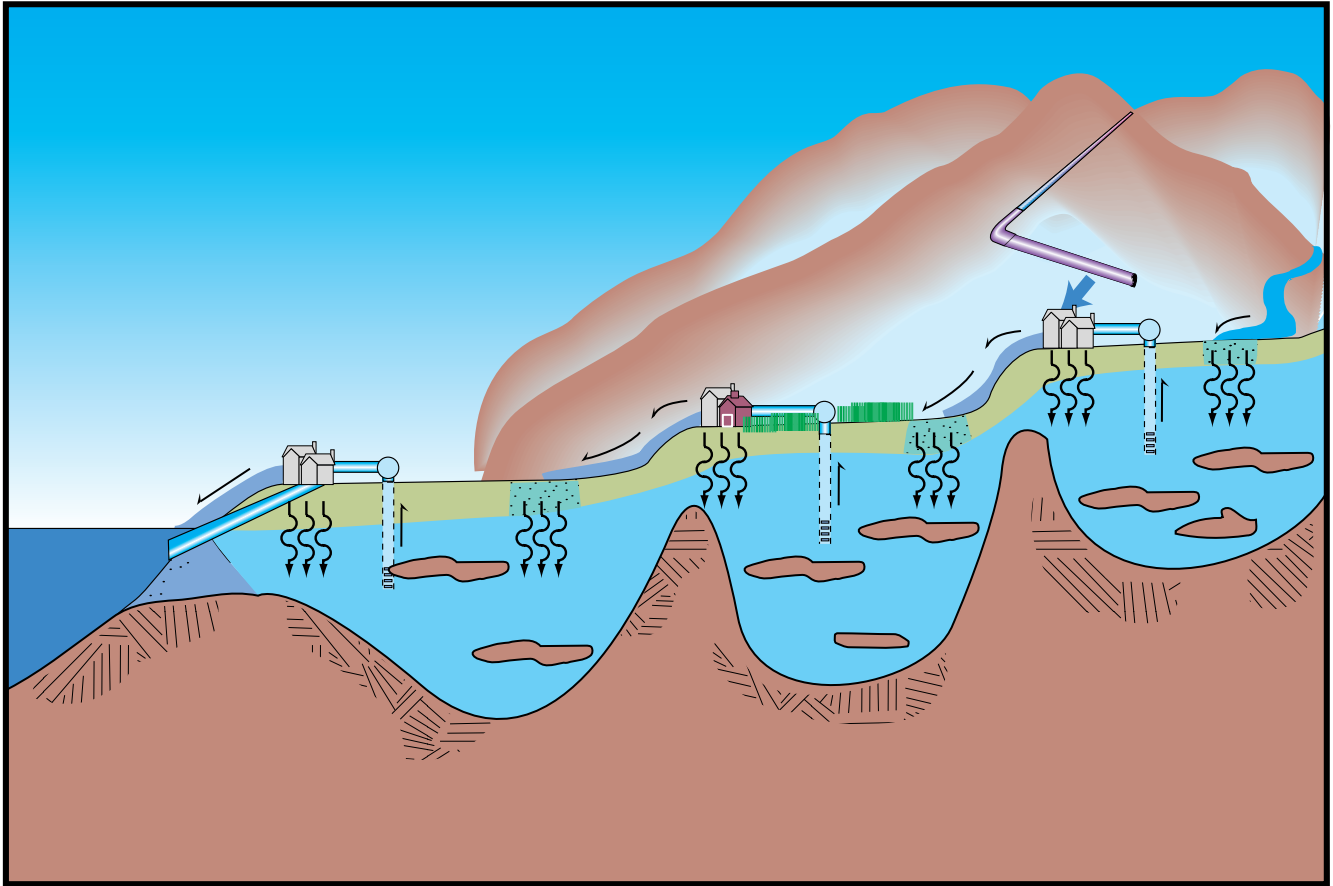


SALINITY MANAGEMENT STUDY Final Report



MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA



UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

June 1999

METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
UNITED STATES BUREAU OF RECLAMATION

SALINITY MANAGEMENT STUDY FINAL REPORT

**LONG-TERM STRATEGY AND
RECOMMENDED ACTION PLAN**

JUNE 1999

BOOKMAN-EDMONSTON
ENGINEERING, INC.

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List of Abbreviations

◆	<i>CDHS</i>	<i>California Department of Health Services</i>
◆	<i>CRA</i>	<i>Colorado River Aqueduct</i>
◆	<i>CRW</i>	<i>Colorado River Water</i>
◆	<i>DWR</i>	<i>Department of Water Resources</i>
◆	<i>EDR</i>	<i>Electrodialysis Reversal</i>
◆	<i>IX</i>	<i>Ion Exchange</i>
◆	<i>mg/L</i>	<i>Milligrams per Liter</i>
◆	<i>RO</i>	<i>Reverse Osmosis</i>
◆	<i>RWQCB</i>	<i>Regional Water Quality Control Board</i>
◆	<i>SPW</i>	<i>State Project Water</i>
◆	<i>SPW EB</i>	<i>State Project Water East Branch</i>
◆	<i>SPW WB</i>	<i>State Project Water West Branch</i>
◆	<i>SWP</i>	<i>State Water Project</i>
◆	<i>SWP EB</i>	<i>State Water Project East Branch</i>
◆	<i>SWP WB</i>	<i>State Water Project West Branch</i>
◆	<i>TDS</i>	<i>Total Dissolved Solids</i>
◆	<i>USBR</i>	<i>United States Bureau of Reclamation</i>

EXECUTIVE SUMMARY

This report presents the findings and recommendations of a two-and-one-half year technical investigation of the impacts of total dissolved solids or salinity to the coastal plain of Southern California. Metropolitan conducted the Salinity Management Study (Study) in close collaboration with member agencies and numerous other concerned agencies. The United States Bureau of Reclamation (USBR) was a primary study partner, contributing financial assistance under its congressional authority (P.L. 102-575) to develop a regional water recycling plan for Southern California, because high salinity is a significant constraint to water recycling.

For analytical purposes in developing this report, the Colorado River Aqueduct (CRA) was considered full for the study period, consistent with the objectives of the California 4.4 Plan.

BENEFITS OF REDUCED SALINITY

When salinity levels of imported water are reduced, the region benefits from:

- Improved use of local groundwater and recycled water
- Reduced costs to water consumers and utilities.

Metropolitan estimates that \$95 million per year of economic benefits would result if the CRA and State Water Project (SWP) waters were to simultaneously experience a 100 milligram per liter (mg/L) reduction in salt content over their historic average. Conversely, about the same dollar amount of impacts would result if imported water salinity increased by 100 mg/L. Primary salinity impact categories include residential, commercial, industrial and agricultural water users; groundwater and recycled water resources; and utility distribution systems.

SALT SOURCES

About half of the region's salt is contributed by imported water, and the other half comes from local sources. The CRA constitutes Metropolitan's highest source of salinity, averaging about 700 mg/L. Hardness comprises about one-half of the CRA salt load and causes troublesome scaling problems to indoor plumbing appliances and equipment at homes, business and industries.

The SWP provides Metropolitan with lower salinity water (an average of 250 mg/L on the East Branch and 325 mg/L on the West Branch), which can be used to blend down CRA concentrations. SWP salinity levels can change rapidly in response to hydrologic conditions, and such changes are noticeable and disruptive as compared to the very gradual, almost imperceptible changes that occur in local streams, groundwater and wastewater collection systems. A CALFED Bay-Delta solution could lower SWP salinity by 100 mg/L and reduce its short-term variability.

Local salinity sources include naturally occurring salts, salts added by urban water users, infiltration of brackish groundwater into sewers, irrigated agriculture, and confined animal waste management practices. Urban use salt contributions to wastewater range from 250 to 400 mg/L or more in some locations.

SALINITY MANAGEMENT POLICY STATEMENT AND ACTION PLAN

The proposed salinity management policy (Section 4) and corresponding Action Plan (Section 5) were adopted by Metropolitan in April 1999. The Action Plan consists of four basic components:

- Imported water source control actions
- Distribution system salinity management actions
- Collaborative actions with other agencies
- Local actions to protect groundwater and recycled water supplies

The adopted action plan should be revisited and updated periodically as clarity emerges from a number of critical areas, including the CALFED Bay-Delta Plan, California's Colorado River Water Supply Plan, wheeling practices, Stage II disinfection by-products rules under the Safe Drinking Water Act Amendments, and operational experience gained through implementation. The first major update is recommended to occur in 2004 when the Inland Feeder becomes operational, or sooner if a significant unanticipated change occurs in controlling conditions.

RESOURCE LIMITATIONS ON BLENDING COLORADO RIVER WATER SALINITY

The foundation of Metropolitan's Action Plan is an imported water salinity target of 500 mg/L. Managing imported water through blending would be supplemented by source control in the two imported water river systems, storage and exchange operations along the CRA, and a CALFED solution. Blending in Metropolitan's system is achieved by curtailing delivery of higher-salinity CRA water and substituting it with comparable amounts of lower-salinity SWP water.

Annual changes in imported water supply availability and salinity concentrations greatly affect Metropolitan's ability to achieve the target through blending. For example, above-normal runoff in 1998 provided unusually favorable conditions resulting in lower-than-target salinity levels in some months. In contrast, under such conditions as the 1977 drought, Metropolitan would not have been able to meet the target because SWP water was in short supply and its salinity levels rose to over 400 mg/L. To meet its blending target, Metropolitan would have had to take less of its CRA water. Whenever a shortage of SWP supply and high salinity occur concurrently, Metropolitan would have to fully use its CRA water and experience the higher salinity. The key trade-off in achieving a salinity target is the risk to supply reliability. To achieve the 500 mg/L

target under certain adverse conditions, up to several hundred thousand acre-feet of CRA water would have to be replaced by SWP water.

On average, the target will be met in about seven of every ten years. In the remaining years, hydrologic conditions constrain primarily the SWP with insufficient and often higher salinity supplies. The proposed policy includes clear recognition of this resource limitation and calls upon local agencies to develop and manage their local projects and groundwater to accommodate these inevitable swings in salinity of imported water due to natural hydrologic variation.

Recognizing the significant constraint of resource availability, the action plan calls for achievement of the 500 mg/L salinity objective in two stages. When conditions are favorable, 500 mg/L would be pursued year-round. When conditions are less favorable, emphasis is placed on reducing salinity during April through September primarily to support irrigation with recycled water. The summer period corresponds to the peak irrigation season and requires proportionally less curtailment of CRA water. Under current conditions, the objective would be achieved in seven out of ten years on average; higher salinity would occur during dry years. A long-term solution will require success in the CALFED process in reducing the salinity of SWP water on a sustained basis. Exchanges for Sierra water south of the Delta offer an additional method of significantly lowering SWP salinity. Furthermore, expanding storage and exchange of CRA water for SWP water will also be necessary to achieve the year-round salinity objective within the constraints of water resource availability.

If the anticipated salinity benefits of a CALFED solution or CRA exchanges and storage fall short of need, then the ultimate method of achieving salinity targets may be desalination associated with the CRA. However, given the current state of technology, the costs would be high and there would be significant resource and environmental concerns associated with large quantities of brine disposal. Hence, the action plan calls for an aggressive program of research and development (R&D) of a more efficient desalination technology. This R&D effort is already being initiated by Metropolitan in partnership with interested agencies

INTEGRATION OF QUALITY AND QUANTITY

The Study shows that managing the salinity of imported water is important to the region's overall supply mix, especially in regards to local groundwater and recycled water. Metropolitan routinely assesses the pros and cons of quality-to-quantity relationships when planning and negotiating new facilities and resources, a practice that is an important part of the Salinity Management Policy and Action Plan.

REGIONAL APPROACH

The region must manage both local and imported sources to achieve a long-term salt balance. About half of the regional salt load is derived from local sources and half from imported water.

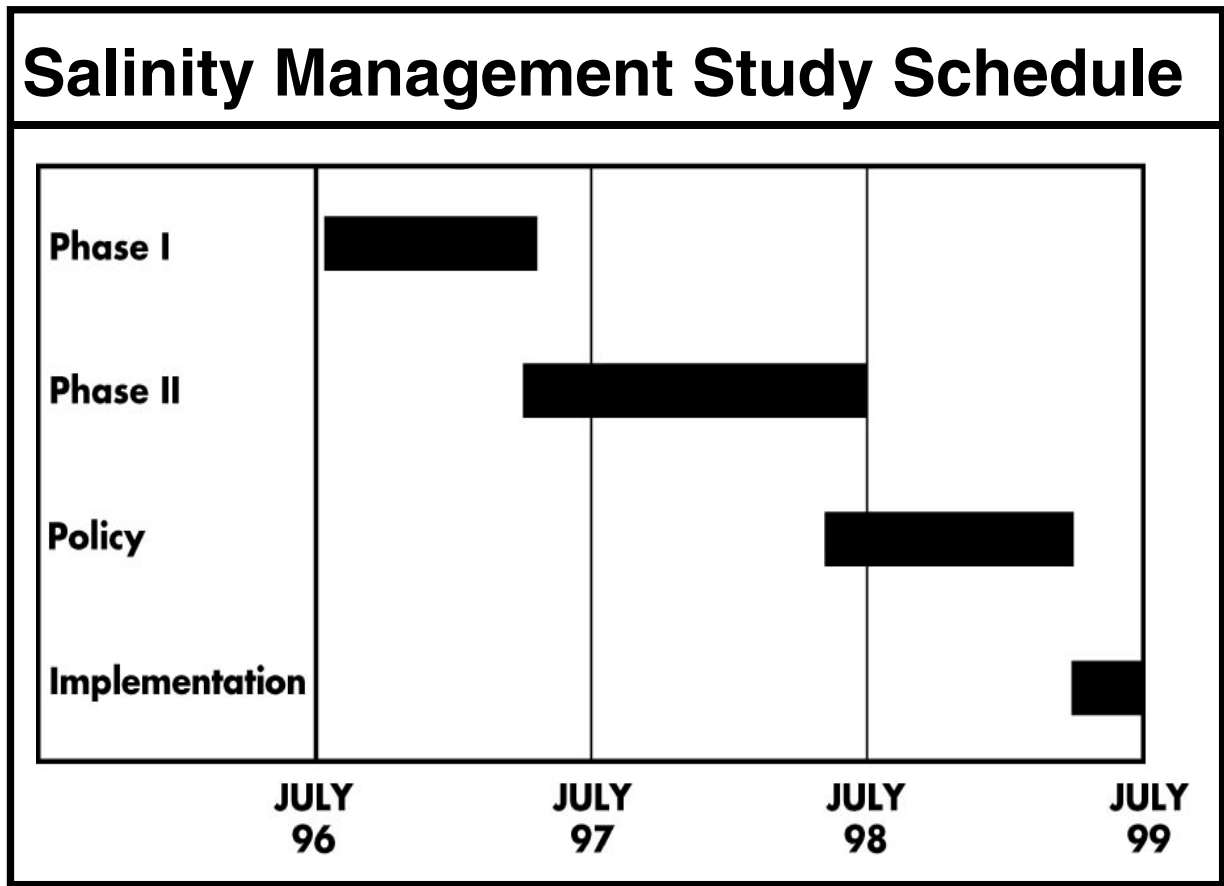
Other agencies that can influence the salt balance of the coastal plain must participate in this effort if the region is to achieve a cohesive strategy. The Action Plan calls for concurrent management of both local and imported sources of salt for the region to achieve a long-term salt balance.

SECTION 1 INTRODUCTION

STUDY PROCESS

Phase I of the Salinity Management Study identified the problems caused by increased salinity, described the sources of salinity, updated some earlier studies on the economic impact of high salinity water supplies, and identified some possible salinity management strategies. In Phase II, regional salinity management strategies have been formulated that can be implemented both in the short-term (such as new imported water blending policy) and long-term (such as improved Delta export salinity to Southern California as a result of CALFED efforts). Figure 1-1 shows the study schedule.

Figure 1-1



This comprehensive investigation was conducted with financial assistance from the U.S. Bureau of Reclamation (USBR) and in coordination with numerous, state, local, and member agencies.

U.S. BUREAU OF RECLAMATION AND METROPOLITAN FUNDING PARTNERSHIP

USBR and Metropolitan agreed in August 1996 to cooperate and jointly fund and support this salinity management study. Each agency provided funding and significant in-kind services. USBR funding was authorized and budgeted from the Southern California Comprehensive Water Reclamation and Reuse Study Program (Title XVI, P.L. 102-575) since salinity is a major constraint to the viability of water reuse projects.

OBJECTIVES

The primary objective of this effort is to develop a functional salinity management strategy for the region served by Metropolitan.

Goals for the study process included:

1. Assess salinity problems and needs of the region;
2. Formulate and evaluate various salinity management strategies; and
3. Develop regional salinity management policies and an action plan.

OUTREACH

Metropolitan formed a task force of member agencies to interact with the study team and USBR during the Study. This group established the scope and budget for the Study using existing agency data and "expert opinion." Information was updated and new assessments, modeling, and surveys were conducted, as needed. The task force coordinated the efforts of the involved agencies to promote effective communication and support for the development of salinity management strategies. In addition, the task force contacted the individual water/wastewater agencies and associations listed below:

- Member Agencies.
- Retail Water Utilities
- Metropolitan, USBR and Department of Water Resources (DWR) Operating Personnel
- Santa Ana Watershed Project Authority (SAWPA)
- Southern California Alliance of Publicly Owned Treatment Works (SCAP)
- Association of Groundwater Agencies (AGWA)
- Los Angeles, Santa Ana and San Diego Regional Water Quality Control Boards
- WaterReuse Association of California
- USBR Southern California Comprehensive Water Reclamation and Reuse Study Executive Management Team
- California Department of Water Resources

- ❑ State Water Contractors and California Urban Water Agencies

SALINITY SUMMIT

The outreach effort culminated with a Salinity Summit in January 1999 where 100 senior managers and technical experts representing 60 agencies discussed practical aspects of implementing the regional action plan. Many of the participants concluded that high salinity levels might be one of the State's biggest water quality problems going into the twenty-first century.

EARLY ACTIONS

Since the initial phase of the Study, Metropolitan has taken several interim steps to address salinity problems:

- ❑ Refined the existing blending policy by adopting an interim total dissolved solids (TDS) concentration target of 500 to 550 mg/L for the months of April – September 1998;
- ❑ Initiated public-private partnerships on research and development for innovative desalination technologies;
- ❑ Initiated efforts with DWR to manage salinity on the State Water Project (SWP) and opportunities to reduce long-term salinity through CALFED.

SECTION 2 SALINITY PROBLEMS, IMPACTS AND TECHNOLOGY

Salinity, or total dissolved solids (TDS), commonly expressed in milligrams per liter (mg/L), is a measure of mineral salts dissolved in water. Typical constituents include calcium, magnesium, sodium, sulfate, and chloride. Figure 2-1 is a breakdown of TDS components found in Metropolitan's water. At salinity levels of about 1,000 mg/L, potable and recycled water use are significantly impaired, and alternate lower salinity supplies are typically sought. Technical Appendix 3 provides detailed information on the regulations and physical impacts of salinity constituents.

Hardness is a component of TDS. It is a measure of specific dissolved salts, principally calcium and magnesium (Table 2-1), which leave deposits in plumbing systems and appliances. Hardness also inhibits the solubility of soap, which is noticeable when bathing or laundering clothes. Water softening reduces hardness, but adds other salts to the water and wastewater in the process.

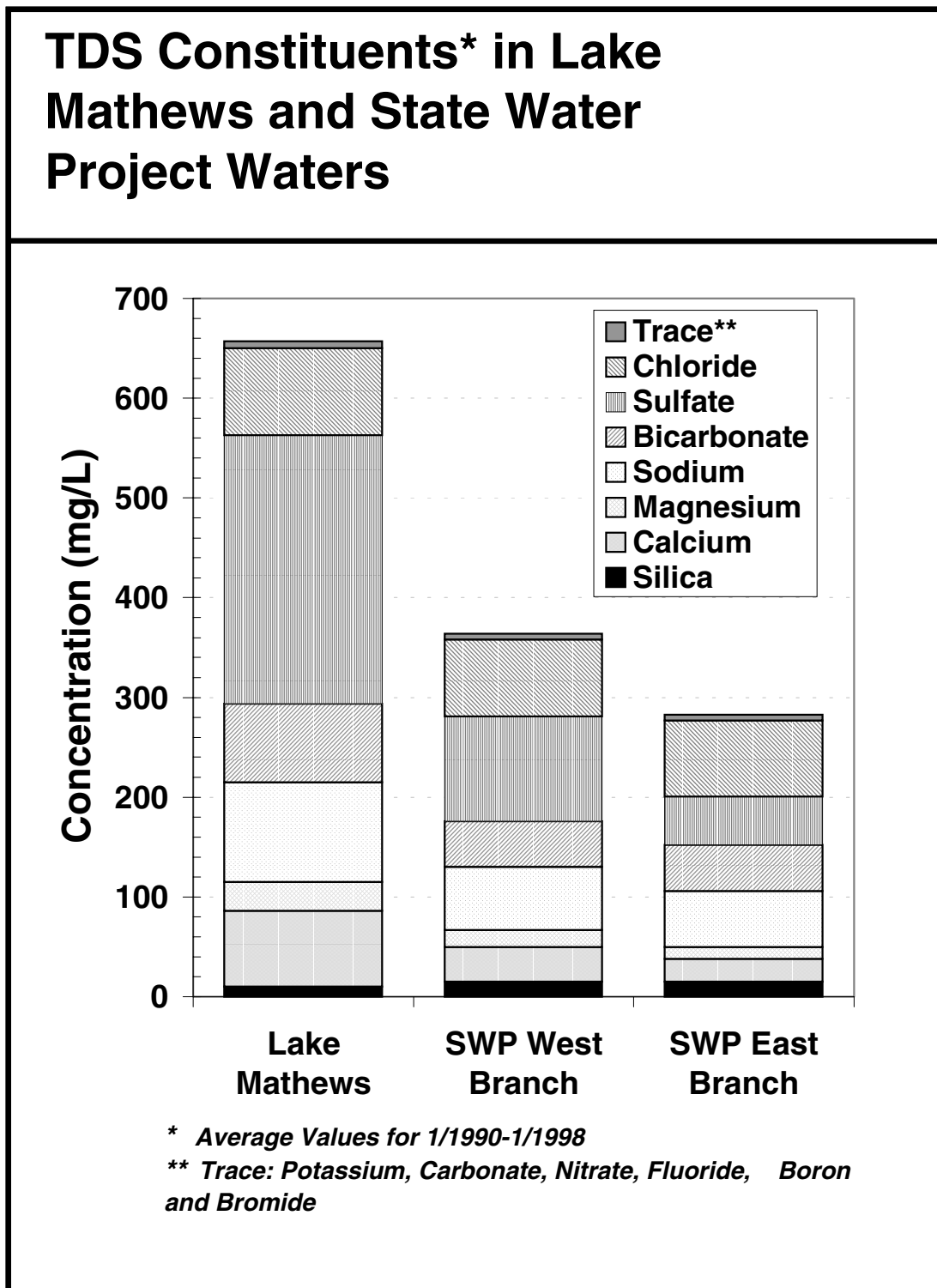
Table 2-1 Hardness Quality Characteristics

Hardness Range mg/L (as CaCO ₃)	Description
0 – 75	Soft
75 – 150	Moderately Hard
150 – 300	Hard
Over 300	Very Hard

Numerous factors contribute to high salinity in Metropolitan's service area. Some are a result of the sources of imported Metropolitan water; others result from salts entering the water as it travels from the foothill areas to the ocean. Imported water from the Colorado River always contains high salinity levels, primarily due to naturally occurring minerals and agricultural runoff. In the arid southwestern states, there is little or no surplus water to flush salts from the environment.

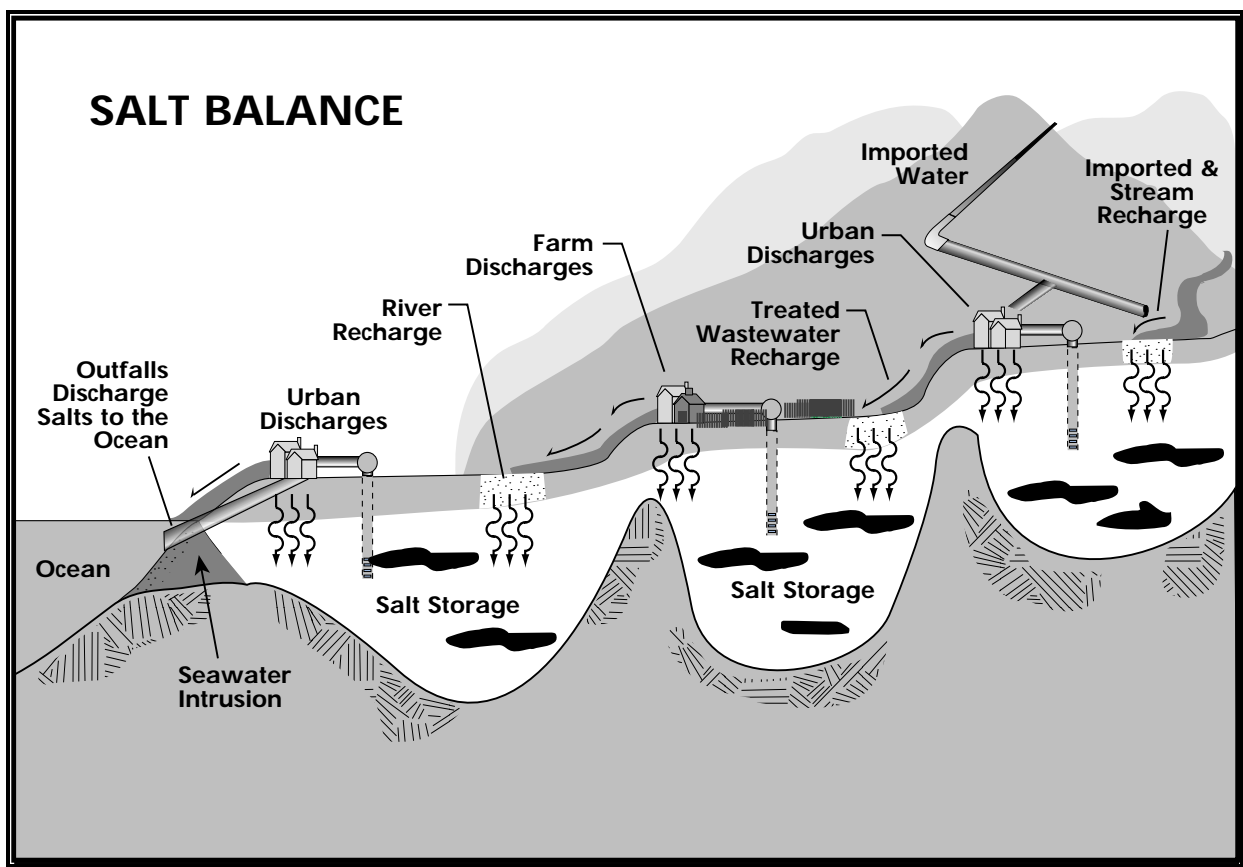
Salinity levels increase with each cycle of urban use for residential, commercial, or industrial purposes. Such urban uses typically add 250 to 400 mg/L of salt to wastewater. Salt increments higher than the typical 250 to 400 mg/L level indicate higher than normal salinity contributions from industrial and commercial brines, residential water softeners, or brackish groundwater infiltration into sewers.

Figure 2-1



Groundwater sources experience increased TDS as a result of agricultural and urban activities and groundwater overdraft. Without an ocean outfall or stream discharge, inland areas that reuse wastewater encounter a build-up of salt in groundwater (Figure 2-2) as salt continues to accumulate without being removed. Some inland agencies have access to brine lines to export salt and concentrated wastes to a coastal treatment plant and ocean outfall. Other agencies have not yet found the construction of brine lines to be economically feasible. In previous years, groundwater overdraft along the coastline has led to seawater intrusion into coastal groundwater basins and has thus impaired the quality of freshwater aquifers.

Figure 2-2



The long-term salt imbalance of Southern California is an important management problem. Smaller basins, like the Arlington and Mission groundwater basins in Riverside and San Diego counties respectively, were abandoned for municipal supply years ago because of high salinity levels. Only recently have these basins been restored to use through construction of relatively expensive demineralization projects. The larger groundwater basins, by virtue of their storage capacity and geographic extent, function as "shock absorbers" when droughts cause TDS to increase in imported supplies. However, even these large basins are experiencing progressive

salt buildup despite the extensive regulatory and management practices in place to control salinity increases. Figure 2-3 shows an example of this buildup. Figure 2-4 illustrates the current estimated salt balance for the region. Clearly, there is an adverse trend. Current annual accumulation of salts within the coastal plain of Southern California is approximately 600,000 tons per year, as depicted in Figure 2-4. Technical Appendix 10 provides a more detailed discussion of the regional salt balance.

Figure 2-3

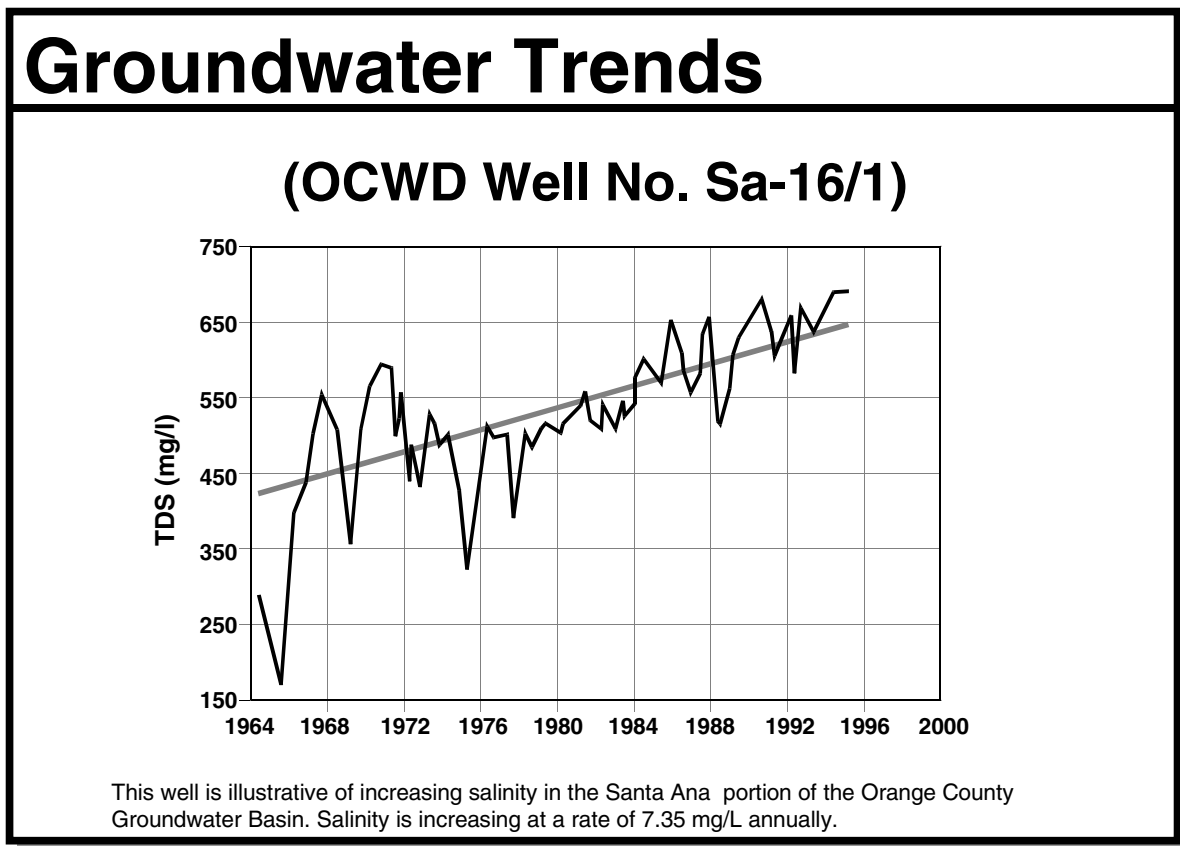
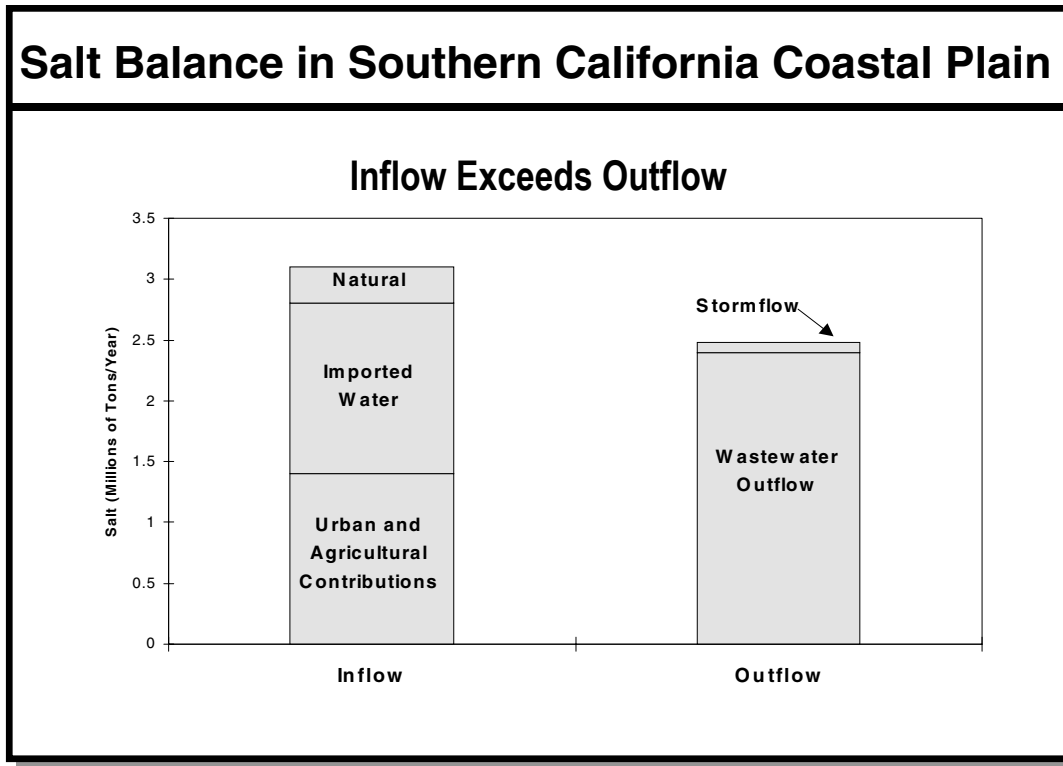


Figure 2-4



BACKGROUND AND HISTORY

Salinity has been a concern of water resource managers in Southern California for most of the 20th century. Agricultural activities since the 1880s have increased TDS in many groundwater basins, and some agricultural and urban areas have been using imported water to blend down high TDS levels in their groundwater supplies since the early days of the twentieth century (Figure 2-5, and Table 2-2).

During the 1950s and 1960s, more than 2 million acre-feet of Colorado River Water (CRW) was spread in the Santa Ana and San Gabriel Rivers to alleviate severe groundwater overdraft. In addition, seawater barriers were built and placed into operation to prevent further seawater intrusion. More than one million acre-feet of imported water has been injected into barriers in the Central and West Coast Basins. With an average TDS of 700 mg/L, this CRW has contributed significant quantities of salts to these groundwater basins.

Figure 2-5

GROUNDWATER BASINS IN SOUTHERN CALIFORNIA

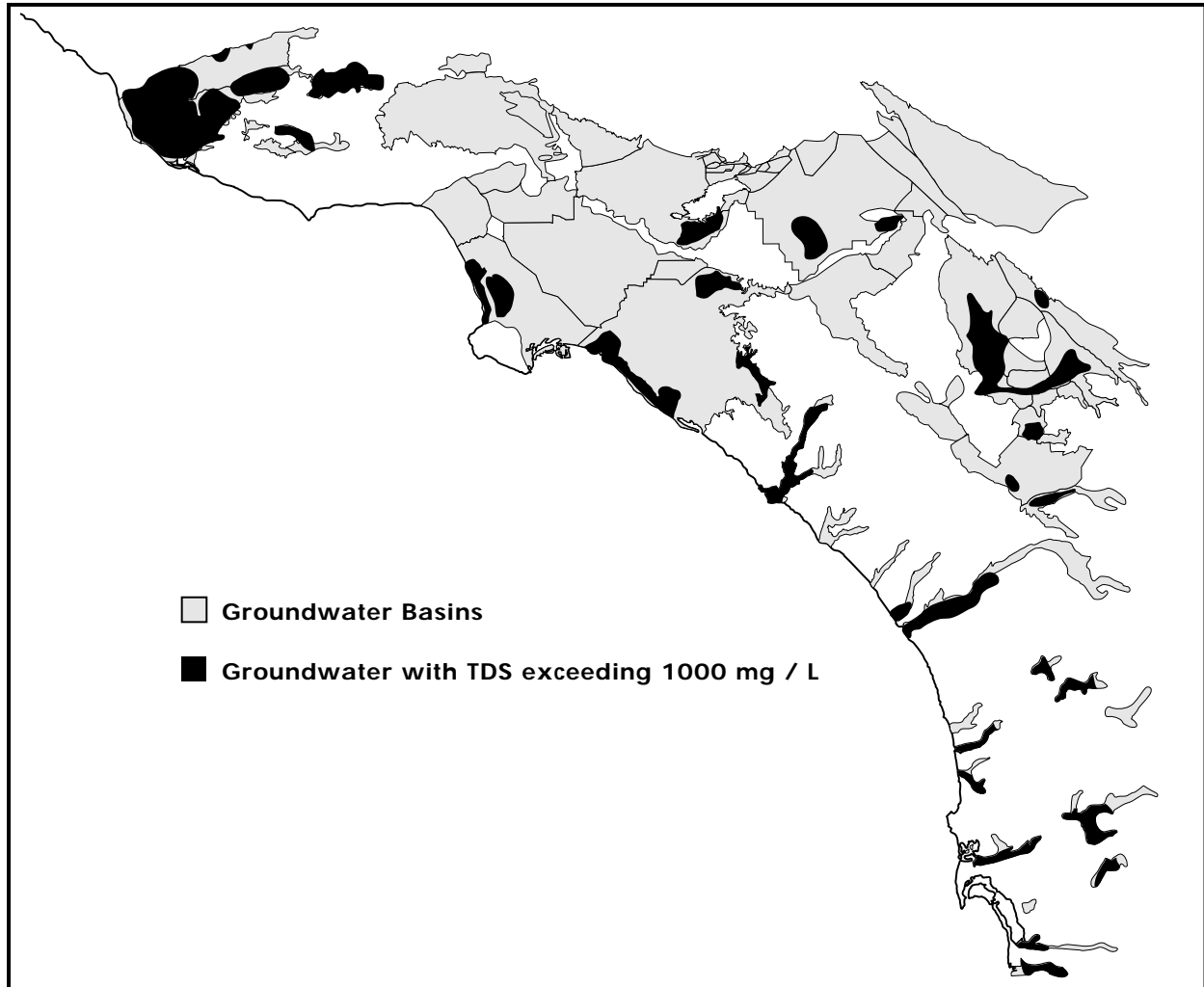


Table 2-2 TDS of Groundwater Wells

TDS Concentration, (mg/L)	Annual Production, (MAF)	Percent
Less Than 500	1.06	78
500 to 1,000	0.15	11
Greater than 1,000	0.15	11
TOTAL	1.36	100

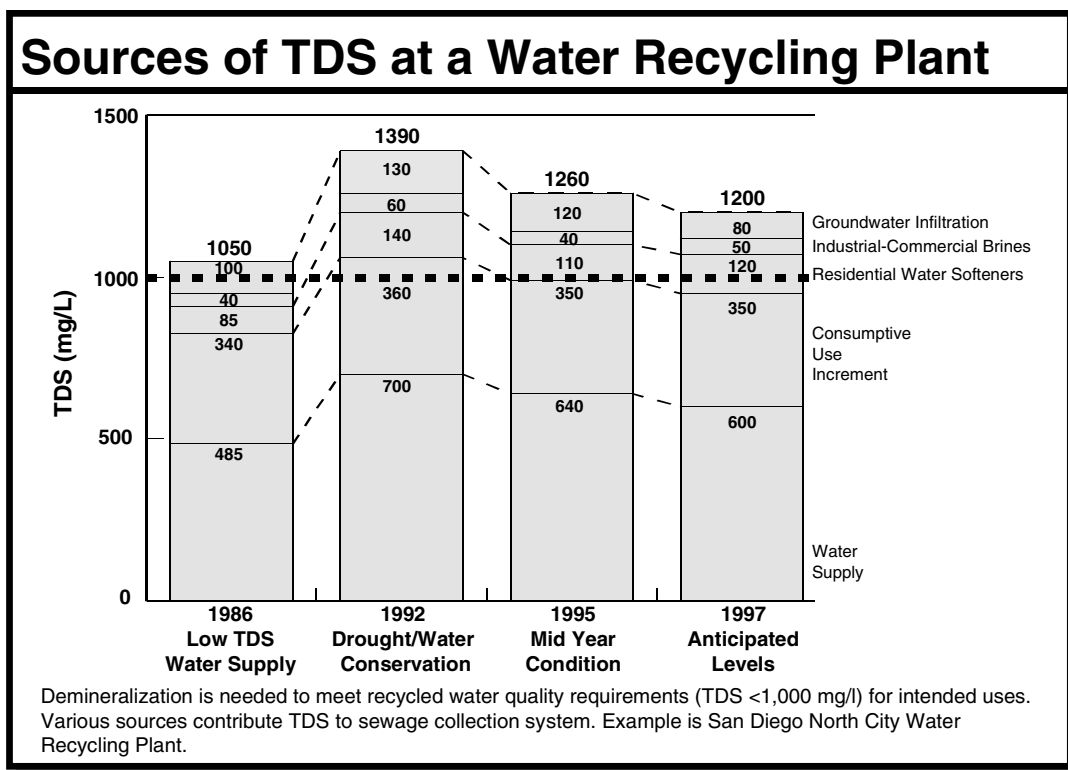
WASTEWATER AND RECYCLING ISSUES

Wastewater managers have addressed salinity management issues since the 1950s. The landmark 1964 water reuse plan prepared by the Los Angeles County Sanitation Districts identified a

blueprint to protect upstream "high quality wastewater" for beneficial reuse, and to divert poorer quality industrial and commercial brine waste streams to the ocean. However, not all inland wastewater agencies have access to an ocean outfall or connecting brine line. Regional brine lines are expensive and usually require multiple agency cooperation and financing.

Other sources of salts flowing into wastewater collection systems contribute to salinity in wastewater treatment plant discharges. Leaky sewers can be infiltrated by brackish groundwater. Certain types of residential water softeners are controversial sources of salts in wastewater. Industrial and commercial discharge to sewer systems are typically not regulated for TDS by pretreatment programs. Water conservation efforts in recent years have prompted many industries to increase internal recycling, thus resulting in higher TDS concentrations in their waste streams. Long-term indoor water conservation measures reduce water use and increase salinity concentrations of residential wastewater by 2 to 5 percent. Figure 2-6 depicts the sources of salinity reaching a coastal recycling water facility in Metropolitan's service area.

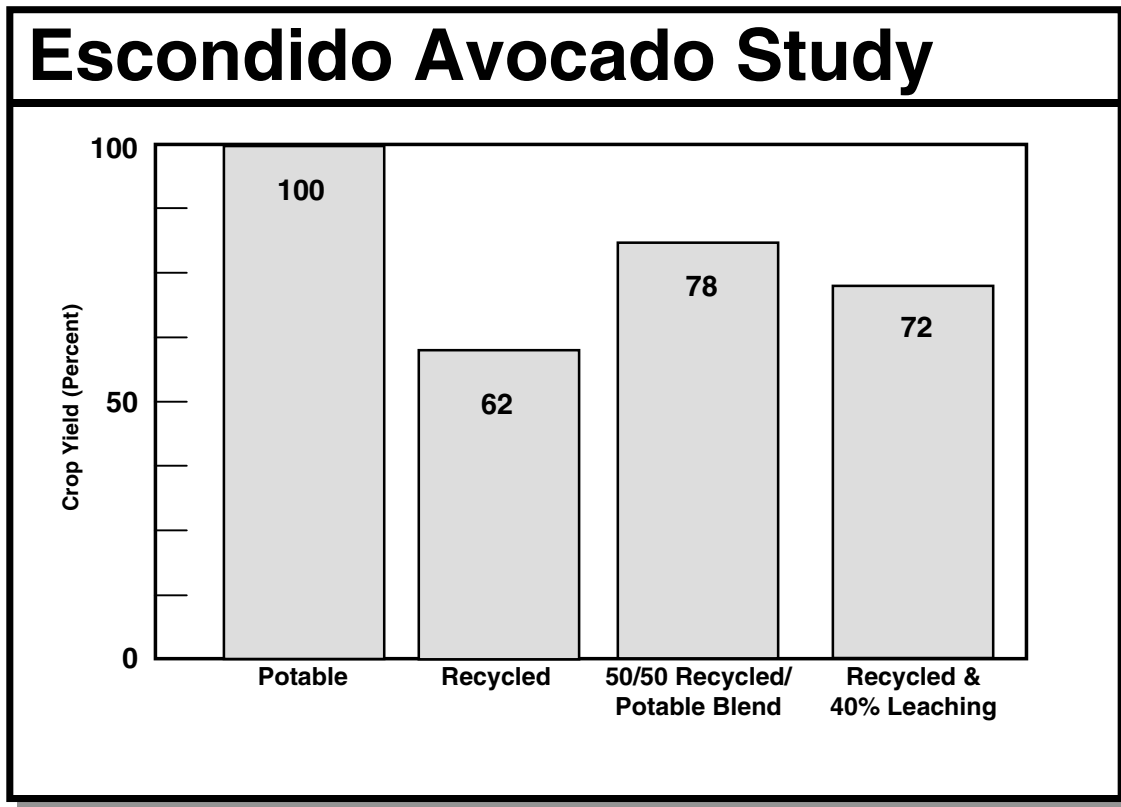
Figure 2-6



Beginning in the mid-1980s with the expansion of water recycling programs, concerns about wastewater TDS have grown significantly. In general, TDS over 1,000 mg/L becomes problematic for irrigation and industrial reuse customers. In addition to TDS, concentrations of

specific minerals, such as boron, chloride, and sodium, must be within certain limits for some crops (such as boron for citrus and avocados). A City of Escondido study of avocado crop yields documented lower crop yields from higher TDS recycled water (Figure 2-7).

Figure 2-7

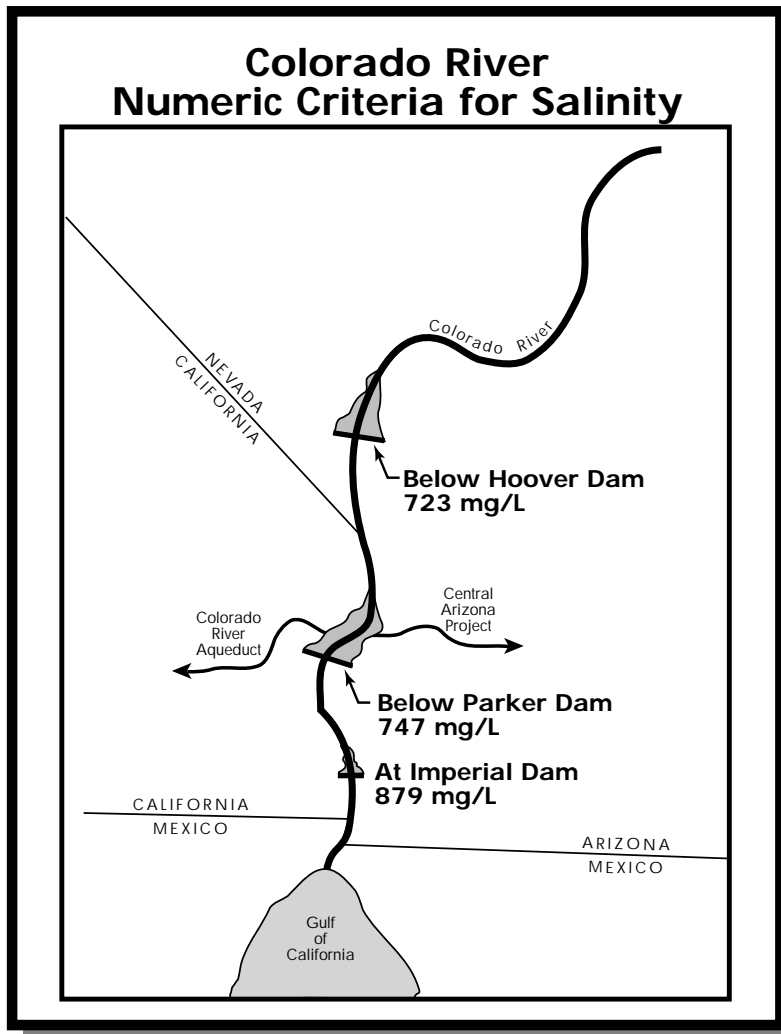


To protect existing high-quality groundwater basins, the Regional Water Quality Control Boards (RWQCBs) often set groundwater quality objectives well below 1,000 mg/L of TDS. In some cases, chlorides, not TDS, are the controlling parameter affecting reuse potential and basin water quality objectives. Reclaimed water users that irrigate or recharge groundwater with reclaimed water containing higher TDS than these objectives must provide expensive solutions such as desalters, blend with lower TDS potable supplies, or practice less reuse.

COLORADO RIVER

Colorado River water has long been identified as a significant source of salinity. The very high TDS impacts on Mexico in the mid-1960s, and the Federal Water Pollution Control Act amendments, led to Minute 242 of the International Boundary and Water Commission and the Colorado River Basin Salinity Control Act in 1973 and 1974, respectively.

Figure 2-8



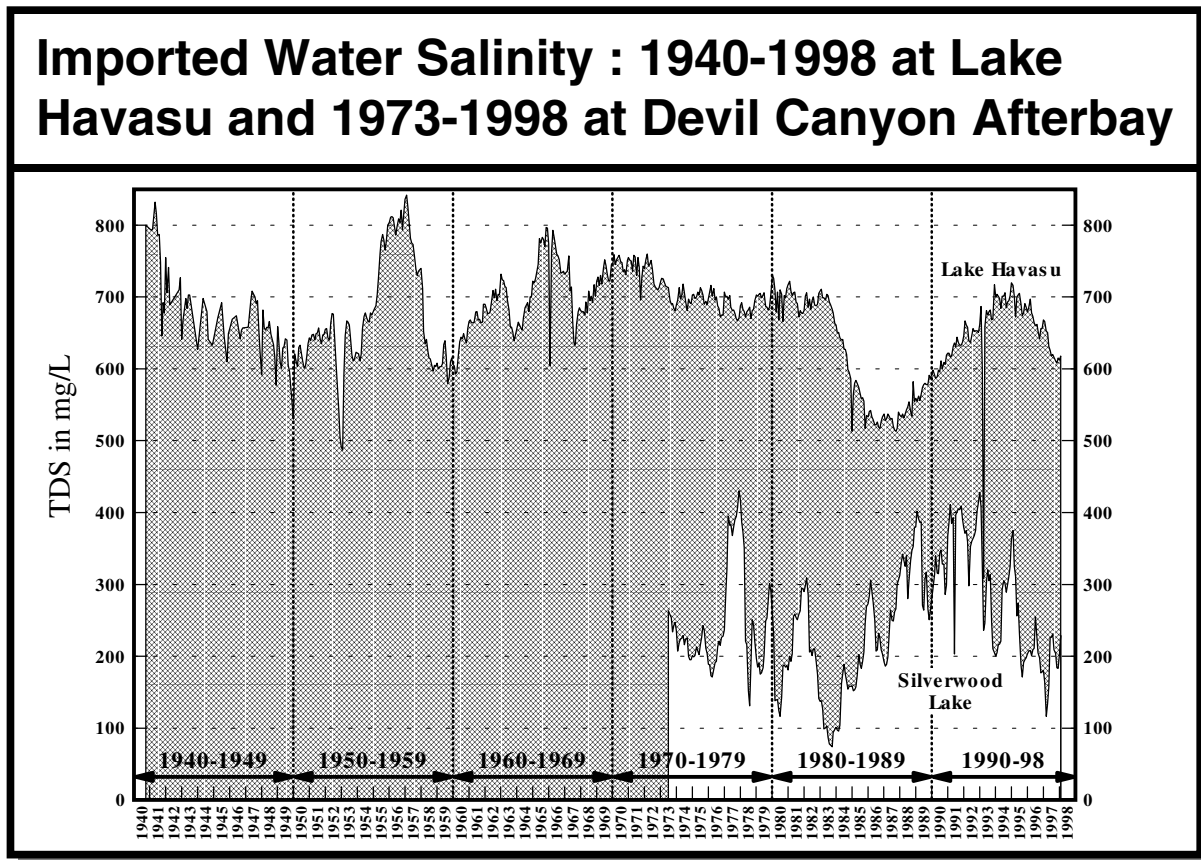
In addition, the seven basin states formed the Colorado River Basin Salinity Control Forum for the purpose of interstate cooperation and to provide the states with the information necessary to comply with Sections 303(a) and (d) of the Clean Water Act. Prior to 1974, evaluation of the impacts associated with changing levels of TDS had not been included in the economic analyses of future water-related projects. This led to development of economic impact estimates of many hundreds of millions of dollars annually from use of CRW in the Lower Basin (1978, 1980, and 1988). The Colorado River Basin Salinity Control Program, which is managed by the federal government and the basin states, undertakes staged measures to offset salinity contributions of new development to meet the adopted salinity criteria (Figure 2-

8). Technical Appendix 1 provides detailed information on the Colorado River Salinity Control Program. The USBR has developed sophisticated modeling to plan the staging of measures to reduce the salt load in the Colorado River.

Starting in the early 1970s with the initial Metropolitan deliveries from the SWP, the blending of SWP and CRW supplies and the use of relatively low TDS supplies of the SWP for groundwater replenishment became a policy objective in some areas. (See Figure 2-9 for the historic SWP and CRW salinity.) The RWQCB developed Basin Plans to address basin-wide salt balance issues. Some of those Basin Plans, however, were based on optimistic assumptions made in the 1970s about the amount of SWP water available and about expected improvements in the salinity levels of imported water. During the historic high Colorado River flows (1983-1986), monthly TDS

levels dropped significantly to a historic low of about 525 mg/L, the lowest sustained salinity concentrations since the Colorado River Aqueduct was completed (Figure 2-9). This drop alleviated concerns about imported water salinity until concentrations returned to their normal higher levels in the 1990s. Figure 2-10 is a bell curve illustrating variability in CRW salinity.

Figure 2-9



CRW and SWP salinity levels increased significantly during the 1987-1992 drought. The cumulative effect was that local potable systems experienced increased TDS, thus making it difficult for reclaimed water producers and wastewater dischargers to comply with Basin Plan objectives. During an extreme drought, CRA supplies could exceed 900 mg/L (a 5-percent probability), as illustrated in Figure 2-11.

Figure 2-10

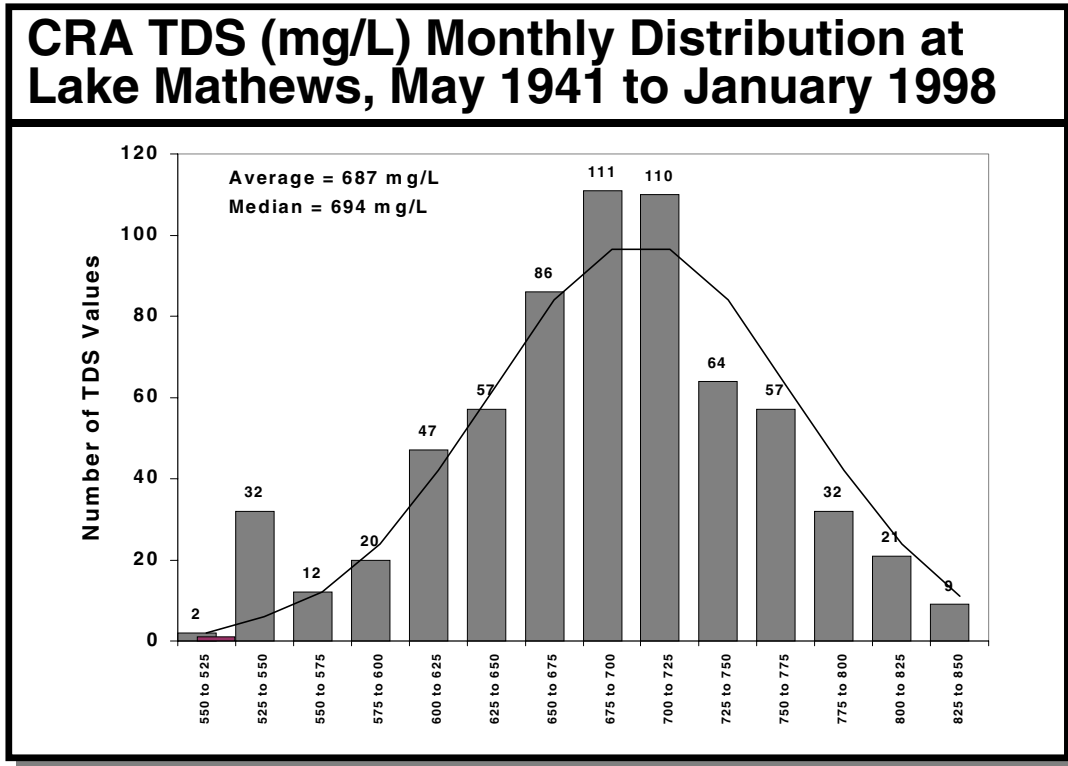
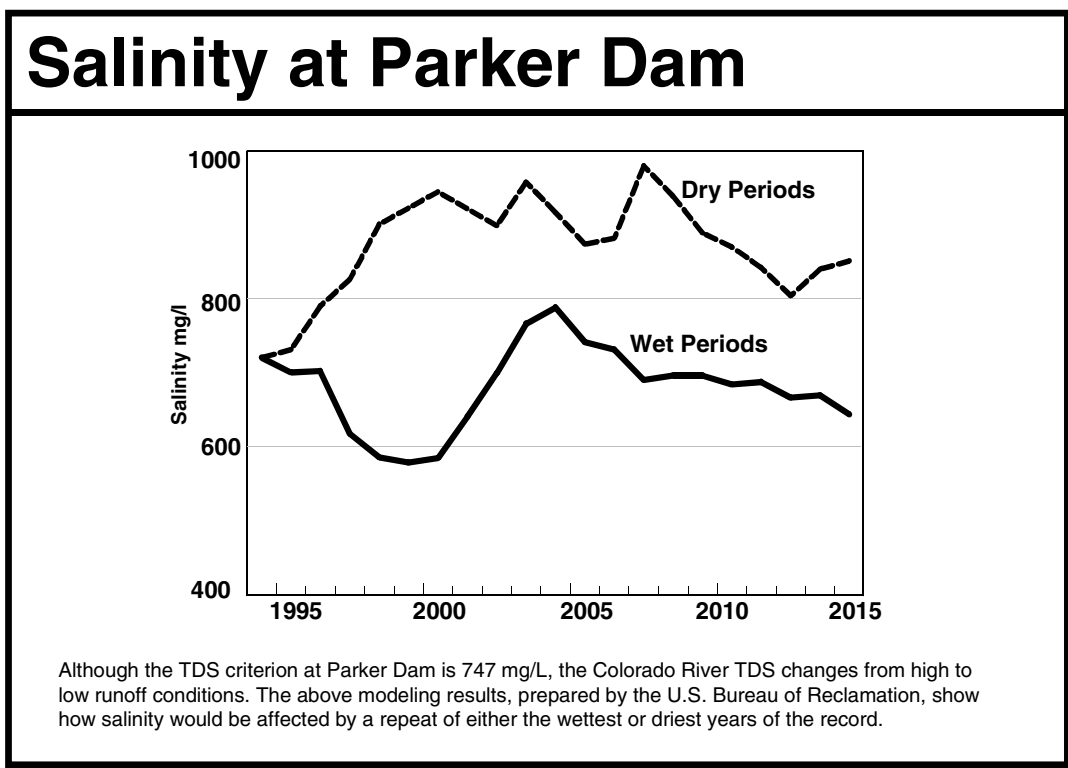


Figure 2-11



Urban and agricultural irrigation uses of imported water and recycled water are especially sensitive to drought events. Wastewater agencies also experience difficulty complying with waste discharge permit requirements designed to protect groundwater basins and the environment. Such an experience during the 1987-1992 drought resulted in the Los Angeles RWQCB adopting a new chloride policy for its region.

Where local groundwater or reservoir water is of good quality, the impacts of these episodic conditions are reduced through blending of local and imported water. However, at locations where the changes in imported supplies cannot be mitigated by local supplies, the impact may be acute. Furthermore, agencies using SWP water to blend down high salinity groundwater would experience added blending costs and reduced use of local supplies when SWP salinity is high.

The apparent dilemma for the region is that during droughts when the use of recycled water projects and marginal quality groundwater are most important, the use of some of these local supplies may be constrained by the quality changes in imported supplies. In response to these constraints, some agencies are developing demineralization facilities to reduce the salinity in the recycled water supply.

STATE WATER PROJECT

When the SWP was originally planned, it was to deliver 220 mg/L TDS water on average to Southern California over any ten-year period (DWR, State Water Service Contract, Article 19). In reality, however, salinity averages about 325 mg/L in the West Branch and about 250 mg/L in the East Branch (Figure 2-13 and 2-14). The Banks Pumping Plant in the Delta averaged about 250 mg/L, with considerable and problematic variations on a monthly basis (Figure 2-12). The difference in West Branch Salinity is attributable to salt loading from local stream flows, reservoir evaporation and filling patterns at Pyramid and Castaic Lakes on the West Branch. In September 1993, TDS levels at the West Branch reached a high of 470 mg/L. During the 1977 drought, TDS in the Delta at the Banks Pumping Plant exceeded 700 mg/L. Compared to the Colorado River, the salinity of SWP water changes rapidly, responding to routine seasonal changes and periodic drought and flood events.

Figure 2-12

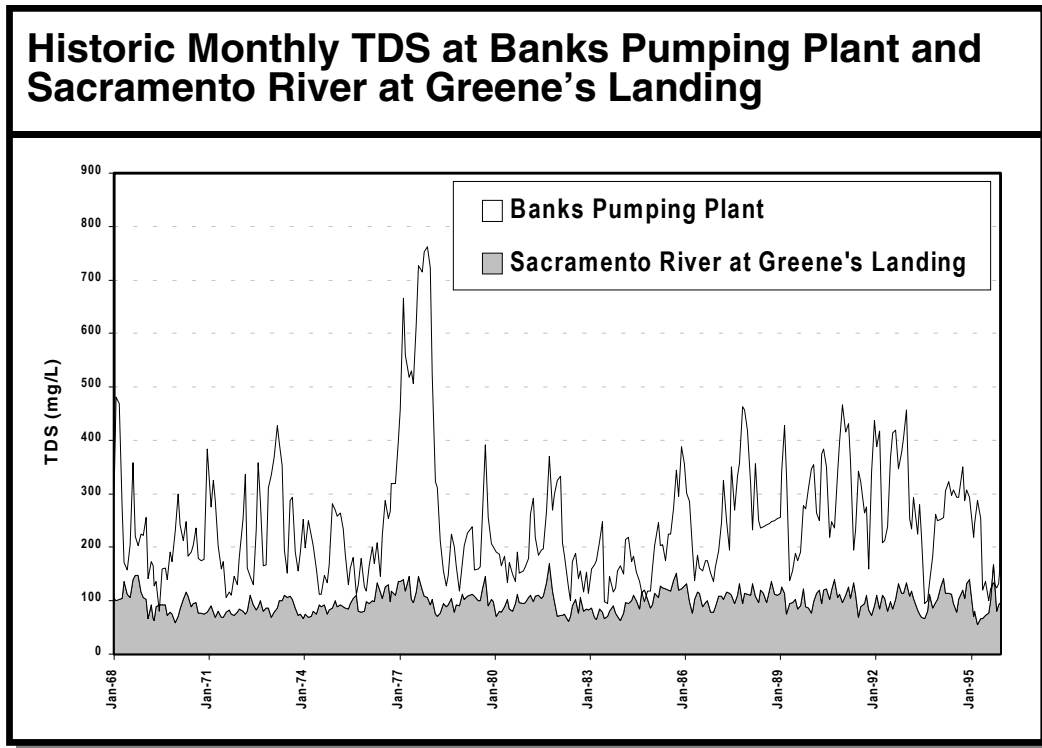


Figure 2-13

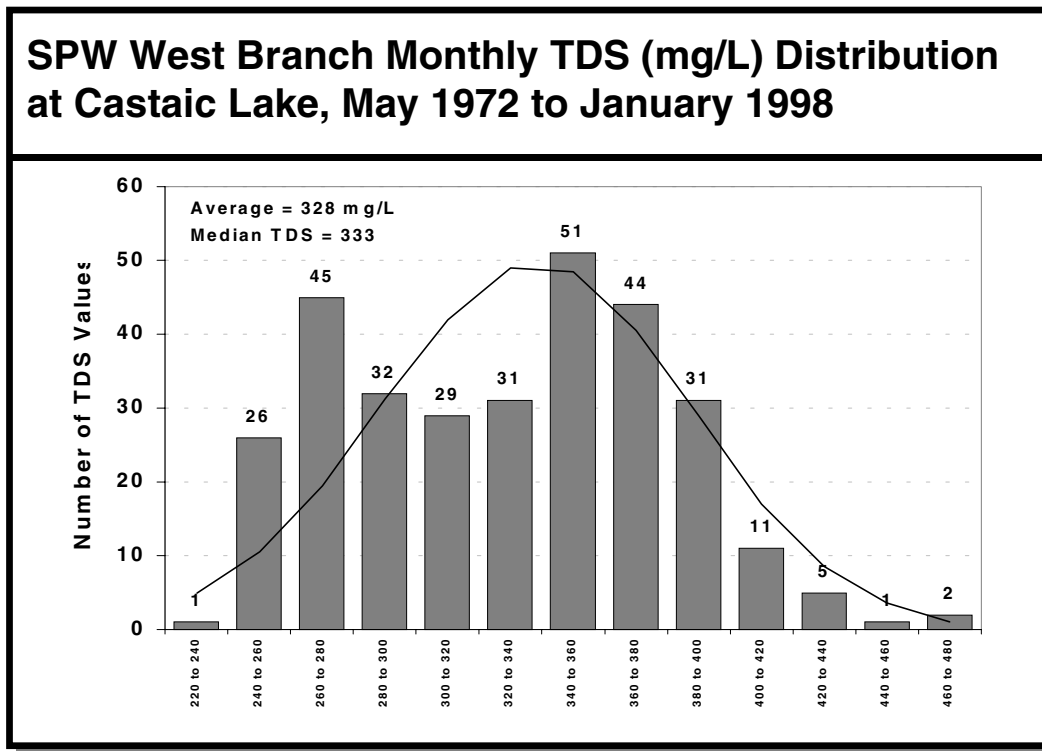
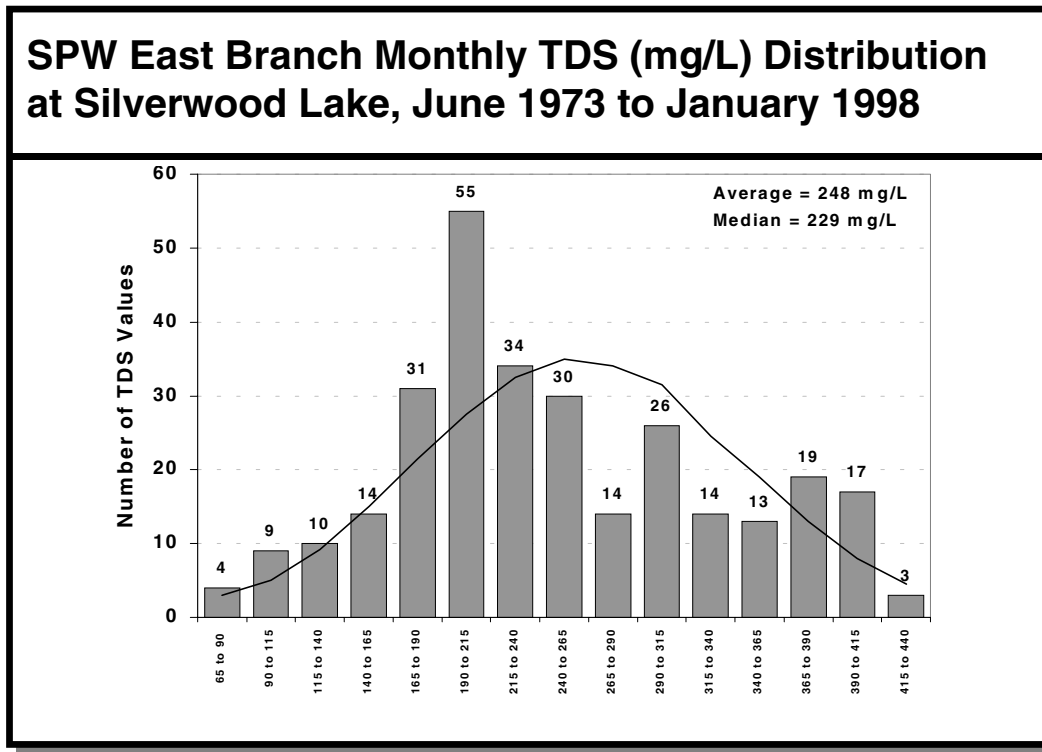


Figure 2-14



Hydrologically driven short-term salinity increases in the Sacramento – San Joaquin Delta are unavoidable. During drought periods, seawater intrusion in the Delta due to tidal action significantly increases TDS, including chloride levels (Figure 2-15, and 2-16). Tidal flow also brings in bromide, which may be transformed into bromate when treated at a water filtration plant with ozone. Bromate is an undesirable disinfection by-product, and regulation of it began in November 1998. Studies show that depending upon future bromate regulations and water treatment measures needed at Metropolitan filtration plants to mitigate bromate formation, water treatment processes could add 30 to 90 mg/L of TDS to Metropolitan's treated water. In comparison, present TDS contributions from filtration plant processes are less than 10 mg/L.

Reservoir management, groundwater wheeling and storm water inflows change the salinity of SWP water between the Banks Pumping Plant at the Delta and Metropolitan's point of delivery on the East Branch at the Devil Canyon Afterbay on a short-term basis as illustrated in Figure 2-17. The changes are favorable in some cases, while in others, they are unfavorable. On a long-term basis, the TDS at Banks and Devil Canyon have been equal at about 250 mg/L. Figure 2-17 also illustrates the consistently better quality of Sacramento River water.

Figure 2-15

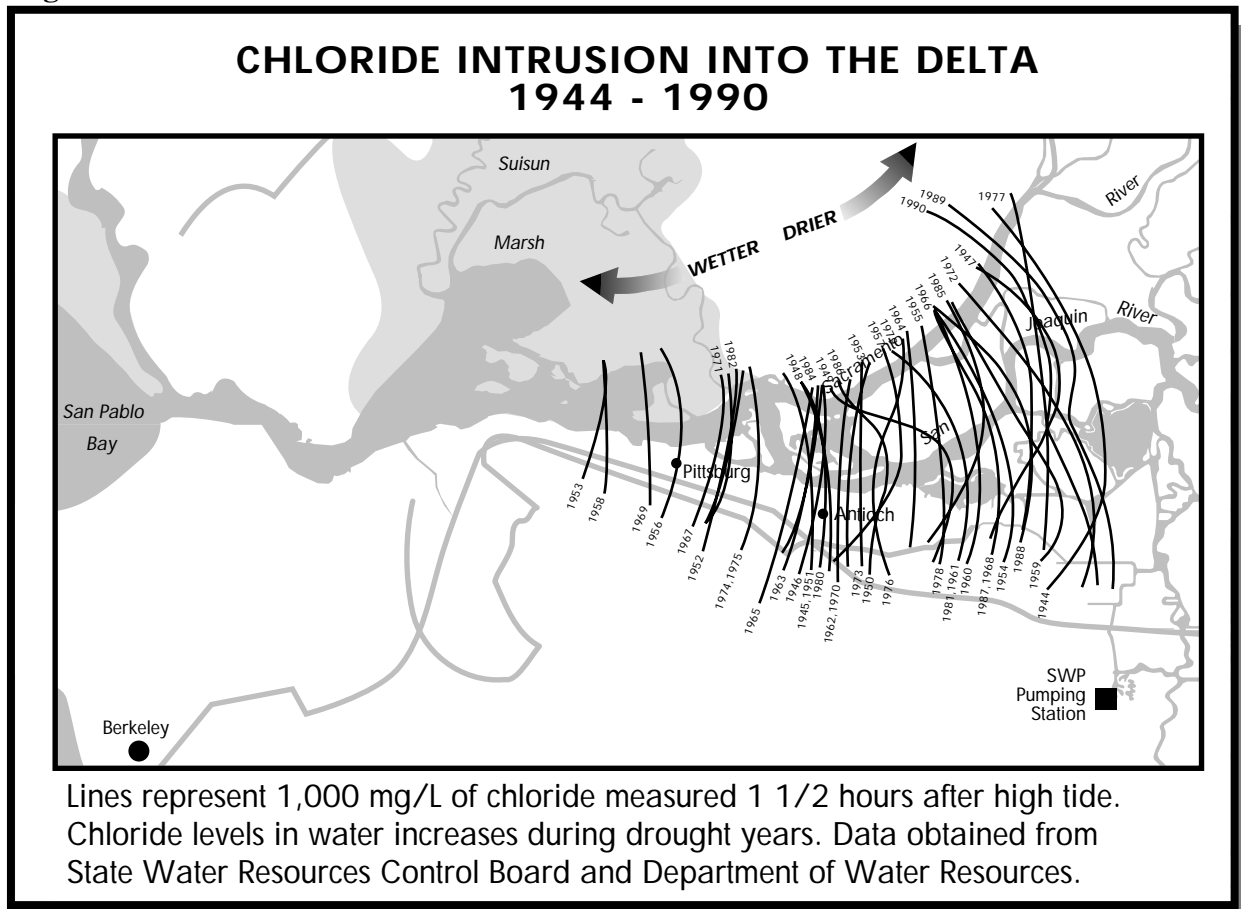


Figure 2-16

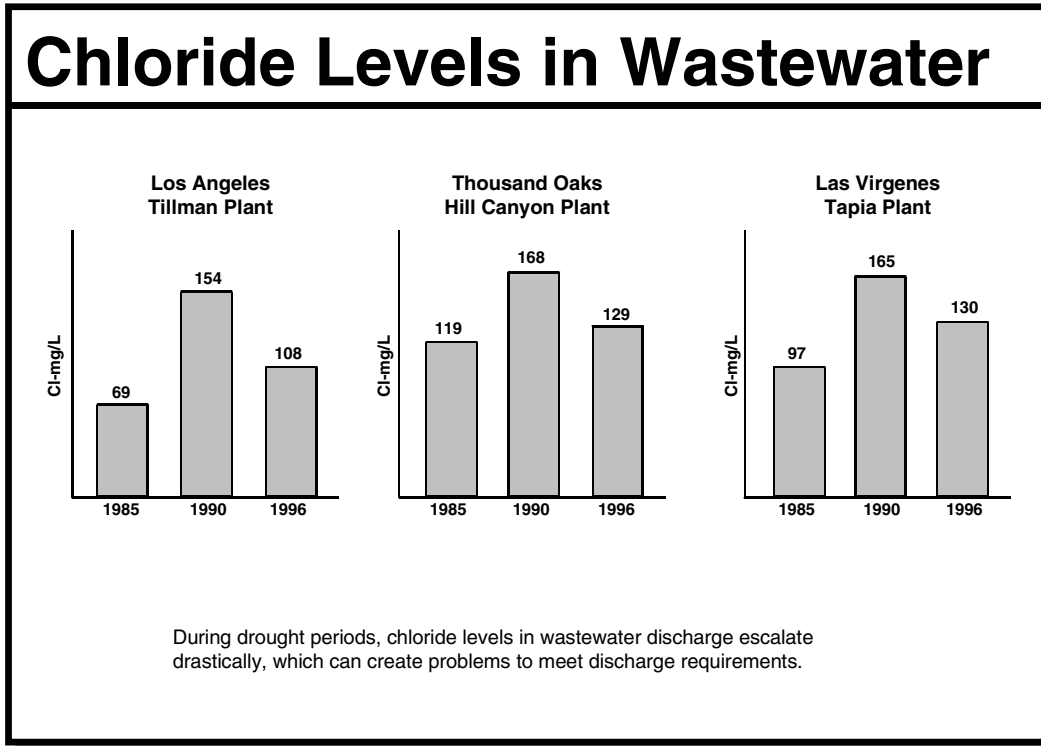
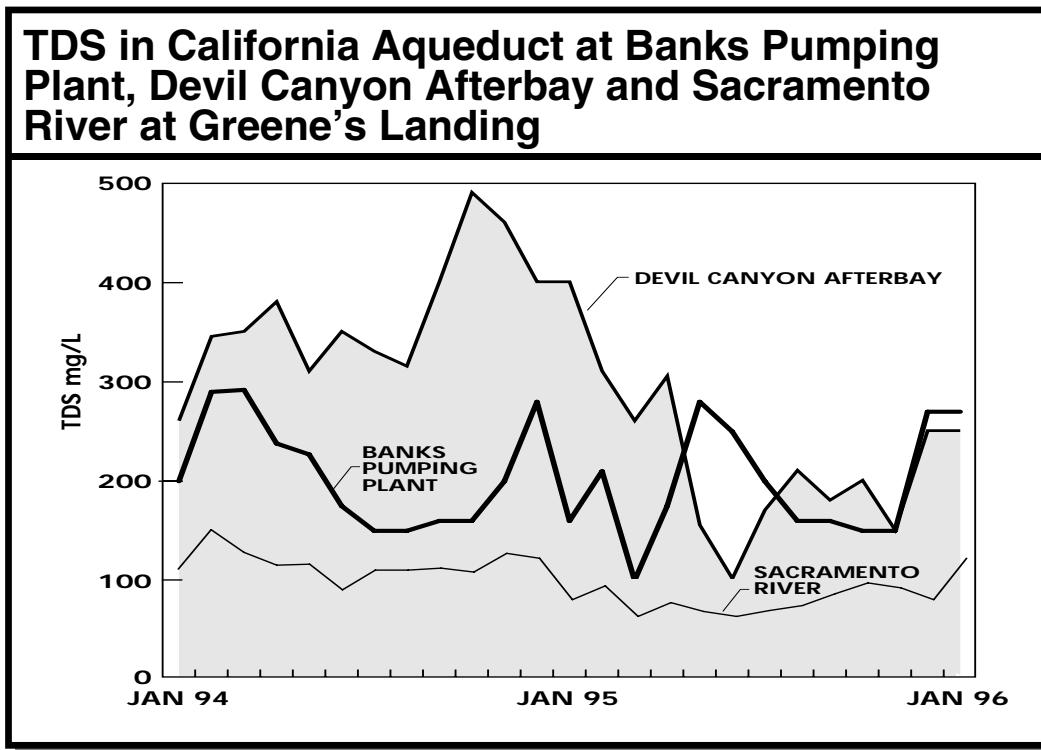


Figure 2-17



Through the CALFED process and through its role as a SWP contractor, Metropolitan is actively working to monitor and support actions that would reduce the salinity content of SWP water. Current TDS objectives cited in the State Water Service Contracts are listed in Table 2-3. Technical Appendix 2 provides additional information regarding SWP salinity.

Table 2-3 Current TDS Objectives for SWP

Constituent	Monthly Average (mg/L)	10-Year Average (mg/L)
TDS	440	220
Chlorides	110	55

PERCHLORATE

Perchlorate, a salt that has recently been detected in local groundwater and Colorado River water, is presenting an emerging water quality issue. Perchlorate (as ammonium perchlorate) is an inorganic chemical used in the production of solid rocket fuels, munitions, and fireworks. It is a commercial product that does not exist naturally in the environment.

The California Department of Health Services (CDHS) has adopted an action level for perchlorate in drinking water of 18 micrograms per liter. CDHS recommends that utilities monitor their water supplies and take the supply out-of-service if the concentration of perchlorate exceeds the action level. The analytical reporting limit is 5 micrograms per liter. Since 1997, perchlorate has been detected statewide in 110 domestic water wells in areas where aerospace material and munitions development, testing, and manufacturing occurred. Thirty-three of those wells have exceeded the state's action level and twenty-two wells have been closed. The remaining wells are blended with other sources to comply with the action level criteria of the CDHS.

Perchlorate has been detected in Metropolitan's Colorado River water at concentrations ranging from 5 to 9 micrograms per liter. SWP water does not have detectable levels of perchlorate. The contamination in Colorado River water has been traced to perchlorate-based manufacturing in the Las Vegas/Henderson, Nevada area (and is discharged into the Las Vegas Wash to Lake Mead). The manufacturers are cooperating with the Nevada Division of Environmental Protection to characterize the extent of the contamination and to provide containment and treatment. In general, because perchlorate is a chemically conservative substance that behaves in water similarly to salinity, measures to mitigate TDS in CRA water will serve to reduce perchlorate concentrations as well.

ECONOMIC BENEFITS OF SALINITY MANAGEMENT

Reducing the salinity of delivered water and correcting the salt imbalance of the coastal plain, offers the potential for sizeable public benefit. Conversely, degradation of higher salt concentrations would cause significant impacts to water consumers and local resources.

High salinity is a serious water quality problem. As salinity increases, laundry detergents work less effectively, plumbing fixtures and home appliances wear out faster; and industrial users incur extra treatment costs for cooling towers, boilers, and manufacturing processes. At sufficiently high levels of salt, water also begins to have an undesirable taste, resulting in increased buying of bottled water or home treatment devices. Recycling and compliance with state and federal wastewater discharge permits becomes difficult to accomplish. Increased salinity in groundwater requires blending with less saline sources. Vegetation can experience restricted growth and reduced crop yield. Technical Appendix 3 provides additional information on the physical impacts of high salinity. Technical Appendix 5 addresses details related to the economic benefits of reducing high-TDS water supplies.

ECONOMIC ASSESSMENT MODEL

The Salinity Management Study task force worked extensively with USBR and Member Agency staffs to update the 1988 USBR model for assessing regional impacts of salinity. New data, assessments, surveys and economic factors applicable to the Metropolitan service area were incorporated into the USBR model to improve the accuracy of the economic impact and benefit estimates.

As a result of extensive peer and expert review, a residential survey, and case study analysis, the task force concluded that municipal consumers, industry, agriculture, and public water and wastewater systems experience significant costs from sustained levels of high salinity. The categories in Table 2-4 were investigated to determine economic relationships:

Table 2-4 Summary of Economic Benefits of Reduced Salinity

<p>Residential</p> <ul style="list-style-type: none"> ▪ Increased life of plumbing system and appliances ▪ Reduced use of bottled water and water softeners
<p>Commercial</p> <ul style="list-style-type: none"> ▪ Decreased cost of water softening ▪ Decreased use of water for cooling ▪ Increased equipment service life
<p>Industrial</p> <ul style="list-style-type: none"> ▪ Decreased cost of water treatment ▪ Decreased water usage ▪ Decreased sewer fees
<p>Agricultural</p> <ul style="list-style-type: none"> ▪ Increased crop yield ▪ Decreased water usage for leaching purposes
<p>Utilities</p> <ul style="list-style-type: none"> ▪ Increased life of treatment facilities and pipelines
<p>Groundwater</p> <ul style="list-style-type: none"> ▪ Improved wastewater discharge requirements for permit compliance ▪ Decreased desalination and brine disposal costs
<p>Recycled Water</p> <ul style="list-style-type: none"> ▪ Decreased use of imported water for leaching ▪ Desalination and brine disposal costs

Figure 2-18 shows \$95 million of regional benefit if average SWP and CRA salinity were to decrease by 100 mg/L.

Figure 2-19 indicates \$64 million of benefits if most local groundwater (about 90 percent) and wastewater (about 80 percent) were to experience a 100 mg/L decrease in salinity. (Good quality groundwater, less than 250 mg/L, and low urban salt additions to wastewater, less than 250 mg/L, were excluded from this analysis.)

Figure 2-18

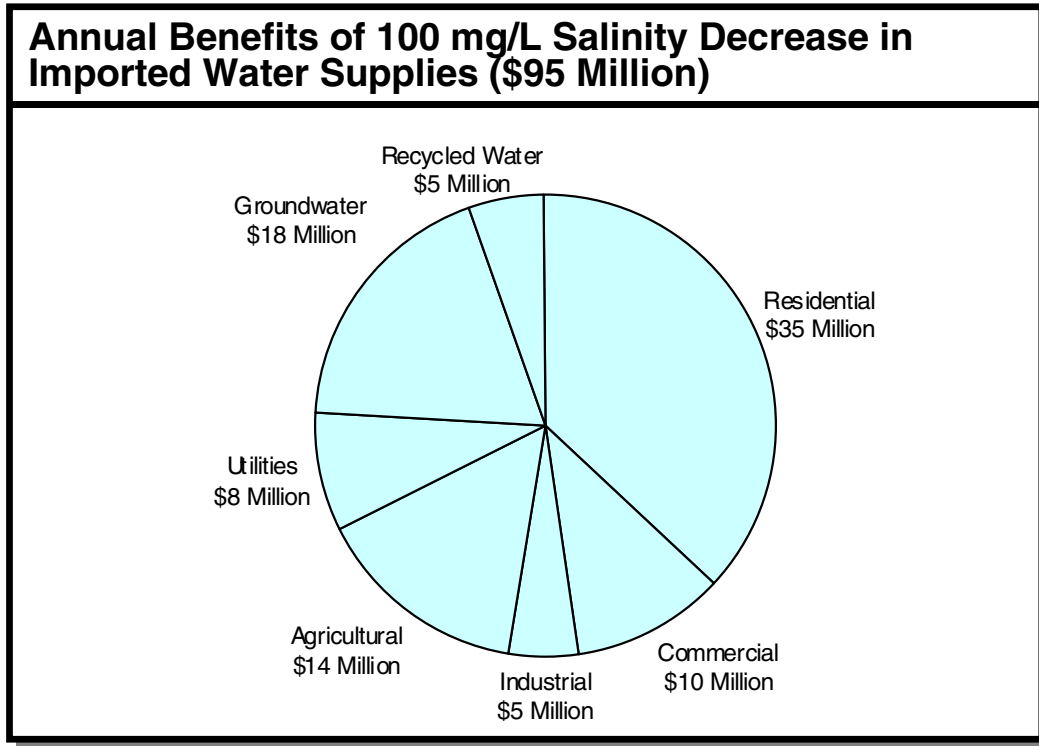


Figure 2-19

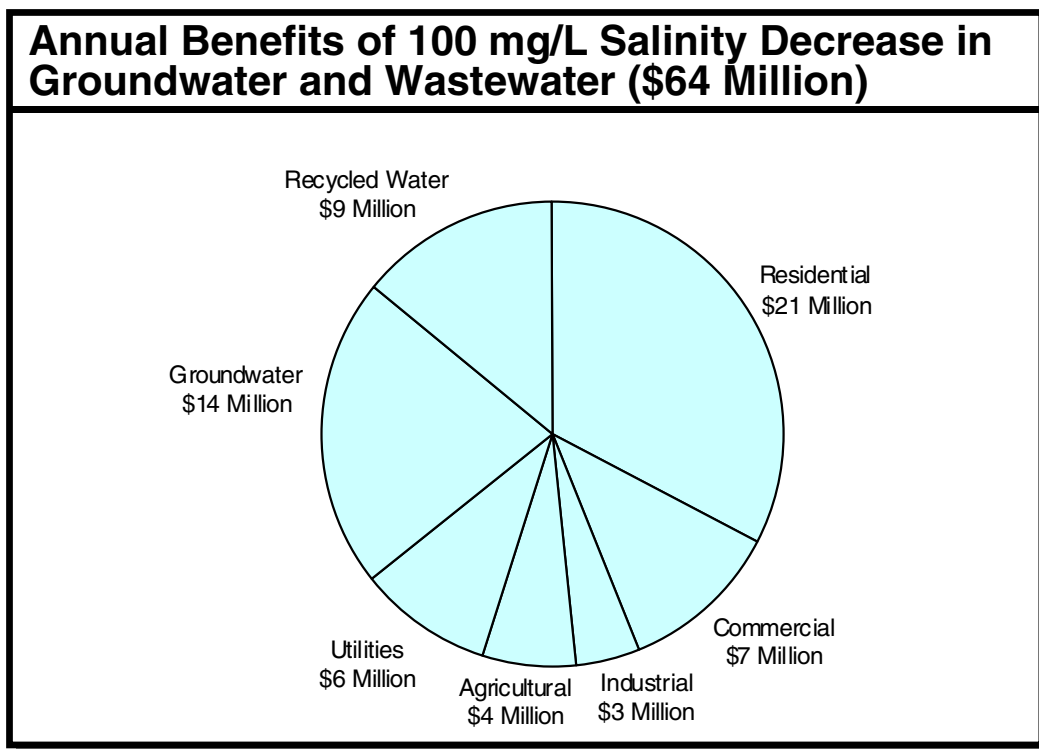


Table 2-5 lists items sensitive to salinity changes.

Table 2-5 Benefit/Impact Categories

RESIDENTIAL Water pipe Water heater Faucet Garbage disposal Clothes washer Dish washer Bottled water purchase Water softener	COMMERCIAL Sanitary Cooling Irrigation Kitchen Laundry Miscellaneous <hr/> WATER UTILITIES Water Treatment Water Distribution	AGRICULTURE Nursery products Cut Flowers Strawberries Misc. Vegetables Citrus Avocados Pasture/Grain Vineyard Deciduous Field
WATER RECYCLING Direct Groundwater Recharge Indirect Groundwater Recharge (through deep percolation) Irrigation Commercial/Industrial	INDUSTRIAL Process Water Cooling Towers Boilers Sanitation Irrigation	GROUNDWATER Direct Groundwater Recharge Indirect Groundwater Recharge (through deep percolation) Incidental Recharge through Wastewater Discharge

Metropolitan's economic model divides the service area into 15 subareas to reflect the unique water supply conditions and benefit factors of each (Figure 2-20).

The salinity model is designed to assess the average annual "regional" benefits or impacts based on demographic data, water deliveries, TDS concentration, and costs for typical household, agricultural, industrial and commercial water uses. It uses mathematical functions that define the relationship between TDS and items in each affected category, such as the useful life of appliances, specific crop yields, and costs to industrial and commercial customers. For example, Figure 2-21 shows the relationship between TDS concentration and the useful life of household water heaters.

Figure 2-20

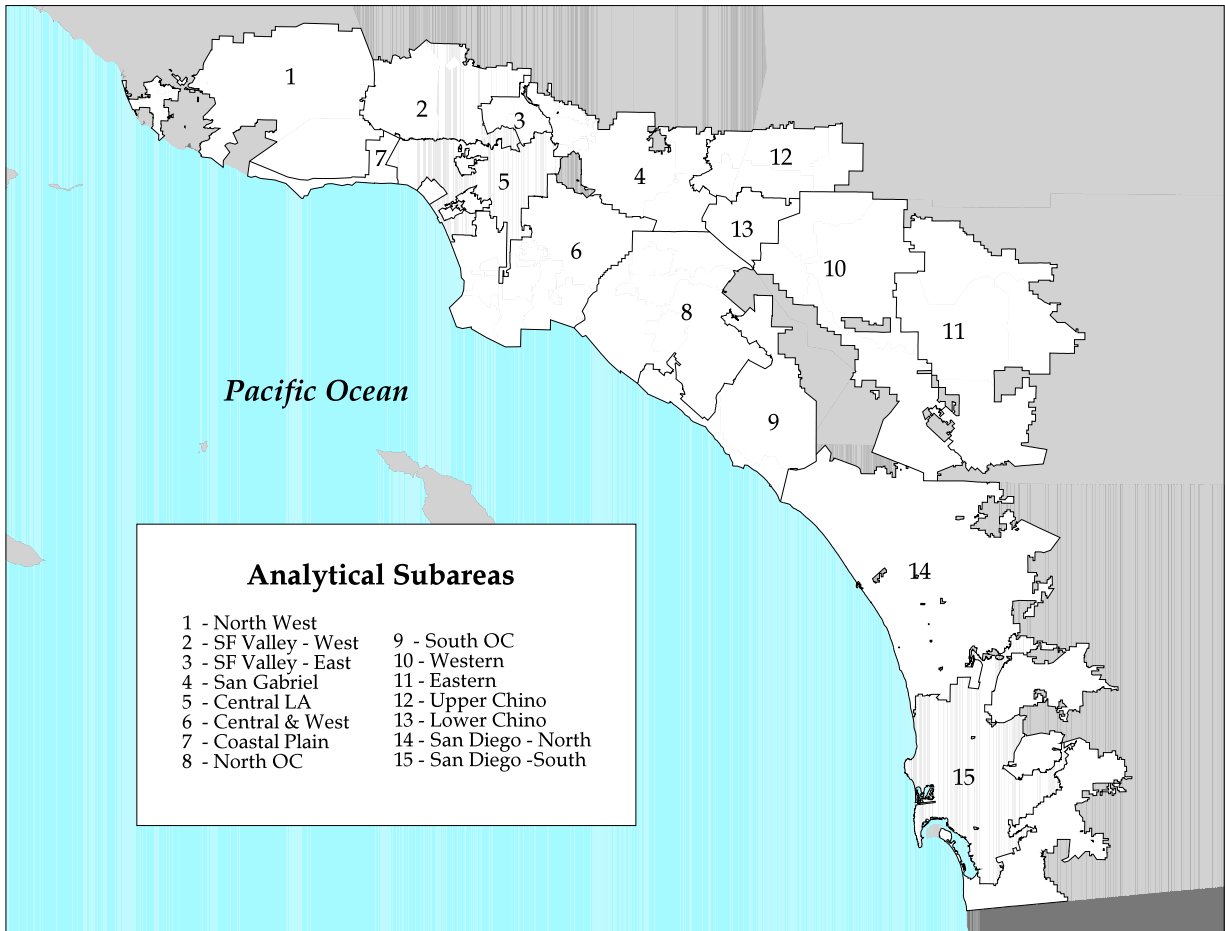
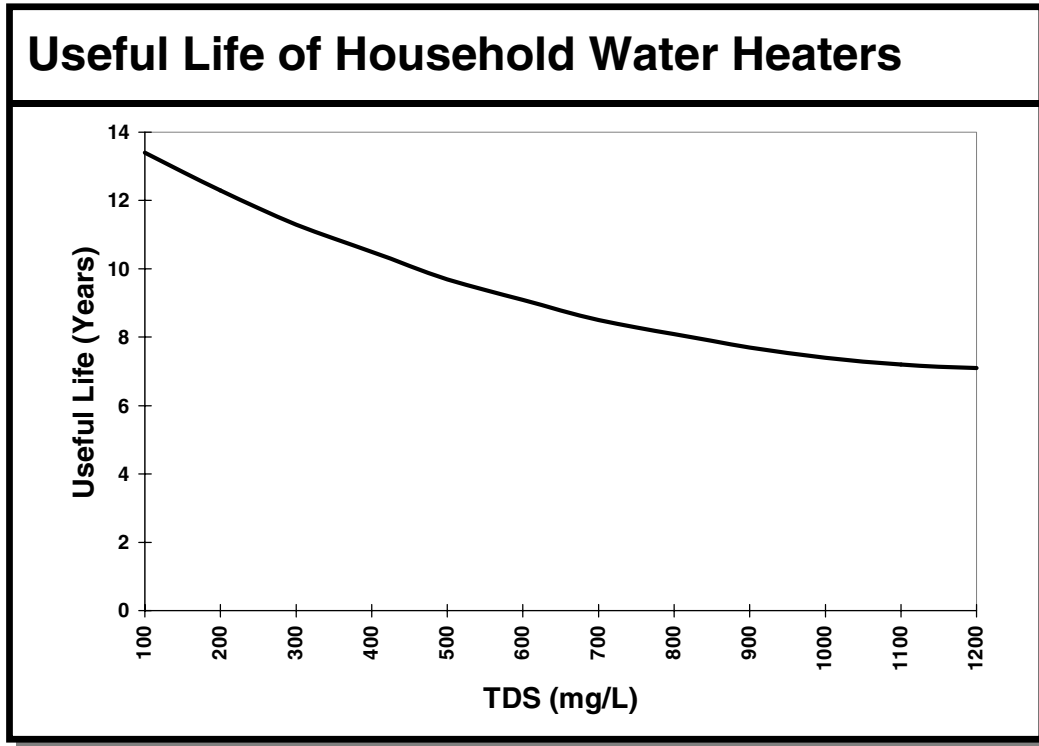


Figure 2-21

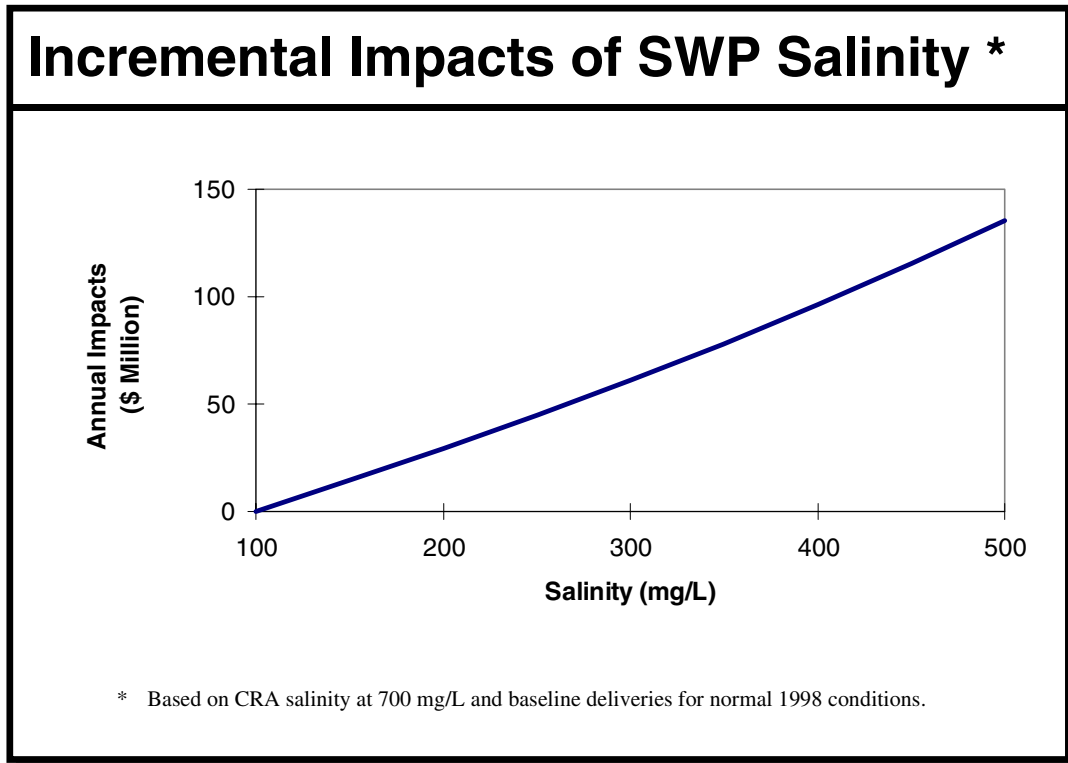


The economic model calculates the "incremental" benefits or impacts of SWP and CRA salinity changes compared to a selected baseline condition. The economic impact functions used (such as the effect of TDS on water heaters, strawberries, or cooling towers, etc.) were developed based on several approaches including technical studies, consumer surveys, interviews of contractors and experts, and engineering judgment. All of the cost factors employed (such as the price of water heaters, water rates, or reverse osmosis costs, etc.) were obtained from retail stores, warehouses, available reports and publications, engineering cost estimates, and Local Resources Program files.

BENEFITS AND IMPACTS OF THE SWP AND CRA

Figure 2-22 depicts the range of "incremental" economic consequences of SWP salinity changes when CRA salinity is fixed at 700 mg/L. While there may be economic benefits when the SWP salinity is below 100 mg/L, this graph shows the "incremental" impacts of SWP salinity compared to 100 mg/L. (Historically, the average annual salinity of SWP has never been below 100 mg/L.)

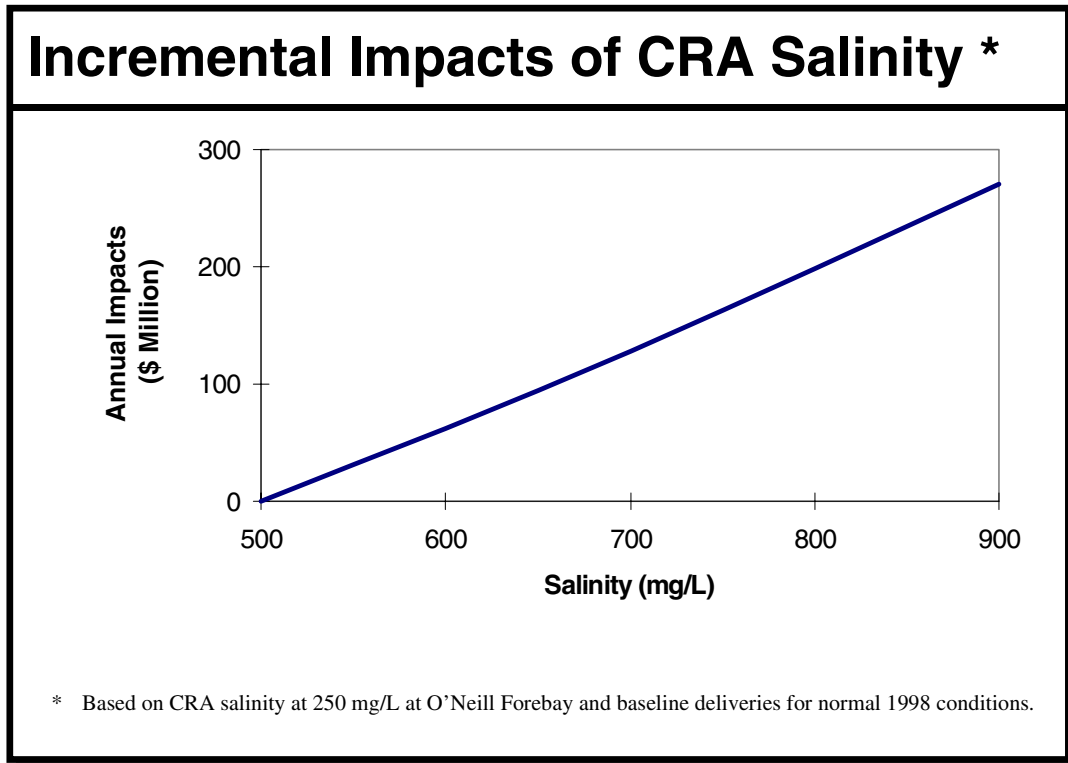
Figure 2-22



Likewise, Figure 2-23 shows the range of economic consequences of CRA salinity changes when the SWP salinity is fixed at 250 mg/L at the O'Neill Forebay. While, there may be economic benefits when CRA salinity is below 500 mg/L, this graph shows the "incremental" impacts of CRA salinity compared to 500 mg/L. Historically, the average annual salinity of CRA has never been below 500 mg/L.

Technical Appendix 5 provides additional information on the derivation of salinity economic functions. Technical Appendix 6 specifically addresses the high-profile issue of the impacts of water softeners.

Figure 2-23



TECHNOLOGY

DESALINATION TECHNOLOGY

Desalination is the ultimate tool to reduce salt accumulation when other methods fail. Desalination can create new potable water supplies from brackish water, thus restoring previously abandoned sources. In addition, membrane desalination technology has the capacity to remove organic carbon, viruses, *cryptosporidium* and other contaminants of health concern. There are more and more full-scale projects that successfully demonstrate the technical capabilities of brackish water desalination. Desalination is a proven technology that has long been used in the production of high-purity industrial water and domestic bottled water.

When desalination is necessary, the main technological options available include:

- Reverse Osmosis (RO)
- Nanofiltration
- Electrodialysis Reversal (EDR)
- Distillation

To treat different types of water (reclaimed, brackish, seawater, potable, and industrial), the desalination technologies most applicable to each are shown in Table 2-6.

Table 2-6 Major Desalination Treatment Options

Supply	RO	Nanofiltration	EDR	Distillation
Reclaimed Water	X		X	
Brackish Ground Water	X		X	
Seawater	X			X
Potable Water	X	X		
Industrial Supply Water	X	X		

Desalination usually separates the source water into two components:

1. Low-salinity production water to be used by the intended customer, and
2. A high-salinity waste brine that must be disposed of.

Brine, which may constitute up to 25 percent of the treated source water volume, is usually disposed of through non-reclaimable brine lines that discharge to the ocean. In some locations, brine is evaporated or injected deep into geologic zones of non-potable water. Inland projects usually require lengthy brine lines and thus cost more than projects conveniently located near the coast or existing ocean outfalls.

DESALINATION COSTS

The use of desalination in the past has been limited by cost and environmental constraints on brine disposal. For those reasons, water supply and sanitation agencies have tended to consider desalination as an action of last resort. However, technological advances and the need to better manage groundwater basins are making desalination of brackish groundwater and recycled water more common.

In this study, the cost of desalination was considered as an economic impact to water recycling and groundwater use when salinity exceeds certain thresholds for each subarea in the region. Those thresholds were 900 mg/L for recycled water; for groundwater basins, the threshold was set by the Regional Water Quality Control Boards. Higher desalination costs were assigned to inland areas because of the extra facilities needed for brine disposal. Existing and proposed projects were reviewed to establish reasonable costs for local water desalination as presented in Table 2-7.

Table 2-7 Cost of Local Water Desalination in Southern California (in dollars per ton of salt removed)

Location	Brackish Groundwater	Recycled Water
Coastal Areas	\$280/ton	\$557/ton
Inland Areas	\$490/ton	\$777/ton

SECTION 3

EVALUATION OF POTENTIAL REGIONAL SALINITY MANAGEMENT STRATEGIES

BACKGROUND

Within the coastal plain of Southern California, approximately one half of the salt input comes from imported water and the remainder comes from local sources. Therefore, a comprehensive approach to salinity management should focus on both imported and local sources of salinity. Figures 2-18 and 2-19 indicate sizeable benefits from reducing both sources.

Numerous potential salinity management actions were formulated and screened during discussions by Metropolitan staff, member agencies, other concerned agencies and pertinent organizations. The Metropolitan Board workshop, held on July 25, 1997, also helped identify key parameters that should be used to assess the potential strategies.

Three distinct time periods related to Metropolitan's Capital Improvement Program schedule, were identified to guide the staging of potential actions:

1998-1999	This near term period is consistent with the current level of facility development.
2000-2004	During this period, the initial filling of the Eastside Reservoir will occur, and Stage II Regulations under the Safe Drinking Water Act will be promulgated
2005-2015	During this period Metropolitan will likely upgrade the disinfection process at its blended water filtration plants, the Inland Feeder will become operational, clarity will be reached on the amounts of water to be exchanged or wheeled through the Colorado River Aqueduct, and benefits of a CALFED program may be realized.

Based on the uncertainty of key conditions affecting salinity beyond 2004, the analyses presented in this report focus on the 1998 to 2004 period. Subsequent studies will be needed in the future to address the period 2005 and beyond, and they will depend on some stability of the controlling conditions.

Given the long-term recognition of a need for salinity management, Metropolitan and other agencies need to cooperate in a cohesive regional strategy. Clearly, Metropolitan alone cannot solve the region's salinity problems.

Possible salinity management strategies fall into four fundamental categories briefly described as:

- ❑ **Imported Water Source Control**
 - Colorado River
 - SWP and CALFED Bay-Delta Program
- ❑ **Metropolitan Distribution System Management**
 - Blend imported water
 - CRA desalting
 - Integration of Quality and Quantity
- ❑ **Metropolitan and Other Agency Collaboration**
 - Expand Desert and Coachella water exchange
 - Demineralization
- ❑ **Local Efforts to Protect Groundwater and Recycled Supplies**
 - Groundwater basin management, which considers use of good quality water for groundwater recharge.
 - Wastewater management.
 - Reduction of salt usage, which includes reduction in the use of water softeners and industrial salts where regeneration brines enter wastewater collection systems destined for water reclamation plants (rather than ocean discharge).
 - Brine lines, which are specially, dedicated pipelines used to carry highly saline water for ocean disposal.

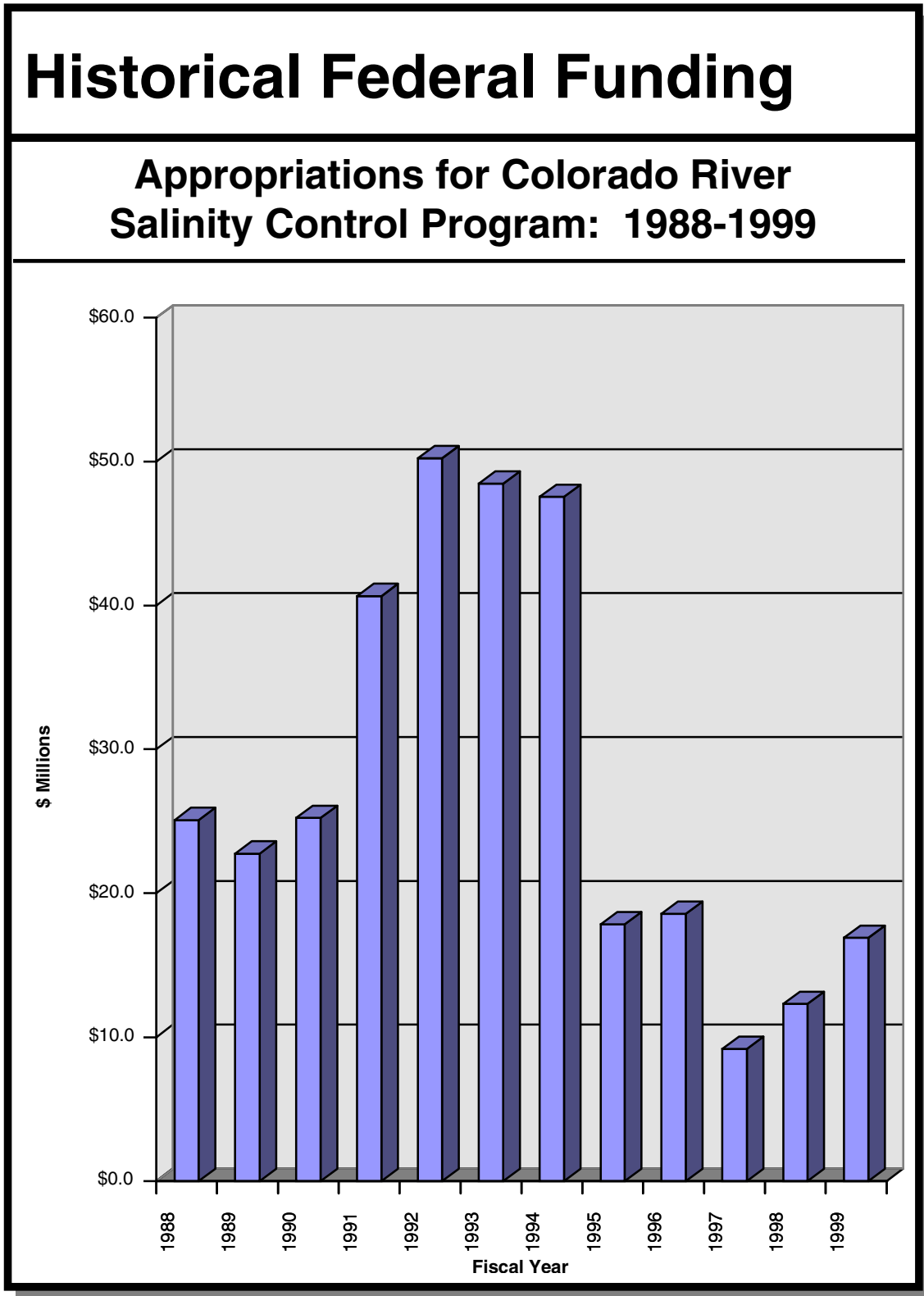
For analytical purposes, the CRA was considered full for the study period, consistent with the objectives of the California 4.4 Plan.

IMPORTED WATER SOURCE CONTROL

ACCELERATE COLORADO RIVER BASIN SALINITY CONTROL ACTIVITIES

The Colorado River Salinity Control Program is based on offsetting salinity impacts of upstream development (primarily agriculture) to maintain salinity at or below criteria levels of 723 milligrams per liter (mg/L) below Hoover Dam, 747 mg/L below Parker Dam and 879 mg/L at Imperial Dam, with average flow conditions (Figure 2-8).

Figure 3-1



Metropolitan and other CRW users would benefit from a lower salinity objective at Parker Dam. However, significant cost increases would result as indicated in Table 3-1.

Numeric Criterion below Parker Dam	Annual Cost
747 mg/L	\$25 million
700 mg/L	\$85 million
650 mg/L	\$150 million

To reduce the numeric criterion will require consensus among and financial commitments by the seven basin states and three federal agencies now engaged in the Salinity Control Program.

Given the existing standards, additional near-term reductions in salinity could be achieved if salinity control measures are accelerated and the corresponding state share (about 30 percent) is provided. However, annual Federal funding, which supports about 70 percent of the program activities, has declined from about \$50 million in 1992 to \$17 million in 1999 (Figure 3-1).

SWP OPERATIONAL CHANGE

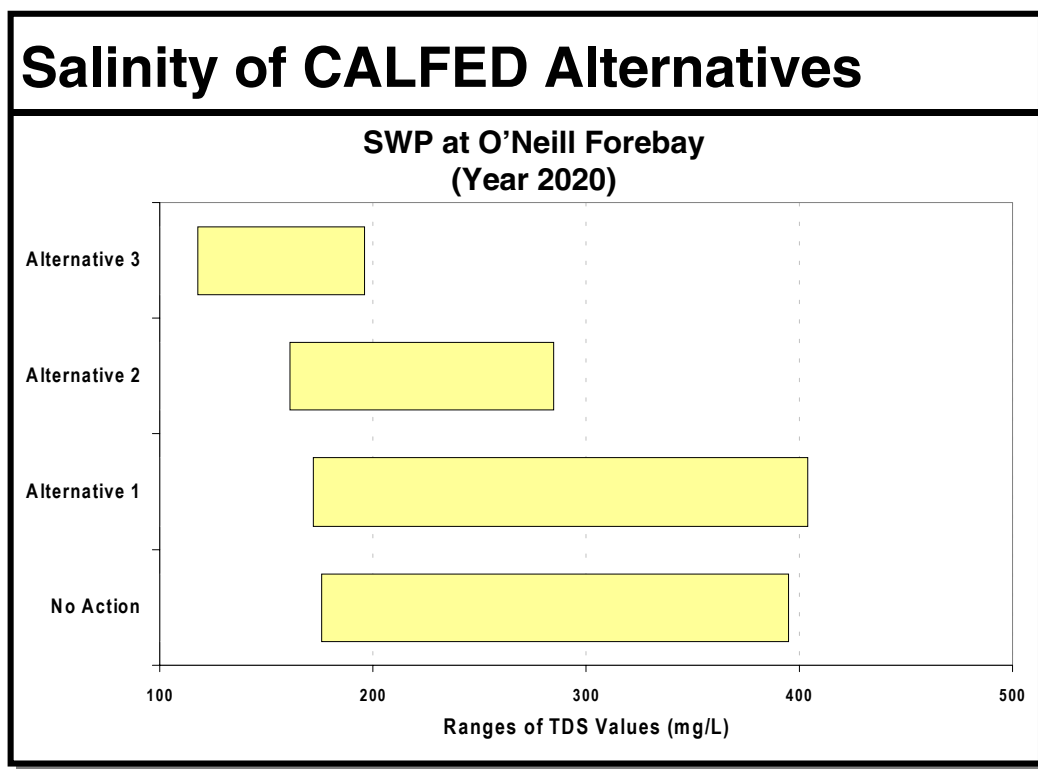
DWR could develop the capability to forecast salinity levels for the SWP, which would enable DWR and SWP water users to make better operational decisions regarding salinity. These forecasts would provide critical information for Metropolitan’s blending and other salinity management operational decisions. In addition, DWR could also develop the ability to quantitatively assess the salinity impacts of various actions and projects that could affect SWP salinity levels in the future.

Metropolitan would benefit if DWR placed greater emphasis on salinity outcomes in its SWP operating decisions. For example, preliminary studies estimate that a 10 to 30 mg/L reduction in SWP salinity levels could be achieved by selective shifting of Central Valley Project (CVP) pumping at the Tracy Pumping Plant to the Banks Pumping Plant to minimize commingling of CVP water at O’Neill Forebay or San Luis Reservoir. This nonstructural action would potentially reduce the influence of higher salinity CVP water, but may be constrained by or conflict with fish-take, contractual, operational, and water rights issues. It will be important, however, to encourage and promote DWR activity of this nature, when feasible.

CALFED BAY-DELTA PROGRAM

By providing policy direction and oversight for the CALFED Bay-Delta Program, the CALFED process has the potential to reduce salinity levels in SWP water significantly. It can do this by improving conveyance capacity to deliver low salinity water from the Sacramento River to the Banks Pumping Plant. Depending on their final decision regarding the conveyance features and operating criteria, the potential exists to reduce average SWP salinity by 100 mg/L. Figure 3-2 shows estimated ranges of monthly averaged TDS values under various alternatives being considered in the recently issued programmatic environmental document.

Figure 3-2



THE CALFED ALTERNATIVES

No Action: 1995 Water Quality Control Board Accord

Alternative 1: Existing Conditions with Storage

Some modifications for water conveyance in the vicinity of existing export pumps. Channels remain largely the same. The main effect is little change.

Alternative 2: Through Delta System with Storage

Widens channels and may flood islands. This alternative slows down and freshens Delta water flows and improves fish habitat. Levees are set back to create shallow habitat for fish.

The main effect is the improvement of Delta water quality and fish habitat.

Alternative 3: Dual Plumbing Facility System with Storage

Allows export pumps to take water either from a conveyance structure, which bypasses the Delta, or directly from Clifton Court Forebay. The main effect is the improvement of supply reliability, quality and safety of water being exported south. It minimizes fish loss at pumps.

METROPOLITAN DISTRIBUTION SYSTEM MANAGEMENT

ANALYSIS OF BLENDING OPTIONS

From 1995 to 1997, Metropolitan provided a blend of 25 percent SWP water during April through September to mitigate the high salinity of its Colorado River water. This blending operation helped support local resource management and reduced consumer impacts. Technical Appendix 4 provides more detailed information on Metropolitan's importation and distribution system as it relates to salinity management. Technical Appendix 11 specifically addresses the technical details of blending operations in Metropolitan's system.

Blending occurs using only two sources of imported water:

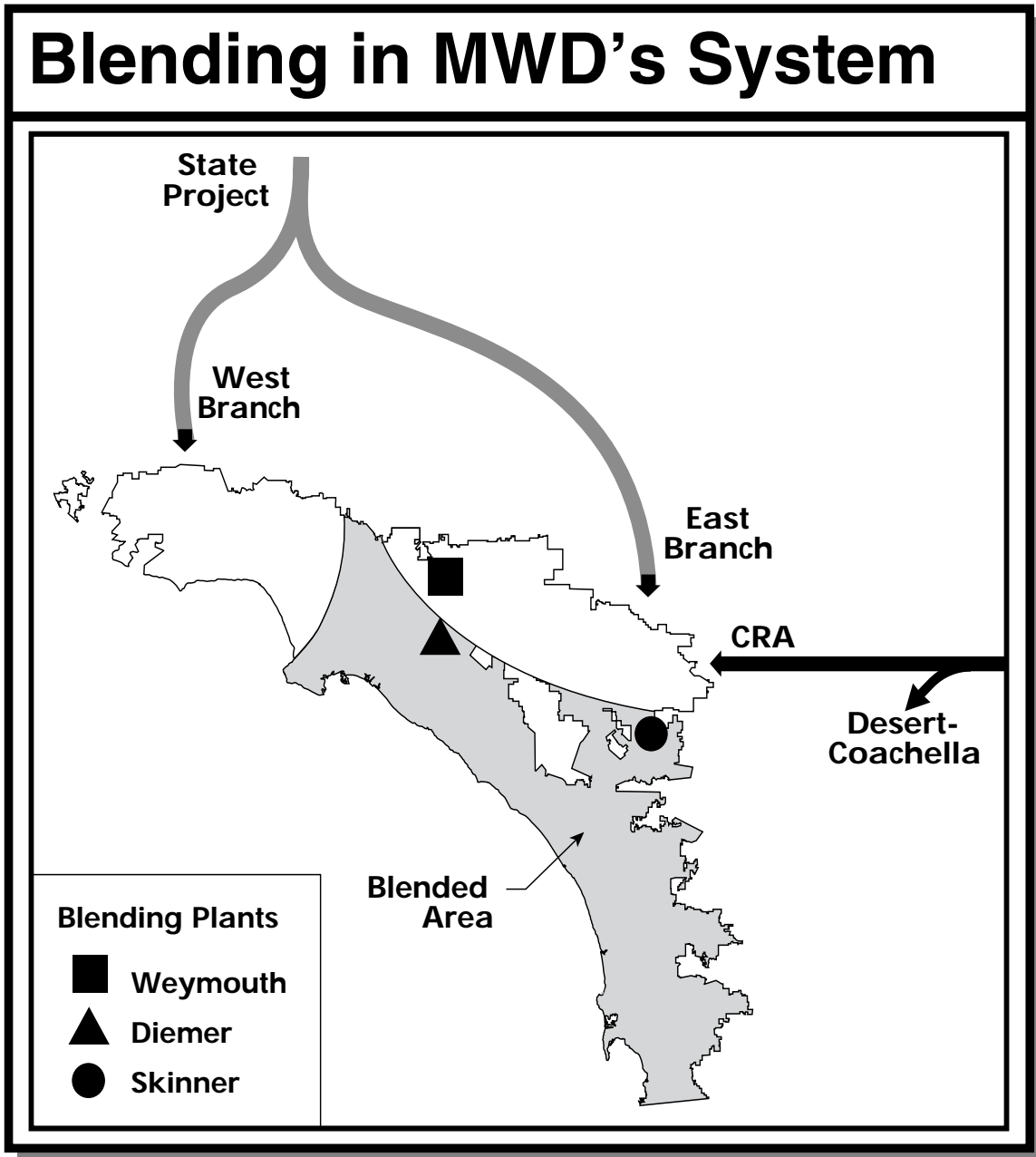
1. SWP water from the East Branch near San Bernardino, and
2. CRA water

The blend may be achieved at three filtration plant locations that collectively provide about 80 percent of Metropolitan's delivered water:

- Weymouth Plant
- Diemer Plant
- Skinner Plant and adjacent untreated lines

The remaining 20 percent of delivered water is unblended SWP water. The system cannot deliver Colorado River supplies directly to some areas because the Jensen Plant on the West Branch and the Mills Plants and Rialto Feeder on the East Branch receive only SWP supplies. Figure 3-3 identifies the area that received blended water.

Figure 3-3



1998 INTERIM BLENDING POLICY

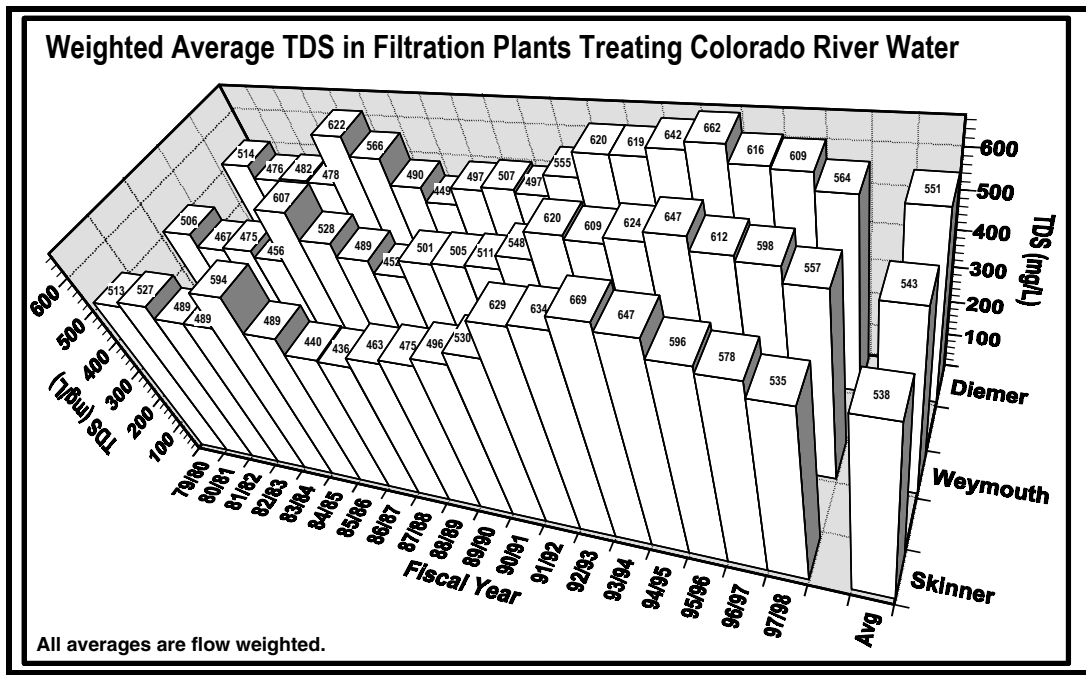
In March of 1998, Metropolitan's Board of Directors adopted an interim one-year blending plan that targets the April through September TDS concentration at 500 to 550 mg/L, contingent upon:

1. Maintaining blending costs within \$10 million before returning to the Board for additional authorization,
2. There being sufficient SWP water available for blending, and
3. Compliance with all primary water quality standards.

Additional short-term factors that occasionally limit the ability to meet the TDS target include flow adjustments to deal with episodes of turbidity and algae blooms, sudden demand changes, and unexpected changes in SWP salinity. SWP salinity has changed as much as 200 mg/L within one year. The 1998 plan provides a good framework for a long-term salinity management policy: the pursuit of common numeric TDS targets for the three plants over a specified period, contingent upon budget, availability of SWP water and compliance with all water quality standards.

The three plants, Weymouth, Skinner and Diemer can be managed to provide consistent salinity within distribution system constraints. The plot of historical salinity concentrations in Figure 3-4 shows consistent effluent salinity levels.

Figure 3-4

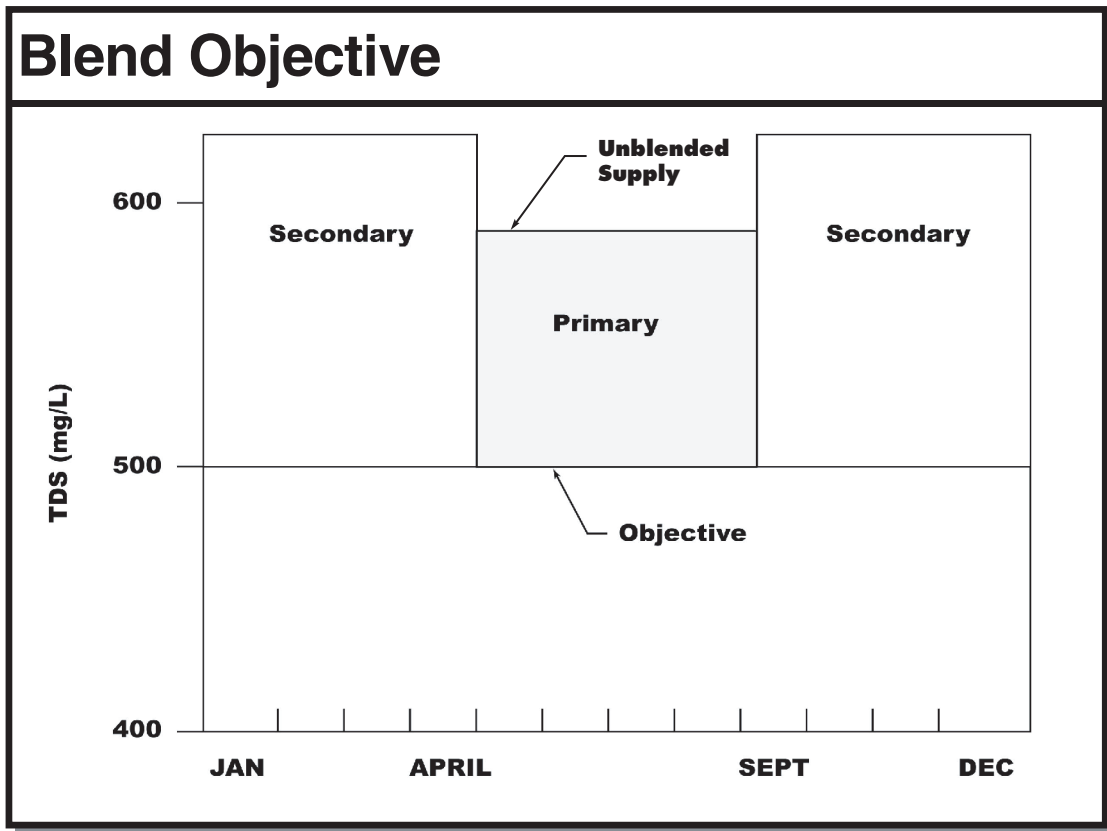


FINAL POLICY AND ACTION PLAN

In April of 1999, Metropolitan's Board of Directors adopted a Salinity Management Policy, and authorized its General Manager to carry out the policy by implementing a Salinity Management Action Plan (Section 4).

A key element of the Policy and Action Plan is the pursuit of a 500 mg/L objective on a year-round basis, predicated on several factors including sufficient quantities of SWP water and adequate low salinity content. The 500 mg/L objective is expected to be achieved in two stages. When conditions are favorable, 500 mg/L would be pursued year-round. In less favorable conditions, emphasis is placed on reducing salinity during April through September (Figure 3-5) primarily to support irrigation with recycled water. The Policy and Action Plan are presented in Sections 4 and 5, respectively.

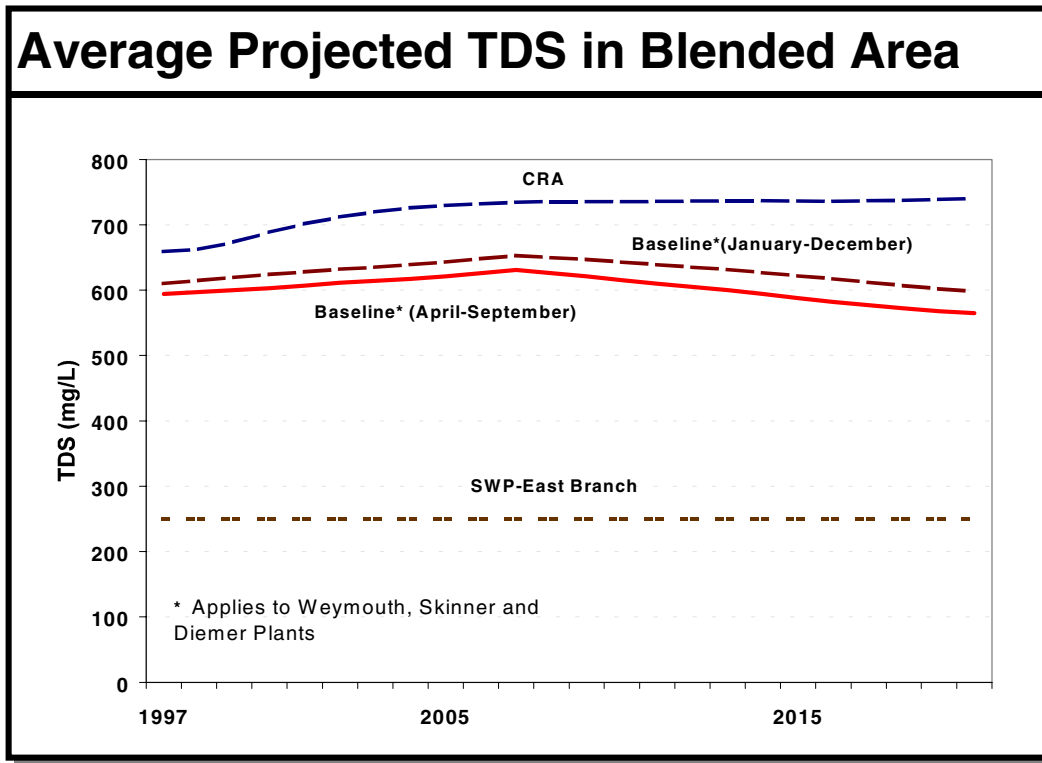
Figure 3-5



As demand increases in future years, Metropolitan will have to use more SWP water. This practice inherently lowers system TDS levels as SWP water mixes with the full flow of the CRA. However, TDS is expected to increase in Lake Havasu and the CRA at the same time in response to additional agricultural and urban development upstream in the Colorado River Basin. Even with the benefit of the Colorado River Salinity Control Program, average TDS in the CRA is forecasted to approach the established criterion of 747 mg/L by about 2015. Given these two opposing phenomena, average annual TDS in Metropolitan’s system is expected to increase through 2008 and then decline as illustrated in Figure 3-6. This illustration represents "baseline"

conditions in which SWP water use is limited to just that amount needed to meet demands, and additional SWP water is not imported specifically for the purpose of blending.

Figure 3-6

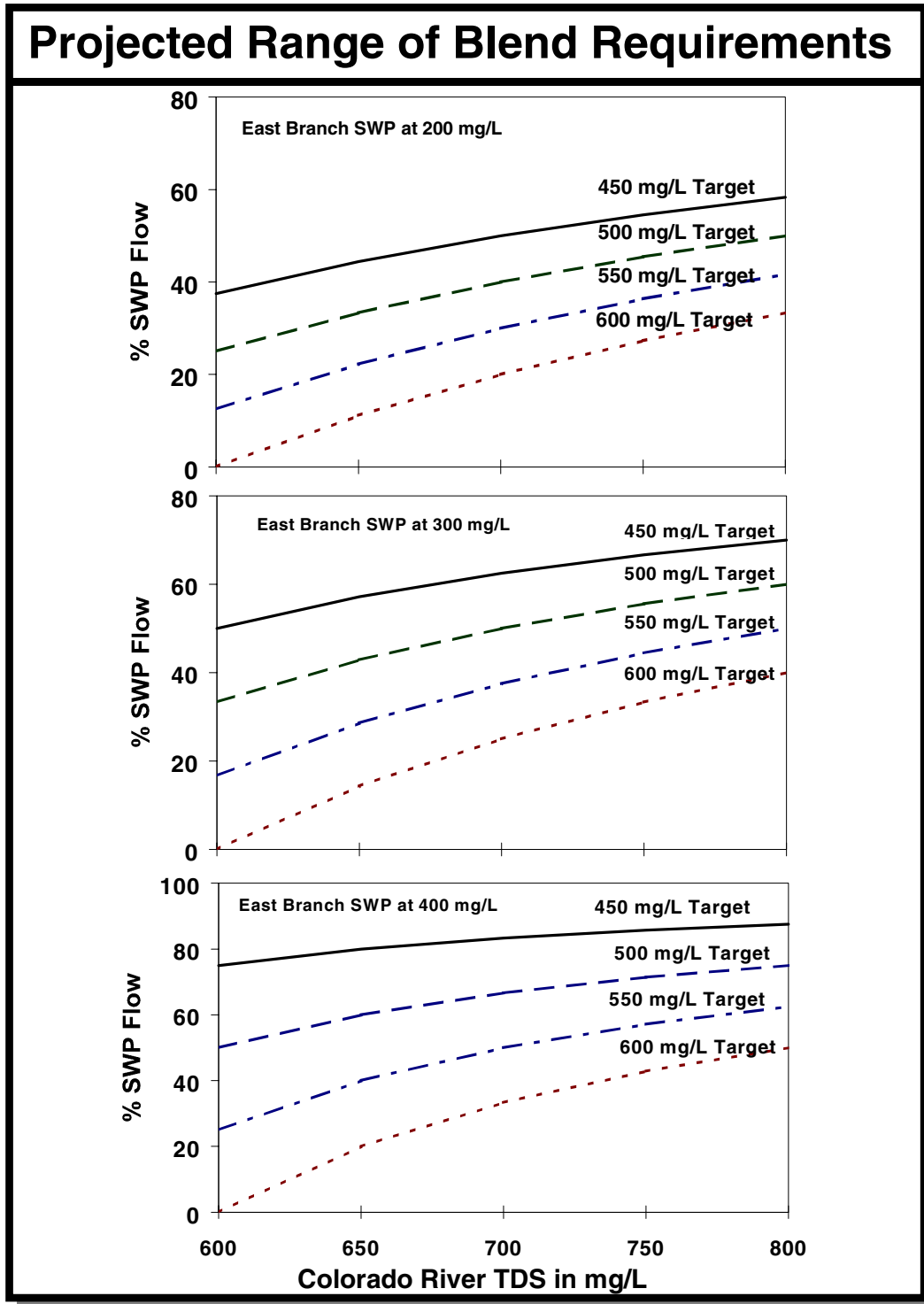


VARIABILITY IN IMPORTED WATER QUALITY

Salinity concentrations in SWP and CRA water vary primarily as a result of hydrologic conditions. During droughts, the salinity concentrations increase significantly. The amount of SWP water needed to blend down CRA water also changes significantly as illustrated in the following three graphs (Figure 3-7).

Although the curves in these graphs show some supply conditions that would require a high percentage of SWP water, hydraulic constraints in Metropolitan’s system limit practical blending from 45 to 50 percent SWP water during summer peak demand periods.

Figure 3-7



BLENDING COSTS

Metropolitan incurs blending costs when it takes extra SWP water from the East Branch to lower salinity, instead of taking maximum supplies from the CRA. Metropolitan's lowest cost water is from the CRA. The second lowest cost water is from the West Branch of the SWP at Castaic Lake. The most expensive water is delivered through the East Branch of the SWP, which is also the source needed for blending. The East Branch costs are higher because more energy is needed for higher pump lifts to the delivery point in Metropolitan's distribution system, and because the SWP energy contracts are more costly than those for the CRA. Table 3-2 lists projected energy costs. These projections are based on current forecasts and an average 3 percent inflation per year. The future values may change due to the expiration of some major SWP power contracts in the year 2004, changes in power prices with electric restructuring, and/or changes in water supply conditions.

Table 3-2 Energy Costs

Water Source	Estimated Marginal Energy Costs		
	1998 (\$/AF)	2000 (\$/AF)	2005 (\$/AF)
CRA	37	39	46
West Branch of SWP	57	60	70
East Branch of SWP	71	75	87

The cost of shifting water deliveries to the East Branch of the SWP from either the West Branch or the CRA is the difference in marginal costs. Metropolitan's expenses for power have changed significantly over the last few years in response to new contracts and market forces. Future changes in the power market are uncertain and likely to be volatile.

Under projected year 2000 supply and member agency demand conditions, up to about a 10 percent blend can be achieved by shifting water from the West Branch to the East Branch at a differential cost of \$15/AF (\$75 - \$60). Further blending is achieved by reducing the amount of CRA water and replacing it with additional East Branch water at a differential cost of \$36/AF (\$75 - \$39). An additional cost of about \$5/AF is incurred at filtration plants for the extra chemical usage and the sludge removal associated with treating SWP rather than CRA water. The costs and resource impacts to achieve a 500 mg/L salinity target in the year 2000 are illustrated in Figures 3-8 and 3-9.

RESOURCE IMPACT

Figure 3-9 illustrates the relative amounts of CRA deliveries to be curtailed over 6-, 9- and 12-month blending periods. The significant increase in CRA layoff for year-round blending

compared to 6-month blending occurs because Metropolitan would otherwise deliver nearly 100 percent CRA water to the blended area in the winter months when demands are low. Conversely, some SWP water is always needed in the blended area to meet the higher summer demands during the 6-month April through September blending period. Figure 3-9 raises two significant resource questions:

1. Is there sufficient SWP water to quantitatively make up for the CRA layoff?
2. Is the CRA layoff compatible with efforts to establish a 4.4 million acre-foot per year California plan for the Colorado River?

In developing its Colorado River strategy, Metropolitan is considering diverting some of its CRA water to groundwater storage facilities. Metropolitan is also considering expanded exchanges with the Coachella Valley Water District and the Desert Water Agency. Such storage or exchange operations could recover beneficial use of the CRA water that Metropolitan would otherwise not pump from the Colorado River in order to meet its salinity targets. However, the amount of CRA water that may be placed into storage or exchanged will have limits, depending upon how these opportunities materialize.

The ability of the SWP to supply water needed for blending is uncertain during the first few months of the year. This ability also varies from year to year in response to hydrologic conditions. Analyses show that on average, a Metropolitan salinity target can be met in about 7 of every 10 years; in the other years SWP supply will be insufficient.

Figure 3-9 also shows that Metropolitan's need for SWP water to meet a salinity target (such as 500 mg/L) diminishes when SWP water is of good (low TDS) quality. Success in the CALFED process or Sierra exchanges in reducing the salinity of SWP water on a sustained basis is critical to the long-term blending practice.

Figure 3-10 illustrates the regional economic benefits of 6-month, 9-month, or year-round blending. Progress in potential CALFED, Sierra exchanges and CRA storage and exchange arrangements could greatly reduce the resource constraints to a year-round blend policy to achieve 500 mg/L compared to the baseline salinity conditions.

Figure 3-8

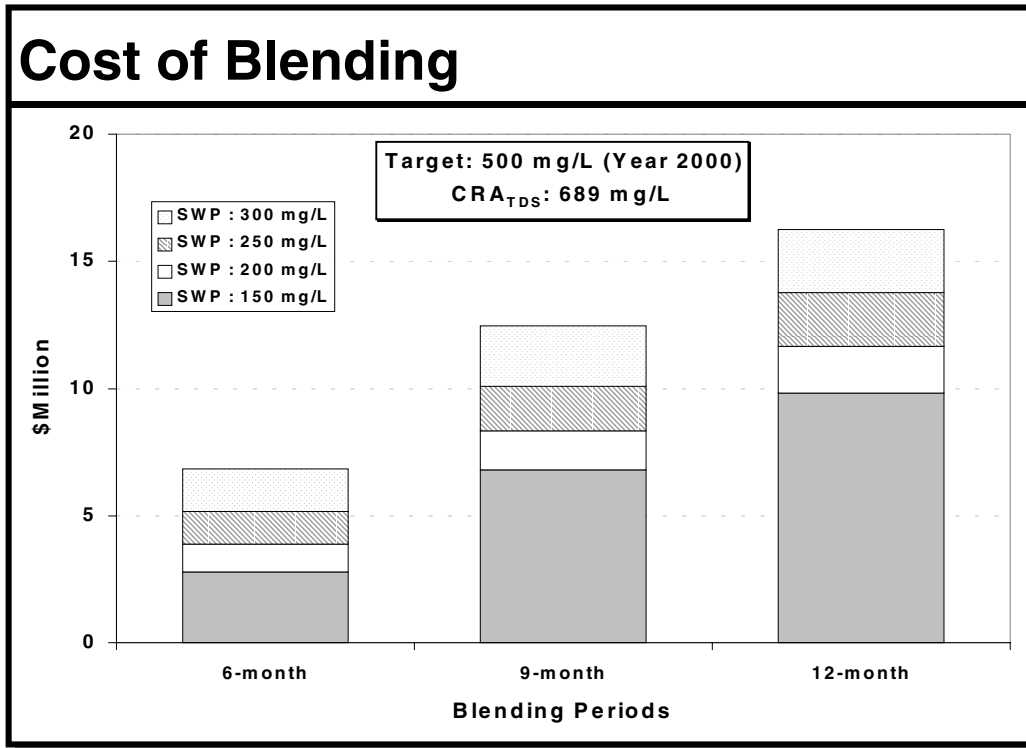


Figure 3-9

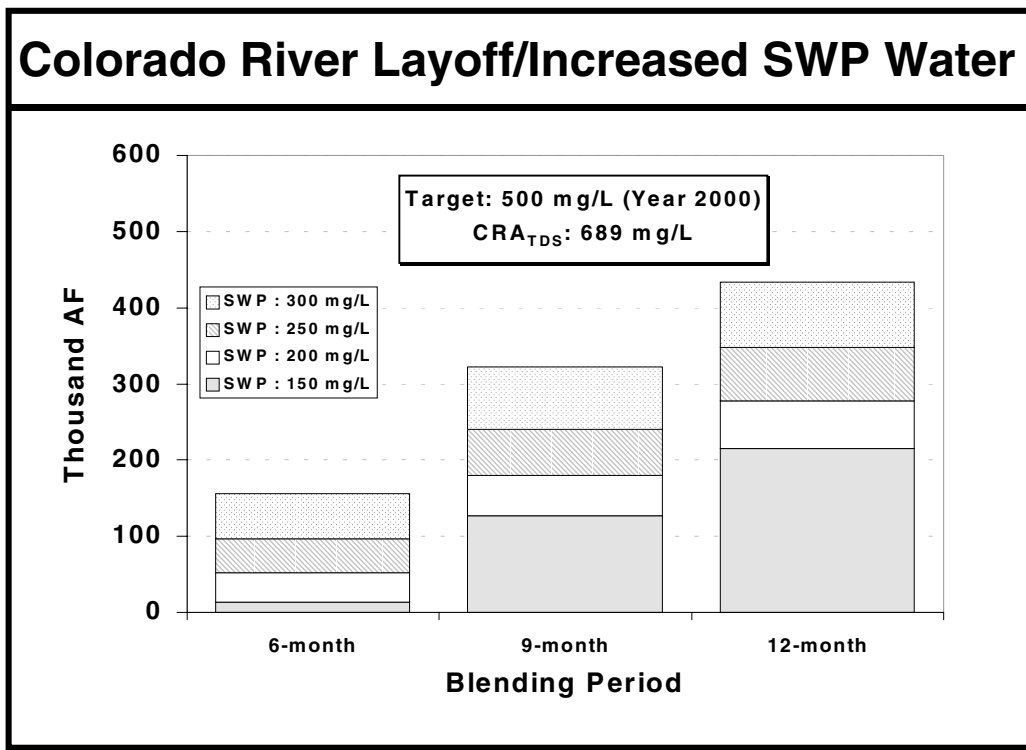
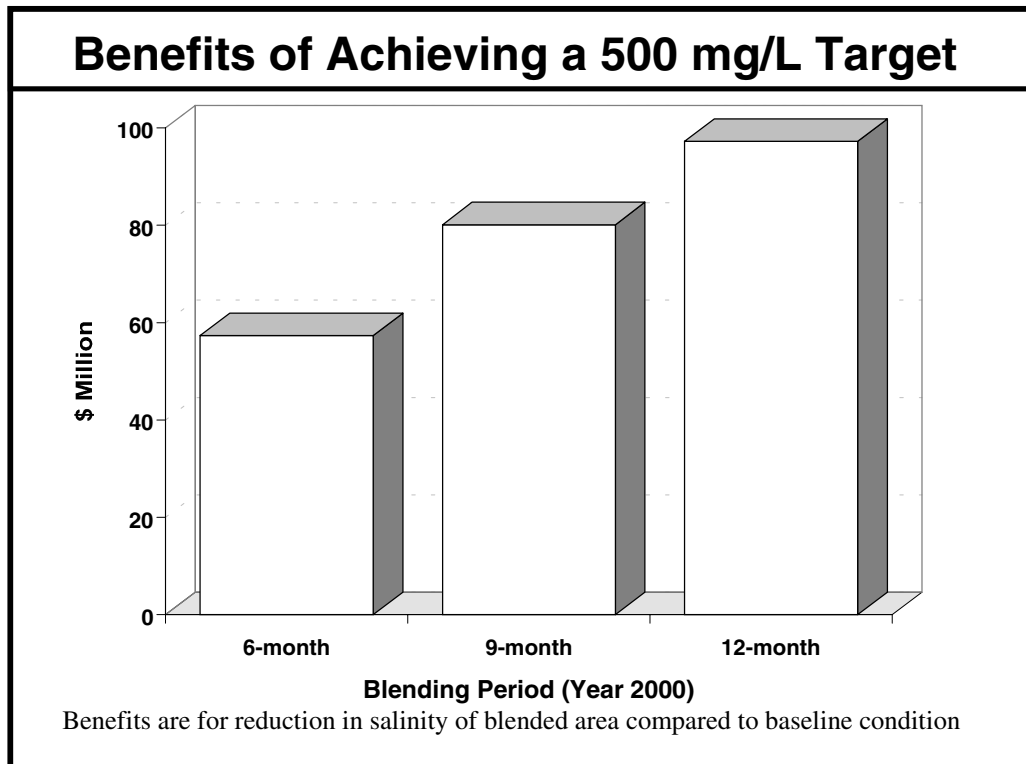


Figure 3-10



EASTSIDE RESERVOIR STORAGE AND CYCLING OF SWP SUPPLIES

Metropolitan could draw down its reservoirs every summer and refill them in the winter when there is generally a surplus flow of low salinity water in the Delta. Likewise, groundwater managers could do the same with their groundwater storage. The ability to cycle stored supplies will greatly increase when the Eastside Reservoir and the Inland Feeder are complete. However, there are risks associated with cycling, including a potential inability to refill the drafted storage because of drought conditions, Delta fish-take constraints, or other operational limitations.

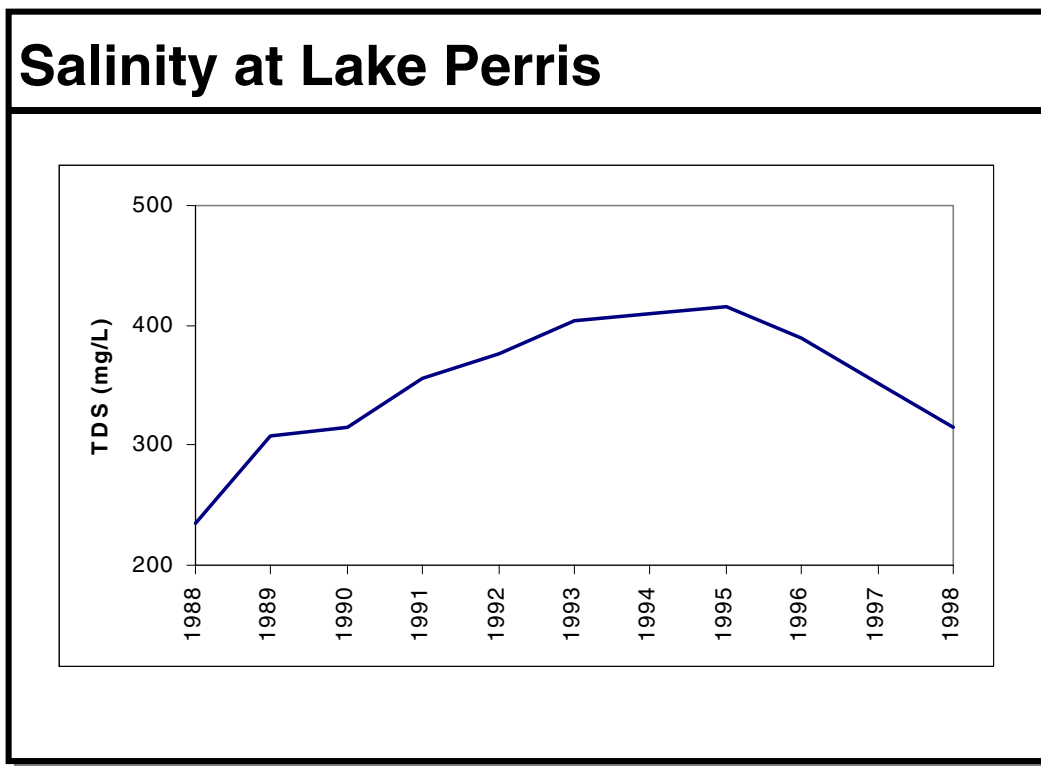
Lake Perris water will be needed at times to achieve summer salinity targets at the Skinner filtration plant. Since the reservoir surface is subject to nearly six feet of evaporation annually, salinity tends to build up in Lake Perris when water is not exchanged by cycling (Figure 3-11). In February 1998 for example, salinity levels in Lake Perris were about 330 mg/L while the East Branch of the SWP was providing 200 mg/L water. Achieving low salinity levels in Lake Perris is constrained by:

1. Inability to cycle storage without conflicting with the desire for stable surface elevations on the part of recreational and fishery interests, and

2. Inability to redirect nearby Santa Ana Valley Pipeline flows through the reservoir, because to do so would bypass the Perris Power Plant and thus lose revenue from power generation.

To deal with these problems, a Metropolitan task force is working with concerned recreational and fishery interests on reservoir cycling operations at Perris. Metropolitan has also implemented some limited flow-through operations (power plant bypass) to flush salts from the reservoir. Since the Perris Power Plant provides about \$1 million in annual revenue, additional assessments of the costs and benefits of bypassing the power plant are being incorporated into the discussions.

Figure 3-11



COLORADO RIVER WATER AND AGRICULTURAL DRAINAGE DESALTING

Three options to reduce CRA salinity levels through desalination have been evaluated at the conceptual level. Two of the options desalt aqueduct water; the other option desalts agricultural drainage water from the Imperial Valley or Coachella Valley and places the product water into the CRA to dilute salinity concentrations.

The primary benefit of reducing the salinity of CRA water is that it would reduce dependence on SWP water for salinity management.

In addition, Metropolitan’s total supply of water flowing through the CRA would increase as a result of desalting irrigation drainage water from the Coachella and Imperial valleys. However, the desalted irrigation drain water would also incur pumping and transportation costs to reach the CRA.

The disadvantage of desalting Colorado River supplies is that a portion of the supply is lost (120,000 acre-feet per year to meet a 500-mg/L target to 240,000 acre-feet per year to meet a 200-mg/L target). This lost supply would be the result of rejection of the brine, which amounts to about 20 percent of the flow through the reverse osmosis membranes. Disposal of this brine is a relatively expensive and raises unresolved environmental issues. Technical Appendix 12 provides additional information on the CRA desalination option and costs. The brine disposal issue is the same for CRA desalting and irrigation water desalting.

In all of the options considered for this analysis, we made the following assumptions: the salinity level for CRA water pumped from Lake Havasu is considered to be 750 mg/L; membrane treatment technology is used; and design and construction would take eight years, with full operations starting in 2006. Table 3-3 summarizes the pertinent information regarding these options. Note that the rate impacts in Table 3-3 reflect project costs and water supply change benefits or costs.

Table 3–3 Potential Desalting Projects

	Colorado River Aqueduct (CRA)		Colorado River Water/ Agricultural Drainage Water ¹
Target TDS in CRA	200 mg/L	500 mg/L	500 mg/L
Source Water TDS	750 mg/L	750 mg/L	2,400 mg/L
Capital Cost (1997)	\$2.7 billion	\$2.4 billion	\$1.1 billion
Annual Debt Service	\$264 million	\$227 million	\$131 million
Rate Impact	\$186/AF	\$155/AF	\$78/AF
Brine Disposal	0.24 MAF/Y	0.12 MAF/Y	0.11 MAF/Y
MWD Supply Changes	loses 0.24 MAF/Y	loses 0.12 MAF/Y	gains 0.35 MAF/Y
¹	Costs excludes Salton Sea mitigation.		
²	MAF/Y – million acre-feet per year.		

Metropolitan recently started planning a demonstration project with the Coachella Valley Water District to assess the practicality of capturing and desalting agricultural drainage.

METROPOLITAN AND OTHER AGENCY COLLABORATION

EXPAND DESERT-COACHELLA EXCHANGE

The existing exchange with the Desert Water Agency (DWA) and Coachella Valley Water District (CVWD) improves Metropolitan's blended water salinity at current demand levels by replacing CRA water with 61,200 acre-feet of East Branch SWP water in most years. If DWA and CVWD obtain additional SWP supplies, the exchange could be expanded. Each 100,000 acre-feet per year of exchange would reduce the salinity levels of Metropolitan's blended water by about 30 mg/L over a 12-month period. From 1995 through 1998, Metropolitan will have exchanged about 440,000 acre-feet and experienced significant financial benefit to offset the costs of its blending operations (Table 3-4).

Table 3-4 Desert Coachella Exchange

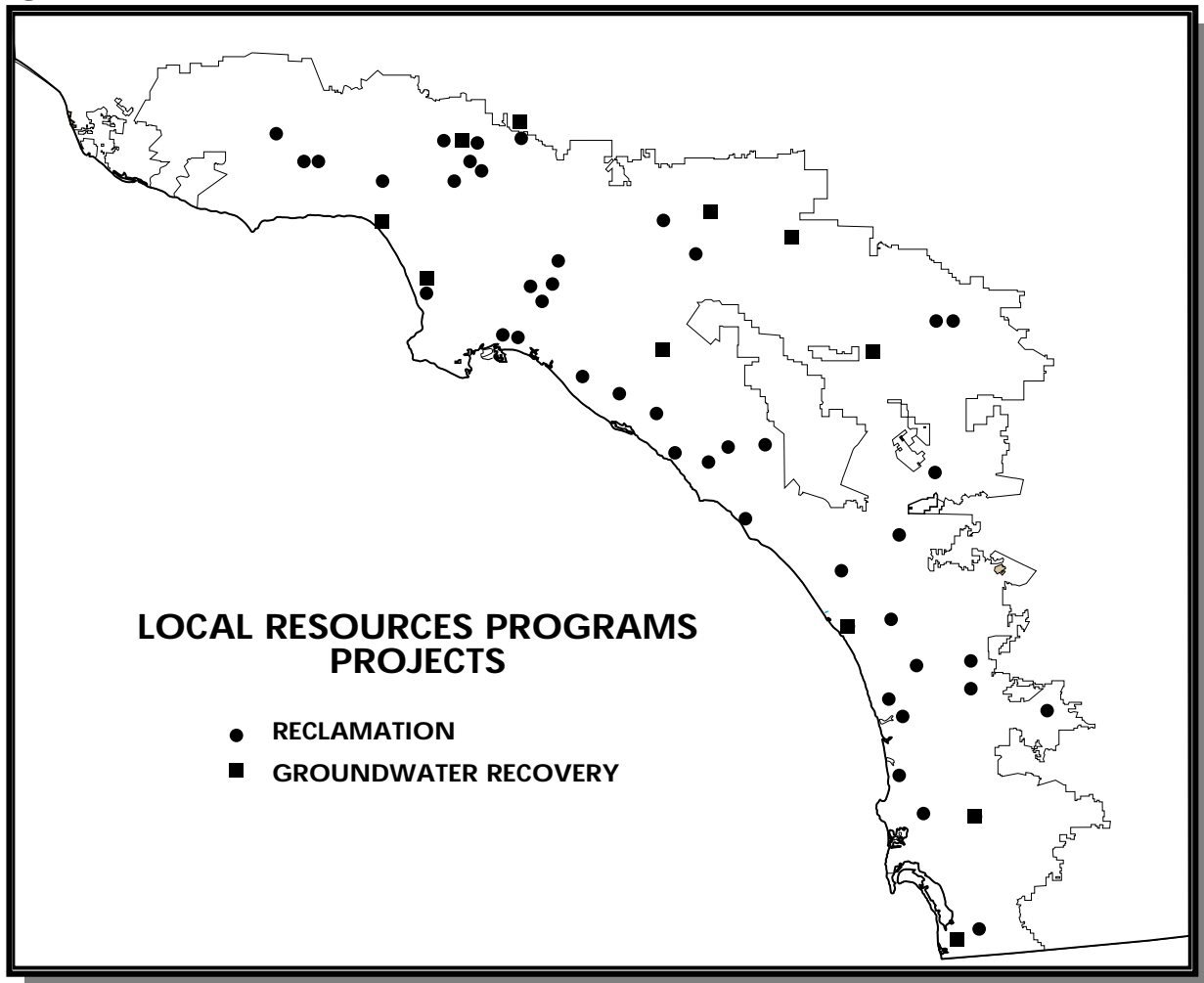
Year	Desert – Coachella Exchange (AF)
1995	61,000
1996	133,000
1997	114,000
1998	132,000

LOCAL RESOURCES PROGRAM SUPPORT OF DESALTING AND BRINE LINES

Through its Local Resources Programs (LRP) Metropolitan is contractually committed to 18 projects expected to remove 144,000 tons per year of salts from Southern California groundwater and recycled water. Metropolitan's participation also helps support the cost of brine lines needed for the disposal of salts to the ocean.

In June 1998, Metropolitan adopted a new LRP with a competitive request for proposals to identify groundwater recovery and water recycling projects that it might participate in. Under existing Integrated Resources Plan goals, additional local production of about 125,000 acre-feet per year will need to be in place by 2020. A number of these new projects will likely include groundwater and recycled water desalination and attendant brine disposal facilities. Figure 3-12 identifies existing LRP agreement project locations.

Figure 3-12

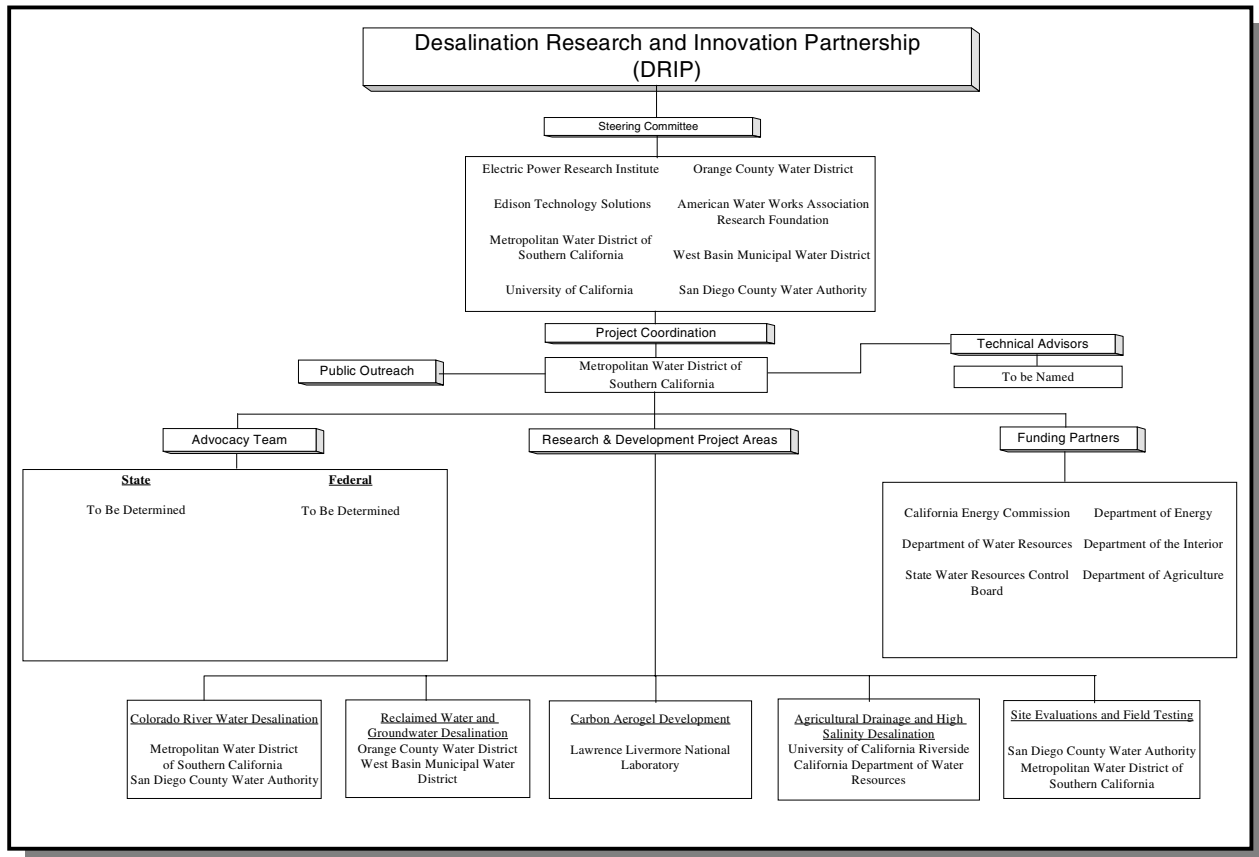


DEMINERALIZATION R&D

Research and development of new desalination technologies are needed to overcome the energy intensity and expense of current practices. More cost-effective technological developments could expand salinity management options in the future. Metropolitan is pursuing such research with other agencies under the proposed Desalination Research and Innovation Partnership (DRIP). Its organizational structure is presented in Figure 3-13.

As of May 1999, the Partnership included the University of California, American Waterworks Association Research Foundation, California Department of Water Resources, Lawrence Livermore National Laboratory, Electric Power Research Institute, Edison Technologies, Orange County Water District, West Basin Municipal Water District, San Diego County Water Authority, and Metropolitan Water District of Southern California.

Figure 3-13



Note: Organization is still tentative and subject to change

EXAMPLES OF NEW AND INNOVATIVE METHODS TO REDUCE THE COST THE DESALINATION

Experimental Membranes

During the reverse osmosis process, salty water, such as brackish surface water is pushed through semi-permeable membranes that filter out dissolved solids and salts. This process is similar to the way plants obtain freshwater from the soil. The partnership will investigate ultra-low pressure membranes that operate at one-third less pressure than current membranes. This reduction in pressure would substantially reduce the energy requirements for reverse osmosis treatment.

Carbon Aerogel Capacitive Deionization

Capacitive deionization with carbon aerogel electrodes is a new and promising technology for removing TDS and impurities from domestic water supplies. Originally developed by Lawrence Livermore National Laboratory for hazardous waste clean-up, carbon aerogel is a material that enables the successful removal of TDS because of its high surface area,

optimum pore size and low electrical resistivity. Unlike other purification methods, carbon aerogels require no membranes, distillation columns or thermal heaters. Consequently, the overall process is more energy efficient.

Pretreatment Options

All desalination technologies require a “pretreatment” step to condition the water. Conventional drinking water treatment plants and microfiltration will be investigated as possible pretreatment options for desalination. Metropolitan’s conventional treatment plants produce water of extremely high quality, and since staff and infrastructure are already in place, they could be ideal locations for salinity removal facilities. According to in-house estimates, the use of existing conventional treatment plants for pretreatment could cut overall desalting costs by 46 percent.

Brine Treatment and Disposal

An unwanted byproduct of desalination is brine, which consists of highly concentrated salt water and presents a serious disposal problem. For carbon aerogel or membrane technologies to be viable for Colorado River water desalination, brine volume must be either minimized or reduced to a solid material. The partnership will investigate innovative brine treatment and disposal options, such as gas-fired distillation, freeze-thaw technology and evaporation ponds.

Economies of Scale

Membrane technology is generally reserved for small-scale applications because of the prohibitive costs associated with large membrane plants. Currently, the largest drinking water membrane plants treat 10 to 20 million gallons per day (with a few exceptions). Additional research is needed before a 100 to 200 million gallon per day membrane plant will be practical. The partnership will evaluate different membrane module configurations and new large-diameter membrane elements to take advantage of economies of scale.

The Future of Desalination

Advances in TDS removal may help to alleviate the economic problems associated with using Colorado River water, as well as aid in treating brackish groundwater, reclaimed water and agricultural drainage. For instance, an estimated 16 million acre-feet of currently non-usable brackish water lies beneath the ground in Southern California. Alone, this water is enough to supply the state’s entire 32 million people with drinking water for roughly four years. If successful, technological and economic advances resulting from this partnership could fundamentally change the salinity issue for Colorado River water and other water sources.

LOCAL EFFORTS TO PROTECT GROUNDWATER AND RECYCLED SUPPLIES

NEED FOR BRINE DISPOSAL

The Santa Ana Watershed Project Authority has demonstrated leadership in developing a regional brine disposal line under a Joint Powers Authority (JPA) arrangement. The Santa Ana Regional Interceptor (SARI) line conveys high salinity municipal wastewater to an ocean outfall. The SARI line helps protect groundwater and recycled water from salt loading. It also provides brine disposal for groundwater desalination plants recovering previously abandoned local groundwater resources. Other JPAs could be formed following this model.

USBR is providing valuable financial assistance to water recycling and groundwater desalting projects in Southern California. The USBR, along with other agencies, is studying opportunities to expand recycling in Southern California. A key constraint to water recycling is the disposal of brine (Technical Appendix 8). The USBR study will investigate regional brine disposal facilities for recycling and groundwater desalting projects.

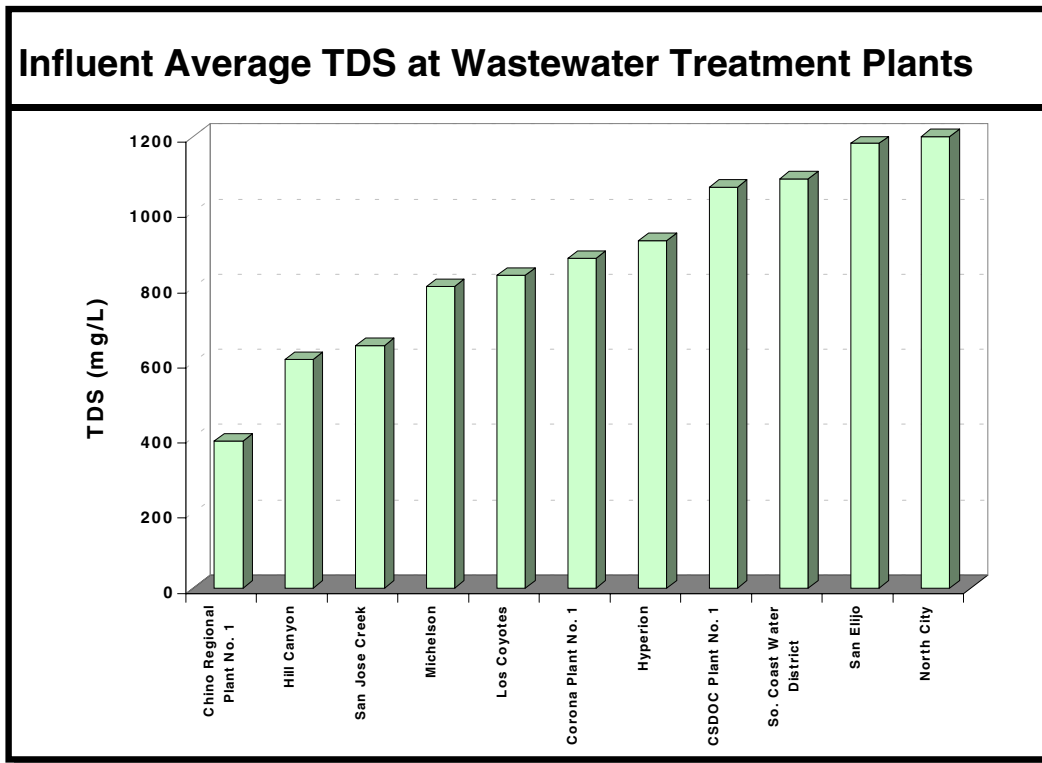
An appraisal-level evaluation was conducted as part of this study to identify potential brine disposal facilities within the Metropolitan service area. It provided estimates of capital costs that would be incurred in the construction of these potential facilities (Technical Appendix 7).

Table 3-5 presents a summary of five potential brine disposal facilities and their respective capital costs. Only the capital costs associated with the construction of the potential brine disposal pipelines are considered. Operation and maintenance costs are negligible unless the line includes pumping stations. Treatment facilities and ocean outfalls are not addressed in this study because they already exist.

Table 3–5 Summary of Proposed Brine Disposal Pipeline Facilities

Facility Name	Ventura County Brine Disposal Pipeline	San Fernando Valley/West Basin Brine Disposal Pipeline	Raymond Basin Brine Disposal Pipeline	Temescal Valley Regional Interceptor Brine Line	San Diego Industrial Brine Export System	Total
Maximum Flow (mgd)	9.8	17.3	7.8	15.0	2.7	52.6
Max. Pipe Diameter (inch)	36	36	21	36	18	--
Miles of Pipeline	37.2	32.3	14.1	25.8	23.5	132.9
TOTAL CAPITAL COSTS (\$ MILLION)	41.2	44.3	9.9	39.4	16.0	150.8

Figure 3-14



WASTEWATER MANAGEMENT

Urban water use in Southern California typically adds 250 to 400 mg/L of salt as measured at wastewater plants. In some cases that salt contribution may be as high as 600 mg/L in coastal zones where seawater may infiltrate into the sewers. This salt loading is problematic for water recycling and downstream receiving groundwater basins. Figure 3-14 illustrates influent salinity at wastewater plants representing a cross-section of Southern California's communities.

On a volumetric basis, Metropolitan’s supplies contribute about half of the salt entering the coastal plain. Other sources of salt include municipal sewage, industry and irrigation (Technical Appendix 10). Under a comprehensive regional approach, wastewater agencies should also work to control salinity contributions into their wastewater collection systems. Possible actions include:

- ❑ Industrial Waste Discharge Permitting by Sanitary Districts/Cities
- ❑ More stringent industrial permitting may help protect groundwater and recycled water from salt loading.

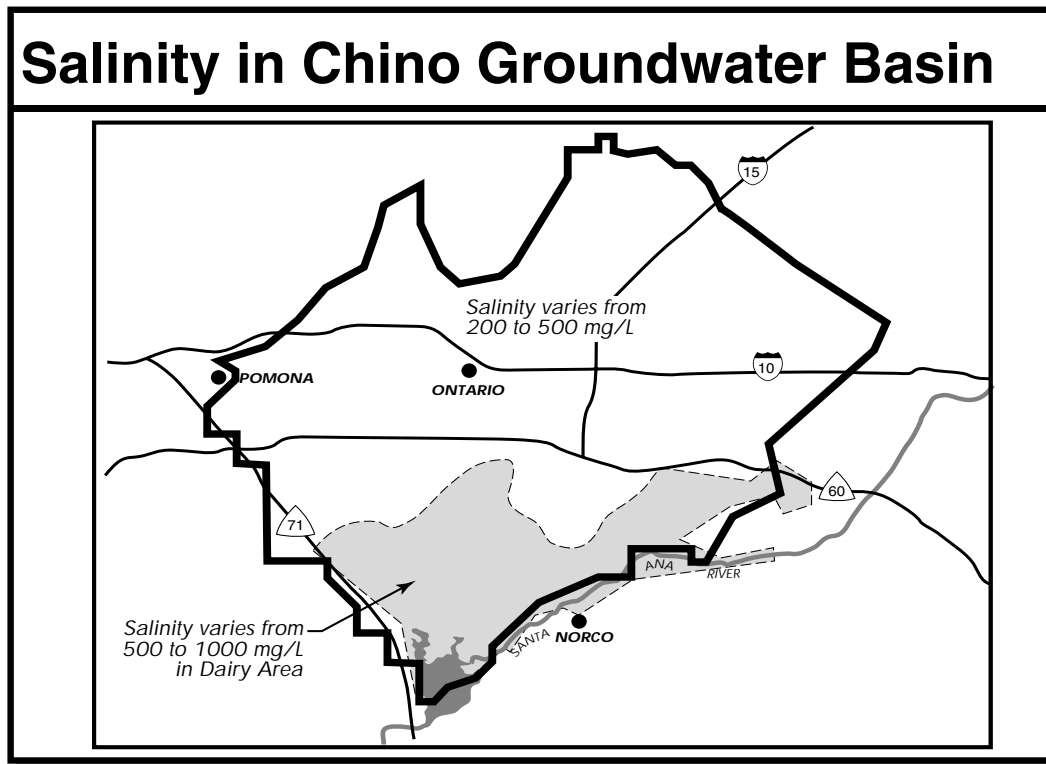
Control of Brackish Groundwater Infiltration into Sewers

Sanitation districts and cities are responsible for controlling brackish groundwater infiltration into sewers that supply water recycling projects. This problem is troublesome in some coastal areas where seawater intrusion has reached and infiltrated old, deteriorating residential, commercial and public sewer lines. In some locations, rainfall temporarily raises the brackish water table, thus exacerbating the infiltration problem.

Agricultural Discharge

The discharge of waste from pastures and the fertilization of irrigated crop land are local sources of salt that have plagued Southern California groundwater quality for years. The principal vehicle to control agricultural salts is enforcement of basin plan objectives and waste discharge permits by RWQCBs. Figure 3-15 identifies the high salinity zone of the Chino Groundwater Basin where there is a historical presence of dairies. Farmers and local water districts are working together to develop effective basin management practices that might mitigate their legacy of high salinity groundwater.

Figure 3-15



Water Softeners

Self-regenerating residential water softeners contribute 50 to 100 mg/L of salt to domestic sewage discharged to wastewater collection systems. This added salt may adversely affect water recycling and receiving groundwater. Recent attempts to control the use of such water softeners have failed because of legal challenges by the Water Quality Association (a home water treatment device manufacturers association). New state regulations or legislation could be pursued to provide water and wastewater agencies with greater authority to regulate the use of water softeners within their jurisdictional areas, while allowing the public to continue enjoying the benefits of water softening. It may be beneficial for water softeners manufacturers and water utilities to pursue actions of common benefits, such as improved salt use efficiency and other advances in technology. (See Technical Appendix 6 for a more thorough discussion of this issue.)

ECONOMIC BENEFITS OF OPTIONS

To allow for a comparison of the merits of the various options, a benefit assessment was conducted for year 2000 conditions. For comparative purposes, the study assumed that each option was fully in effect under average demand and salinity conditions in the year 2000. This approach, of course, results in moving some options forward in time, such as a CALFED solution that would not be fully realized until perhaps 2015. Table 3–6 represents the result of this comparative assessment.

Table 3-6 Benefits of Various Alternatives if Implemented in Year 2000

Benefits of Alternatives if Implemented in Year 2000*		
Project	Salinity Reduction Benefits (\$ million)	Total Salt Reduction (1000 Tons)
CRA water desalted from 689 to 200 mg/L	289	787
CRA water desalted from 689 to 500 mg/L	144	354
Place desalted agricultural drainage into CRA to lower CRA salinity to 500 mg/L	127	311
CRA salinity control programs to reduce CRA TDS by 100 mg/L (from 689 to 589 mg/L)	70	165
CRA salinity control programs to reduce CRA TDS by 50 mg/L (from 689 to 639 mg/L)	35	82
CALFED alternative that lowers SWP TDS from 250 to 150 mg/L at O'Neill Forebay	41	105
Additional 100,000 AFY of Desert-Coachella exchange (33 mg/L of TDS reduction in blended area)	22	60
6-month 500 mg/L salinity target	57	138
9-month 500 mg/L salinity target	80	193
Year-round 500 mg/L salinity target	97	234
Reduce urban TDS contribution to wastewater by 100 mg/L, but to not less than a 250 mg/L contribution	8	10 **
Reduce groundwater TDS by 100 mg/L, but to not less than about 250 mg/L at the wellhead	66	n/a
<p>* This presentation is for comparative purposes. Some of the alternatives could not be implemented by year 2000. Benefits are for a hypothetical condition where each alternative would be fully implemented by year 2000.</p> <p>** Excludes ocean disposal</p> <p>n/a:Not applicable</p>		

SECTION 4

SALINITY MANAGEMENT POLICY

The following policy was adopted by the Metropolitan's Board of Directors on April 13, 1999:

MANAGEMENT OF SALINITY BY THE METROPOLITAN DISTRICT OF SOUTHERN CALIFORNIA

Metropolitan, in cooperation with other water and wastewater agencies throughout Southern California, is committed to the following long-term policy to control salinity:

- Protect Metropolitan's imported source supplies from additional salinity, and where feasible seek reductions.
- Achieve, to the extent reasonable and practical, a total dissolved solids (TDS) concentration objective of 500 milligrams per liter (mg/L) in Metropolitan's distribution system.
- Recognize that natural events beyond Metropolitan's control will at times increase the salinity of imported water supplies, hindering Metropolitan's ability to continuously meet its 500 mg/L objective.
- Optimize the long-term use of Colorado River water in conjunction with State Water Project supplies in pursuing salinity management objectives and Metropolitan's Integrated Resource Plan.
- Integrate water quality and quantity objectives in planning facilities and resources.
- Support regional regulatory and management actions to minimize salinity contributions to groundwater and recycled water resources.
- Make the Salinity Management Action Plan the primary strategy to carry out this policy. Regularly assess the implementation and results of the Action Plan, and make revisions based upon experience gained and changing conditions.

SECTION 5

SALINITY MANAGEMENT ACTION PLAN

On April 13, 1999, Metropolitan's Board of Directors authorized its General Manager to implement a comprehensive Action Plan to carry out Metropolitan's policy for management of salinity. The Action Plan focuses on reducing salinity concentrations in Southern California's water supplies through collaborative actions with pertinent agencies, recognizing that an effective solution requires a regional commitment. Actions specifically under Metropolitan's control will be predicated on Board-approved funding. Four fundamental categories of action are included:

- Imported Water Source Control and Salinity Reduction Actions;
- Distribution System Salinity Management Actions;
- Collaborative Actions with Other Agencies; and
- Local Salinity Management including Actions to Protect Groundwater and Recycled Water Supplies.

IMPORTED WATER SOURCE CONTROL AND SALINITY REDUCTION ACTIONS

(Action Item No. 1) Colorado River

Metropolitan will diligently support funding for the Colorado River Salinity Control Program. Added emphasis will be given to accelerating implementation of program measures. This will entail coordination with the Colorado River Board of California, the Colorado River Basin Salinity Control Forum, participating federal agencies, the proposed Southern California Salinity Coalition and other interested parties.

Metropolitan will provide the U.S. Bureau of Reclamation (Reclamation) with its updated salinity impacts model for Reclamation's use to help develop economic justification for new salinity control measures and funding.

IMPORTED WATER SOURCE CONTROL/SALINITY REDUCTION ACTIONS

(Action Item No. 2) State Water Project

Metropolitan will work with other State Water Project (SWP) Contractors, and the California Urban Water Agencies to encourage the Department of Water Resources (DWR) to engage in operational and management practices which support Metropolitan's salinity management objectives including:

- DWR to provide timely water quality information to aid Metropolitan's operational decisions.

- DWR to develop a TDS assessment methodology to provide routine salinity forecasts and to assess actions that may affect source or delivered water quality.
- DWR and Metropolitan to seek mitigation offsets for proposed projects that have potential to significantly degrade source or delivered water quality.
- Metropolitan and DWR to assess the tradeoffs of projects affecting SWP salinity, including economic impacts.
- Metropolitan to promote inclusion of salinity control and reduction as a major objective for Delta exports as part of CALFED's long-term Bay-Delta solution.
- DWR to conduct water cycling and flow-through operations in its reservoirs to lower salinity levels without impairing water supply reliability.
- CALFED to adopt watershed management activities and water quality programs that reduce salinity to municipal water supplies.

DISTRIBUTION SYSTEM SALINITY MANAGEMENT ACTIONS

(Action Item No. 3) Blending

Metropolitan will operate its system with the objective to maintain an average salinity concentration equal to the secondary State and federal drinking water standard of 500 mg/L in its blended water at its Weymouth, Diemer, and Skinner filtration plants, the untreated San Diego pipelines, and the Eastside Reservoir subject to the following:

- Compliance with all water quality standards and aesthetic parameters,
- Availability of sufficient State Project water to accomplish the blend without using drought supplies from special transfer or storage accounts,
- Adequate distribution system delivery capacity, and
- An annually budgeted amount to cover operational cost,

Actual system concentrations will vary by time and location in response to routine operational constraints and practices. The blending objective is estimated to be achievable in 7 out of 10 years on average, hindered primarily by periodic episodes of high salinity in Metropolitan's imported water sources caused by drought conditions. Staff will inform Metropolitan's Board whenever constraints will prevent achievement of the objective. Staff will also provide reports to the Board of the cost incurred and the amount of salinity reduction achieved at the end of each year.

Duration of blending operations:

- Interim: Through 2004, Metropolitan will plan its operations to meet a 500 mg/L objective in a two stage process:

1. April-September will be the primary time window when water resources are limited, and
 2. October - March will be secondary time window when water resource conditions are favorable.
- Long-term: In 2004, Metropolitan will assess changes in resource conditions and revise the blending duration to the extent that supply improvements permit to achieve the 500 mg/L objective on a year-round basis. Success in a CALFED solution; development of new storage and exchange arrangements along the Colorado River Aqueduct; and exchanges of lower salinity Sierra Nevada water into the State Water Project will be important factors in expanding the blending duration.

(Action Item No. 4) Exchange and Storage and Conveyance

Metropolitan will pursue: (1) storage and exchange arrangements along the Colorado River Aqueduct to minimize the loss of Colorado River water periodically curtailed and replaced by State Project water when blending to meet salinity targets; (2) exchanges and transfers of Sierra water that could lower State Project water salinity; and (3) conveyance of low salinity groundwater in its distribution system.

(Action Item No. 5) Integration of Water Quality and Quantity

Metropolitan will integrate water quality and quantity objectives in conducting its system overview planning studies, updating its Integrated Water Resource Plan and in negotiating resource developments. Metropolitan, in coordination with its member agencies and other concerned entities, will periodically review its distribution system and assess the merit of facility improvements needed for regional salinity management for all classes of water service.

COLLABORATIVE ACTIONS WITH OTHER AGENCIES

(Action Item No. 6) Local Resources Program Support

Metropolitan will continue its financial support of local recycled water and groundwater desalination projects, including associated brine disposal through its Local Resources Program and will encourage protection and enhancement of the quality of those water resources.

(Action Item No. 7) Desalination Research and Development

Metropolitan will continue to pursue research and development partnerships to reduce the costs associated with removing TDS from the Colorado River Aqueduct and other water supplies, including brackish groundwater, recycled water, and agricultural drainage. The Desalination Research and Innovation Partnership (DRIP) is a collaborative effort that will focus on developing new and innovative technologies to reduce the cost of desalting water supplies.

Practical technologies that may reduce the salinity content of the water supplied to member agencies will be evaluated. The partnership will also investigate water softener technology and its salinity impacts to the region's recycled water and groundwater resources.

(Action Item No. 8) Southern California Salinity Coalition

Metropolitan will collaborate with Association of Groundwater Agencies, Southern California Alliance of Publicly Owned Treatment Works, member agencies and other concerned agencies in Southern California to form a coalition that will assess progress in correcting the regional salt imbalance and coordinate needed actions with key agencies that influence regional salinity, including DWR, the Bureau of Reclamation, the State Water Resources Control Board, the Regional Water Quality Control Boards, and CALFED.

Public Education: The coalition will pursue public education and awareness regarding the need to correct the region's salinity problems.

Annual Salinity Report Card: The coalition will prepare an annual report on salt balance to track key indicators of the region's success in managing salinity and assess overall implementation of this Action Plan. Metropolitan will consider revisions based on the assessment, the experience it gains and changing conditions.

Statewide Water Softener Study: The coalition will pursue passage of legislation that would fund a statewide investigation by the State Water Resources Control Board of the impacts of water softeners and other sources of salt in local wastewater affecting recycled water and groundwater resources.

Advocate Federal Funding: The coalition will support needed funding for the Colorado River Salinity Control Program.

LOCAL SALINITY MANAGEMENT ACTIONS

(Action Item No. 9) Local Wastewater Discharge Management

Discharge Permits: Local leadership is needed to reduce the amount of salts entering groundwater and recycled water resources from sewer and agricultural discharges. Opportunities for improvement include more stringent industrial permitting, controlling infiltration of brackish groundwater and seawater, as well as developing dedicated brine or interceptor lines.

Local permitting and design practices need to consider the unavoidable salinity increases that will occur in imported water in response to periodic droughts and progressive changes in the Colorado River watershed. Normal fluctuations in imported water salinity need to be fully

recognized in the design of water recycling facilities, when developing groundwater management plans, and in establishing waste discharge permit standards.

Expand Regional Brine Disposal: Local leadership is needed to develop new dedicated brine disposal facilities to protect groundwater and recycled water resources. Metropolitan is currently working with a group of local agencies, member agencies, DWR and the Bureau of Reclamation in a regional water recycling planning study for Southern California. Part of that effort includes the planning of new brine disposal lines that would support water recycling and groundwater desalination developments.

Management of Water Softener Brines: Local leadership is needed to rectify existing statutes that hinder local agencies from managing salt discharges from residential water softeners. Metropolitan can help organize concerned local agencies to assess the regional scale of this issue and facilitate an effective outcome among the WaterReuse Association, the Water Quality Association, and State regulators.

(Action Item No. 10) Groundwater Management

Local leadership is needed to pursue groundwater management practices that minimize groundwater basin salt loading. Where none exist, institutional arrangements for groundwater quality management should be pursued. Some agencies have the opportunity to selectively schedule spreading, injection, or in-lieu replenishment in response to imported water salinity conditions to minimize basin salt loading. Basin managers should address salt loading from local sources with regulatory agencies and pertinent dischargers.

