central Basins is quite straightforward -- they are taken from the tables in those chapters. Similarly, arriving at the water replenishment expenditures for West Basin, Central Basin, and Orange County is quite straightforward -- total expenditures of the Central and West Basin Water Replenishment District are divided between West Basin and Central Basin on the basis of their shares of total groundwater production in the District, and total expenditures of the Orange County Water District are obtained directly from its annual report.

Arriving at the adjudication costs requires some calculation. Simply to treat all adjudication costs as having been paid in the past and therefore no longer affecting the calculation of basin management costs would not be proper (even though those fees have all long since been paid). It would make for an unfair comparison between Orange County (where the costs of an intra-basin adjudication were avoided) and the other basins. Orange County water users have deliberately avoided this expense, on the theory that "adjudication never produced one drop of water". Their approach should be compared with those where adjudication expenses were incurred in order to see the savings realized by Orange County. So, adjudication costs in the other three basins have been included by amortization. Taking the best estimate available of the total adjudication costs in a basin ($300,000 in Raymond, $3,000,000 in West, and $450,000 in Central), let us engage in the following speculation: suppose the parties had, at the outset of the litigation, borrowed enough money to pay the entire cost of the adjudication up front, and then had made annual payments each year thereafter to pay off the loan. By using a 50-year loan period and a conservative interest rate (reflecting the times in which the money would have been borrowed -- 1937, 1945, and 1962) of 5%, we obtain an annual payment for the adjudication that can then be divided by total groundwater extractions to obtain a current cost per acre-foot of ground water resulting from the adjudication of ground water rights within the Raymond, West, and Central Basins.

The resulting basin management costs are summarized in Figure 9-10. Adjudication costs in Raymond Basin work out to $.50 per

FIGURE 9-10

Basin Management Costs and Savings per Acre-Foot from Basin Management in the Four Basins

	Raymond Basin	West Basin	Central Basin	Orange County
Basin Management Costs per Acre-Foot of Groundwater Extractions, 1985	$ 3.50	$ 77.40	$ 73.77	$ 151.79
Average Cost of an Acre-Foot of Water With Basin Management	$ 184.65	$ 235.71	$ 224.85	$ 267.93
Estimated Cost of an Acre-Foot of Water if All Ground Water Replaced by Imported Water	$ 748.68	$ 739.30	$ 739.94	$ 740.21

acre-foot per year, and watermaster expenditures for 1985 were $3.00 per acre-foot of ground water, yielding a total of $3.50 per acre-foot of ground water. Adjudication costs in West Basin amortize to $2.50 per acre-foot per year, watermaster expenditures were $2.40, and CWBWRD expenditures were $72.50 per acre-foot of ground water, for a total of $77.40 per acre-foot of ground water in West Basin. In Central Basin, adjudication costs are calculated at $.11 per acre-foot per year, watermaster expenditures were $1.16 per acre-foot, and CWBWRD expenditures were $72.50 per acre-foot, giving a total of $73.79 per acre-foot of ground water. In Orange County, Orange County Water District expenditures were $151.79 per acre-foot of ground water extracted, which is the total basin management costs since there were no adjudication costs or separate watermaster service expenditures (monitoring of groundwater production is also performed by the OCWD).

It would not appear that Orange County water users have saved themselves much money by foregoing assignment of shares. Indeed, the basin management costs in Orange County are substantially higher than they are for the similarly-situated Central and West Basins. By avoiding an intra-basin adjudication putting a ceiling on groundwater extractions, Orange County has had to invest much more heavily in additional spreading facilities to provide enough replenishment capacity to meet the annual overdrafting of the ground water supply, and has had to purchase more imported replenishment water than has CWBWRD, even as the cost of that water has escalated sharply in the first half of this decade. Preservation of the ground water supply in West and Central Basins and Orange County has come at a much higher price than in Raymond Basin. There, the reduction of pumping to the safe yield of the Basin combined with the absence of an artificial replenishment program and the need for a barrier against the sea has kept basin management costs to just $3.50 per acre-foot per year. Basin preservation has by far come at the highest price in Orange County, where the supply-side approach has necessitated much greater expenditures to accommodate unlimited pumping.

It bears noting that the Orange County basin management costs, stated in "per acre-foot" terms, should not be misread as indicating that groundwater producers pay $151.79 per acre-foot in addition to their direct production costs. If that were the case, Orange County groundwater producers would probably rely upon imported water to a much greater degree than they do. The Orange County Water District still raises a considerable portion of its revenue from property taxes, so property owners still subsidize groundwater production. When District expenditures are divided by total groundwater production, one obtains the $151.79 per acre-foot figure as the cost of basin management per acre-foot produced. But the groundwater producer pays only his direct production costs (estimated at $134.00 per acre-foot) plus the pump tax of $32.00, for a total of $166.00 per acre-foot of groundwater produced, rather than $285.79 per acre-foot, which would be the cost if all basin management costs were paid by taxing groundwater production.

c. Efficiency Considerations

Each year, the Orange County Water District publishes estimates of the direct production costs from pumping ground water, as well as the cost of treated imported MWD water. Assuming for the sake of this presentation that the direct production costs of extracting an acre-foot of ground water are the same whether the well used is located in Orange County or in Los Angeles County, we can adopt the 1985 estimate of $134.00 per acre-foot for use in considering the savings achieved in the four basins from preserving their ground water supplies relative to total reliance on imported water at $240.00 per acre-foot.

As has been noted throughout this study, a groundwater basin can be used in more than one way. The water supplied by the basin can be used to meet the base supply needs of the users, or the basin can be used as a storage facility to provide water for peak and emergency use while base supply needs are met from surface and imported supplies. Given the growth in total water use in each of the four basins, if the water users had pursued the first of these methods, each of the four basins would have been destroyed by now, by depletion or by contamination or both. Had this occurred, the provision of a water supply to the population and commerce of these areas would now require use of imported direct service water to meet 100 percent of total water use. However, because of the variability of supply of imported water (i.e., there are wet and dry seasons within each year and there are wet and dry years), and because of the variability of demand for water (i.e., water needs at the peak hour of the peak day of the peak season may be as much as twenty times the average rate of use), considerable investment would have to be made in storage facilities to replace those provided naturally by the groundwater basins. In order to evaluate whether the price that has been paid for preservation of the groundwater basins has been worth it to the local users, we need to find some way of estimating the costs they would be incurring for their water supply if they had allowed the basins to be destroyed.

In order not to overstate the case, we will proceed as follows. We will take the lowest estimate found of the amount of surface storage capacity required to make up for the loss of the underground system. This is an LACFCD estimate, that storage facilities would have to be constructed equivalent to 16 percent of total water use. We will then use the lowest estimate available of the capital cost of constructing that amount of surface storage in each of the basins. Again, we rely on an LACFCD estimate, of $57,440 per acre-foot ($16,000 per acre-foot in 1960 adjusted upward by the all-item CPI, which is itself a conservative adjustment as the price of land that would have to be acquired for the construction of such facilities in Los Angeles and Orange Counties has escalated at a faster pace than the all-item CPI). We then amortize this construction at 5% per year over a 50-year period, as was done with adjudication costs earlier, to obtain an annual cost of the construction of the required surface storage. Finally, we include no cost for annual maintenance of these surface storage facilities -- i.e., we will assume that they never need cleaning, repainting, or repairs, thus treating them as equivalent to natural underground storage.

The results of these calculations are presented in Figure 9-10. In Raymond Basin, where the current mix of ground water and imported water is 54% to 46%, calculating ground water at $134.00 per acre-foot plus the $3.50 basin management costs and imported water at $240.00 per acre-foot, an average acre-foot of water costs $184.65. If Raymond Basin water users were totally reliant on imported water, they would require 8,571 acre-feet of storage capacity (.16 times total water use of 53,567 acre-feet), which at $57,440 per acre-foot would cost $492,318,240.00. Annual payments for this construction would be $27,248,400.00, or $508.68 per acre-foot of water used. Adding this to the $240.00 per acre-foot cost of imported direct service water yields a total of $748.68 per acre-foot of water in Raymond Basin. Since an acre-foot of water is the average annual demand for a five-person household, we can translate this difference between $184.65 per acre-foot under the current system and $748.68 per acre-foot under the alternative as the difference between an average monthly water bill of $15.00 and an average monthly water bill of $62.50.

In West Basin, where the current mix of ground water and imported water is 15% to 85%, calculating ground water at $134.00 per acre-foot plus the $77.40 basin management costs and imported water at $240.00 per acre-foot, an average acre-foot of water costs $235.71. Total reliance on imported water would require 52,390 acre-feet of storage capacity, which at $57,440 would cost $3,009,281,600.00. Annual payments would be $163,490,000, or $499.30 per acre-foot of water used. Adding this to the $240.00 per acre-foot cost of imported direct service water gives a total of $739.30 per acre-foot of water in West Basin. Compared with the cost of $235.71 per acre-foot under the current system, this is the difference between an average monthly water bill for a five-person household of $19.64 and an average monthly water bill of $61.67.

In Central Basin, where the current mix of ground water and imported water is 47% to 53%, calculating ground water at $134.00 per acre-foot plus the $73.77 basin management costs and imported water at $240.00 per acre-foot, an average acre-foot of water costs $224.85. Total reliance on imported water would require 59,300 acre-feet of storage capacity, which at $57,440 per acre-foot would cost $3,406,192,000.00. Annual payments would be $185,289,120.00, or $499.94 per acre-foot of water used. Adding this to the $240.00 per acre-foot cost of imported direct service water yields a total of $739.94 per acre-foot of water in Central Basin. Compared with the cost of $224.85 per acre-foot under the current system, this is the difference between an average monthly water bill of $18.74 and an average monthly water bill of $61.72.

In Orange County, where the current mix of ground water and imported water is 69% to 31%, calculating ground water at $134.00 per acre-foot plus the $151.79 basin management costs and imported water at $240.00 per acre-foot, an average acre-foot of water costs $267.93. Total reliance on imported water would require 66,240 acre-feet of storage capacity, which would cost $3,804,825,600.00. Annual payments for this would be $207,087,840.00, or $500.21 per acre-foot of water used. Adding this to the $240.00 per acre-foot cost of imported direct service water gives a total of $740.21 per acre-foot of water in Orange County. Compared with the cost of $267.93 per acre-foot under the current system, this is the difference between an average monthly water bill of $22.30 and an average monthly water bill of $61.74.

Even with conservative estimates of the cost of replacing the groundwater basins in this study with surface storage and imported water, it appears that basin preservation has been a good bargain. We are unable to make efficiency determinations of the type that would indicate whether basin management costs are as low as they can possibly be in each of these basins, and there is no reason to presume prima facie that they are, but we can conclude that the basin management costs being paid in each of the basins are considerably less than the costs the water users in these areas would be facing if the basins had been destroyed.

d. Distributional Considerations

We have observed in each of the basins that there has been a reduction in the number of entities producing ground water. The question now becomes how to evaluate this phenomenon.

There is no doubt that in West and Central Basins, the adjudication process itself eliminated many of the small producers. They abandoned groundwater production rather than pay the costs of defending their right to a few acre-feet or less of ground water. This occurred despite the fact that the ground water industry in each of these two basins was sufficiently concentrated that a smaller group of large producers could have curtailed their use and preserved the basins by their own actions. The impact of the production by the very small producers on aggregate groundwater extractions would have been minimal. Yet in the adjudications of those basins, the parties sought to spread the costs over the total set of producers, even though this resulted in the elimination of most of them from production. Those small producers, had they not been eliminated, could today still be pumping their one or two acre-feet per year and enjoying the lower cost and high quality of the ground water instead of having to acquire imported water.

There are, however, other considerations that counsel caution in attributing all of the reduction in the number of small pumpers to the adjudication process. Some small pumpers were agricultural producers. As land use in the area has changed from agricultural to residential and commercial, several of these producers sold their farmland to real estate developers, and so would not have been pumping ground water anymore regardless of the onset of adjudication.

In Orange County, where there has been no intra-basin adjudication of rights, many more small producers have continued production of ground water. Given the physical similarity of Orange County with Central and West Basins, it is therefore reasonable to suppose that many more small producers would also have continued production in those basins had it not been for adjudication (although it should be reiterated that irrigated agriculture represents a larger share of land use in Orange County, so again, not all of the differences can be attributed solely to adjudication). This discussion does not relate as strongly to Raymond Basin, as the ground water industry there was small to begin with and remains so, and during the process of adjudication itself the number of parties declined only from 31 to 25.

If the criterion one uses to evaluate the distributional consequences of the actions in the various basins is the effect on the small vs. large producers, one would therefore conclude that Orange County's approach has been considerably more equitable than that of West and Central Basins. Small producers have not been chased out of the ground water industry in Orange County, and continue to derive substantial benefits from being able to produce their own water from underground rather than having to purchase it from others.

However, there is another aspect to distribution. In addition to the issue of whether the large producers could have suffered the small producers to continue production (which they surely could have) by omitting them from the assignment of shares, there is the issue of whether the value of rights to groundwater production has been appropriately reflected in the various basins. In Orange County, the absence of an assignment of shares to the groundwater supply means that there are no tradable groundwater rights in Orange County -- rights remain usufructory and hence untradable. Small producers thus continue to produce, but we cannot be sure whether they do so because they prefer their groundwater rights to whatever compensation they could receive for them or because they simply have no other option but to use their right to produce as opposed to buying water from another source.

In Raymond, West, and Central Basins, there has been further reduction in the number of parties owning rights since the end of the adjudication process in each of those basins. In other words, parties who went through the adjudication process, paid the costs thereof, and acquired decreed rights to groundwater production nonetheless have disposed of their rights subsequently. In Raymond Basin, the 25 parties who completed the adjudication process are now 17. In West Basin, 99 parties were decreed to have non-zero rights in 1961; now there are 74, of whom only 37 are active pumpers (the rest lease their rights to the 37). In Central Basin, there were 508 parties with pumping allocations in the first year after the judgment; there are 184 now, of whom 116 are active pumpers. In these basins, parties with rights have four options: (a) exercise their rights to pump in full; (b) sell their rights in full and become water consumers instead of water producers; (c) retain their rights for future use but lease them to another for current use; and (d) some combination of the other three options -- i.e., pump some, sell some, lease some.

This other aspect of distribution, then, is whether rights to ground water are possessed by those who most value them. In Raymond, West, and Central Basins, we cannot presume that the market for water rights works perfectly. We cannot therefore conclude that groundwater rights are entirely in the hands of those who most value them. We can, however, at least observe that the capacity exists for those who value their water rights less than others to exchange them with those others for something they value more. We are then able to infer that, when a water right owner ceases production and transfers his right to another, he has made a judgment about the relative value of his right and has received some form of compensation for it that he deems acceptable.

By contrast, in Orange County, when a groundwater producer ceases production and becomes a water consumer rather than a water producer, it is much less clear what we are to make of that action. The number of ground water producers pumping 25 acre-feet per year or less in Orange County has declined from 780 in 1970 to 250 in 1985. All that we can say of the 530 small producers who have given up ground water production in those 15 years is (a) that they did not continue their groundwater production, and (b) that they received no compensation when they ceased that production.

Our conclusions, then, are mixed on the issue of the distributional consequences of the actions taken in the four basins. The process of adjudication undoubtedly eliminated several small producers from access to and use of the basins (especially West and Central), even though they could have been excluded from that process. The absence of an adjudication process in Orange County likely accounts for the continued presence of 250 relatively small ground water producers there. However, had the small producers in West and Central Basins been omitted from the adjudication of rights, they would also have ended up with no firm, tradable shares that they could exchange with others who valued them more. In Orange County, there is no way to determine that groundwater production is being pursued by those who value it most; one can only say that groundwater production is pursued by those who value it more than not producing. In the other basins, there is at least the possibility that rights to groundwater production have moved from those who valued them less to those who valued them more.

B. Summary: Getting Out of the Trap

We began with an arid place that is now home to 13 million people, with a natural water supply that alternates between droughts and floods, and with some people -- a vegetable grower, employees at an oil refinery, workers in a city water department -- facing problems there. The problems they face have a structure and a name. They are the problems of the commons. In particular, they are the problems of the endangered commons.

The endangered commons resembles two other kinds of problems to which scholars have devoted a great deal of attention. Both of these other kinds of problems are known as "social traps", situations of interdependent action where perverse incentive structures result in undesirable outcomes for rational, self-interested individuals. One is the problem of collective action, where people who may desire some non-excludable good do not obtain it because the incentive for each of them to contribute to its provision is overwhelmed by the incentive to "free ride" on the contributions of others. The other "social trap" is the Prisoner's Dilemma, where people who could (by coordinating their actions) generate a joint best outcome forego it in their pursuit of their individual best outcome and realize instead an outcome that is less preferred than either the joint best or the individual best outcome.

The problems of the endangered commons, because they share certain characteristics with these other "social traps", have often been treated as identical with them. This has been useful up to a point: the incentives facing the people involved in commons problems are indeed similar to the incentives in a collective action problem or a Prisoner's Dilemma game. There is a joint best outcome that could be obtained by coordinated action-- maintaining total use of the commons at the maximum level it can sustain. There is an individual best outcome that differs from this-- maximizing one's use of the commons while everyone else maintains their use at a sustainable level. And the benefits of the maintenance of use of the commons at a sustainable level are, as with the benefits of the provision of a collective good, non-excludable. So, within the endangered commons, individuals such as our vegetable grower, refinery employees, and municipal water department staff, face incentives to maximize their use of the commons and wait for others to exercise restraint, even as they begin to suffer losses from their collective overuse of this limited resource.

We thus understand the basic incentive structure of the endangered commons somewhat better through the use of the collective-action and Prisoner's Dilemma metaphors, by seeing the commons as yet another "social trap". But we can become trapped by this way of thinking itself. In our appreciation of the similarities among these situations, we can overlook their differences.

Unlike collective goods, for example, about which the theory of collective action was and is concerned, the commons generates subtractable yields. Non-excludability is common to both the collective-goods problem and the common-pool problem, but subtractability in use is not. As a result, in the commons it may be possible for people to make assignments of shares of the yield, to assess the costs of provision in relation to those shares, and to monitor individuals' appropriation of those shares. If we fail to see the difference between collective goods and common-pool goods, we can miss the opportunities this difference presents.

There are also differences between the endangered commons and the Prisoner's Dilemma game. By the nature of the rules that structure a Prisoner's Dilemma, the individuals involved cannot communicate about their situation and may not (depending on the iterations of the game) anticipate future interactions with the other player or players. But this may not be the case in many commons situations. People using a commons may anticipate an indefinite future of continued use of the commons, and they may even be members of a community in which they have other interactions with one another and capacities for discovering the nature of their situation and for communicating with one another about it. But most importantly, unlike the players in a Prisoner's Dilemma game, the users of a commons may have the capacity of changing the rules of the very "game" they are playing. Players in a Prisoner's Dilemma must take the rules of the game, and the incentive structure those rules produce, as a given; the rules are exogenous from the standpoint of the players. The users of a commons are not playing a game created by some master designer who sets the rules and creates the incentive structure and then inserts the users into it. The rules may be unrecognized by the users, and they may face considerable barriers in coordinating their behavior and changing the rules, but the rules are not exogenously determined, and the commons does not create its own destruction.

What can happen when we become trapped in our thinking about the commons by excessive reliance on these metaphors is well illustrated by the policy prescriptions that dominate the literature on commons problems. We become convinced that the endangered commons is the only kind of commons there can be. The commons is perceived as _ipso facto_ an insoluble problem. The only solution perceived by some is to change the commons so that it will no longer be a commons. There are some who advocate transforming the commons into public property, treating a limited resource as though it were some sort of collective good necessitating centralized provision by a Leviathan who coerces responsible behavior (i.e., restrained use and contributions to maintenance and investment) from the users. Others advocate transforming the commons into private property, so that each owner can manage his little piece, destroying it if he so desires.

Such prescriptions are premised on the commons situations as being intractible. There is, in these views, only one kind of commons. That one kind of commons is one where there are no restrictions on access and use. Yet, as is the case with a Prisoner's Dilemma, a commons situation is structured by rules. Unrestricted access is a rule. It can be changed. Unrestricted use is a rule. It can be changed. The absence of monitoring of individuals' use is a rule. So too is the absence of any reporting of use. So is the arrangement where each user can individually decide for himself how much of the yield of the commons to appropriate, and how much to contribute to the preservation of the resource. These rules can be changed.

If these rules are changed, there can still be a commons. The commons is a resource not under the ownership of an individual, to which more than one individual has access, and which generates subtractable yields that are appropriated by individuals with access to that resource. Those basic identifiers can remain in place. But within that commons, if the community of people with access can be restricted, if contributions to the maintenance of the resource can be enforced, if appropriation of the yield of the resource can be restricted, and if compliance with these rules can be sustained, then there may emerge a very different kind of commons situation. The endangered commons may be replaced by the managed commons.

But how will such rule changes take place? For some, the only way rule changes transforming the endangered commons into the managed commons can occur is through their coercive imposition by an omniscient external regulator. The advocates of privatization of the commons have well articulated the dangers of placing our faith in omniscient external regulators. To these we can add two others. The first is that rule systems that are externally generated and imposed upon users are likely to be poorly-fitted to the idiosyncrasies of a particular resource and to the idiosyncracies of a particular community of users, and thus may fail to produce optimal (or even improved) results no matter how assiduously they are followed. The second is that rule systems that are imposed upon local users may fail to be complied with no matter how appropriate they are to the problems to which they are addressed. As Colin Clark (2) and others have dicovered, users of a commons are likely to seek ways of thwarting restrictions that are imposed upon them. When people are the makers of their own rules, however, those rules are much more likely to fit the situation to which they are addressed, and they are also more likely to obtain compliance from those who are ruled since they were also the rule-makers.

But can people be the makers of their own rules governing the use of a commons, and can they do so in ways that conform to neither of the established policy prescriptions of the literature? There are no guarantees that this will happen, and there are no guarantees that people who engage in such rule-making will necessarily do so successfully. The likelihood of success will be affected by a number of characteristics of the particular commons situation and the institutional setting within which it occurs. If success is to be realized, it will involve at a minimum information-gathering about the resource and its users, communication among the users, the establishment by them of some manner of collective decision-making (which may involve the adaptation of some other established form to which they have access), some arrangement for sharing the costs of these undertakings, the assignment of shares to the appropriable yield of the resource, the establishment of sanctions to induce conforming behavior, and monitoring to detect non-conforming behavior.

This is a delicate process. It is subject to breakdown. It is also an open-format process. Different communities of users in different places at different times with different institutional capacities will work their ways through these steps differently. If such a process can be successfully pursued, however, it can result in an arrangement for a managed commons that is subject to high levels of compliance and considerable stability.

The question that remains is, can we establish that this alternative to the imposition of commons management by a Leviathan (whether in the form of conversion of the commons to public property or conversion of the commons to private property) is in fact possible? There are four groundwater basins in southern California that suggest that it is. In these cases, perfection has not been attained, but endangered commons have been turned into managed commons. In three of the cases -- the Raymond, West, and Central Basins in Los Angeles County -- all of the steps of a resolution process have been completed and the basins have been turned away from destruction and toward more efficient use. In the fourth case -- the groundwater basin in Orange County -- the step of assignment of shares has been omitted, and the basin, while much improved, remains highly exposed to depletion in the future.

In each of the cases, the local water producers themselves capitalized on the favorable elements of their situations, especially the availability of institutional capacities for information-gathering and the development of their own public and private agencies for communication, collective decision-making, cost-sharing, and monitoring. In addition, existing capacities were adapted for the establishment of sanctions and (in three cases) assignment of shares. In all of the cases, compliance with the locally-developed basin management programs has been so high that sanctions have never yet been assessed, even though hundreds of operators have been involved and as many as forty years have passed since the rules governing access and use were changed.

We cannot conclude from the experiences of these four commons that all commons will be preserved and successfully managed. Our conclusions must be far more limited than that. What we can conclude is the following:

(1) common-pool resources are not destined to be destroyed simply by virtue of the fact that they are organized as common-pool resources;

(2) destruction of a commons can be averted without either transforming the commons into public property regulated by a central manager or transforming the commons into private property in an attempt to eliminate the interdependent character of its use;

(3) the process of changing a commons from endangerment to management involves changing the rules regarding access to and use of the resource; and,

(4) the users of a commons themselves may make those rule changes, doing so with a sensitivity to the particular characteristics of the resource they use and to the particular attributes of their community, when they are allowed to do so.

It is this last phrase, "when they are allowed to do so", that should be emphasized in closing. The history of water resource management in California is instructive to us in a broader sense than might at first be revealed by a discussion of the particulars of some groundwater basins. In that setting, there is a "home rule" tradition. It is more than an article in the State Constitution. It is a policy commitment. The California legislature has operated with a working rule of ratifying people's initiatives for the creation of their own local units of government with which to tax themselves and through which to provide themselves with such collective benefits as they warrant. Within the water resource arena alone, this has led to the creation of hundreds of public water organizations. (3) Some of these are enormous, like the Metropolitan Water District of Southern California. Others are quite small, like the Foothill Municipal Water District. Many of them overlap city boundaries in an attempt to match the boundaries of the problems they are established to address, as with the Central and West Basin Water Replenishment District.

The policy commitment extends to the State agency that has the responsibility for water problems, the California Department of Water Resources. That agency has long operated on the principle that the local water users are the closest to the problems and thus should be the people who devise the solutions. The Department assists and advises, and has been an invaluable source of information-gathering and monitoring capabilities, but it has continually resisted any tendency toward centralization and uniformity in addressing local water resource management issues, maintaining instead that "[s]ince the history of use and the problems varied from basin to basin, there was good reason for diversity in water management efforts." (4) Local water users have, for better or worse, largely been allowed to work out their own solutions.

The State of California has provided another vital element of institutional infrastructure for water resource management in its court system, the maintenance therein of equity jurisprudence, and the establishment of the Court Reference Procedure for use in complicated water rights adjudications. Courts are deciders, but they are also institutions into which citizens can take problems and disputes where the citizens themselves largely shape the issues for decision. Settlements of disputes negotiated by the parties can be ratified in a court, and given the status of law, enforceable by the State, while the remedy remains specific to the particular dispute at issue. And within such institutions, there can be considerable inventiveness, as the development of "mutual prescription" in the Raymond Basin case attests.

This is not meant as an extended testimonial to the State of California. That State has its shortcomings, as do all others. The passage of Proposition 13 is the most prominent recent example of how, even in a State with as strong a "home rule" tradition as California's, if commitment to that tradition is not kept with vigilence, a decision can be made determining for every group of local citizens how much they can vote to tax themselves. But the example of water resource management in California's "home rule" setting does demonstrate for us that wisdom and expertise are not the sole preserve of central public managers, that innovation in resource management is not limited to the public sector, that diversity is not a sign of disorderliness or impending ruin, and that local citizens are not to be underestimated when it comes to their ability to solve local problems. Consider the complexity of the problems in West Basin: if local resource users can resolve that tangle of interrelated threats, then we should be cautious indeed about selling short the capacity of vegetable growers, refinery employees and municipal water department workers for getting out of their trap and changing an endangered commons to a managed commons.

This, then, is the broader lesson of the experience of water resource management in southern California. When they are allowed to do so, people can exhibit remarkable capacities for self-governance. And before we leap from the observation of complicated resource problems to the conclusion that "the only way" to address them is through some imposed package solution, we do well to look first at what John Wesley Powell wrote nearly one hundred years ago in an essay about the water problems of the arid lands of the western States: (5)

> Furnish the people with institutions of justice,
> and let them do the work for themselves.

Notes to Chapter Nine

1. Panel on Common Property Resource Management (1986).

2. Clark (1980).

3. Henley (1957), p. 665.

4. Rolph (1982), p. 16.

5. Powell (1890), p. 113.

APPENDIX

CHRONOLOGIES OF EVENTS IN THE FOUR BASINS

The Raymond Basin Chronology

1771 Fra Junipero Serra establishes San Gabriel Mission south of Raymond Basin; earliest known use of Raymond Basin Area waters

1881 First well drilled in Raymond Basin

1908 U.S. Geological Survey report published; 141 wells in operation in Raymond Basin

1913 Overdraft of Raymond Basin begins

1914 City of Pasadena Water Department initiates spreading

1928 Metropolitan Water District of Southern California (MWD) established, with City of Pasadena as original member

1937 City of Pasadena initiates legal action against other Raymond Basin water producers

1939 Superior Court appoints Department of Public Works as Referee in Raymond Basin litigation

1943 Referee's Report filed; stipulated agreement among Raymond Basin producers

1944 Trial of Pasadena v. Alhambra; Judgment issued; establishment of Watermaster Service for Raymond Basin

1945 Pasadena v. Alhambra judgment appealed

1947 District Court of Appeal reverses and remands Pasadena v. Alhambra

1949 California Supreme Court affirms Pasadena v. Alhambra

1950 City of Pasadena requests redetermination of Raymond Basin safe yield

1952 Foothill Municipal Water District formed

1953 Foothill Municipal Water District annexes to MWD

1955 Safe yield redetermined; judgment modified; decreed rights of parties increased

1960 City of Pasadena sues East Pasadena Water Company

1965 Pasadena's suit against East Pasadena Water Company settled

1974 Modification of Judgment allows parties credit for spreading and begins studies of pumping patterns

1984 Raymond Basin Management Board assumes Watermaster responsibilities

The West Basin Chronology

1870 Water users in the vicinity of Newport-Inglewood Uplift tap artesian wells and springs, primarily for agricultural use

1904 United States Geological Survey reports over 100 producing wells in West Basin, shrinkage of artesian area, lowered underground water elevations

1912 Southern California Edison Company abandons well in Redondo Beach due to salt water contamination

1913 City of Los Angeles begins importing water from Owens River

1920 Continuing overdraft begins in West Basin; water levels below sea level at wells along coast

1922 Wells in El Segundo are shut down

1928 Metropolitan Water District (MWD) established; Los Angeles, Long Beach, Torrance and Compton among original members

1929 MWD study conclude West Basin being invaded by Pacific Ocean water

1931 City of Inglewood study reports long-term threats from declining water levels and salt-water encroachment

1934 Division of Water Resources report published, showing extent of salt water intrusion in West Basin along western and southern boundaries

1938 LACFCD initiates spreading of flood waters in Montebello Forebay in Central Basin

1941 First Colorado River water deliveries arrive in Los Angeles County

1942 LACFCD Chief Engineer and Manhattan Beach City Engineer correspond regarding salt-water intrusion, initiate contacts with other West Basin producers

1943 West Basin Survey Committee formed, contracts with USGS to study ground water conditions and prospects

1945 West Basin Ground Water Conservation Group replaces West Basin Survey Committee, appoints Ways and Means Committee to organize report for West Basin producers; Ways and Means Committee report and recommendations published and distributed; West Basin water rights adjudication initiated by California Water Service Co., Palos Verdes Water Co., and City of Torrance

1946 West Basin Water Association established, succeeding West Basin Ground Water Conservation Group; WBWA appoints Engineering Advisory Committee to aid in West Basin adjudication; Order of Reference issued to Division of Water Resources to act as Referee in West Basin adjudication; County Supervisor organizes Southwest Water Fact-Finding Committee, later re-named West Basin Campaign Committee, to organize formation in West Basin of a municipal water district to annex to MWD to secure imported water supplies

1947 First special election to form West Basin Municipal Water District (WBMWD), formation defeated; second special election for smaller District, formation carried

1948 WBMWD annexes to MWD; Gardena annexes to WBMWD

1949 Amended complaint in West Basin suit names 340 additional parties; MWD water deliveries to WBMWD begin

1950 Groundwater extractions in West Basin 81,626 acre-feet, total water use 140,700 acre-feet; experimental injection well operates successfully at Manhattan Beach; Los Angeles County Flood District Act amended to allow creation of Conservation Zones within the District

1951 State of California appropriates $750,00 for prototype injection barrier

1952 City of Inglewood and Dominguez area annex to WBMWD; first Referee's Report issued in West Basin suit; WBWA appoints Legal Settlement Committee to negotiate pumping reduction; construction of prototype injection barrier begins; LACFCD Zone I created to finance artificial replenishment

1953 Injections at prototype barrier begin; City of Hawthorne annexes to WBMWD

1954 Draft Interim Agreement for pumping reduction presented to parties in West Basin litigation; LACFCD Zone II created to finance barrier; artificial replenishment in Montebello Forebay begins; Committee of 12 drafts Water Recordation Act and Water Replenishment District Act

1955 Interim Agreement presented to Court; Court issues exparte order requiring signers to comply with pumping reduction, establishing Watermaster Service, beginning Water Exchange Pool; State of California enacts Water Recordation Act and Water District Act

1956 Reference Continuance ordered in West Basin suit; second water rights suit, American Plant Growers case, initiated against new pumpers

1957 Judge in West Basin adjudications disqualifies himself, voiding all orders and halting operation of Interim Agreement and Reference Continuance

1958 New judge reinstates previous orders in West Basin adjudications

1959 Special election to form Central and West Basin Water Replenishment District (CWBWRD), formation passes; draft Second Referee Report circulated; WBWA Settlement Committee begins work on Stipulated Judgment

1960 Draft stipulation presented to WBWA, circulated for signatures

1961 Stipulation presented to Court, Judgment entered; Hawthorne appeal begins; CWBWRD operations begin, first pump tax assessed ($3.19/acre-foot)

1964 Hawthorne appeal ends unsuccessfully

1965 Alamitos Gap Barrier Project begins operation

1966 Stipulated Judgment entered in American Plant Growers case

1971 Dominguez Gap Barrier Project begins operation

1972 LACFCD Conservation Zones expire, not renewed by County Board of Supervisors

1980 Groundwater extractions in West Basin 57,085 acre-feet; total water use 309,681 acre-feet

The Central Basin Chronology

1870 Artesian waters in use in vicinity of Newport-Inglewood Uplift

1913 Los Angeles begins imports of Owens River water

1928 Metropolitan Water District (MWD) established; Los Angeles, Long Beach, and Compton among original members

1938 LACFCD begins spreading of flood waters in Montebello Forebay

1941 First Colorado River water deliveries arrive in Los Angeles County

1942 Continuing overdraft in Central Basin begins; groundwater production exceeds 200,000 acre-feet

1949 City of Compton convenes meeting of Central Basin cities to discuss ground water conditions; City of Long Beach reports appearance of salt-water intrusion on inland side of Newport-Inglewood Uplift

1950 Central Basin Water Association (CBWA) formed, requests investigation of Basin conditions by State Water Resources Board

1952 State Water Resources Board Central Basin Investigation report published; CBWA distributes report to Central Basin water producers; LACFCD Zone I created to finance artificial replenishment program; CBWA campaigns for formation of a municipal water district to annex to MWD; Special election held on formation of Central Basin Municipal Water District (CBMWD), formation carries

1954 CBMWD annexes to MWD
LACFCD spreading of imported replenishment water at Montebello Forebay begins

1955 MWD Colorado River water deliveries to CBMWD begin
State of California enacts Water Recordation Act and Water Replenishment District Act

1959 Lawsuit against Upper San Gabriel Valley water producers initiated by City of Long Beach, City of Compton, and CBMWD
Central and West Basin Water Replenishment District (CWBWRD) formed by special election

1960 Groundwater extractions reach 300,000 acre-feet, accumulated overdraft tops one million acre-feet, use of MWD imports less than 10% of capacity

1961 CBWA Board adopts resolution supporting an adjudication of water rights in Central Basin; "Principles of Settlement" agreed to in suit against Upper San Gabriel producers

1962 CWBWRD initiates adjudication of Central Basin water rights; CWBWRD engineer begins compilation of production histories; CBWA appoints settlement committee, which presents draft Interim Agreement to CBWA and parties; signed Interim Agreement presented to Court, which enjoins signers to reduce pumping and appoints Watermaster; pumping reduction begins; Los Angeles County Board of Supervisors authorizes LACFCD to begin Alamitos Gap Barrier Project using Zone I funds; Whittier Narrows Reclamation Plant begins supply of reclaimed waste water to CWBWRD

1964 CBWA settlement committee completes draft Stipulation for Central Basin adjudication; negotiation committees in suit against Upper San Gabriel producers reach settlement agreement

1965 Stipulation among Central Basin parties presented to Court, Central Basin Judgment entered; Stipulation between Central Basin parties and Upper San Gabriel producers presented to Court, Judgment entered; Alamitos Gap Barrier begins operation

1967 San Jose Creek Reclamation Plant begins supplying reclaimed waste water to CWBWRD

1972 LACFCD Conservation Zones expire

1985 Total water use in Central Basin reaches 370,625 acre-feet, water imports total 222,916 acre-feet, exceeding groundwater extractions of 195,349 acre-feet

The Orange County Chronology

1769 First Spanish overland expedition through Orange County area; Santa Ana River and Valley named for St. Anne

1776 Mission San Juan Capistrano dedicated

1857 Anaheim founded by German settlers

1861 Severe flooding of the coastal plain

1863-1864 Great Drought of 1863-64 ends dominance of land holdings by the rancheros; smaller holdings develop thereafter

1868 A.B. Chapman and Andrew Glassell receive 40 acres of land in payment of attorneys' fees. They call the town built there Richland; name changed to Orange in 1875

1869 Santa Ana founded by William Spurgeon

1870 First local orange trees raised in Anaheim area; James Irvine begins acquiring land to comprise the original 172-square mile Irvine Ranch

1873 William Spurgeon drills a 340-foot well and constructs a 2,500-gallon storage tank, which serves as the town "water works" for Santa Ana

1879 City of Anaheim taps an artesian well for municipal supply to supplement private wells during the dry season

1880s Northern landowners in the County sue southside users to establish a predominant claim to Santa Ana River water. Trial court judgment favors nothside users, but is reversed by the California Supreme Court based on the riparian right of the Rancho de Santiago de Santa Ana downstream.

1884 Another severe flood; possible to row a boat overland to Los Angeles

1889 Governor Waterman signs bill calling for vote on the question of Orange/Los Angeles County division. The Orange County area votes 3,004 to 499 to separate from Los Angeles County and become an independent county.

1908 Santa Ana River rechanneled

1910 Cleveland National Forest, a preserve of 390,000 acres, formed to insure watershed protection

1916 Another flood inundates the County's coastal plain

1920	Orange County population 61,375; 30,310, or 49%, in urban areas Representatives of local water agencies (public and private) note receding water levels in wells
1920s	Early signs of sea-water intrusion along the coast
1925	Lippincott Report on conditions and utilization of the Santa Ana River Valley in Orange County issued
1927	February flooding; Orange County Flood Control District formed; Metropolitan Water District of Southern California formed by special act of the California Legislature
1931	Orange County Farm Bureau requests that State Legislature seek the formation of a district for conservation and replenishment of the basin
1932	Irvine Company files suit against water users in the upper basin, claiming that upstream actions endanger the Company's riparian right and the supply to its 80 wells.
1933	State Senator Edwards introduces Senate Bill 1201 authorizing formation of an Orange County Water District; bill is passed. Orange County Water District is created, originally including most of the overlying owners of the main Orange County basin, but excluding the three major cities, parts of Irvine Ranch, and some coastal area
1938	Orange County Water District Act amended, more territory included; another disastrous flood, the most destructive ever in the area
1940s	Study of sea water intrusion undertaken by United States Geological Survey
1941	Prado Dam completed by the Army Corps of Engineers
1942	Upper Basin - Lower Basin litigation settled with an agreement governing upstream spreading activities
1948	Orange County Water District begins purchases of MWD water from the Colorado Aqueduct for replenishment purposes
1951	Orange County Water District initiates court action, filing a complaint against the four upstream cities of Riverside, San Bernardino, Colton, and Redlands
1952	Joint meeting of local water committees and the Water District Board to discuss increasing purchases of MWD water for replenishment of the basin Committee of 12 formed to formulate a water management plan

1953 Committee recommendations for amendments to the Orange County Water District Act adopted by the State legislature. Water District gains more territory, pump tax authority, and authority to require registration of all wells and reporting on groundwater production.

1957 Orange County Water District suit against the four upstream cities tried; judgment favors the District, and is subsequently upheld and modified on appeal

1963 OCWD files action seeking adjudication of water rights of substantially all users in the area tributary to Prado Dam in the Santa Ana River watershed

1967 Construction of Orange County Coastal Barrier Project begun at Talbert Gap

1968 Settlement of the OCWD action for adjudication of rights in the Santa Ana River watershed; Santa Ana River Watermaster created
Extraction wells at Talbert Gap Unit of the Coastal Barrier operational.
Orange County Water District Act amended by State Legislature to give the District the authority to determine a basin production percentage (of total water use), and to assess a basin equity assessment against those using in excess of the basin production percentage.

1977 Statewide drought: no surplus Colorado River water was available for replenishment after March 1977, and no State Project water for any purposes after March.

1978 MWD institutes in-lieu replenishment program, In-lieu program continues through 1981.

1979 District Act amended to allow greater funding flexibility as a result of reduced ad valorem revenue (due to Proposition 13 passed in 1978), allowing District operations to be funded with Replenishment Assessment collections.

1980 Orange County population, 1,932,709; 1,926,911, or 99.7% in urban areas

1982 Interruptible water pricing program begun by MWD

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I. Personal Information

Born: October 20, 1957; Rockford, Illinois
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Education:
- -- B.S. (Economics), Honors Tutorial College, Ohio University, Athens, Ohio, June 1978
- -- M.A. (American Government), Ohio University, Athens, Ohio, November 1979
- -- Certificate in Public Administration, Ohio University, Athens, Ohio, November 1979
- -- Ph.D. (Political Science), Indiana University, Bloomington, Indiana; admitted to candidacy, May 1986; completion of degree expected May 1987

II. Areas of Specialization

Political Theory and Methodology
(Methodology of Political Science, Collective Action and Commons Problems, Institutional Analysis)

American Politics
(American Constitutional Law and Judicial Process, American National Institutions)

III. Academic Experience

Teaching:

--Associate Instructor, Department of Political Science, Indiana University - Purdue University at Indianapolis (IUPUI), Fall 1986; taught Y101, Principles of Political Science, and Y103, Introduction to American Government

--Associate Instructor, Department of Political Science, Indiana University, Summer 1986; taught Y308, Urban Politics

--Associate Instructor, Department of Political Science, Indiana University, Spring 1985; taught Y302, Public Bureaucracy in Modern Society

--Associate Instructor, Department of Political Science, Indiana University, Summer 1983; taught Y200, Women and Public Policy

--Associate Instructor, Department of Political Science, Ohio University, Summer 1979; taught 102, Issues in American Politics

--Teaching Assistant, Department of Political Science, Ohio University, 1978-79; Political Science 101, Introduction to American Government, Fall, Winter, and Spring Quarters

Research Skills and Experience:

--Research Associate, Workshop in Political Theory and Policy Analysis, Indiana University, 1982-1986; research work on collective action and common-pool resources supported by National Science Foundation grant NSF SES-830-9829 and by U.S. Agency for International Development grant AID DHR-1096-GSS-6042

--Program Evaluation: Seminars at University of Michigan, 1979-80; Program Planner/Evaluator, Washtenaw County Employment and Training Program, Ann Arbor, Michigan, 1980-81, Research Analyst, Washtenaw County Community Mental Health Center, 1981-82

--Statistical Analysis and Modelling: Econometrics completed at 600s level at University of Michigan, 1979-80, and at Indiana University, 1982-83

Other:

--John V. Gillespie Dissertation Fellowship, Department of Political Science, Indiana University, 1986-87

--Institute Fellowship, Institute for Public Policy Studies, University of Michigan, 1979-80

--Distinguished Professor's Award, Department of Economics, Ohio University, 1977-78

IV. Publications

William Blomquist and Elinor Ostrom, "Institutional Capacity and the Resolution of a Commons Dilemma", Policy Studies Review, Vol. 5, No. 3, November 1985, pp. 373-394

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