SOUTHERN CALIFORNIA'S
INTEGRATED WATER RESOURCES PLAN

VOLUME 3:
TECHNICAL APPENDICES

Report No. 1107

January, 1996

VOLUME 3 - TECHNICAL APPENDICES

Purpose:

The purpose of Volume 3 is present the details of demands and supplies used for the technical analyses during the IRP process, as well as the technical description of the models and tools used.

Volume 3 is separated into 7 appendices:

Appendix A - Retail Water Demands
Appendix B - Local Project Data
Appendix C - Groundwater Conjunctive Use Storage Potential
Appendix D - State Water Project Supply Variation and Development Potential
Appendix E - MWD Capital Projects
Appendix F- IRPSIM Model Description
Appendix G - Supply Reliability and Least-Cost Planning

SOUTHERN CALIFORNIA'S
INTEGRATED WATER RESOURCES PLAN

APPENDIX A:
RETAIL WATER DEMANDS

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APPENDIX A:

RETAIL WATER DEMANDS

Metropolitan uses the MWD-MAIN water demand forecasting model to project future urban water use for the region. MWD-MAIN is an econometric computer model that relates demographic and economic trends to residential, commercial, and industrial water demands. MWD-MAIN is a regionally calibrated version of the national IWR-MAIN model, developed for the U.S. Corps of Engineers, Institute for Water Resources. IWR-MAIN has gone through some major improvements which were jointly funded by the Federal Government, Metropolitan, the City of Phoenix, and the States of New York and Illinois. IWR-MAIN is considered to be state-of-the-art in demand forecasting and is currently used by district offices of the U.S. Corps of Engineers and U.S. Geological Survey, the Cities of Phoenix and Las Vegas, the States of New York and Illinois, and by some of Metropolitan's member agencies, including the City of Los Angeles and the San Diego County Water Authority.

Over the years, Metropolitan's water demand model has been reviewed during the Bay-Delta Hearings, Metropolitan's Blue-Ribbon Task Force, and the IRP. During these reviews, MWD-MAIN has been evaluated by experts from the University of California, University of Colorado, Johns Hopkins University, University of North Carolina, and Southern Illinois University. The reviewers found the model to be an acceptable and credible methodology for forecasting water demands in Metropolitan's service area. Where improvements could be made, they were incorporated into subsequent versions of the model and are reflected in the current forecast.

DEMOGRAPHIC/ECONOMIC DATA

MWD-MAIN uses projections of the following demographic and economic trends to project urban water use:

- ☐ Population
- ☐ Housing by Type
- ☐ Employment by Category
- ☐ Personal Income
- ☐ Price of Water/Sewer
- ☐ Climate

The major sources of data include: (1) the Census Bureau; (2) California Department of Finance; (3) the California Employment Development Department; (4) the Bureau of Labor Statistics; (5) the National Oceanic Atmospheric Administration; (6) the Southern California Association of Governments; and (7) the San Diego Association of Governments. Metropolitan reviews this data to ensure accuracy and consistency. Table A-1 presents some of the key demographic data used to project regional demands for the SCAG region (Los Angeles, Orange, Riverside, San Bernadino, and Ventura Counties) and the SANDAG region (San Diego County).

Table A-1
Demographic Data Provided by SCAG and SANDAG*

Demographic Data	1980 Census	1990 Census	2000 Projection	2010 Projection
SCAG Region:				
Population (millions)	10.20	12.35	14.08	15.86
Total Housing (millions)	3.68	4.15	4.64	5.25
Single-family (millions)	2.09	2.26	2.44	2.69
Multifamily (millions)	1.59	1.89	2.20	2.56
% Share of SF to Total	56.9%	54.3%	52.5%	51.2%
Persons per Household	2.78	2.97	3.04	3.02
Total Employment (millions)	5.10	6.18	7.04	8.18
Industrial (millions)	1.19	1.16	1.13	1.12
Commercial (millions)	3.91	5.02	5.91	7.06
SANDAG Region:				
Population (millions)	1.81	2.44	2.93	3.21
Total Housing (millions)	0.63	0.83	1.00	1.13
Single-family (millions)	0.41	0.52	0.62	0.68
Multifamily (millions)	0.22	0.31	0.38	0.45
% Share of SF to Total	65.2%	63.2%	61.7%	60.3%
Persons per Household	2.88	2.95	2.92	2.85
Total Employment (millions)	0.81	1.20	1.30	1.41
Industrial (millions)	0.11	0.14	0.15	0.15
Commercial (millions)	0.70	1.06	1.15	1.26
Metropolitan's Service Area:				
Population (millions)	12.01	14.79	17.01	19.07
Total Housing (millions)	4.30	4.98	5.64	6.37
Single-family (millions)	2.50	2.78	3.05	3.37
Multifamily (millions)	1.80	2.20	2.59	3.00
% Share of SF to Total	58.1%	55.8%	54.1%	52.8%
Persons per Household	2.79	2.97	3.02	2.99
Total Employment (millions)	5.91	7.38	8.34	9.59
Industrial (millions)	1.30	1.30	1.28	1.28
Commercial (millions)	4.61	6.08	7.06	8.31

*** Based on draft growth management plans, originally developed in 1993.**

Figure A-1 presents the projected population for Metropolitan's service area for three different SCAG/SANDAG forecasts. The prior two forecasts made by the regional governments fell short of actual population growth in the first three years. Figure A-2 presents the annual population growth in the service area, showing the components of growth (natural increase and net migration).

Figure A-1
Population Forecasts for Metropolitan's Service Area

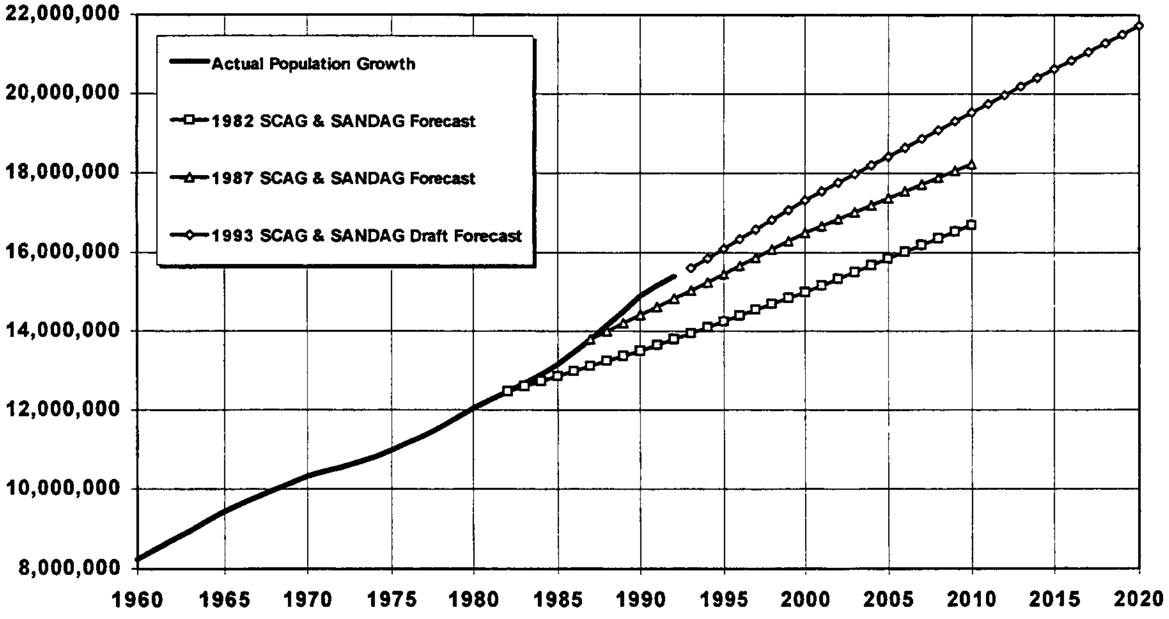
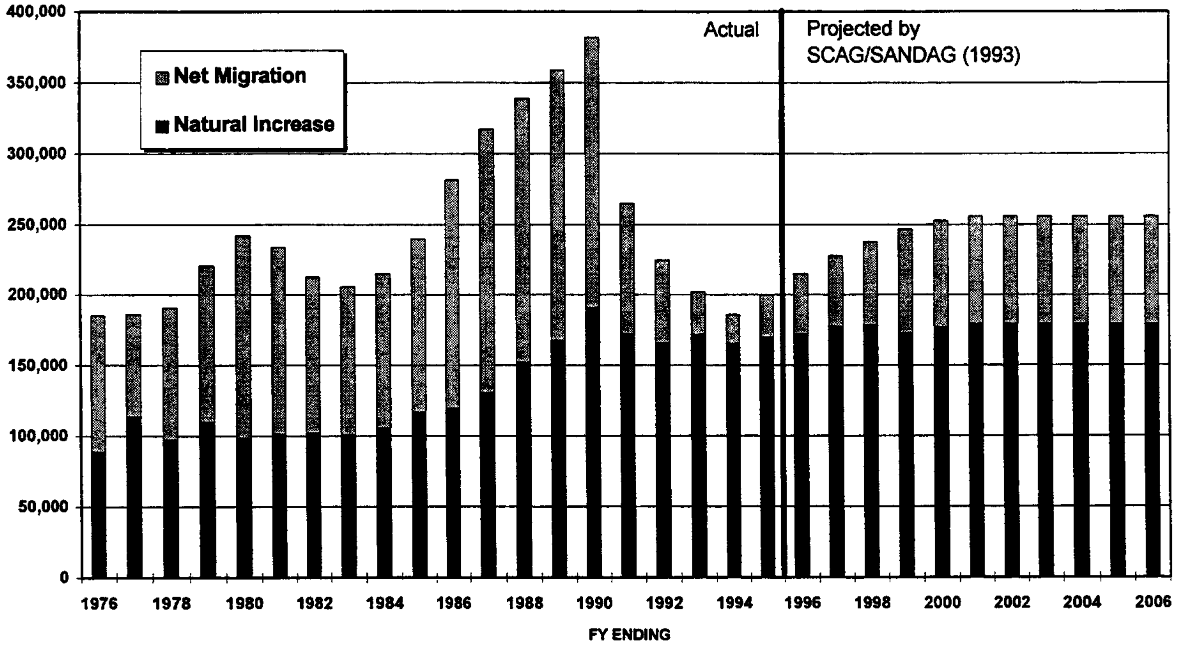


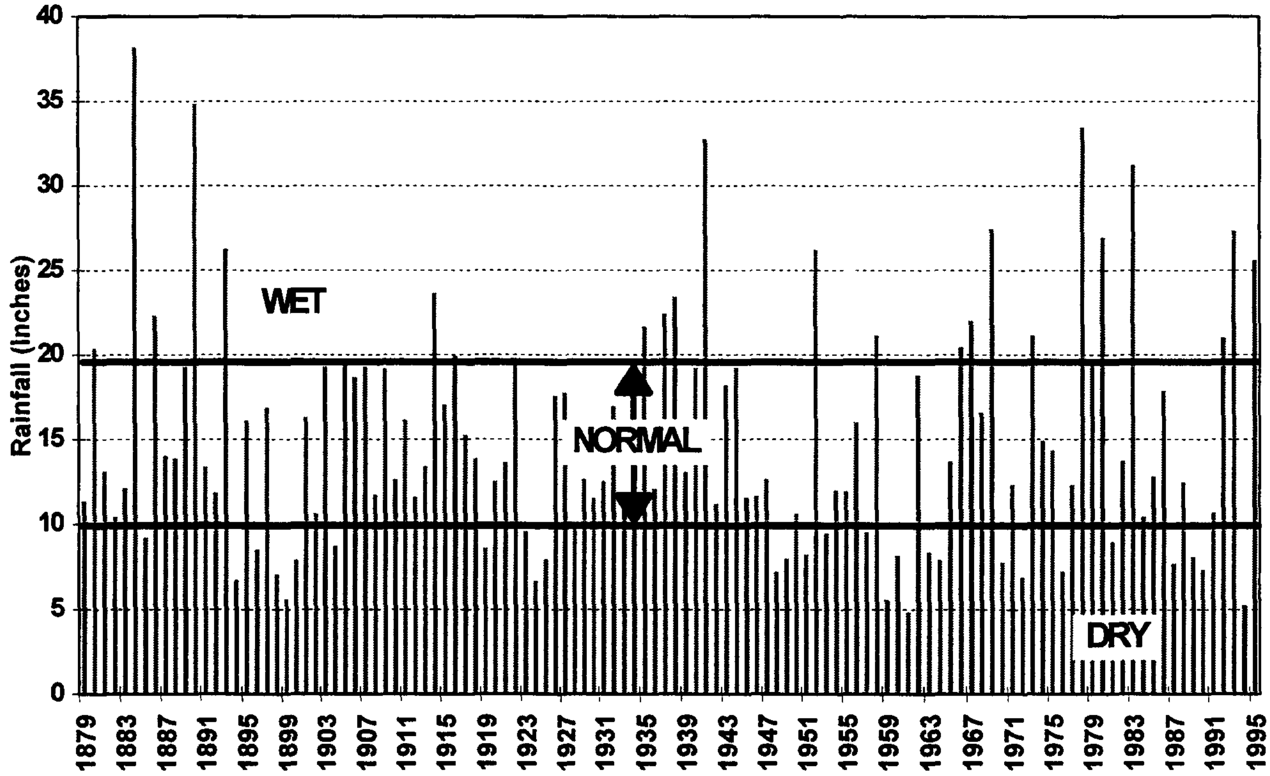
Figure A-2
Annual Population Growth in Metropolitan's Service Area



RAINFALL DATA

Local rainfall can impact Metropolitan's water sales in two ways. The first impact relates to retail water demands. When rainfall is heavy (wet conditions), retail water demands are low; and when rainfall is light (dry conditions), retail water demands are high. This is mainly due to landscape irrigation of residential yards and large public areas. The second impact relates to local supplies. When rainfall is heavy, local runoff is high -- naturally filling local reservoirs and groundwater basins; but when rainfall is low, local runoff is unable to naturally fill local storage -- thereby increasing Metropolitan's seasonal sales. Figure A-3 presents 117 years of Los Angeles civic center rainfall, from 1887 to 1995. Note that three of the last four years (1992, 1993, and 1995) had annual rainfall totals greater than 20 inches. This recent rainfall is one of the major reasons why current water sales are so low.

Figure A-3
Los Angeles Civic Center Rainfall



WATER AND SEWER PRICES

Based on ten years of retail water use data, demographic data, climate, and price of water and sewer service, price elasticity estimates were statistically derived. Price elasticity is a measurement of water customers' response to changes in the price of water. Generally, if the price of water goes up, it is expected that the quantity of water demanded will go down. Measuring price elasticity is very difficult because all of the other factors that could be responsible for changes in historical water use (such as changes in population growth, economy, weather, and conservation) must be controlled for. Statistical regression analysis is used to parcel out the effect that changes in the price of water have on changes in water demand. Metropolitan's water demand consultants have estimated that the price elasticity for urban water use ranges from -0.13 to -0.27, depending on the season (winter or summer) and type of use (single-family, industrial, or commercial). The overall, weighted urban annual average price elasticity for Metropolitan's service area is about -0.22, meaning that a 10 percent real (above inflation) *increase* in price will lead to a 2.2 percent *decrease* in water use.

Based on the regional supply investments identified in the IRP Preferred Resource Mix, the average retail cost increase is about 4.5 percent per year. Discounting for the effects of inflation (estimated to be about 3 percent per year), yields a real increase in retail cost of about 1.5 percent per year. Therefore, after 10 years the real increase in the price of water is expected to be about 15 percent greater than it is today. The quantity of water at the retail level will, therefore, be about 3 percent lower than it would have been if prices remained constant (in real dollars).

URBAN PER CAPITA WATER USE

In reaction to the recent low water sales, the question of "what is the long-term trend in water demands, and has that trend changed recently" has been raised. To help answer that question, urban per capita water use can be examined. Per capita water use (dividing retail urban water use by population) can be useful when evaluating trends in water use only if the major factors that drive changes in per capita water use are known. MWD-MAIN does not use the per capita use approach to project water demands, but the model can summarize the resulting demand forecast in per capita use terms in order to help explain future trends.

Factors that cause per capita water use to increase include: (1) income -- the greater the income, the greater the landscaping requirements and indoor water using appliances; (2) commercial industry mix -- those commercial establishments that use more water, such as restaurants, hotels, and amusement/recreation, are expected to grow faster than those establishments that use less water; (3) commercial labor force -- the fraction of people employed in commercial activities is expected to increase, thereby increasing overall water use; and (4) inland growth -- the growth of people and jobs in the inland desert regions of the service area is going to be greater in the future, where water use is higher because of the hot and dry conditions. Factors that cause per capita water to decrease include: (1) housing mix -- multifamily housing, which uses less water than single-family housing, is expected to grow faster; (2) family size -- the average persons per household is expected to continue to increase until 2010 (when it starts to decline slightly), which causes per capita water use to decrease; (3) industrial industry mix -- those manufacturing activities that use more water, such as aerospace and defense related industries, are expected to decrease overtime; and (4) industrial labor force -- as time goes on, manufacturing jobs will be replaced by service oriented jobs (which use less water), thereby reducing overall urban water use.

Table A-2 presents a summary of actual and projected per capita water use from 1990 to year 2010. The table shows how per capita use, which is split into residential, commercial, industrial, and public/other, is expected to change in the future, and the factors responsible for that change. It should be noted that these per capita estimates do <u>not</u> include conservation. The effects that anticipated conservation has on reducing overall per capita water use is shown at the bottom of the table.

Table A-2
Changes in Per Capita Water Use
(assumes normal weather conditions)

	Base Per Capita Water Use (GPCD)			Factors Affecting Per Capita Use Changes in GPCD Between 1990 - 2010					
	1990	2010	Change	Income	Housing Mix	Family Size	Industry Mix	Labor Force	Inland Growth[1]
Residential	136.7	141.5	4.8	4.9	-3.3	-0.3	0.0	0.0	3.5
Commercial	38.9	43.8	4.9	0.0	0.0	0.0	2.3	0.5	2.1
Industrial	12.3	10.0	-2.3	0.0	0.0	0.0	-1.5	-1.9	1.1
Public/Other	18.1	19.7	1.6	0.0	0.0	0.0	0.0	0.0	1.6
Total	206.0	215.0	9.0	4.9	-3.3	-0.3	0.8	-1.4	8.3
With Conservation[2]	206.0	190.0							

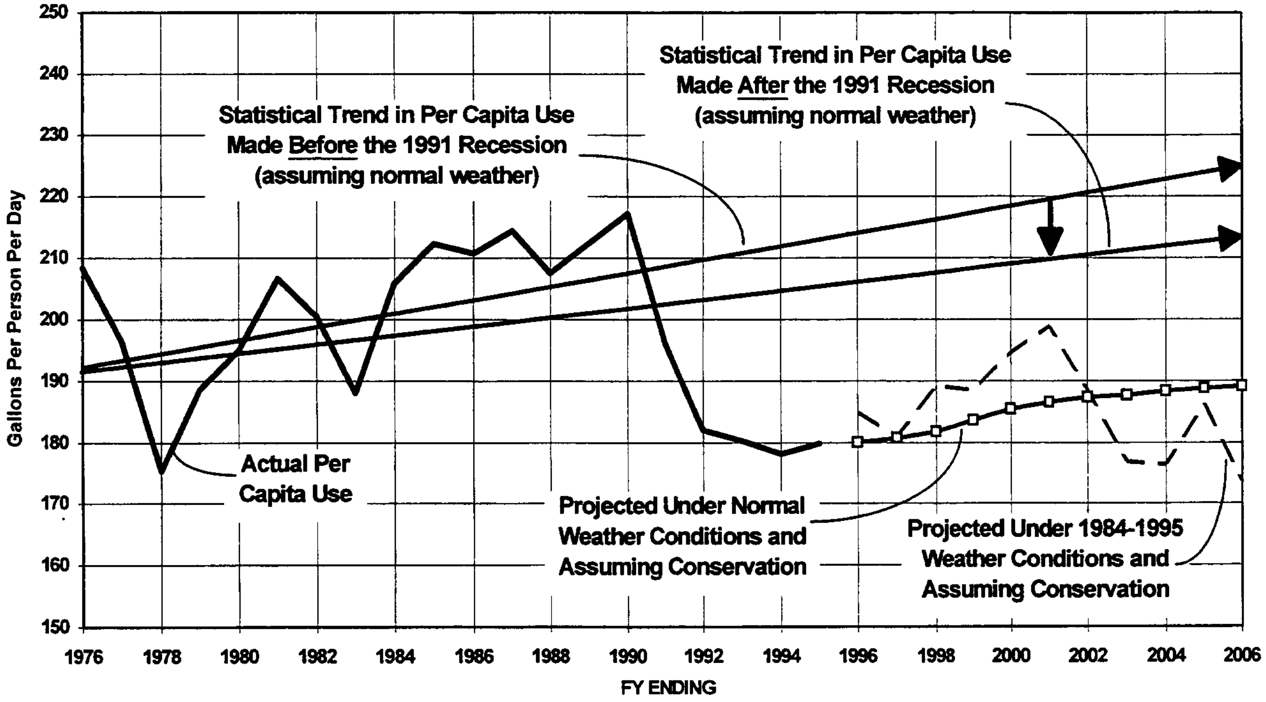
[1] Represents growth shifting from coastal areas to inland desert areas that have hotter & drier climates.

[2] Reflects new conservation (post 1990), including 1991 plumbing codes, plumbing retrofits, landscaping efficiency, commercial & industrial, leak detection/repair, and effects of retail water prices.

Table A-2 indicates that per capita water use is expected to increase from 206 gallons per person per day (GPCD) in 1990 to 215 GPCD by 2010. However, if planned conservation programs are fully implemented, then per capita water use will be about 190 GPCD, a reduction of about 12 percent.

Figure A-4 presents actual per capita water use from 1976 to 1995 and projected per capita use based on different statistical trends. During the 1977-78 period, per capita water use decreased from 210 GPCD to 175 GPCD, a 16.6 percent reduction over two years. This decrease was due to three factors: (1) mandatory conservation due to the 1976-77 drought; (2) an economic recession; and (3) three years of extreme wet weather. However, after these events "normalized," per capita water use quickly increased to its pre-1977-78 levels. During 1983, local rainfall was one of the heaviest on record (over 32 inches) causing per capita use to decrease from 205 GPCD to about 188 GPCD. During the period from 1985 to 1990, the region experienced strong economic growth (annual population growth was over 300,000) and hot and dry weather. This caused per capita water use to remain over 210 GPCD. During the 1991-1992 period, per capita use decreased from 217 GPCD to about 181 GPCD, a 16.6 percent reduction over two years. The events that caused the significant decrease were remarkably similar to those that caused per capita use to decrease back in 1978, namely drought related-conservation, an economic recession, and three years of extreme wet weather.

Figure A-4
Urban Per Capita Water Use in Metropolitan's Service Area



Based on the best data available before the 1991 economic recession, the statistical trend for long-term per capita water use (without conservation and under normal weather conditions) indicated that future per capita water use would be around 225 GPCD by year 2005. After the 1991 recession, many demographers and economists revised their long-term economic outlooks for California showing slower and more dense growth. Based on these new demographic and economic projections, Metropolitan staff made another demand forecast, reducing the long-term trend in per capita water use to about 212 GPCD by 2005. However, neither of these trends in per capita use accounted for conservation. Assuming full implementation of conservation BMPs, the long-term trend in per capita water use is expected to remain at about 190 GPCD. This is the demand trend staff has been projecting for the last three years and during the IRP process.

RETAIL DEMAND PROJECTIONS

Based on the SCAG/SANDAG demographic data and the trends in urban per capita water use, the projection of total regional demands are shown in Figure A-5. The demands are shown for three weather scenarios: (1) wet conditions; (2) normal conditions; and (3) dry conditions. In addition, demands under a repeat of 1984-1995 weather conditions is shown for illustrating how projected demands could vary year to year. Based on 70 different historical weather traces, retail demands can vary as much as 500,000 acre-feet in any given year due to weather alone.

Figure A-5
Regional Retail Water Demands for Metropolitan's Service Area

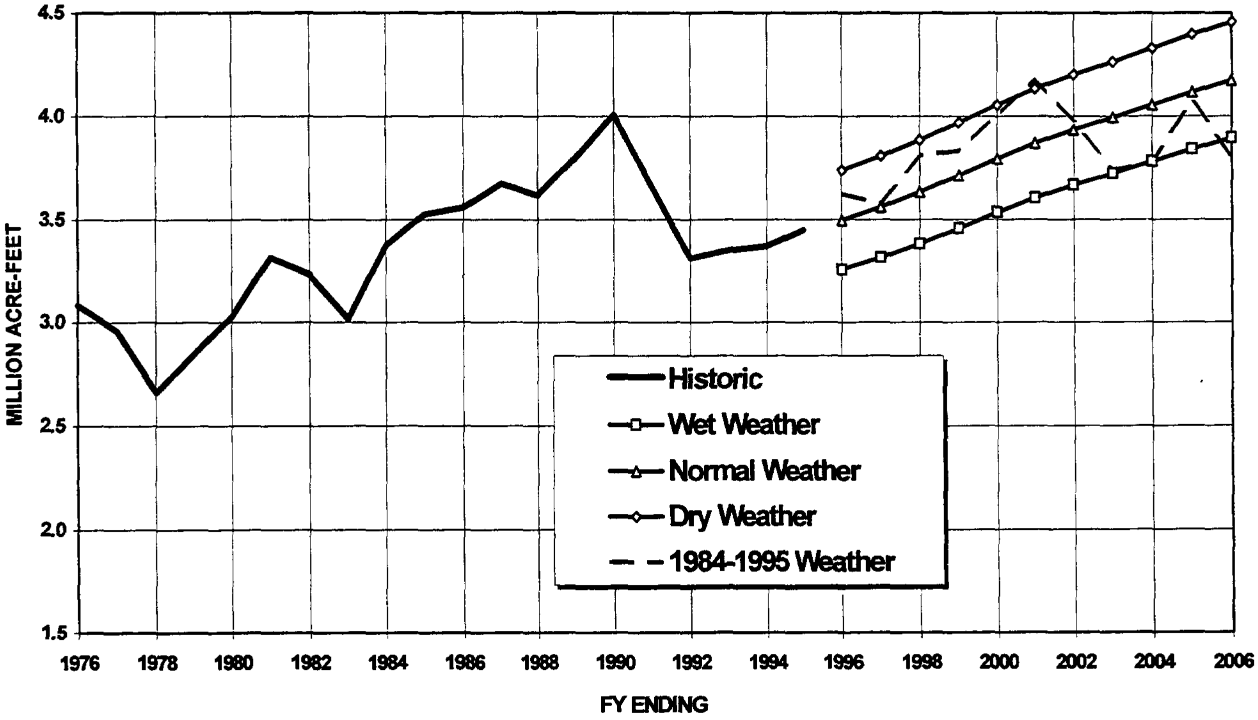


Table A-3 presents the population forecast by member agency. Table A-4 presents the M&I retail-level demand projections by member agency. Table A-5 presents the retail-level agricultural demands. The agricultural demands were projected based on current and future land use trends.

SOUTHERN CALIFORNIA'S

INTEGRATED WATER RESOURCES PLAN

APPENDIX B:

LOCAL PROJECT DATA

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LOCAL PROJECT DATA

During the IRP process, Metropolitan's member agencies and sub-agencies provided data to Metropolitan on local water recycling and groundwater recovery projects. The data included any projects that were already operational, under construction, or in some stage of design, planning, feasibility, or reconnaissance. The local project database currently consists of 159 reclamation projects and 38 groundwater recovery projects. Project information contained in the local project database include: on-line dates, supply yield, capital costs, interest rates, terms of debt, and O&M costs. The data was used to estimate annual total unit costs for each project through the year 2020. Table B-1 shows data on local water recycling projects. Table B-2 shows data on groundwater recovery projects.

Table B-1

LOCAL WATER RECYCLING PROJECTS

NAME	MEMBER AGENCY	PROJECT TYPE	PROJECT STATUS	FIRST YEAR OF YIELD	YIELD1995	YIELD2000	YIELD2010	YIELD2020	INTEREST	TERM	Annual Debt Service	OPCOST1995 ($/AF)	OPCOST2000 ($/AF)	OPCOST2010 ($/AF)	ESTIMATED OPCOST2020 ($/AF)	ULTIMATE TOTALCOST ($/AF)
PSD Power Plant	Burbank	D	O	1967	900	900	900	900	7.0	25	$0	3	4	7	11	$11
Caltrans	Burbank	D	O	1983	21	65	65	100	4.0	25	$3,612	95	108	131	176	$176
Media City Center	Burbank	D	O	1993	25	25	50	50	7.1	25	$45,524	413	480	280	340	$340
Reclaimed Water Expansion Debell/Landfill	Burbank	D	C	1997	0	550	700	800	4.2	20	$391,304	250	297	371	378	$378
Olsen Road/Sunset Hills Wastewater Trmt Fac	Calleguas MWD	D	C	1995	0	249	249	249	6.0	25	$101,058	332	390	576	701	$701
Oak Park/North Ranch Reclaimed Water Line	Calleguas MWD	D	C	1996	0	1,300	1,300	1,300	6.0	25	$391,134	69	84	138	185	$486
Oxnard Reclaimed Water Project	Calleguas MWD	R	R	2000	0	7,500	7,500	7,500	6.0	25	$1,865,736	97	84	138	185	$434
Simi Valley Reclaimed Water Pilot Project	Calleguas MWD	D	D	2000	0	200	200	200	6.0	30	$129,953	64	85	150	202	$851
Hill Canyon Reclaimed Water Project	Calleguas MWD	D	D	2000	0	2,000	2,000	2,000	6.0	25	$932,868	74	141	229	308	$774
Simi Valley Reclaimed Water Project	Calleguas MWD	D	R	2000	0	5,000	5,000	5,000	6.0	25	$1,399,302	69	84	138	185	$465
Central Basin Replenishment	Central Basin MWD	R	O	1961	50,000	75,000	75,000	75,000	7.0	25	$0	28	34	56	75	$75
Cerritos Reclamation Project	Central Basin MWD	D	O	1978	2,000	4,000	4,000	4,000	4.0	25	$173,908	127	155	252	339	$339
Bellflower Reclamation Project	Central Basin MWD	D	O	1978	50	50	50	50	5.0	25	$1,928	207	254	414	556	$556
Lakewood Water Reclamation Project	Central Basin MWD	D	O	1989	350	440	440	440	4.0	25	$56,445	308	376	613	824	$824
Cerritos Reclaimed Water Extension Project	Central Basin MWD	D	O	1993	260	260	260	260	6.1	25	$20,761	120	147	240	373	$323
Century Water Recycling Project	Central Basin MWD	D	O	1994	1,800	5,500	5,500	5,500	5.4	25	$1,554,854	174	212	346	465	$465
Rio Hondo Water Recycling Project Phase 1	Central Basin MWD	D	O	1995	100	5,000	5,000	5,000	6.1	30	$667,527	174	212	346	465	$599
Alamitos Barrier Project Parts 1	Central Basin MWD	R	D	2000	0	5,000	5,000	5,000	7.0	25	$2,046,613	438	315	513	513	$922
Rio Hondo Water Recycling Project Phase 2	Central Basin MWD	D	D	2000	0	7,000	7,000	9,500	6.0	25	$1,912,380	174	212	346	465	$666
Whittier Narrows Recreation Area	Central Basin MWD	D	R	2000	0	3,138	3,138	3,138	6.0	25	$802,267	146	188	298	400	$656
Western Hills Country Club	Chino Basin MWD	D	O	1963	17	17	17	17	6.5	25	$0	2155	2635	4296	5773	$5,773
Ontario Golf Course and Westwind Park	Chino Basin MWD	D	O	1968	1,200	1,200	1,200	1,200	6.5	25	$0	103	115	150	202	$202
California Institution for Men	Chino Basin MWD	D	O	1976	700	700	700	700	6.5	25	$0	440	538	876	1177	$1,177
El Prado Park and Golf Course	Chino Basin MWD	D	O	1977	1,300	1,300	1,300	1,300	6.5	25	$0	62	70	90	121	$121
Upland Hills Country Club	Chino Basin MWD	D	O	1983	224	224	224	224	6.5	25	$0	938	1052	1210	1626	$1,626
Regional Plant #4 Core	Chino Basin MWD	D	F	1999	0	3,937	5,000	7,500	7.0	25	$665,884	116	223	330	443	$532
Carbon Canyon Core	Chino Basin MWD	D	D	2000	0	1,050	1,500	2,000	7.0	25	$644,683	139	322	368	495	$817
Regional Plant #1 Core	Chino Basin MWD	D	F	2000	0	4,000	5,000	7,500	7.0	25	$2,466,168	141	223	330	443	$772
South Laguna Reclaimed Water	Coastal MWD	D	O	1984	860	860	860	860	6.5	25	$0	565	667	944	1222	$1,222
South Laguna Reclamation Expansion	Coastal MWD	D	O	1990	0	500	700	700	6.0	25	$150,175	389	333	417	417	$417
San Clemente Water Reclamation Project	Coastal MWD	D	O	1991	350	2,000	4,000	4,000	6.5	25	$157,887	776	985	1606	2158	$2,158
Compton	Compton	D	R	2010	0	0	500	500	7.0	25	$794,582	205	230	300	403	$1,992
Hemet/SJ Reg Rec Recharge Phase A	Eastern MWD	R	O	0	1,037	1,037	1,037	1,037	6.5	25	$0	32	39	63	85	$85
Hemet/SJ Regional Reclamation Direct	Eastern MWD	D	O	1966	14,178	28,123	27,464	22,815	4.0	25	$97,420	32	39	63	85	$85
Sun City Golf Courses	Eastern MWD	D	O	1983	652	652	652	652	6.5	25	$0	331	404	658	884	$884
Moreno Valley Reclamation	Eastern MWD	D	O	1987	10,579	10,571	10,761	10,811	4.0	25	$314,440	190	232	378	508	$508
Perris Valley Regional Reclamation	Eastern MWD	D	O	1989	2,824	9,346	11,346	11,346	6.5	25	$0	32	39	63	85	$85
Temecula Valley Reclamation Phase A	Eastern MWD	D	O	1989	3,300	3,300	3,300	3,300	6.5	25	$0	190	232	378	508	$508
South Lasselle Reclamation	Eastern MWD	D	O	1993	357	357	357	357	6.5	25	$35,920	190	232	378	508	$508
Winchester/Temecula Regional Reclamation Sys	Eastern MWD	D	O	1993	4,000	3,983	3,423	3,423	6.5	25	$1,436,802	190	232	378	508	$508
Rancho California Reclamation Expansion	Eastern MWD	D	O	1994	1,000	3,500	6,000	6,000	6.5	25	$2,402,333	190	232	378	508	$508
Temecula Valley Reclamation - Phase B	Eastern MWD	D	D	2000	0	1,803	1,803	1,803	7.0	25	$102,331	190	232	378	508	$565
Haun Road (Rose Hills Memorial Park)	Eastern MWD	D	D	2000	0	2,876	2,876	2,876	7.0	25	$432,859	190	232	378	508	$659
Nason Street Reclamation	Eastern MWD	D	R	2000	0	1,350	1,350	1,350	7.0	25	$133,030	190	232	378	508	$607
Hemet/SJ Reg Rec Recharge Phase B	Eastern MWD	R	R	2000	0	3,963	4,963	4,963	7.0	25	$143,263	32	39	63	85	$114
La Canada Flintridge Country Club	Foothill MWD	D	O	1962	135	135	135	135	6.5	25	$0	1534	1871	2388	2388	$2,388
Power Plant Project	Glendale	D	O	1980	450	450	450	450	6.5	25	$0	121	148	242	242	$242
Forest Lawn Project	Glendale	D	O	1992	250	600	600	600	6.0	25	$163,995	121	148	242	242	$242
Brand Park Project	Glendale	D	D	1995	0	150	225	225	7.0	25	$205,288	126	154	251	251	$251
Verdugo Schol Project	Glendale	D	C	1998	0	700	1,700	1,716	6.5	25	$1,163,836	178	218	355	477	$1,155
Verdugo Schol Pipeline Extension	Glendale	D	R	2020	0	0	0	284	7.0	25	$1,727,546	197	329	484	650	$6,733
Las Virgenes Valley System	Las Virgenes MWD	D	O	1972	300	300	300	300	6.5	25	$0	156	190	310	310	$310
Calabasas System	Las Virgenes MWD	D	O	1972	1,000	1,000	1,000	1,000	6.5	25	$0	377	459	748	748	$748
Las Virgenes Western System	Las Virgenes MWD	D	O	1986	2,000	2,700	2,700	2,700	6.5	25	$0	377	459	748	748	$748
Calabasas System Expansion	Las Virgenes MWD	D	O	1991	600	700	700	700	6.5	25	$0	377	459	748	748	$748
Two Wells in Westlake	Las Virgenes MWD	D	C	1996	0	600	600	600	6.5	25	$81,981	82	92	120	161	$298
Long Beach Reclamation Project	Long Beach	D	O	1980	2,500	2,500	2,500	2,500	6.5	25	$0	390	477	777	777	$777
Long Beach Reclamation Project	Long Beach	D	O	1980	900	1,700	1,700	1,700	4.0	20	$72,768	390	477	777	777	$777
City of Long Beach Reclaimed Water MasterPlan	Long Beach	D	F	2000	0	4,780	4,780	4,780	7.0	25	$3,399,424	115	141	230	230	$941
Griffith Park	Los Angeles	D	O	1976	900	1,900	9,900	9,900	6.5	25	$0	73	89	145	195	$195

Project Type D = Direct, R = Replenishment, B = Both
Project Status O = Operational, C = Construction, D = Design, R = Reconnaissance, F = Feasibility

Table B-1 (cont.)

LOCAL WATER RECYCLING PROJECTS

NAME	MEMBER AGENCY	PROJECT TYPE	PROJECT STATUS	FIRST YEAR OF YIELD	YIELD1995	YIELD2000	YIELD2010	YIELD2020	INTEREST	TERM	Annual Debt Service	OPCOST1995 ($/AF)	OPCOST2000 ($/AF)	OPCOST2010 ($/AF)	ESTIMATED OPCOST2020 ($/AF)	ULTIMATE TOTALCOST ($/AF)
Cal Trans (5 & 134 Fwys)	Los Angeles	D	O	1984	100	100	100	100	6.5	25	$0	73	89	145	195	$195
Los Angeles Greenbelt	Los Angeles	D	O	1992	700	1,200	1,200	1,200	6.1	30	$431,017	82	89	145	195	$554
Westside Los Angeles	Los Angeles	D	C	1995	600	1,850	1,850	10,000	6.1	30	$562,128	344	64	104	140	$196
Sepulveda Basin Phase I	Los Angeles	D	C	1996	0	1,200	1,200	1,200	6.1	30	$234,969	69	161	185	249	$444
Central City/Elysian Park	Los Angeles	D	F	1999	0	2,100	4,100	4,100	6.1	30	$1,675,870	100	100	163	219	$628
LADWP West Basin Westside Extension	Los Angeles	D	D	2000	0	2,000	5,000	7,500	7.0	25	$2,558,266	205	230	300	403	$744
East Valley	Los Angeles	R	D	2000	0	11,500	35,000	35,000	6.1	30	$4,816,032	192	150	245	329	$467
LADWP West Basin Refinery Extension	Los Angeles	D	P	2000	0	7,500	7,500	7,500	7.0	25	$1,534,960	205	230	300	403	$608
Los Angeles Harbor	Los Angeles	B	R	2000	0	5,500	10,500	30,000	6.1	30	$4,378,211	383	300	489	657	$803
Eastside Los Angeles	Los Angeles	D	R	2000	0	800	1,500	1,500	6.1	30	$875,642	410	460	600	806	$1,390
LADWP Rio Hondo Extension	Los Angeles	D	R	2000	0	2,000	2,000	2,000	7.0	25	$511,653	170	190	250	336	$592
Headworks	Los Angeles	R	R	2000	0	5,000	10,000	10,000	6.1	30	$1,751,284	209	256	417	560	$736
Sepulveda Basin - Phase 2	Los Angeles	D	D	2000	0	300	700	700	6.1	30	$420,308	69	161	185	249	$849
West Valley Greenbelt	Los Angeles	D	R	2010	0	0	2,350	2,350	6.1	30	$3,399,614	104	125	149	200	$1,647
Moulton Niguel WD Existing	MWDOC	D	O	1964	470	470	470	470	3.5	25	$22,252	184	205	270	363	$363
El Toro Existing	MWDOC	D	O	1965	500	500	500	500	5.0	25	$25,380	272	332	542	728	$728
Los Alisos WD	MWDOC	D	O	1966	1,700	2,100	2,100	2,100	5.0	25	$200,810	220	269	438	589	$589
OCWD WF21 Above 12 yr Avg	MWDOC	R	O	1974	8,192	8,192	8,192	8,192	5.0	25	$188,585	463	566	922	1239	$1,239
Irvine Ranch Part 1 Expansion	MWDOC	D	O	1975	3,887	3,887	3,887	3,887	5.0	25	$295,607	197	240	392	527	$527
Santa Margarita WD Oso	MWDOC	D	O	1977	1,148	1,148	1,284	1,284	5.0	25	$522,645	290	738	1203	1617	$1,617
Trabuco Canyon WD Parts 1 & 2	MWDOC	D	O	1982	100	800	800	800	5.0	25	$306,499	222	79	129	173	$173
Irvine Ranch Part 1	MWDOC	D	O	1986	6,474	6,474	6,474	6,474	5.0	25	$1,009,710	197	240	392	527	$527
Green Acres Project	MWDOC	D	O	1991	950	6,000	7,000	7,000	5.0	25	$3,302,281	146	127	207	278	$278
Moulton Niguel WD Expansion AWMA	MWDOC	D	C	1992	1,130	3,530	5,530	5,530	3.0	25	$1,902,193	184	205	270	363	$363
Santa Margarita WD Oso Expansion	MWDOC	D	O	1992	1,500	1,500	1,500	1,500	5.0	25	$1,189,960	290	738	1203	1617	$1,617
IRWD Reclaimed Well 78	MWDOC	D	C	1995	1,500	1,500	1,500	1,500	5.0	25	$101,846	290	738	1203	1617	$1,617
Irvine Ranch Part 2	MWDOC	D	C	1995	526	526	3,526	3,526	5.0	25	$746,868	197	240	392	527	$527
Moulton Niguel WD Expansion SERRA	MWDOC	D	C	1995	1,000	2,000	2,000	2,000	2.5	25	$467,448	290	738	1203	1617	$1,617
El Toro Expansion	MWDOC	D	F	1998	0	1,327	2,581	2,581	7.5	30	$3,975,914	420	424	691	929	$2,469
Trabuco Canyon WD Part 3	MWDOC	D	F	2000	0	50	500	650	7.0	25	$51,165	65	79	129	173	$252
IRWD Reclaimed Wells LIA	MWDOC	D	F	2000	0	7,000	7,000	7,000	5.0	25	$643,052	213	280	365	491	$582
MNWD/CVWD SERRA	MWDOC	B	F	2000	0	6,780	6,780	6,780	7.0	25	$716,314	247	280	365	491	$596
Los Alisos WD Expansion	MWDOC	D	F	2000	0	378	778	778	5.0	25	$67,690	220	269	438	589	$676
OCWD Regional Water Reclamation Project	MWDOC	R	F	2000	0	50,000	75,000	100,000	7.0	25	$23,638,377	321	425	692	930	$1,166
OCWD WF21 Expansion 1	MWDOC	R	F	2000	0	8,000	8,000	8,000	7.0	25	$1,637,290	407	566	922	1239	$1,444
Santa Margarita WD Chiquita	MWDOC	D	R	2000	0	2,100	3,600	3,600	7.0	25	$3,346,212	281	187	304	409	$1,338
Irvine Ranch Michelson Expansion	MWDOC	D	F	2005	0	0	6,000	11,000	7.0	25	$5,674,755	237	290	472	634	$1,150
Irvine Ranch Part 2 Expansion	MWDOC	D	F	2005	0	0	3,813	3,813	5.0	25	$2,783,671	202	248	403	542	$1,272
Irvine Ranch Part 3	MWDOC	D	F	2005	0	0	4,500	6,300	7.0	25	$9,564,194	220	269	438	589	$2,107
Alamitos Barrier Project - Parts 2	MWDOC	R	F	2010	0	0	5,000	5,000	7.0	25	$1,906,996	438	315	513	513	$894
Santa Margarita WD Chiquita Expansion	MWDOC	D	P	2010	0	0	5,000	11,000	7.0	25	$5,562,072	321	425	692	930	$1,436
OCWD WF21 Expansion 2	MWDOC	R	P	2010	0	0	8,000	8,000	7.0	25	$3,178,327	419	640	922	1239	$1,636
City of Pasadena Reclaimed Water System	Pasadena	D	D	2000	0	4,700	4,700	4,700	7.0	25	$2,742,461	296	275	448	448	$1,032
Santa Monica Water Gardens	Santa Monica	D	O	1994	22	22	22	22	7.0	25	$78,579	253	329	484	650	$650
MGM/SONY Building	Santa Monica	D	C	1996	0	10	10	10	0.0	25	$0	55	329	484	650	$650
Santa Maria Phase A	SDCWA	R	O	0	700	700	700	700	7.0	25	$0	360	410	560	753	$753
Camp Pendleton	SDCWA	B	O	1942	3,900	3,900	3,900	3,900	7.0	25	$0	253	329	484	650	$650
Santee - Phase A	SDCWA	D	O	1968	400	300	300	300	7.0	25	$0	294	410	550	739	$739
Valley Center Phase A	SDCWA	R	O	1974	300	300	300	300	7.0	25	$0	267	410	550	739	$739
San Vicente	SDCWA	B	O	1975	600	600	600	600	7.0	25	$0	278	480	580	779	$779
Fairbanks Ranch	SDCWA	R	O	1981	150	150	150	150	7.0	25	$0	267	410	550	739	$739
Whispering Palms	SDCWA	B	O	1981	200	150	150	150	7.0	25	$0	267	410	560	753	$753
Otay Water Reclamation Project (Chapman Phas	SDCWA	D	O	1990	750	1,500	1,500	1,500	3.3	20	$110,912	608	410	560	753	$753
Fallbrook Reclaimed Water Distr Phase A	SDCWA	D	O	1990	200	600	1,200	1,200	5.3	20	$240,141	258	230	250	336	$336
Rancho Santa Fe (Existing)	SDCWA	R	O	1992	200	200	300	350	0.0	0	$0	267	410	550	739	$739
Vista Phase A (Shadow Ridge)	SDCWA	D	O	1992	300	375	375	375	0.0	0	$0	478	410	550	739	$739
Encina Basin Phase A	SDCWA	D	O	1992	900	2,050	2,050	2,050	3.4	20	$268,960	710	410	550	739	$739
Encina Water Pollution Control Facility	SDCWA	D	O	1992	130	165	165	165	8.0	10	$24,994	185	410	560	753	$753
Oceanside Phase A	SDCWA	D	O	1992	30	250	300	300	7.0	30	$135,153	200	410	560	753	$1,203
San Pasqual Phase A	SDCWA	D	O	1994	80	1,100	1,100	1,100	5.0	20	$301,270	235	550	600	806	$806

Project Type D = Direct, R = Replenishment, B = Both
Project Status O = Operational, C = Construction, D = Design, R = Reconnaissance, F = Feasibility

Table B-1 (cont.)

LOCAL WATER RECYCLING PROJECTS

NAME	MEMBER AGENCY	PROJECT TYPE	PROJECT STATUS	FIRST YEAR OF YIELD	YIELD1995	YIELD2000	YIELD2010	YIELD2020	INTEREST	TERM	Annual Debt Service	OPCOST1995 ($/AF)	OPCOST2000 ($/AF)	OPCOST2010 ($/AF)	ESTIMATED OPCOST2020 ($/AF)	ULTIMATE TOTALCOST ($/AF)
Rancho Santa Fe	SDCWA	D	D	1996	0	220	220	220	3.1	20	$81,406	364	410	550	739	$739
San Elijo	SDCWA	D	D	1997	0	1,150	1,750	1,750	3.3	20	$963,111	342	410	560	753	$753
Santee Phase B	SDCWA	D	D	1997	0	500	700	700	3.3	20	$632,491	294	410	550	739	$739
Olivenhain	SDCWA	D	R	1998	0	750	3,000	3,000	7.0	30	$1,496,040	531	410	550	739	$1,238
Poway	SDCWA	D	R	1998	0	500	2,000	2,000	7.0	30	$1,152,831	406	410	550	739	$1,316
Clean Water Program - Phase A (North City)	SDCWA	D	C	1998	0	5,000	14,500	14,500	7.0	30	$19,932,536	193	410	550	739	$2,114
Santa Maria Phase B	SDCWA	D	D	1998	0	250	850	850	7.0	25	$0	363	410	550	739	$739
Santa Maria Phase A	SDCWA	D	D	1998	0	500	750	750	1.6	20	$419,166	363	410	560	753	$753
Escondido	SDCWA		R	1999	0	1,000	2,800	2,800	5.1	25	$2,463,252	711	410	560	753	$1,632
Rincon del Diablo	SDCWA	D	D	2000	0	100	400	400	5.1	25	$643,524	711	410	560	753	$2,361
Valley Center Phase B	SDCWA	D	D	2000	0	0	150	300	7.0	30	$134,541	152	410	550	739	$1,188
San Pasqual Phase B	SDCWA	D	P	2001	0	0	1,000	1,000	7.0	30	$753,190	523	410	600	806	$1,560
Oceanside Phase B	SDCWA	D	R	2001	0	0	1,200	1,200	7.0	30	$702,977	200	410	560	753	$1,338
Vista Phase B	SDCWA	D	R	2001	0	0	700	1,000	7.0	30	$622,637	243	410	550	739	$1,362
Clean Water Program Phase B (North City)	SDCWA	D	R	2001	0	0	3,000	3,000	7.0	30	$5,101,606	193	410	300	403	$2,104
Oceanside Phase C	SDCWA	D	P	2005	0	0	500	1,000	7.0	30	$718,554	200	410	560	753	$1,471
San Marcos	SDCWA	D	P	2005	0	0	1,000	1,000	7.0	30	$1,053,880	294	410	560	753	$1,806
Santee - Phase C	SDCWA	D	P	2005	0	0	1,000	1,000	7.0	30	$1,904,169	294	410	550	739	$2,643
Chapman (Jamacha) WRF Phase B	SDCWA	D	R	2005	0	0	2,600	2,600	7.0	30	$6,790,339	519	410	560	753	$3,364
Fallbrook Reclaimed Water Dist Phase B	SDCWA	D	P	2005	0	0	600	600	7.0	30	$479,036	288	410	250	336	$1,134
Encina Basin Phase B	SDCWA	D	R	2010	0	0	1,900	1,900	7.0	30	$2,537,107	229	410	550	739	$2,074
Clean Water Program - Phase C	SDCWA	D	P	2020	0	0	0	4,000	7.0	30	$19,352,596	193	410	300	403	$5,241
Pomona Reclamation Project	Three Valleys MWD	D	O	1966	9,000	9,400	9,600	9,600	0.0	0	$0	141	172	281	378	$378
City of Industry Reclaimed System Phase A	Three Valleys MWD	D	O	1983	3,360	3,360	3,360	3,360	6.5	25	$0	253	329	484	650	$650
Walnut Valley Reclamation Project	Three Valleys MWD	D	O	1986	1,500	2,000	2,000	2,000	6.5	25	$0	206	252	411	552	$552
Walnut Valley Reclamation Plant Expansion	Three Valleys MWD	D	O	1996	0	500	500	500	7.0	25	$600,674	206	252	411	552	$1,754
Rowland Reclamation Project	Three Valleys MWD	D	D	2000	0	2,000	2,000	2,000	7.0	25	$818,645	188	329	484	650	$1,060
West Basin Torrance Extension	Torrance	D	F	2000	0	6,600	6,600	6,600	7.0	25	$1,023,306	222	329	484	650	$806
California Country Club	Upper SGV MWD	D	O	1978	375	375	375	375	6.5	25	$0	8	9	11	15	$15
San Gabriel Valley Water Reclamation Project	Upper SGV MWD	R	D	2000	0	25,000	25,000	25,000	7.0	30	$2,402,520	79	96	157	211	$307
San Gabriel Valley Water Reclamation Project P	Upper SGV MWD	D	F	2000	0	6,000	10,000	10,000	7.0	30	$961,008	79	96	157	211	$307
Puente Hills/Rose Hills	Upper SGV MWD	D	R	2000	0	2,810	3,267	4,000	7.0	25	$511,653	123	140	160	200	$328
West Basin Water Recycling Project - Phase I	West Basin MWD	D	C	1995	850	15,000	20,000	20,000	5.4	25	$3,532,222	209	256	417	560	$560
West Coast Barrier Project	West Basin MWD	R	C	1997	0	5,000	20,000	20,000	6.5	25	$4,283,532	419	512	835	1122	$1,336
West Basin Water Recycling Project - Phase II	West Basin MWD	D	D	1998	0	5,000	15,000	15,000	7.0	25	$3,279,753	209	256	417	560	$779
West Basin Water Recycling Project Phase III	West Basin MWD	D	R	2000	0	5,000	15,000	15,000	7.0	25	$2,558,266	222	329	417	560	$731
March Reclamation Project	Western MWD	D	O	0	261	261	261	261	6.5	25	$0	253	329	484	650	$650
Indian Hills Reclamation Project	Western MWD	D	O	1980	1,310	1,310	1,310	1,310	6.5	25	$0	253	329	484	650	$650
Rancho California/Joaquin Ranch Reclamation	Western MWD	D	O	1984	360	360	672	672	6.5	25	$0	253	329	484	650	$650
Elsinore Valley/Railroad Canyon Reclamation	Western MWD	D	O	1984	730	730	730	730	6.5	25	$0	253	329	484	650	$650
Elsinore Valley/Horse Thief Reclamation	Western MWD	D	O	1989	110	224	560	560	6.5	25	$0	253	329	484	650	$650
Santa Rosa Water Reclamation Facility	Western MWD	D	O	1990	1	2	3	5	6.5	25	$0	253	329	484	650	$650
Elsinore Valley Water Reclamation Project	Western MWD	D	P	2000	0	4,500	5,400	5,400	7.0	25	$2,762,927	147	329	484	650	$1,162

Project Type D = Direct, R = Replenishment, B = Both
Project Status: O = Operational, C = Construction, D = Design, R = Reconnaissance, F = Feasibility

Table B-2

METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
GROUNDWATER RECOVERY PROGRAM

Project Background Data

Cost Year: 1994

	Project Name	Contaminant	Total Yield (af/yr)	MWD Replenishment (af/yr)	Est. Start Year	Estimated Capital ($ millions)	Estimated Ann. Capital ($1000/yr)	Estimated O&M Cost ($1000/yr)	Estimated Repl Cost ($1000/yr)	Estimated Unit Cost (1994$/af)
	APPROVED PROJECTS									
1	Santa Monica GW Treatment Plant	VOC	1,800	0	1993	$2.9	$300	$371		$373
2	Burbank Lake Street GAC Plant	VOC	2,744	2,744	1993	$1.4	$145	$607	$571	$482
3	West Basin Desalter No 1	TDS	1,524	0	1993	$1.5	$130	$833		$632
4	Oceanside Desalter No 1	TDS	2,200	0	1994	$5.8	$595	$888		$674
5	Tustin Desalter	TDS	3,271	909	1996	$6.9	$651	$996	$189	$561
6	Irvine Desalter	TDS, VOC, Se	6,700	1,926	1998	$28.5	$2,197	$2,832	$401	$810
7	Rowland GW Treatment Project	TCE/TDS	516	0	2000	$2.3	$191	$216		$787
8	Menifee Basin Desalter	TDS	3,360	0	1999	$16.5	$1,141	$1,571		$807
9	Chino/SAWPA Desalter No. 1	TDS/Nitrate	8,000	0	1998	$41.5	$3,349	$2,200		$694
	APPROVED PROJECTS - Subtotal		30,115	5,579		$107	$8,700	$10,513	Ave =	$647
	PROJECTS UNDER REVIEW									
10	Beverly Hills Desalter	TDS	2,688	0	1999	$10 3	$898	$800		$632
11	Arlington Desalter *	TDS/Nitrate	7,200	0	1998	$23 4	$1,727	$2,310		$561
12	Capistrano Beach Desalter	TDS	1,372	0	1999	$4 2	$352	$389		$540
13	San Juan Basin Desalter No. 1	TDS	2,200	0	1999	$11.4	$959	$796		$798
14	Baldwin Park Operable Unit	VOC	24,100	24,100	1999	$18.1	$1,878	$3,907	$5,013	$448
15	Sweetwater Desalter No. 1	TDS	3,440	0	1998	$8 3	$1,214	$1,092		$670
	PROJECTS UNDER REVIEW - Subtotal		41,000	24,100		75.7	7029.5	9293.6	Ave =	$608
	(Approved + Review Projects) TOTAL		71,115	29,679						
	PROJECTS UNDER PLANNING									
16	Oceanside Desalter No. 2	TDS	3,360	0	1998	$5 5	$464	$857		$393
17	San Juan Basin Desalter No. 2	TDS	2,800	0	2000	$13.0	$1,097	$826		$687
	PROJECTS UNDER PLANNING - Subtotal		6,160	0		$19	$1,561	$1,683	Ave =	$540
	(Approved + Review + Planning Projects) TOTAL		77,275	29,679						
	POSSIBLE PROJECTS									
18	San Pasqual Basin Desalter	TDS/Nitrate	5,000	0	2005	$9.6	$810	$1,700		$502
19	Winchester/Hemet Desalter	TDS	3,000	1,500	2001	$12.5	$1,055	$1,300	$312	$889
20	Laguna Beach GW Treatment Project	Color	2,000	500	2001	$6 3	$532	$336	$104	$486
21	Santee/El Monte Basin Desalter	TDS	1,000	0	2001	$2.7	$230	$455		$685
22	Otay/Sweetwater Desalter	TDS	3,000	0	2002	$8.9	$753	$1,155		$636
23	Corona/Temescal Basin Desalter	TDS/Nitrate	10,000	0	2002	$28.4	$2,392	$2,730		$512
24	Perris Basin Desalter	TDS	6,000	0	2002	$17.0	$1,434	$1,750		$531
25	Chino/SAWPA Desalter No. 2	TDS/Nitrate	8,000	9,200	2002	$33 1	$2,311	$2,010	$1,914	$779
26	Torrence Elm Ave. Fac.	Chloride	4,000	0	2004	$3 7	$312	$2,081		$598
27	Western/Bunker Basin Treatment Pro	Nitrate	8,100	0	2002	$15 4	$1,302	$3,360		$576
28	IRWD Colored Water Treatment Proj.	Color	10,000	2,625	2012	$16.8	$1,417	$1,680	$546	$364
29	West Basin Desalter No 2	TDS	6,000	0	2002	$13 5	$1,139	$2,701		$640
30	West Basin Desalter No 3	TDS	5,000	0	2003	$14.0	$1,181	$2,179		$672
31	Tijuana River Valley Desalter	TDS	2,500	0	2004	$5 3	$443	$1,107		$620
32	San Dieguito Basin Desalter	TDS	5,000	0	2003	$14 7	$1,240	$1,575		$563
33	OCWD Undetermined Colored Water Projects	Color	12,000	3,000	2004	$26.3	$2,215	$3,150	$624	$499
34	Rubidoux/Western Desalter	TDS/Nitrate	3,000	0	2004	$8.9	$753	$1,155		$636
35	Chino/SAWPA No. 3	TDS/Nitrate	9,050	10,400	2005	$37.4	$2,614	$2,273	$2,163	$779
36	Hunt Beach Colored Water	Color	5,000	1,250	2005	$21.0	$1,772	$210	$260	$448
37	Mesa Colored Water Project	Color	2,500	625	2005	$10.5	$886	$105	$130	$448
38	Sweetwater Desalter No.2	TDS	4,000	0	2005	$6.6	$964	$1,070		$508
	POSSIBLE PROJECTS - Subtotal		114,150	29,100		$313	$25,757	$34,081	Ave =	$589
	GROUNDWATER RECOVERY PROGRAM TOTAL		191,425	58,779						

SOUTHERN CALIFORNIA'S

INTEGRATED WATER RESOURCES PLAN

APPENDIX C:

GROUNDWATER CONJUNCTIVE USE STORAGE POTENTIAL

Report No. 1107

January, 1996

APPENDIX C:

GROUNDWATER CONJUNCTIVE USE STORAGE POTENTIAL

This appendix summarizes the groundwater basin storage assumptions used in the IRP resource simulation. Most of the data was provided by consultants working for the Association of Groundwater Agencies (AGWA). Other data was based on water master reports and annual water surveys of the groundwater agencies and Member Agencies, collected by Metropolitan. The following presents a brief description of the terms used in this report.

Conjunctive Use Storing:
Storing excess imported water in the local groundwater basins for regional purposes. The stored water could be used for drought protection and/or to reduce seasonal peaks on Metropolitan.

Storage Capacity:
The total volume (or space) of the groundwater basin dedicated to conjunctive use (storing excess imported water for regional benefits). It does not represent the total capacity of the basin, which can be significantly greater. It also does not represent the actual monthly or annual groundwater production, which is usually much less.

Maximum Production Capacity:
The maximum pumping (well) capacity in the basin, which can be expressed in monthly or annual amounts. It represents the maximum quantity of water that could be pumped from the basin in a given time period.

Typical Groundwater Production:
The typical (average) amount of water that is pumped from the basin to meet demand (usually expressed as monthly or annual amounts). Its monthly pattern usually follows the pattern of water demand, because groundwater usually represents the cheapest supply available to the local agency.

Conjunctive Use Production Capacity:
The additional production capacity available for conjunctive use storage. It represents the difference between the maximum production (pumping) capacity and the typical groundwater production for a given month.

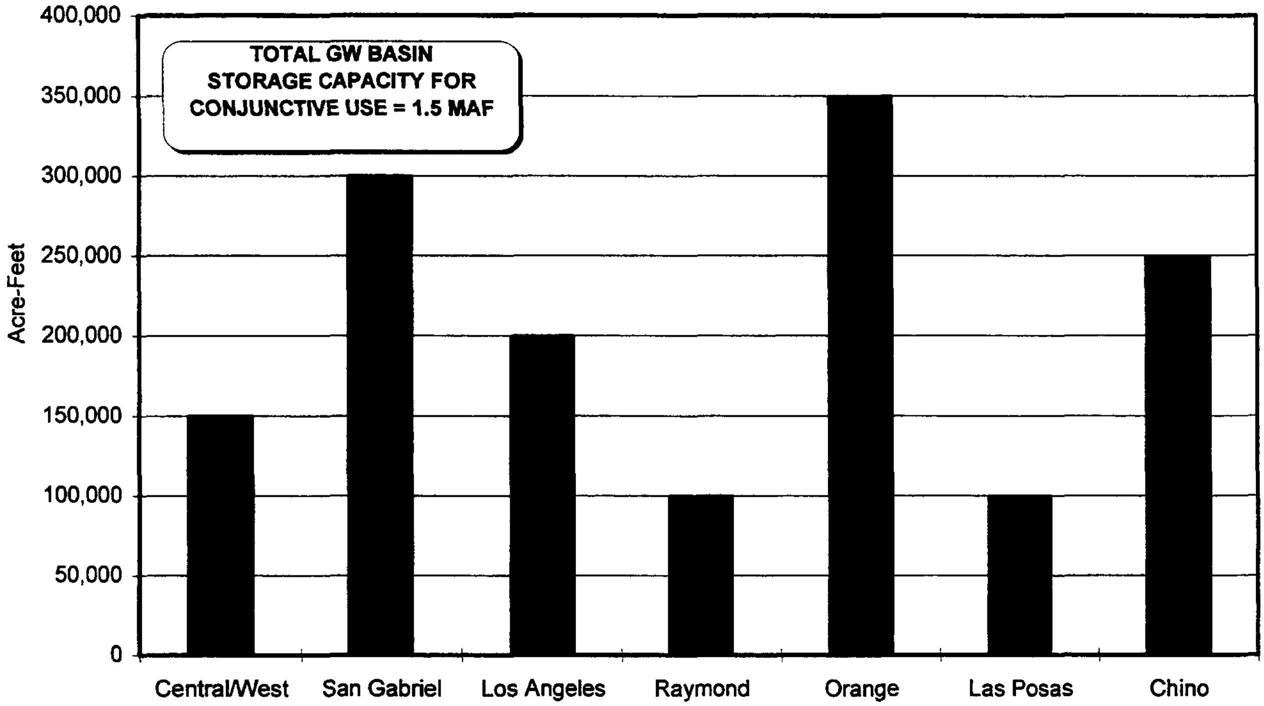
Spreading/Injection Capacity:
The physical spreading and/or injection capacity in the groundwater basin available for putting (storing) water. Spreading facilities are usually percolation ponds, while injection facilities are usually large injection pumps.

In-Lieu Capacity:
The amount of imported water that local agencies can receive in-lieu of water being pumped from the basin. This has the effect of storing water in the basin for later use. The capacity for in-lieu is limited by: (1) the ability of the individual groundwater agency to take direct deliveries of imported water; (2) the local agencies' water demand; and (3) Metropolitan's conveyance distribution system.

For the purposes of the IRP simulation, monthly values for groundwater production, spreading, and in-lieu capacities were used. It should also be noted that all of the groundwater values presented in this report are the usable amounts available for Metropolitan's service area only. For example, Chino and Raymond Basins serve areas outside of Metropolitan's region.

Figure C-1 presents the total storage capacity made available for conjunctive use for each of the major basins. In total, about 1.5 million acre-feet of groundwater storage could be used by the region for emergency, drought, and seasonal purposes. This storage capacity does not represent the amount of additional groundwater production that could be used in any given year -- that amount is significantly less. Of the major basins, Orange County has the greatest potential for storage capacity at 350,000 acre-feet. San Gabriel and Chino Basins also have significant storage potentials, estimated to be 300,000 acre-feet and 250,000 acre-feet, respectively. Raymond and Las Posas both have about 100,000 acre-feet of storage potential. These storage capacities were provided by AGWA's consultants.

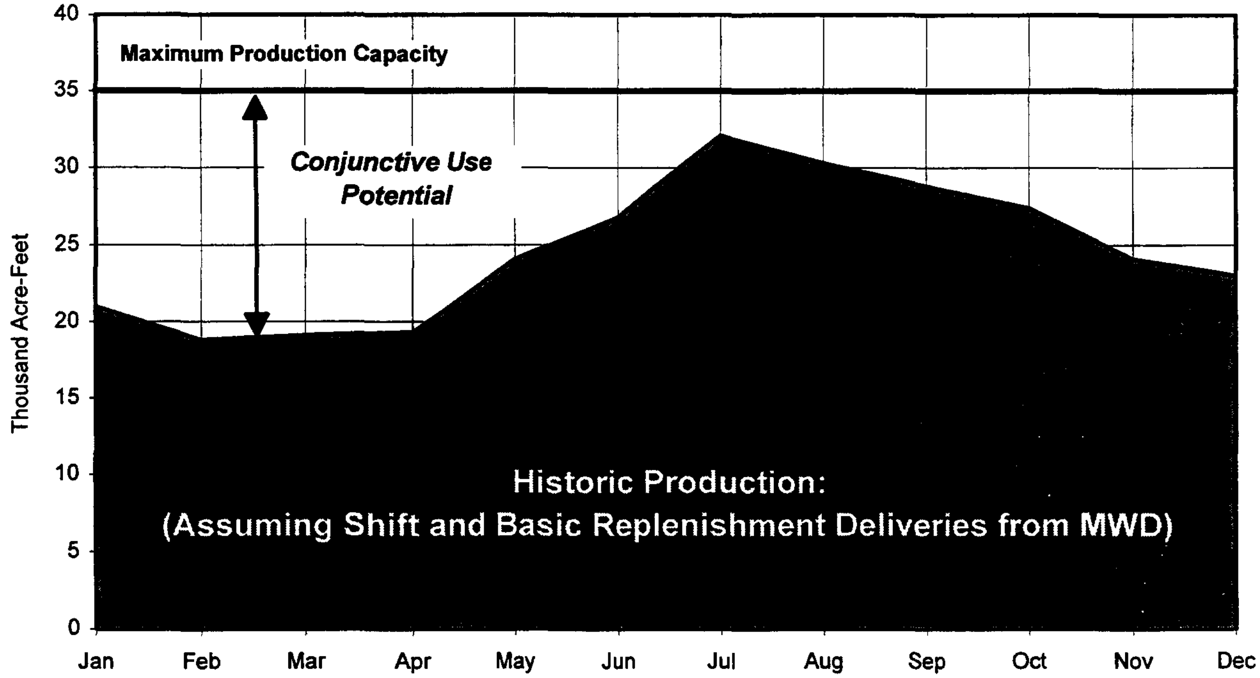
Figure C-1
Groundwater Storage Capacity Available for Conjunctive Use Storage



In order to develop the monthly production capacity available for conjunctive use, two pieces of data are needed: (1) the maximum monthly production (well) capacity; and (2) the historic (typical) monthly groundwater production pattern. Figure C-2 presents an example of this calculation for a specific groundwater basin. The maximum monthly production for this basin is 35,000 acre-feet (represented by the dark line running across the graph). The basin's historic monthly production pattern is represented by the dark shaded area. In any given month, the difference between the maximum monthly pumping capacity and the historic monthly production equals the remaining pumping capacity available for conjunctive use. For example, in the month of March about 20,000 acre-feet is typically produced from the basin, while the maximum monthly production capacity is

35,000 acre-feet. The difference between the two values, estimated to be about 15,000 acre-feet, is the additional production that could be used for regional storage purposes. During the summer months, the additional production capacity for conjunctive use storage is significantly less.

Figure C-2
Estimating the Potential for Groundwater Storage



The maximum monthly production (well) capacities for each of the major basins were provided by AGWA's consultants. They basically represent existing facilities, except for Orange, Chino, Raymond and Las Posas Basins -- where additional facilities were assumed. The historic monthly production estimates were based on 1985-1989 safe-yield production data obtained by Metropolitan through its annual surveys. These historic monthly production estimates were reviewed by AGWA and the Member Agencies. Figure C-3 presents the average winter and summer month production capacity potential for conjunctive use storage by basin. In general, the largest potential for conjunctive use storage is during the winter, when water demands in the basin are low. However, in most cases the need for significant conjunctive use storage production is during the summer.

In order to estimate how much water could be stored in the basins, two pieces of data are required: (1) the maximum monthly spreading capacity; and (2) estimates of monthly natural runoff. The difference between the two values indicates the remaining spreading capacity for storing excess imported water for regional purposes. Maximum monthly spreading capacities for each basin were provided by AGWA's consultants. Estimates of natural runoff were calculated from data provided by flood control districts and/or by the groundwater agency reports. Figure C-4 presents an example of the spreading capacity for a basin.

Figure C-3
Monthly Groundwater Production

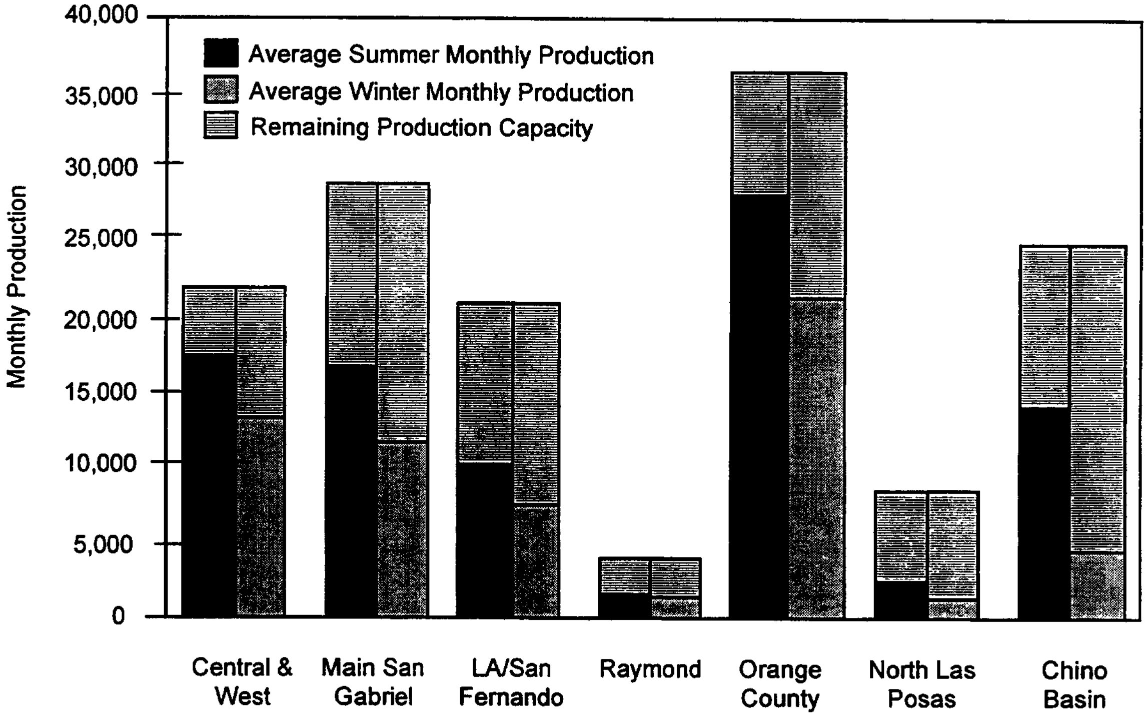
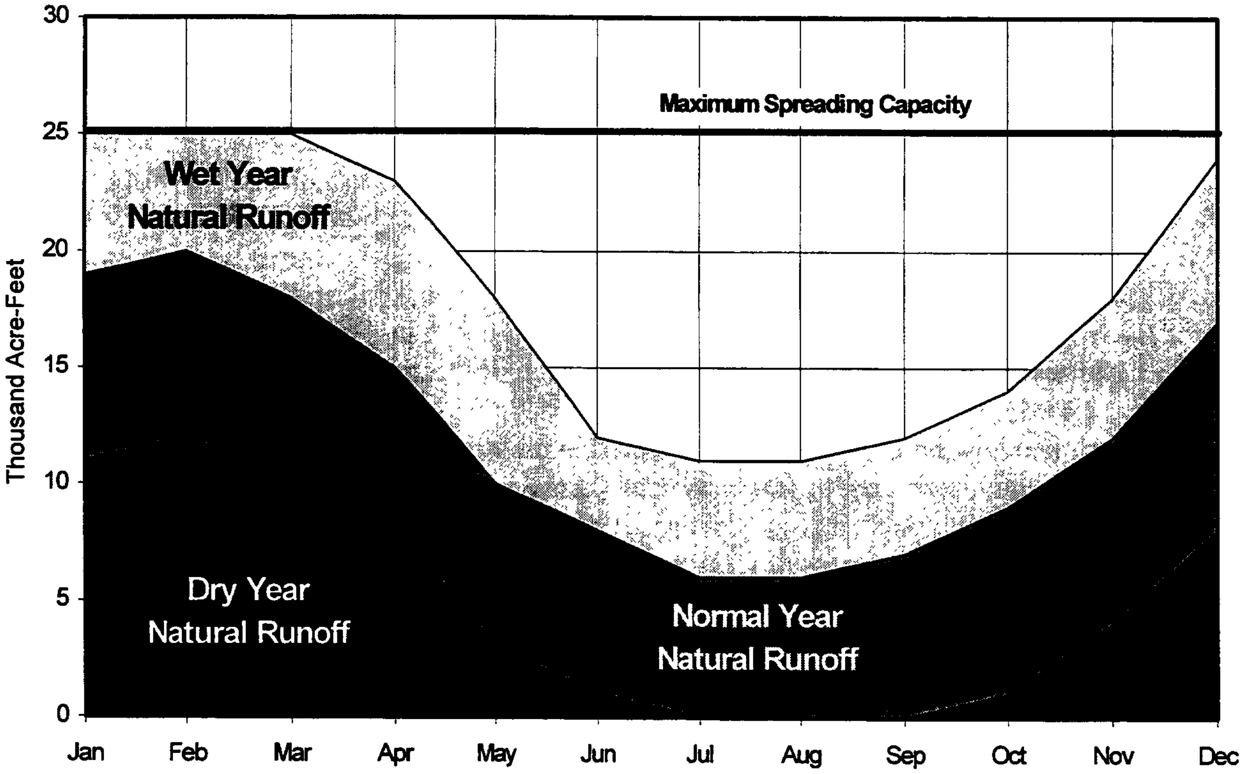
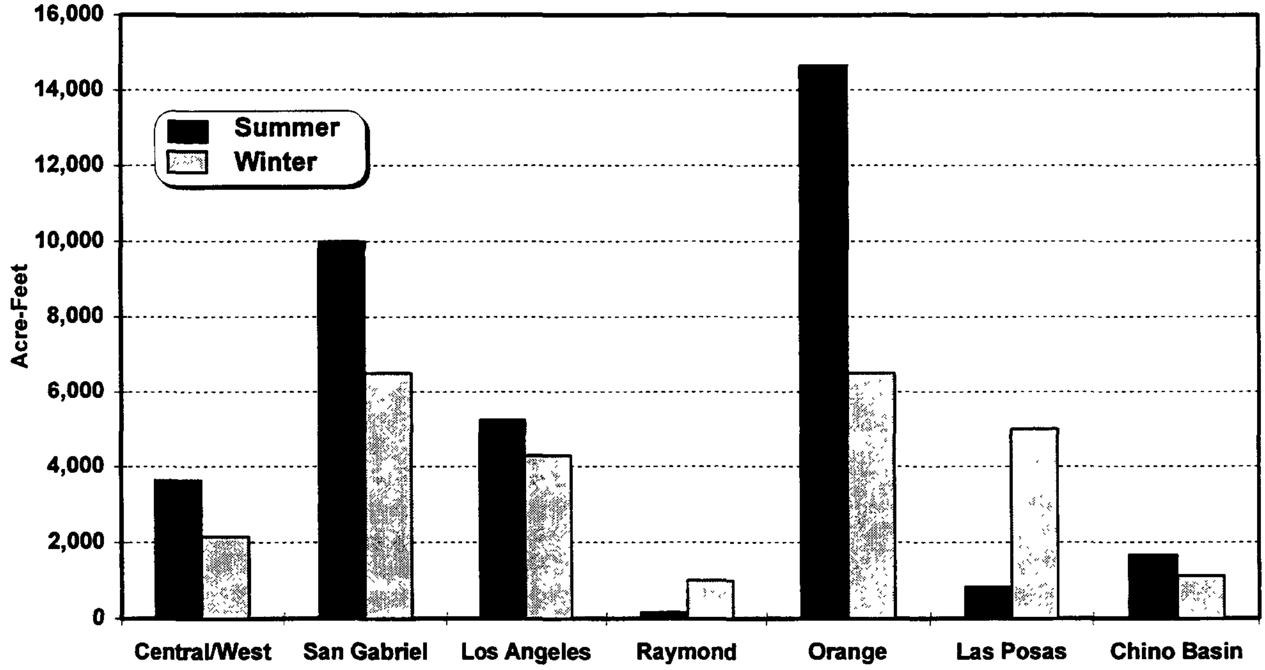


Figure C-4
Groundwater Basin Spreading Capacity



As shown in Figure C-4, winter months have lower spreading capacities for storing excess imported water because the basin is making use of natural runoff. This calculation gets somewhat complicated because in addition to winter vs. summer runoff data, the type of local hydrologic year must also be taken into account. For example, during local wet years natural runoff is very high -- even during the summer. In fact, for most basins wet year runoff prevents any winter-time spreading of imported water. However, it is important to note that the majority of excess imported water is available during winter months and these local wet and normal years (because northern California hydrology typically mirrors local hydrology). A benefit of the Eastside Reservoir Project is that excess imported water can be stored in the surface reservoir during the winter and than cycled into the groundwater basins during the summer months -- when groundwater spreading capacities are the greatest. Figure C-5 presents the winter and summer month spreading/injection capacities for each basin available for additional conjunctive use storage.

Figure C-5
Monthly Spreading/Injection Capacities for Conjunctive Use Storage



Another way to store excess water into the groundwater basins is by in-lieu deliveries of Metropolitan water. This method does not require spreading facilities or connections to physically get water into the basin. Instead of pumping from the groundwater basin, direct deliveries of imported water are made to the local groundwater pumping agency. These deliveries are made in-lieu of the agency pumping groundwater.

For example: Member Agency X usually pumps an average of 30,000 acre-feet per month from the basin during the winter and buys no Metropolitan non-interruptible water. When excess imported water is available -- Metropolitan makes available discount water to be sold in-lieu of Member Agency X pumping the water from the basin. The Member Agency still meets its demand and keeps the groundwater supply it would have pumped for later use.

The limitations to in-lieu deliveries as a means to store water include: (1) local ground-water pumping agencies that cannot receive imported water (either directly from Metropolitan or indirectly through local interconnections) cannot take advantage of the excess imported water; and (2) Metropolitan's distribution system is pushed harder because instead of delivering its typical non-interruptible water, more water is being delivered to for in-lieu purposes. Table C-1 presents a summary of the storage parameters used in the resource simulation model regarding groundwater storage.

Table C-1
Groundwater Storage Parameters

Storage Parameter	Time Period	Central/ West	San Gabriel	LA/San Fernando	Raymond	Orange	Las Posas	Chino
Storage Capacity for Conjuctive Use (acre-feet)		150,000	300,000	200,000	100,000	350,000	100,000	250,000
Availabel Monthly Production Capacity (acre-feet)*		22,000	29,000	21,000	4,000	36,500	8,500	25,000
In-lieu Capacity for Conjunctive Use, expressed as percent of monthly groundwater safe-yield production **	1996	40%	25%	55%	80%	40%	3%	30%
	2000	40%	30%	60%	85%	45%	3%	45%
	2010	50%	30%	70%	85%	60%	3%	45%
Wet Year Spreading of Additional Imported Water (acre-feet)	Jan	0	0	0	1,000	0	5,000	0
	Feb	0	0	0	1,000	0	5,000	0
	Mar	0	0	0	1,000	0	5,000	0
	Apr	0	0	0	1,000	0	5,000	1,000
	May	1,000	0	2,500	0	0	0	1,800
	Jun	2,200	7,000	2,700	0	12,000	0	1,800
	Jul	2,500	10,000	3,500	0	14,000	0	2,000
	Aug	3,000	11,000	4,000	0	15,000	0	1,800
	Sep	2,500	10,000	4,000	0	15,000	0	1,000
	Oct	2,200	8,000	2,200	1,000	14,000	5,000	1,000
	Nov	1,000	5,000	1,000	1,000	8,000	5,000	0
	Dec	0	0	0	1,000	0	5,000	0
Normal Year Spreading of Additional Imported Water (acre-feet)	Jan	1,500	4,000	3,000	1,000	0	5,000	500
	Feb	2,000	5,000	4,600	1,000	5,000	5,000	1,200
	Mar	2,400	8,000	5,200	1,000	6,500	5,000	1,500
	Apr	2,500	9,000	5,400	1,000	6,500	5,000	2,000
	May	3,500	10,000	5,400	0	13,000	0	2,000
	Jun	3,800	10,000	5,400	0	15,000	0	2,000
	Jul	4,000	11,000	5,400	0	15,000	0	2,000
	Aug	4,000	11,000	5,400	0	15,000	0	2,000
	Sep	3,500	10,000	5,100	0	15,000	0	1,000
	Oct	3,000	8,000	4,700	1,000	15,000	5,000	1,000
	Nov	2,500	8,000	4,500	1,000	13,000	5,000	1,000
	Dec	2,000	5,000	3,000	1,000	8,000	5,000	500
Dry Year Spreading of Additional Imported Water (acre-feet)	Jan	3,000	20,000	5,600	1,000	20,000	5,000	1,800
	Feb	3,300	21,000	5,700	1,000	21,000	5,000	2,000
	Mar	3,500	25,000	6,500	1,000	25,000	5,000	2,200
	Apr	4,000	28,000	6,700	1,000	28,000	5,000	2,500
	May	4,300	30,000	6,700	0	30,000	0	2,700
	Jun	4,300	30,000	6,700	0	30,000	0	2,700
	Jul	4,300	30,000	6,700	0	30,000	0	2,700
	Aug	4,300	30,000	6,700	0	30,000	0	2,700
	Sep	4,000	28,000	6,400	0	28,000	0	2,700
	Oct	3,500	25,000	5,900	1,000	25,000	5,000	2,500
	Nov	3,300	21,000	5,600	1,000	21,000	5,000	2,200
	Dec	3,000	20,000	5,700	1,000	20,000	5,000	1,900

* Additional monthly capacity available for conjunctive use represents the difference between this maximum production capacity and the typical monthly groundwater production.

** Represents only the in-lieu deliveries for conjunctive use purposes; in-lieu potential improves over time as improvements are made to MWD's distribution system.

Table C-2 presents the typical (average of 1985-1989) groundwater safe-yield production and additional production from conjunctive use storage for the major basins in Metropolitan's service area. Note that Santa Monica, Eastern, and Western groundwater basins are shown in Table C-2, but not in Table C-1. This is because the storage potential in these basins are not significant and/or could not be determined at this time. However, these basins do provide year-round local supplies to the region and are therefore included in the analysis.

Table C-2
Average Groundwater Production

Historic Groundwater Safe-Yield Production From 1980-1989 *

	Central/ West	San Gabriel	LA/San Fernando	Raymond	Santa Monica	Orange	Las Posas	Chino	Eastern	Western	Total
Jan	13,301	11,101	7,577	1,377	451	22,008	1,156	7,185	2,253	5,611	72,019
Feb	12,192	10,589	6,723	1,245	407	19,034	1,063	6,546	2,170	4,790	64,759
Mar	13,116	11,784	7,150	1,226	363	19,034	1,202	7,824	2,754	5,748	70,200
Apr	14,040	13,150	8,110	1,415	385	19,629	1,688	10,857	5,258	8,758	83,290
May	16,072	15,883	9,604	1,472	402	24,090	2,289	15,647	8,597	13,548	107,602
Jun	17,180	17,420	10,458	1,321	418	26,766	2,659	18,681	11,852	16,559	123,312
Jul	19,212	18,445	11,098	2,056	550	32,120	2,821	21,555	14,188	19,296	141,340
Aug	18,843	17,932	11,098	2,019	556	30,335	2,705	20,597	12,352	18,611	135,047
Sep	17,180	16,054	10,031	1,811	495	28,848	2,474	17,244	9,848	15,601	119,585
Oct	16,072	14,517	9,070	1,811	506	27,361	2,219	14,849	7,428	13,274	107,107
Nov	14,224	12,467	8,110	1,660	473	24,090	1,526	10,378	4,173	8,621	85,723
Dec	13,301	11,443	7,683	1,453	495	24,090	1,318	8,303	2,587	6,432	77,103
Total	184,731	170,785	106,712	18,865	5,500	297,404	23,119	159,663	83,462	136,848	1,187,088

Additional Groundwater Production for Conjunctive Use Storage **

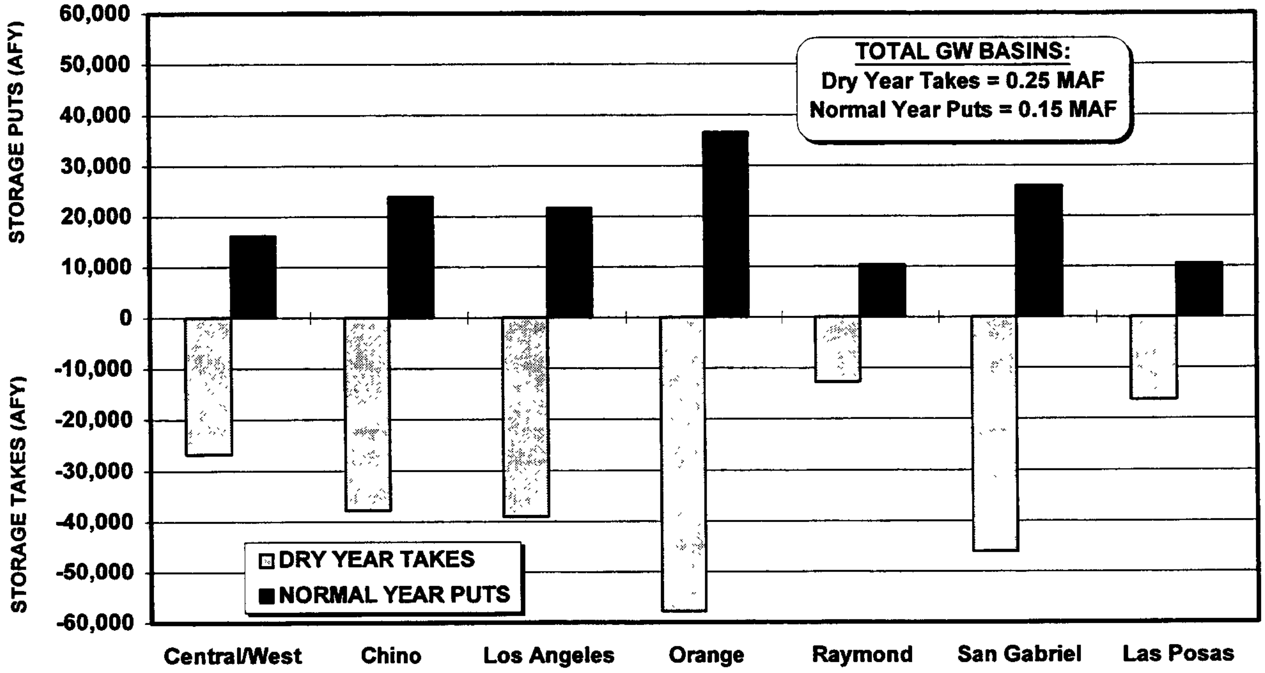
	Central/ West	San Gabriel	LA/San Fernando	Raymond	Santa Monica	Orange	Las Posas	Chino	Eastern	Western	Total
Jan	8,699	17,899	13,423	2,623	NA	14,492	7,344	17,815	NA	NA	82,296
Feb	9,808	18,411	14,277	2,755	NA	17,466	7,437	18,454	NA	NA	88,608
Mar	8,884	17,216	13,850	2,774	NA	17,466	7,298	17,176	NA	NA	84,664
Apr	7,960	15,850	12,890	2,585	NA	16,871	6,812	14,143	NA	NA	77,112
May	5,928	13,117	11,396	2,529	NA	12,410	6,211	9,353	NA	NA	60,944
Jun	4,820	11,580	10,542	2,679	NA	9,734	5,841	6,319	NA	NA	51,516
Jul	2,788	10,555	9,902	1,944	NA	4,380	5,679	3,445	NA	NA	38,694
Aug	3,157	11,068	9,902	1,981	NA	6,165	5,795	4,403	NA	NA	42,472
Sep	4,820	12,946	10,969	2,189	NA	7,652	6,026	7,756	NA	NA	52,359
Oct	5,928	14,483	11,930	2,189	NA	9,139	6,281	10,151	NA	NA	60,101
Nov	7,776	16,533	12,890	2,340	NA	12,410	6,974	14,622	NA	NA	73,545
Dec	8,699	17,557	13,317	2,547	NA	12,410	7,182	16,698	NA	NA	78,411
Total	79,269	177,215	145,288	29,135	NA	140,596	78,881	140,337	NA	NA	790,721
Winter	51,827	103,466	80,648	15,624	NA	91,116	43,047	98,908	NA	NA	484,635
Summer	27,442	73,749	64,641	13,511	NA	49,480	35,834	41,429	NA	NA	306,086

* Does not include Metropolitan's basic replenishment, which averages to be about 100,000 acre-feet per year for all basins.

** Calculated by subtracting the historic monthly safe-yield production from the maximum monthly production capacity in Table C-1.

Based on the results of the resource simulation model, the following dry year storage production (takes from storage) and normal year spreading, injection, and in-lieu deliveries (puts into storage) were estimated for each basin. Dry years are estimated to occur 1 in 10 years, and normal years are estimated to occur 7 in 10 years. Figure C-6 presents this storage summary. In total, the average (from 1995 to 2020) additional groundwater production (takes from storage) is about 250,000 acre-feet per year. In some years this storage production is much greater -- about 350,000 acre-feet, while in other years it is much less -- about 100,000 acre-feet. The variation has to do with the projection of demands, core local supplies, and available imported supplies. In total, the average (from 1995 to 2020) spreading and in-lieu deliveries (puts into storage) is about 150,000 acre-feet per year. Orange County has the greatest potential for storage, followed by San Gabriel, Chino, and Los Angeles.

Figure C-6
Storage Simulation Results Indicating the Average Storage Puts and Takes



TOTAL GW BASINS:
Dry Year Takes = 0.25 MAF
Normal Year Puts = 0.15 MAF

SOUTHERN CALIFORNIA'S

INTEGRATED WATER RESOURCES PLAN

APPENDIX D:

STATE WATER PROJECT SUPPLY VARIATION AND DEVELOPMENT POTENTIAL

Report No. 1107

January, 1996

APPENDIX D:

STATE WATER PROJECT SUPPLIES AND MODELING

For the IRP, Metropolitan needed to capture the effect of two potential variations in SWP supplies. First, the effect of hydrologic conditions on SWP supplies needed to be determined. Second, the effect of different levels of investment on SWP operational standards needed to be determined. To answer each of these questions, Metropolitan started with projected SWP supplies that were generated by the California Department of Water Resources (DWR) simulation model, DWRSIM.

DWRSIM is used by DWR to forecast SWP water supplies for the 29 State Water Contractors (Contractors). As inputs, DWRSIM uses a set of operational constraints or "standards" for water operations in the Delta, a level of investment and development on the SWP, and a demand for water by the Contractors. For a given set of operational rules, level of investment, and water demand, DWRSIM cycles through historical hydrologic conditions and calculates the supply yield that would result from those conditions. The supply yield is calculated for each historical hydrologic year used by DWR, from 1922 through 1991, and includes the carryover storage effect along the SWP system.

For Metropolitan's IRP modeling, four levels of SWP investment were requested from DWRSIM. In each of the four DWRSIM runs, a full project demand of 4.23 million acre-feet was requested, corresponding to a 2.01 million acre-foot request by Metropolitan. Metropolitan made this assumption because it was necessary to know the potential amount of water supply available, with all Contractors requesting their full allocation. Operational constraints on the SWP were specified using the State Water Resources Control Board proposed Decision 1630 (D-1630). Although D-1630 had not been adopted, the standards were considered to be a reasonable surrogate for anticipated operational constraints in the Delta. The four investment levels represented the different development paths that could occur on the SWP. By requesting four sets of DWRSIM output based on four development paths, Metropolitan could impose completion of the development levels at different points in the planning horizon. The four levels of investment specified for IRP modeling are: (1) Existing Facilities , (2) Interim Delta Improvements, (3) Full Delta Fix, and (4) South of the Delta Storage.

Under the "existing facilities" scenario, no new investment is made on the SWP. This scenario most closely represents current conditions on the SWP and in the Delta. For the IRP modeling, a degradation path was assumed with the "existing facilities" supply scenario. The current political and environmental controversy surrounding water supply issues in the Delta led to the assumption that, without any improvements on the SWP, potential water supply would decrease over time. It was specifically assumed that in each future year, the amount of water that was available under D-1630 would degrade 5% incrementally until the year 2005. With degradation, supplies available under the "existing facilities" scenario would equal one-half of the current supplies available under D-1630 operational constraints by the year 2005.

Under the "Interim Delta Improvements" scenario, investments that improve the conditions at the South end of Delta are assumed to occur. In the IRP modeling, "Interim Delta Improvements" are assumed to occur in the year 2000, providing an increase in expected supply yield. However, because the improvements are understood to be "interim" and provide only a temporary "fix" to Delta problems, the available supply is degraded over time. The degradation path occurs over a ten year period. The supply available under the "Interim South Delta Improvements" scenario would degrade gradually until it became equal to 75% of the current supplies available under the "existing facilities" scenario.

Under the "Full Delta Fix" scenario, a "fix" to the Delta, presumably in the form of a peripheral canal, results in a significant increase in the amount and reliability of SWP supply. In the IRP modeling, the "Full Delta Fix" is assumed to be on-line in 2010. Since the "Full Delta Fix" involves a permanent fix to many issues surrounding Delta water exports, no degradation is assumed when using this scenario. Supply varies only by hydrology.

Under the "South of the Delta Storage" scenario, nearly 3 million acre-feet of storage capacity is added to the SWP south of the Delta. In conjunction with the implementation of the "Full Delta Fix" facilities, this scenario provides a full SWP allocation of 2 million acre-feet nearly 85% of the time. This facility is assumed to be available by the year 2015, and because the scenario is created by permanent facilities, no degradation path is assumed.

For IRP modeling purposes, the four scenarios could be joined together at different points in the planning horizon to form the assumption of a specific development path on the SWP. In the Preferred Resources Mix SWP assumption, the "existing facilities" case was used for forecast years 1995-1999. The "Interim Delta Improvements" case was brought on line in the forecast year 2000 and was effective until the year 2009. In 2010, the "Full Delta Fix" was implemented and assumed to be the scenario describing SWP deliveries through 2020, the end of the planning horizon.

Table D-1 shows the matrix of available SWP for existing facilities under operational rule D-1630. The forecast years are shown across the top of the table and the hydrologic trace years are shown along the side of the table. Tables D-2 through D-4 show similar data for the Interim Improvements, Full Delta Fix, and South of Delta Storage, respectively.

If the data in Tables D-1 through D-4 were ranked by percentile and joined together into development paths, as described above, then the available SWP supplies during certain types of hydrologic years could be estimated. For example, what would the top 10 percentile projected SWP supply be? Figures D-1 through D-3 show the projected SWP supplies and development potential under the top 10 percentile (hot and dry conditions), the middle 50 percentile (normal hydrology), and the bottom 90 percentile (cool and wet conditions).

Table D-1
Simulated SWP Supplies Under Existing Facilities

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1922	1991	1891	1792	1692	1593	1493	1394	1294	1195	1095	996	996	996	996	996	996	996	996	996	996	996	996	996	996	996	996
1923	1998	1898	1798	1698	1598	1499	1399	1299	1199	1099	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999
1924	742	705	668	631	594	557	519	482	445	408	371	371	371	371	371	371	371	371	371	371	371	371	371	371	371	371
1925	1165	1107	1049	990	932	874	816	757	699	641	583	583	583	583	583	583	583	583	583	583	583	583	583	583	583	583
1926	1308	1243	1177	1112	1046	981	916	850	785	719	654	654	654	654	654	654	654	654	654	654	654	654	654	654	654	654
1927	1775	1686	1598	1509	1420	1331	1243	1154	1065	976	888	888	888	888	888	888	888	888	888	888	888	888	888	888	888	888
1928	1526	1450	1373	1297	1221	1145	1068	992	916	839	763	763	763	763	763	763	763	763	763	763	763	763	763	763	763	763
1929	1279	1215	1151	1087	1023	959	895	831	767	703	640	640	640	640	640	640	640	640	640	640	640	640	640	640	640	640
1930	1586	1507	1427	1348	1269	1190	1110	1031	952	872	793	793	793	793	793	793	793	793	793	793	793	793	793	793	793	793
1931	643	611	579	547	514	482	450	418	386	354	322	322	322	322	322	322	322	322	322	322	322	322	322	322	322	322
1932	1200	1140	1080	1020	960	900	840	780	720	660	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
1933	829	788	746	705	663	622	580	539	497	456	415	415	415	415	415	415	415	415	415	415	415	415	415	415	415	415
1934	869	826	782	739	695	652	608	565	521	478	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435
1935	1475	1401	1328	1254	1180	1106	1033	959	885	811	738	738	738	738	738	738	738	738	738	738	738	738	738	738	738	738
1936	1901	1806	1711	1616	1521	1426	1331	1236	1141	1046	951	951	951	951	951	951	951	951	951	951	951	951	951	951	951	951
1937	1767	1679	1590	1502	1414	1325	1237	1149	1060	972	884	884	884	884	884	884	884	884	884	884	884	884	884	884	884	884
1938	1978	1879	1780	1681	1582	1484	1385	1286	1187	1088	989	989	989	989	989	989	989	989	989	989	989	989	989	989	989	989
1939	1447	1375	1302	1230	1158	1085	1013	941	868	796	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724
1940	1572	1493	1415	1336	1258	1179	1100	1022	943	865	786	786	786	786	786	786	786	786	786	786	786	786	786	786	786	786
1941	1960	1862	1764	1666	1568	1470	1372	1274	1176	1078	980	980	980	980	980	980	980	980	980	980	980	980	980	980	980	980
1942	1844	1752	1660	1567	1475	1383	1291	1199	1106	1014	922	922	922	922	922	922	922	922	922	922	922	922	922	922	922	922
1943	1986	1887	1787	1688	1589	1490	1390	1291	1192	1092	993	993	993	993	993	993	993	993	993	993	993	993	993	993	993	993
1944	1700	1615	1530	1445	1360	1275	1190	1105	1020	935	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850
1945	1751	1663	1576	1488	1401	1313	1226	1138	1051	963	876	876	876	876	876	876	876	876	876	876	876	876	876	876	876	876
1946	1640	1558	1476	1394	1312	1230	1148	1066	984	902	820	820	820	820	820	820	820	820	820	820	820	820	820	820	820	820
1947	1257	1194	1131	1068	1006	943	880	817	754	691	629	629	629	629	629	629	629	629	629	629	629	629	629	629	629	629
1948	1214	1153	1093	1032	971	911	850	789	728	668	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607
1949	1458	1385	1312	1239	1166	1094	1021	948	875	802	729	729	729	729	729	729	729	729	729	729	729	729	729	729	729	729
1950	1694	1609	1525	1440	1355	1271	1186	1101	1016	932	847	847	847	847	847	847	847	847	847	847	847	847	847	847	847	847
1951	1975	1876	1778	1679	1580	1481	1383	1284	1185	1086	988	988	988	988	988	988	988	988	988	988	988	988	988	988	988	988
1952	2008	1908	1807	1707	1606	1506	1406	1305	1205	1104	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004
1953	1879	1785	1691	1597	1503	1409	1315	1221	1127	1033	940	940	940	940	940	940	940	940	940	940	940	940	940	940	940	940
1954	1755	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667
1955	1400	1330	1260	1190	1120	1050	980	910	840	770	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
1956	1833	1741	1650	1558	1466	1375	1283	1191	1100	1008	917	917	917	917	917	917	917	917	917	917	917	917	917	917	917	917
1957	1907	1812	1716	1621	1526	1430	1335	1240	1144	1049	954	954	954	954	954	954	954	954	954	954	954	954	954	954	954	954
1958	1996	1896	1796	1697	1597	1497	1397	1297	1198	1098	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998
1959	1672	1588	1505	1421	1338	1254	1170	1087	1003	920	836	836	836	836	836	836	836	836	836	836	836	836	836	836	836	836
1960	1405	1335	1265	1194	1124	1054	984	913	843	773	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703
1961	1249	1187	1124	1062	999	937	874	812	749	687	625	625	625	625	625	625	625	625	625	625	625	625	625	625	625	625
1962	1384	1315	1246	1176	1107	1038	969	900	830	761	692	692	692	692	692	692	692	692	692	692	692	692	692	692	692	692
1963	1938	1841	1744	1647	1550	1454	1357	1260	1163	1066	969	969	969	969	969	969	969	969	969	969	969	969	969	969	969	969
1964	1352	1284	1217	1149	1082	1014	946	879	811	744	676	676	676	676	676	676	676	676	676	676	676	676	676	676	676	676
1965	1826	1735	1643	1552	1461	1370	1278	1187	1096	1004	913	913	913	913	913	913	913	913	913	913	913	913	913	913	913	913
1966	1717	1631	1545	1459	1374	1288	1202	1116	1030	944	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859
1967	1973	1874	1776	1677	1578	1480	1381	1282	1184	1085	987	987	987	987	987	987	987	987	987	987	987	987	987	987	987	987
1968	1868	1775	1681	1588	1494	1401	1308	1214	1121	1027	934	934	934	934	934	934	934	934	934	934	934	934	934	934	934	934
1969	1990	1891	1791	1692	1592	1493	1393	1294	1194	1095	995	995	995	995	995	995	995	995	995	995	995	995	995	995	995	995
1970	1669	1586	1502	1419	1335	1252	1168	1085	1001	918	835	835	835	835	835	835	835	835	835	835	835	835	835	835	835	835
1971	1958	1860	1762	1664	1566	1469	1371	1273	1175	1077	979	979	979	979	979	979	979	979	979	979	979	979	979	979	979	979
1972	1568	1490	1411	1333	1254	1176	1098	1019	941	862	784	784	784	784	784	784	784	784	784	784	784	784	784	784	784	784
1973	1951	1853	1756	1658	1561	1463	1366	1268	1171	1073	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976
1974	2008	1908	1807	1707	1606	1506	1406	1305	1205	1104	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004
1975	2008	1908	1807	1707	1606	1506	1406	1305	1205	1104	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004
1976	1379	1310	1241	1172	1103	1034	965	896	827	758	690	690	690	690	690	690	690	690	690	690	690	690	690	690	690	690
1977	341	324	307	290	273	256	239	222	205	188	171	171	171	171	171	171	171	171	171	171	171	171	171	171	171	171
1978	1802	1712	1622	1532	1442	1352	1261	1171	1081	991	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901
1979	1917	1821	1725	1629	1534	1438	1342	1246	1150	1054	959	959	959	959	959	959	959	959	959	959	959	959	959	959	959	959
1980	1996	1896	1796	1697	1597	1497	1397	1297	1198	1098	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998
1981	1653	1570	1488	1405	1322	1240	1157	1074	992	909	827	827	827	827	827	827	827	827	827	827	827	827	827	827	827	827
1982	1962	1864	1766	1668	1570	1472	1373	1275	1177	1079	981	981	981	981	981	981	981	981	981	981	981	981	981	981	981	981
1983	2008	1908	1807	1707	1606	1506	1406	1305	1205	1104	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004
1984	2008	1908	1807	1707	1606	1506	1406	1305	1205	1104	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004
1985	1764	1676	1588	1499	1411	1323	1235	1147	1058	970	882	882	882	882	882	882	882	882	882	882	882	882	882	882	882	882
1986	1830	1739	1647	1556	1464	1373	1281	1190	1098	1007	915	915	915	915	915	915	915	915	915	915	915	915	915	915	915	915
1987	1069	1016	962	909	855	802	748	695	641	588	535	535	535	535	535	535	535	535	535	535	535	535	535	535	535	535
1988	948	901	853	806	758	711	664	616	569	521	474	474	474	474	474	474	474	474	474	474	474	474	474	474	474	474
1989	1086	1032	977	923	869	815	760	706	652	597	543	543	543	543	543	543	543	543	543	543	543	543	543	543	543	543
1990	985	936	887	837	788	739	690	640	591	542	493	493	493	493	493	493	493	493	493	493	493	493	493	493	493	493
1991	304	289	274	258	243	228	213	198	182	167	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152

Table D-2
Simulated SWP Supplies Under Interim Delta Improvements

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1922	0	0	0	0	0	1493	1505	1503	1502	1501	1500	1498	1497	1496	1495	1493	1443	1394	1344	1294	1244	1195	1145	1095	1045	996
1923	0	0	0	0	0	1499	1505	1505	1504	1503	1502	1502	1501	1500	1499	1499	1449	1399	1349	1299	1249	1199	1149	1099	1049	999
1924	0	0	0	0	0	557	856	823	790	756	723	690	656	623	590	557	538	519	501	482	464	445	427	408	390	371
1925	0	0	0	0	0	874	874	874	874	874	874	874	874	874	874	874	845	816	786	757	728	699	670	641	612	583
1926	0	0	0	0	0	981	958	961	963	966	968	971	973	976	978	981	948	916	883	850	818	785	752	719	687	654
1927	0	0	0	0	0	1331	1310	1312	1314	1317	1319	1322	1324	1326	1329	1331	1287	1243	1198	1154	1109	1065	1021	976	932	888
1928	0	0	0	0	0	1145	1166	1164	1161	1159	1157	1154	1152	1149	1147	1145	1106	1068	1030	992	954	916	877	839	801	763
1929	0	0	0	0	0	959	857	868	879	891	902	914	925	936	948	959	927	895	863	831	799	767	735	703	671	640
1930	0	0	0	0	0	1190	1173	1175	1176	1178	1180	1182	1184	1186	1188	1190	1150	1110	1071	1031	991	952	912	872	833	793
1931	0	0	0	0	0	482	816	779	742	705	668	631	594	557	519	482	466	450	434	418	402	386	370	354	338	322
1932	0	0	0	0	0	900	938	934	930	926	921	917	913	909	904	900	870	840	810	780	750	720	690	660	630	600
1933	0	0	0	0	0	622	665	660	655	651	646	641	636	631	627	622	601	580	560	539	518	497	477	456	435	415
1934	0	0	0	0	0	652	670	668	666	664	662	660	658	656	654	652	630	608	587	565	543	521	500	478	456	435
19[illegible]	0	0	0	0	0	1106	1124	1122	1120	1118	1116	1114	1112	1110	1108	1106	1069	1033	996	959	922	885	848	811	774	738
19[illegible]	0	0	0	0	0	1426	1397	1400	1403	1406	1410	1413	1416	1419	1423	1426	1378	1331	1283	1236	1188	1141	1093	1046	998	951
19[illegible]7	0	0	0	0	0	1325	1308	1310	1312	1314	1316	1318	1320	1322	1323	1325	1281	1237	1193	1149	1104	1060	1016	972	928	884
1938	0	0	0	0	0	1484	1481	1482	1482	1482	1482	1483	1483	1483	1483	1484	1434	1385	1335	1286	1236	1187	1137	1088	1038	989
1939	0	0	0	0	0	1085	1304	1280	1255	1231	1207	1182	1158	1134	1110	1085	1049	1013	977	941	904	868	832	796	760	724
1940	0	0	0	0	0	1179	1317	1302	1287	1271	1256	1241	1225	1210	1194	1179	1140	1100	1061	1022	983	943	904	865	825	786
1941	0	0	0	0	0	1470	1485	1483	1482	1480	1478	1477	1475	1473	1472	1470	1421	1372	1323	1274	1225	1176	1127	1078	1029	980
1942	0	0	0	0	0	1383	1494	1481	1469	1457	1445	1432	1420	1408	1395	1383	1337	1291	1245	1199	1153	1106	1060	1014	968	922
1943	0	0	0	0	0	1490	1413	1421	1430	1438	1447	1455	1464	1472	1481	1490	1440	1390	1341	1291	1241	1192	1142	1092	1043	993
1944	0	0	0	0	0	1275	1251	1253	1256	1259	1262	1264	1267	1270	1272	1275	1233	1190	1148	1105	1063	1020	978	935	893	850
1945	0	0	0	0	0	1313	1232	1241	1250	1259	1268	1277	1286	1295	1304	1313	1269	1226	1182	1138	1094	1051	1007	963	919	876
1946	0	0	0	0	0	1230	1449	1424	1400	1376	1352	1327	1303	1279	1254	1230	1189	1148	1107	1066	1025	984	943	902	861	820
1947	0	0	0	0	0	943	988	983	978	973	968	963	958	953	948	943	911	880	848	817	786	754	723	691	660	629
1948	0	0	0	0	0	911	963	957	951	946	940	934	928	922	916	911	880	850	819	789	759	728	698	668	637	607
1949	0	0	0	0	0	1094	1088	1089	1089	1090	1091	1091	1092	1092	1093	1094	1057	1021	984	948	911	875	838	802	765	729
1950	0	0	0	0	0	1271	1237	1241	1244	1248	1252	1256	1259	1263	1267	1271	1228	1186	1143	1101	1059	1016	974	932	889	847
1951	0	0	0	0	0	1481	1477	1477	1478	1478	1479	1479	1480	1480	1481	1481	1432	1383	1333	1284	1234	1185	1136	1086	1037	988
1952	0	0	0	0	0	1506	1506	1506	1506	1506	1506	1506	1506	1506	1506	1506	1456	1406	1355	1305	1255	1205	1155	1104	1054	1004
1953	0	0	0	0	0	1409	1496	1487	1477	1467	1458	1448	1438	1429	1419	1409	1362	1315	1268	1221	1174	1127	1080	1033	986	940
1954	0	0	0	0	0	1667	1462	1446	1430	1413	1397	1381	1365	1349	1332	1316	1272	1229	1185	1141	1097	1053	1009	965	921	878
1955	0	0	0	0	0	1050	1116	1109	1101	1094	1087	1079	1072	1065	1057	1050	1015	980	945	910	875	840	805	770	735	700
1956	0	0	0	0	0	1375	1408	1404	1400	1397	1393	1389	1386	1382	1378	1375	1329	1283	1237	1191	1146	1100	1054	1008	962	917
1957	0	0	0	0	0	1430	1367	1374	1381	1388	1395	1402	1409	1416	1423	1430	1383	1335	1287	1240	1192	1144	1097	1049	1001	954
1958	0	0	0	0	0	1497	1488	1489	1490	1491	1492	1493	1494	1495	1496	1497	1447	1397	1347	1297	1248	1198	1148	1098	1048	998
1959	0	0	0	0	0	1254	1326	1318	1310	1302	1294	1286	1278	1270	1262	1254	1212	1170	1129	1087	1045	1003	961	920	878	836
1960	0	0	0	0	0	1054	1069	1068	1066	1064	1062	1061	1059	1057	1055	1054	1019	984	948	913	878	843	808	773	738	703
1961	0	0	0	0	0	937	1032	1021	1011	1000	990	979	968	958	947	937	906	874	843	812	781	749	718	687	656	625
1962	0	0	0	0	0	1038	1049	1048	1047	1046	1044	1043	1042	1041	1039	1038	1003	969	934	900	865	830	796	761	727	692
1963	0	0	0	0	0	1454	1454	1454	1454	1454	1454	1454	1454	1454	1454	1454	1405	1357	1308	1260	1211	1163	1114	1066	1017	969
1964	0	0	0	0	0	1014	1212	1190	1168	1146	1124	1102	1080	1058	1036	1014	980	946	913	879	845	811	777	744	710	676
1965	0	0	0	0	0	1370	1413	1409	1404	1399	1394	1389	1384	1379	1374	1370	1324	1278	1233	1187	1141	1096	1050	1004	959	913
1966	0	0	0	0	0	1288	1373	1364	1354	1345	1335	1326	1316	1307	1297	1288	1245	1202	1159	1116	1073	1030	987	944	901	859
1967	0	0	0	0	0	1480	1489	1488	1487	1486	1485	1484	1483	1482	1481	1480	1430	1381	1332	1282	1233	1184	1134	1085	1036	987
1968	0	0	0	0	0	1401	1438	1434	1430	1426	1422	1418	1413	1409	1405	1401	1354	1308	1261	1214	1168	1121	1074	1027	981	934
1969	0	0	0	0	0	1493	1497	1497	1496	1496	1495	1495	1494	1494	1493	1493	1443	1393	1343	1294	1244	1194	1144	1095	1045	995
1970	0	0	0	0	0	1252	1247	1248	1248	1249	1249	1250	1250	1251	1251	1252	1210	1168	1127	1085	1043	1001	960	918	876	835
1971	0	0	0	0	0	1469	1473	1472	1472	[illegible]	1471	1470	1470	1469	1469	1469	1420	1371	1322	1273	1224	1175	1126	1077	1028	979
1972	0	0	0	0	0	1176	1196	1193	1191	[illegible]	1187	1185	1183	1180	1178	1176	1137	1098	1058	1019	980	941	902	862	823	784
1973	0	0	0	0	0	1463	1465	1464	1464	1464	1464	1464	1464	1464	1463	1463	1414	1366	1317	1268	1219	1171	1122	1073	1024	976
1974	0	0	0	0	0	1506	1506	1506	1506	1506	1506	1506	1506	1506	1506	1506	1456	1406	1355	1305	1255	1205	1155	1104	1054	1004
1975	0	0	0	0	0	1506	1506	1506	1506	1506	1506	1506	1506	1506	1506	1506	1456	1406	1355	1305	1255	1205	1155	1104	1054	1004
1976	0	0	0	0	0	1034	1287	1259	1231	1203	1175	1147	1119	1091	1062	1034	1000	965	931	896	862	827	793	758	724	690
1977	0	0	0	0	0	256	291	287	283	279	275	271	267	264	260	256	247	239	230	222	213	205	196	188	179	171
1978	0	0	0	0	0	1352	1352	1352	1352	1352	1352	1352	1352	1352	1352	1352	1306	1261	1216	1171	1126	1081	1036	991	946	901
1979	0	0	0	0	0	1438	1376	1383	1389	1396	1403	1410	1417	1424	1431	1438	1390	1342	1294	1246	1198	1150	1102	1054	1006	959
1980	0	0	0	0	0	1497	1489	1490	1491	1492	1493	1493	1494	1495	1496	1497	1447	1397	1347	1297	1248	1198	1148	1098	1048	998
1981	0	0	0	0	0	1240	1276	1272	1268	1264	1260	1256	1252	1248	1244	1240	1198	1157	1116	1074	1033	992	950	909	868	827
1982	0	0	0	0	0	1472	1476	1475	1475	1474	1474	1473	1473	1472	1472	1472	1422	1373	1324	1275	1226	1177	1128	1079	1030	981
1983	0	0	0	0	0	1506	1506	1506	1506	1506	1506	1506	1506	1506	1506	1506	1456	1406	1355	1305	1255	1205	1155	1104	1054	1004
1984	0	0	0	0	0	1506	1506	1506	1506	1506	1506	1506	1506	1506	1506	1506	1456	1406	1355	1305	1255	1205	1155	1104	1054	1004
1985	0	0	0	0	0	1323	1452	1438	1423	1409	1395	1380	1366	1352	1337	1323	1279	1235	1191	1147	1103	1058	1014	970	926	882
1986	0	0	0	0	0	1373	1379	1379	1378	1377	1376	1376	1375	1374	1373	1373	1327	1281	1235	1190	1144	1098	1052	1007	961	915
1987	0	0	0	0	0	802	879	871	862	854	845	836	828	819	810	802	775	748	722	695	668	641	615	588	561	535
1988	0	0	0	0	0	711	795	786	777	767	758	749	739	730	720	711	687	664	640	616	593	569	545	521	498	474
1989	0	0	0	0	0	815	927	915	902	890	877	865	852	840	827	815	787	760	733	706	679	652	624	597	570	543
1990	0	0	0	0	0	739	737	737	737	737	738	738	738	738	739	739	714	690	665	640	616	591	566	542	517	493
1991	0	0	0	0	0	228	253	250	247	245	242	239	236	234	231	228	220	213	205	198	190	182	175	167	160	152

Table D-3
Simulated SWP Supplies Under Full Delta Fix

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1922	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1923	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1285	1285	1285	1285	1285	1285	1285	1285	1285	1285	1285
1925	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1704	1704	1704	1704	1704	1704	1704	1704	1704	1704	1704
1926	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1547	1547	1547	1547	1547	1547	1547	1547	1547	1547	1547
1927	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1951	1951	1951	1951	1951	1951	1951	1951	1951	1951	1951
1928	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1675	1675	1675	1675	1675	1675	1675	1675	1675	1675	1675
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1241	1241	1241	1241	1241	1241	1241	1241	1241	1241	1241
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1503	1503	1503	1503	1503	1503	1503	1503	1503	1503	1503
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1228	1228	1228	1228	1228	1228	1228	1228	1228	1228	1228
1932	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1569	1569	1569	1569	1569	1569	1569	1569	1569	1569	1569
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1165	1165	1165	1165	1165	1165	1165	1165	1165	1165	1165
1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108
1935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1904	1904	1904	1904	1904	1904	1904	1904	1904	1904	1904
1936	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1963	1963	1963	1963	1963	1963	1963	1963	1963	1963	1963
1937	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1605	1605	1605	1605	1605	1605	1605	1605	1605	1605	1605
1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1956	1956	1956	1956	1956	1956	1956	1956	1956	1956	1956
1939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1839	1839	1839	1839	1839	1839	1839	1839	1839	1839	1839
1940	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1986	1986	1986	1986	1986	1986	1986	1986	1986	1986	1986
1941	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1942	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1943	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1944	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1757	1757	1757	1757	1757	1757	1757	1757	1757	1757	1757
1945	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1776	1776	1776	1776	1776	1776	1776	1776	1776	1776	1776
1946	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1981	1981	1981	1981	1981	1981	1981	1981	1981	1981	1981
1947	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1770	1770	1770	1770	1770	1770	1770	1770	1770	1770	1770
1948	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1977	1977	1977	1977	1977	1977	1977	1977	1977	1977	1977
1949	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1585	1585	1585	1585	1585	1585	1585	1585	1585	1585	1585
1950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1811	1811	1811	1811	1811	1811	1811	1811	1811	1811	1811
1951	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1872	1872	1872	1872	1872	1872	1872	1872	1872	1872	1872
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1851	1851	1851	1851	1851	1851	1851	1851	1851	1851	1851
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1481	1481	1481	1481	1481	1481	1481	1481	1481	1481	1481
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1491	1491	1491	1491	1491	1491	1491	1491	1491	1491	1491
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1852	1852	1852	1852	1852	1852	1852	1852	1852	1852	1852
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1996	1996	1996	1996	1996	1996	1996	1996	1996	1996	1996
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1958	1958	1958	1958	1958	1958	1958	1958	1958	1958	1958
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960
1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1777	1777	1777	1777	1777	1777	1777	1777	1777	1777	1777
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1978	1978	1978	1978	1978	1978	1978	1978	1978	1978	1978
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1812	1812	1812	1812	1812	1812	1812	1812	1812	1812	1812
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	593	593	593	593	593	593	593	593	593	593	593
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1971	1971	1971	1971	1971	1971	1971	1971	1971	1971	1971
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1709	1709	1709	1709	1709	1709	1709	1709	1709	1709	1709
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1969	1969	1969	1969	1969	1969	1969	1969	1969	1969	1969
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1530	1530	1530	1530	1530	1530	1530	1530	1530	1530	1530
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1091	1091	1091	1091	1091	1091	1091	1091	1091	1091	1091
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1172	1172	1172	1172	1172	1172	1172	1172	1172	1172	1172
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1112	1112	1112	1112	1112	1112	1112	1112	1112	1112	1112

Table D-4
Simulated SWP Supplies Under South of Delta Storage

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1922	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1923	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1814	1814	1814	1814	1814	1814
1925	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1832	1832	1832	1832	1832	1832
1926	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1701	1701	1701	1701	1701	1701
1927	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1972	1972	1972	1972	1972	1972
1928	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1598	1598	1598	1598	1598	1598
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1846	1846	1846	1846	1846	1846
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1556	1556	1556	1556	1556	1556
1932	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1757	1757	1757	1757	1757	1757
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1296	1296	1296	1296	1296	1296
1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1218	1218	1218	1218	1218	1218
1935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1886	1886	1886	1886	1886	1886
1936	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2004	2004	2004	2004	2004	2004
1937	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1940	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1941	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1942	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1943	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1944	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1945	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1946	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1947	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1948	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1949	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1951	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1971	1971	1971	1971	1971	1971
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1806	1806	1806	1806	1806	1806
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1982	1982	1982	1982	1982	1982
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1506	1506	1506	1506	1506	1506
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1942	1942	1942	1942	1942	1942
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008	2008	2008	2008	2008	2008
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1991	1991	1991	1991	1991	1991
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1701	1701	1701	1701	1701	1701
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1516	1516	1516	1516	1516	1516
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1316	1316	1316	1316	1316	1316
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1202	1202	1202	1202	1202	1202

Figure D-1
Projected SWP Supplies Assuming Top 10 Percentile of Hydrology

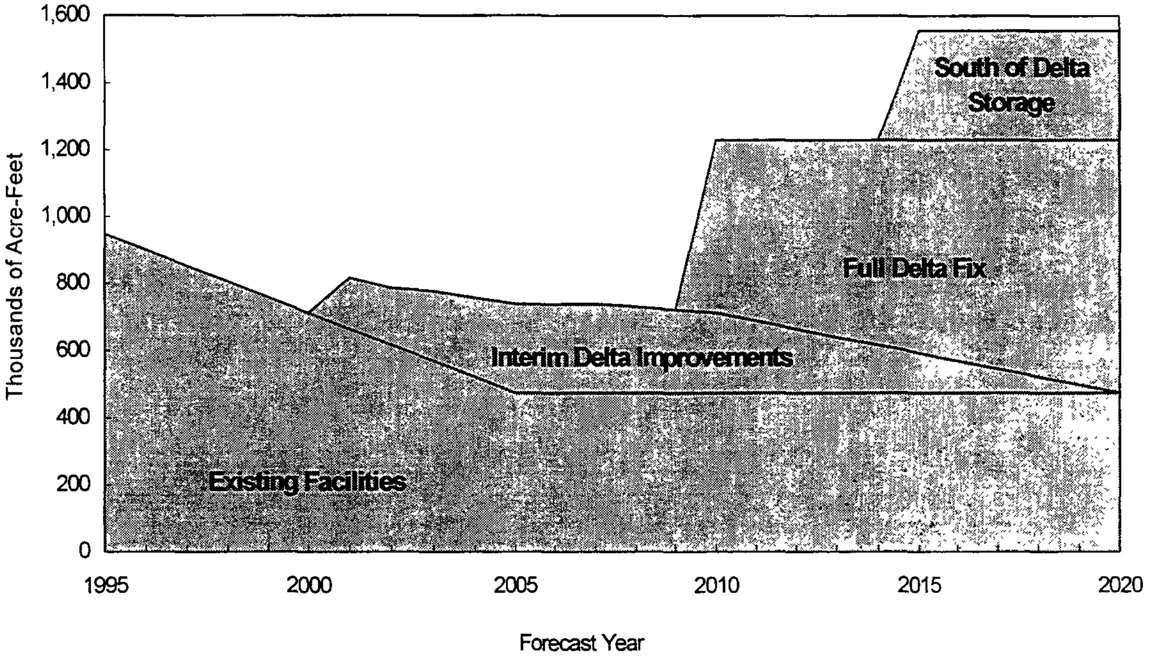


Figure D-2
Projected SWP Supplies Assuming Middle 50 Percentile of Hydrology

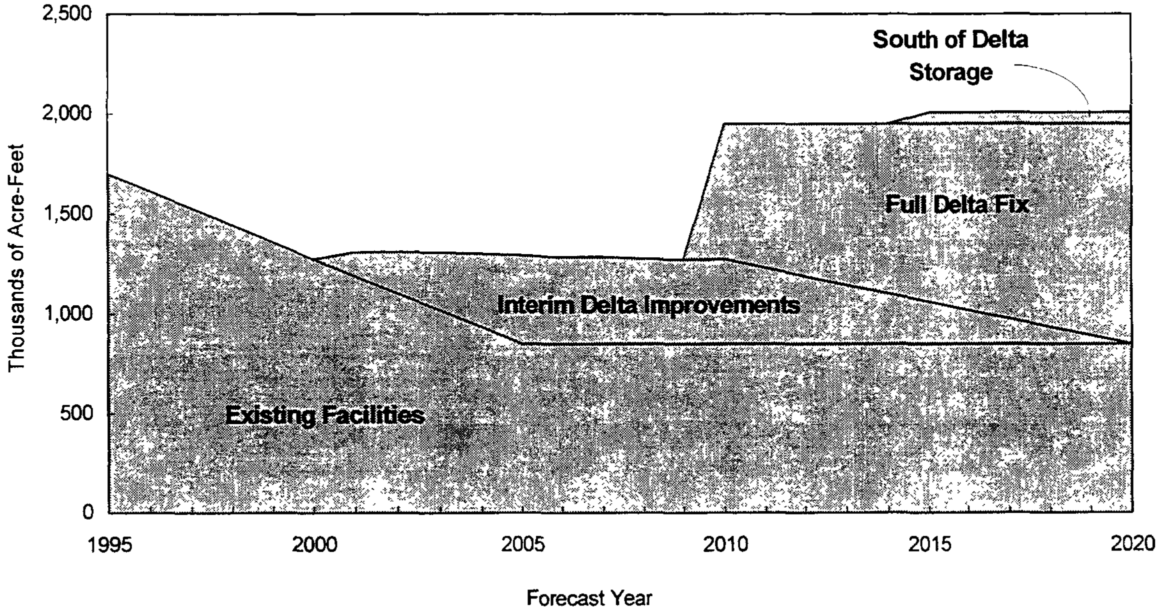
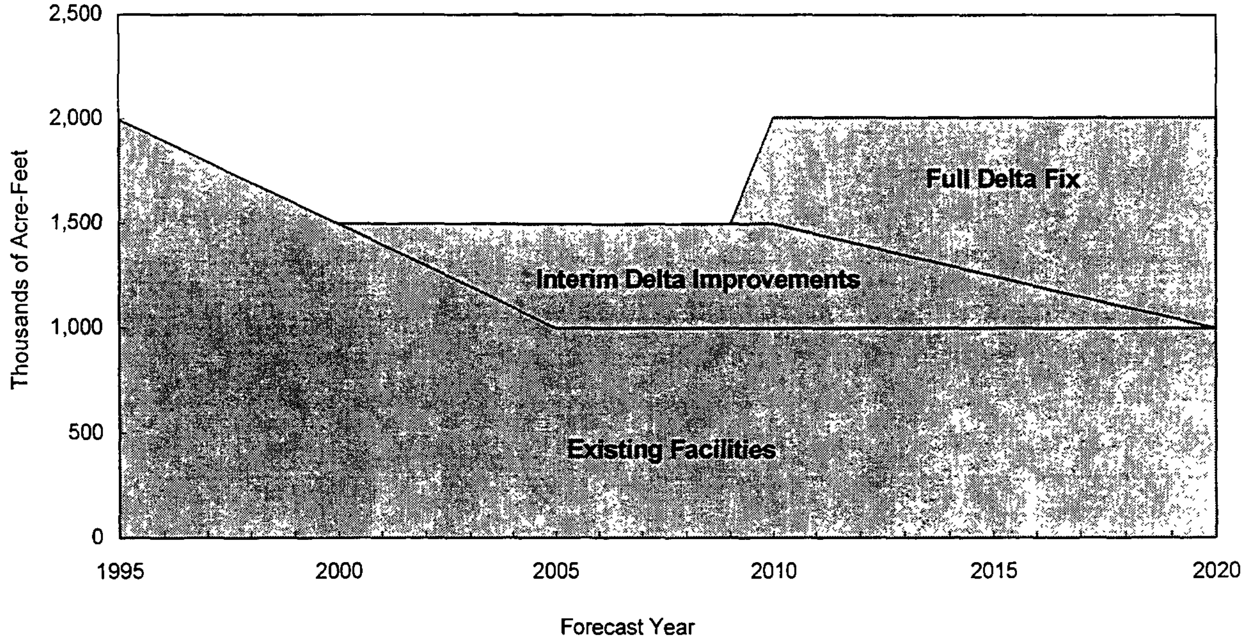


Figure D-3
Projected SWP Supplies Assuming Bottom 90 Percentile of Hydrology



SOUTHERN CALIFORNIA'S
INTEGRATED WATER RESOURCES PLAN

APPENDIX E:
MWD CAPITAL PROJECTS

Report No. 1107

January, 1996

APPENDIX E
MWD CAPITAL PROJECTS

Metropolitan's anticipated capital expenditures have been divided into two broad categories of projects to facilitate financial analyses. The first category, supply, distribution, and storage projects, includes raw water supply and treated water distribution lines, groundwater and surface water storage projects, and projects that maintain the operational reliability and efficiency of Metropolitan's existing conveyance and distribution system. The second category, water treatment projects, includes new water treatment projects to enable Metropolitan to meet existing and future water quality regulations, and upgrades, modifications, or rehabilitation projects at existing treatment facilities so these plants can continue to meet water quality regulations.

The following table summarizes estimated capital costs over 10 years, over 25 years, and shows the total program estimate (including contingencies and actual costs since project inception) for the major projects anticipated. The table reflects the first quarterly update of Metropolitan's capital improvement program. Volume 2 of the final IRP report will be revised to reflect the data contained in this appendix. Costs are escalated at five percent per year as required to reflect the appropriate fiscal year cost. Metropolitan uses the 10-year and 25-year escalated costs in determining revenue requirements and the impact the capital expenditures would have on commodity rates and indebtedness.

The supply, distribution, and storage projects category represents about 80 percent of the 10-year escalated capital costs and 76 percent of the 25-year escalated capital costs. Major projects under this category include the Eastside Reservoir Project, several groundwater conjunctive use projects, the Inland Feeder, San Diego Pipeline No. 6, the CPA Tunnel and Pipeline, the Allen-McColloch Pipeline and the South County Pipeline. Other major projects include repair or replacement of the outlet tower at Lake Mathews, a supervisory control and data acquisition system for the CRA, seismic upgrades along the CRA, the Union Station long-term headquarters and the Desalination Demonstration Project.

The water treatment projects category accounts for the remaining 20 percent of capital expenditures for the next 10 years and 24 percent of the remaining capital expenditures over the next 25 years. New major water treatment projects include the CPA Filtration Plant, the Perris Filtration Plant, the oxidation retrofit program for the five existing filtration plants, completing expansions of the Mills and Jensen filtration plants, and a second finished water reservoir at Diemer. Other major projects include the Cryptosporidium action plan, and various modifications or upgrades at the five existing filtration plants to enable these plants to continue to meet water quality regulations.

Program No	Title	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	10 Yr. CIP 95/96-04/05 Total
	SUPPLY, DISTRIBUTION, AND STORAGE PROJECTS											
5-0413-63	All Facilities - Security Systems Improvements	415.8	1,507.8	558.8	-	-	-	-	-	-	-	2,482.3
5-6070-11	All Pumping Plants - Discharge Pipelines and Pump Buildings, Seismic Modifications	3,170.2	3,321.4	988.3	-	-	-	-	-	-	-	7,479.8
5-6230-11	All Pumping Plants and Reservoirs - Install Hypochlorination	835.8	1,023.4	-	-	-	-	-	-	-	-	1,859.2
5-6890-22	Automatic Meter Reading System/Water Information System (WIN)	2,799.6	14.8	-	-	-	-	-	-	-	-	2,814.3
5-0500-61	Capital Program For Projects *Costing Less Than $250,000 For Fiscal Year 1995-96*	644.1	603.8	621.1	336.9	243.9	-	-	-	-	-	2,449.8
5-6310-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1991-92	14.6	-	-	-	-	-	-	-	-	-	14.6
5-6450-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1992-93	272.5	-	-	-	-	-	-	-	-	-	272.5
5-6610-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1993-94	605.9	-	-	-	-	-	-	-	-	-	605.9
5-6930-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1994-95	1,134.5	711.5	-	-	-	-	-	-	-	-	1,846.0
5-Z035-81	Capital Suspense Accounts	1,471.6	-	-	-	-	-	-	-	-	-	1,471.6
5-6750-11	Colorado River Aqueduct - Supervisory Control and Data Acquisition (SCADA) System	3,139.6	2,389.4	-	-	-	-	-	-	-	-	5,528.9
5-5840-43	Data and Digital Microwave Network - Communication System Upgrade	2,993.5	3,051.4	-	-	-	-	-	-	-	-	6,045.0
5-0312-42	Digital Microwave Services To Plants and Desert Facilities	336.7	347.5	-	-	-	-	-	-	-	-	684.2
5-6720-22	Distribution System - Metro Green Line Electrolysis Monitoring Stations	175.4	-	-	-	-	-	-	-	-	-	175.4
5-5770-42	Distribution System - Replacement Of Area Control Systems	3,599.8	2,874.9	2,319.7	-	-	-	-	-	-	-	8,794.4
5-6850-63	Etiwanda Cavitation Test Facility	337.0	-	-	-	-	-	-	-	-	-	337.0
5-5280-21	Etiwanda Pipeline and Control Facility	543.6	62.8	-	-	-	-	-	-	-	-	606.3
5-0601-91	Future System Reliability Projects FY 1996/97	-	8,268.8	17,364.4	9,116.3	-	-	-	-	-	-	34,749.4
5-0701-91	Future System Reliability Projects FY 1997/98	-	-	8,682.2	18,232.6	9,572.1	-	-	-	-	-	36,486.9
5-0801-91	Future System Reliability Projects FY 1998/99	-	-	-	9,116.3	19,144.2	10,050.7	-	-	-	-	38,311.2
5-0901-91	*Future System Reliability Projects FY 1999/00*	-	-	-	-	9,572.1	20,101.4	10,553.3	-	-	-	40,226.8
5-2000-91	Future System Reliability Projects FY 2000/01	-	-	-	-	-	10,050.7	21,106.5	11,080.9	-	-	42,238.1
5-2001-91	Future System Reliability Projects FY 2001/02	-	-	-	-	-	-	10,553.3	22,161.8	11,635.0	-	44,350.0
5-2002-91	Future System Reliability Projects FY 2002/03	-	-	-	-	-	-	-	11,080.9	23,269.9	12,216.7	46,567.5
5-2003-91	Future System Reliability Projects FY 2003/04	-	-	-	-	-	-	-	-	11,635.0	24,433.4	36,068.4
5-2004-91	Future System Reliability Projects FY 2004/05	-	-	-	-	-	-	-	-	-	12,216.7	12,216.7
	Future System Reliability Projects FY 2005/06	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2006/07	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2007/08	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2008/09	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2009/10	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2010/11	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2011/12	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2012/13	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2013/14	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2014/15	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2015/16	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2016/17	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2017/18	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2018/19	-	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2019/20	-	-	-	-	-	-	-	-	-	-	-
5-6400-21	Garvey Reservoir Repair	1,699.6	8,898.2	7,788.9	-	-	-	-	-	-	-	18,386.7
5-6830-11	Implementation of the Drainage Water Quality Management Plan	795.2	7,005.9	8,620.9	3,927.3	52.6	-	-	-	-	-	20,402.0
5-6340-43	Information Systems Strategic Plan - Implementation	5,052.2	2,098.9	448.1	-	-	-	-	-	-	-	7,599.2
5-6840-22	Insulating Joint Test Station	237.6	491.8	-	-	-	-	-	-	-	-	729.4
5-7110-99	Iron Mountain Rip/Rap Quarry	875.5	701.8	-	-	-	-	-	-	-	-	1,577.4
5-0001-63	La Verne Construct Office and Warehouse Storage	-	473.2	3,762.7	-	-	-	-	-	-	-	4,235.9
5-0594-63	La Verne Facilities - Mortar Lining and Gunite Coating Facil	-	127.3	305.4	219.5	225.4	213.1	-	-	-	-	1,090.7
5-6780-61	La Verne Facility Auto Repair and Utility Shop Bldg. Seismic	185.5	66.6	-	-	-	-	-	-	-	-	252.1
5-0510-11	Lake Mathews - Construct Outlet Facility	1,356.4	4,682.7	46,836.9	48,971.1	24,198.8	-	-	-	-	-	126,045.9
5-6620-11	Lake Mathews - Valves and Appurtenances, Refurbishment Progr	135.7	0.4	-	-	-	-	-	-	-	-	136.1
5-6790-53	Lake Mathews and Temescal Power Plants - Install 34.5-KV Cir	209.8	9.1	-	-	-	-	-	-	-	-	218.9
5-0408-61	Lake Mathews Auto and Heavy Equipment Shop.	-	-	461.1	1,468.5	2,068.1	434.7	-	-	-	-	4,432.4
5-0404-61	Lake Mathews Multi-Purpose Building	-	-	200.2	903.1	-	-	-	-	-	-	1,103.3
5-0405-61	Lake Mathews Warehouse and Tool Crib Extension	-	-	376.7	-	-	-	-	-	-	-	376.7
5-0143-11	Lake Perris Pumpback Improvement	491.4	-	-	-	-	-	-	-	-	-	491.4
5-6410-21	Lake Skinner - Bypass Pipeline No. 2, Screen Installation	197.5	-	-	-	-	-	-	-	-	-	197.5
5-5730-21	Lake Skinner *Facilities* - Outlet Tower and Bypass Pipelines	419.8	-	-	-	-	-	-	-	-	-	419.8
5-0104-21	Lakeview Pipeline - Airstack Installation	-	-	230.3	-	-	-	-	-	-	-	230.3
5-5160-22	Lower Feeder - Air Release	-	109.4	131.8	-	-	-	-	-	-	-	241.3
5-6490-21	Lower, Middle, and West Coast Feeders - Cathodic Protection	1,783.8	992.9	10.0	-	-	-	-	-	-	-	2,786.7
5-0108-22	Middle Feeder - Rio Hondo Pressure Control Structure - Repla	-	-	55.9	208.0	68.2	-	-	-	-	-	332.1
5-5670-43	Operations Control Center at Eagle Rock	2,398.5	-	-	-	-	-	-	-	-	-	2,398.5
5-0506-61	Record Drawing Restoration	1,149.7	1,384.1	1,316.2	1,331.6	1,329.9	-	-	-	-	-	6,511.6
5-7100-99	Retrofit 28 Manhole-Risers on the Santa Monica Feeder	323.8	-	-	-	-	-	-	-	-	-	323.8
5-7000-42	Rolm 8000 CBX Network	684.3	963.6	436.6	319.0	-	-	-	-	-	-	2,403.5
5-5970-11	San Jacinto Tunnel, West Portal - Seismic Modifications	1,531.2	342.7	-	-	-	-	-	-	-	-	1,873.9
5-6960-42	Strategic Operations and Maintenance Management System	223.6	1,301.5	186.2	-	-	-	-	-	-	-	1,711.4
5-6880-61	Union Station Long-Term Headquarters Facility	27,806.4	48,438.7	38,876.9	13,492.4	-	-	-	-	-	-	128,614.4
5-0512-43	Upgrade and Replacement of Two-Way Radio System with New Wire	141.9	794.6	76.0	-	-	-	-	-	-	-	1,012.5
	TOTAL RELIABILITY / REHABILITATION / ADMINISTRATIVE FACILITIES	**70,189.7**	**103,060.8**	**140,655.3**	**107,642.7**	**66,475.2**	**40,850.7**	**42,213.0**	**44,323.7**	**46,539.8**	**48,866.8**	**710,817.7**
5-0507-21	Allen-McColloch Pipeline Parallel (S4B/S5 Reach)	-	1,349.6	3,153.5	-	-	-	-	-	-	-	4,503.1
5-6690-21	*Allen-McColloch Pipeline Purchase*	6,108.6	-	-	-	-	-	-	-	-	-	6,108.6
5-5710-21	South (Orange) County Pipeline - Joint Participation and Purchase	142.4	-	-	-	-	-	-	-	-	-	142.4
	TREATED WATER DISTRIBUTION	**6,251.0**	**1,349.6**	**3,153.5**	-	-	-	-	-	-	-	**10,754.1**
5-5600-11	Eastside Reservoir Project	196,849.9	388,868.3	443,630.4	224,446.3	25,052.9	-	-	-	-	-	1,278,847.9
	TOTAL EASTSIDE RESERVOIR PROJECT	**196,849.9**	**388,868.3**	**443,630.4**	**224,446.3**	**25,052.9**	-	-	-	-	-	**1,278,847.9**
5-5590-11	Inland Feeder	38,213.4	74,427.6	133,466.5	218,207.4	195,576.3	149,218.9	45,281.2	-	-	-	854,391.3
	TOTAL INLAND FEEDER	**38,213.4**	**74,427.6**	**133,466.5**	**218,207.4**	**195,576.3**	**149,218.9**	**45,281.2**	-	-	-	**854,391.3**
5-5580-21	San Diego Pipeline No. 6	865.7	16,503.2	26,701.5	50,127.3	59,508.8	91,766.5	29,716.4	-	-	-	275,189.5
	TOTAL SAN DIEGO PIPELINE NO.6	**865.7**	**16,503.2**	**26,701.5**	**50,127.3**	**59,508.8**	**91,766.5**	**29,716.4**	-	-	-	**275,189.5**
5-5990-71	West Valley Area Study	19.4	-	-	-	-	-	-	-	-	-	19.4
5-0229-21	West Valley Project	-	-	-	-	-	-	-	-	-	-	-
	West Valley Interconnection	-	-	-	-	-	-	-	-	-	-	-
	TOTAL WEST VALLEY	**19.4**	-	-	-	-	-	-	-	-	-	**19.4**
5-0141-21	Central Pool Augmentation Tunnel & Pipeline	-	-	-	-	-	-	-	-	-	-	-
	Central Pool Augmentation Conveyance Extension Project	-	-	-	-	-	-	-	-	-	-	-
	TOTAL CENTRAL POOL AUGMENTATION (Supply, Distribution, & Storage Projects)	-	-	-	-	-	-	-	-	-	-	-
5-3990-11	Chino Basin Groundwater Storage Program	55.0	-	-	-	-	-	-	-	-	-	55.0
5-6580-71	Foothill Area Study	19.1	-	-	-	-	-	-	-	-	-	19.1
5-0517-11	Local Groundwater Storage Agreements	2,000.0	9,000.0	15,725.0	17,558.3	17,558.3	21,558.3	25,308.3	23,541.7	23,541.7	19,708.3	175,500.0
	TOTAL CONJUNCTIVE USE / GW STORAGE	**2,074.1**	**9,000.0**	**15,725.0**	**17,558.3**	**17,558.3**	**21,558.3**	**25,308.3**	**23,541.7**	**23,541.7**	**19,708.3**	**175,574.1**
5-5810-71	San Bernardino / Riverside Area Study	-	702.8	1,456.6	184.7	-	-	-	-	-	-	2,344.1
	TOTAL SAN BERNARDINO / RIVERSIDE AREA STUDY	-	**702.8**	**1,456.6**	**184.7**	-	-	-	-	-	-	**2,344.1**
5-6040-11	Desalination Demonstration Project	3,543.9	19,282.2	1,412.1	1,368.2	-	-	-	-	-	-	25,606.4
	TOTAL DESALINATION	**3,543.9**	**19,282.2**	**1,412.1**	**1,368.2**	-	-	-	-	-	-	**25,606.4**
	SUBTOTAL FOR SUPPLY, DISTRIBUTION, AND STORAGE PROJECTS	**318,007.2**	**613,194.5**	**766,200.3**	**619,534.9**	**364,171.6**	**303,394.5**	**142,519.0**	**67,865.3**	**70,081.5**	**68,575.2**	**3,333,544.6**

Program No	Title	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	10 Yr. CIP 95/96-04/05 Total
	WATER TREATMENT PROJECTS											
5-6270-61	All Facilities - Discharge Elimination	357.0	1,730.4	75.4	-	-	-	-	-	-	-	2,162.9
5-6030-31	All Filtration Plants and Distribution System - *Chemical Spill Containment*	9,394.4	894.7	-	-	-	-	-	-	-	-	10,289.1
5-0122-33	Diemer - Relocate Front Entrance Gate and Install Lighting, Sec Camera and Gate Control	-	-	239.4	539.7	-	-	-	-	-	-	779.0
5-6810-31	Diemer and Weymouth Install Emergency Generators	1,580.2	1,724.4	-	-	-	-	-	-	-	-	3,304.6
5-6820-31	Diemer Chemical Feed Pumps Relocation	558.4	335.6	-	-	-	-	-	-	-	-	894.0
5-6760-31	Diemer Filtration Plant - Chlorination System Modifications	1,424.9	1,109.4	-	-	-	-	-	-	-	-	2,534.2
5-0503-31	Diemer Filtration Plant - *Construct Sedimentation* Basin Spillway	827.7	2,004.1	-	-	-	-	-	-	-	-	2,831.8
5-0509-31	Diemer Filtration Plant - Domestic Water System Improvement	795.8	44.4	-	-	-	-	-	-	-	-	840.2
5-6570-31	Diemer Filtration Plant - *Mixing and Settling Basin No. 8 - North* Slope Remediation	1,105.5	251.0	-	-	-	-	-	-	-	-	1,356.5
5-0501-31	Diemer Filtration Plant - New Finished Water Reservoir	667.4	2,621.9	20,377.6	14,410.1	15,261.3	326.5	-	-	-	-	53,664.7
5-0502-61	Diemer Filtration Plant - New Maintenance Building	-	2,910.9	926.2	-	-	-	-	-	-	-	3,837.1
5-6990-11	Diemer Filtration Plant - Upgrade Flocculator Drives	330.3	-	-	-	-	-	-	-	-	-	330.3
5-5500-31	Diemer Filtration Plant Modifications and Washwater Reclamation Plant Enlargement	1,869.3	-	-	-	-	-	-	-	-	-	1,869.3
5-6640-31	Diemer Land Acquisition and Habitat Conservation Plan	2,721.9	2,668.9	-	-	-	-	-	-	-	-	5,390.8
5-0520-31	Diemer, Weymouth & Skinner Filtrations Plants - Oxidation Retrofit Program	-	8,553.9	36,275.6	22,361.1	51,557.4	106,356.5	72,392.9	9,288.1	-	-	306,785.4
5-6080-32	Filt.Plts., Distr. System, and *Colorado River* Aqueduct - Backflow Prevention Assemblies	2,837.1	3,518.8	1,679.3	440.8	462.9	484.7	508.9	533.1	559.7	587.5	11,612.8
5-6100-31	Jensen & Mills Filtration Plants - Oxidation Retrofit Program	20,002.1	58,259.3	64,143.2	23,064.6	-	-	-	-	-	-	165,469.3
5-5270-31	Jensen Filtration Plant - Expansion No. 1	10,442.0	4,496.3	469.0	-	-	-	-	-	-	-	15,407.3
5-0508-31	Jensen Filtration Plant - Repair Roof at Reservoir No 1	810.6	602.0	-	-	-	-	-	-	-	-	1,412.7
5-5820-32	Jensen Filtration Plant - Replace Filter Media	-	-	-	-	-	-	-	-	-	-	-
5-6980-32	Jensen Filtration Plant - Sludge Handling Study	302.8	-	-	-	-	-	-	-	-	-	302.8
5-6860-31	Jensen Plant - Chemical Tank Farm Modifications	147.9	-	-	-	-	-	-	-	-	-	147.9
5-0112-63	La Verne *Facilities - Construct a Utility* Shop Building	-	-	532.3	549.2	7,223.4	-	-	-	-	-	8,305.0
5-0317-61	La Verne Facilities - Electrical Service Upgrade	-	575.8	-	-	-	-	-	-	-	-	575.8
5-6550-61	La Verne Facility - Hazardous Waste Staging Area	5.8	2,011.3	-	-	-	-	-	-	-	-	2,017.1
5-5570-31	Mills Filtration Plant - Expansion No 2	28,061.6	17,017.4	1,088.0	-	-	-	-	-	-	-	46,167.0
5-0111-31	Mills Filtration Plant - Landfill	-	390.4	2,241.1	1,139.1	1,850.8	1,968.4	-	-	-	-	7,589.8
5-5610-21	San Joaquin Reservoir - Improvement	79.4	595.4	13,564.8	7,076.5	-	-	-	-	-	-	21,316.0
5-7010-11	San Joaquin Reservoir - Slope Repair (Met's Share)	244.4	249.7	-	-	-	-	-	-	-	-	494.1
5-6280-33	Skinner - Relocate Front Entrance Gate and Fencing, and Construck New Parking Lot	-	-	239.8	-	-	-	-	-	-	-	239.8
5-6110-31	Skinner Filtration Plant - Emergency Power Generating System	1,721.0	94.7	-	-	-	-	-	-	-	-	1,815.6
5-6660-31	*Skinner Filtration* Plant - Filter Media Replacement	1,185.7	4,110.1	31.4	-	-	-	-	-	-	-	5,327.2
5-0515-31	Skinner Filtration Plant - Flocculator Replacement in Modules 1 & 2	177.6	1,326.7	-	-	-	-	-	-	-	-	1,504.2
5-0304-31	Skinner *Filtration Plant - Install Effluent* Adjustable Weir	-	549.0	142.7	-	-	-	-	-	-	-	691.7
5-0410-31	Skinner Filtration Plant - Modules 4, 5, and 6 Sedimentation Basin	-	1,971.4	11,178.0	22,168.0	3,881.1	-	-	-	-	-	39,198.4
5-6510-31	Skinner Filtration *Plant Monofill*	3.1	724.5	480.5	-	-	-	-	-	-	-	1,208.0
5-6920-31	Skinner Modules 1-3 Electrical Conduit and Wireways Replace	221.8	221.9	-	-	-	-	-	-	-	-	443.8
5-0402-61	Warehouse and Storage Building *At Mills Filtration* Plant	11.1	-	1,967.1	357.3	-	-	-	-	-	-	2,335.5
5-0514-31	Water Quality - Cryptosporidium Action Plan	1,364.1	2,409.6	1,259.9	-	-	-	-	-	-	-	5,033.6
5-6590-31	Water Quality - Demonstration-Scale Testing	1,951.5	2,341.1	799.0	-	-	-	-	-	-	-	5,091.6
5-0401-61	Water Quality Lab - Inductively Coupled Plasma Mass Spectrometer	294.4	-	-	-	-	-	-	-	-	-	294.4
5-6350-63	Water Quality Laboratory Building Expansion	2,643.9	5,223.3	4,097.4	-	-	-	-	-	-	-	11,964.6
5-6910-32	*Weymouth Filtration* Plant - Sludge Handling Facility	65.1	5,109.2	-	-	-	-	-	-	-	-	5,174.3
5-6530-31	Weymouth Filtration Plant- Ferric Chloride Retrofit and Storage Augmentation	357.3	953.9	-	-	-	-	-	-	-	-	1,311.2
5-0002-32	Weymouth Replace Existing Asphalt Paving	-	134.6	773.4	-	-	-	-	-	-	-	908.0
	TOTAL WATER QUALITY AND TREATMENT (EXISTING PLANTS)	**94,663.2**	**137,736.9**	**162,581.1**	**92,106.3**	**80,236.9**	**109,136.0**	**72,901.8**	**9,821.2**	**559.7**	**587.5**	**760,229.6**
5-5560-71	Central Pool Augmentation and Water Quality Project - Study and Land Acquisition	3,507.2	19,486.9	-	-	-	-	-	-	-	-	22,994.1
5-0221-32	Central Pool Augmentation Filtration Plant	-	-	-	-	-	-	-	-	-	-	-
	Central Pool Augmentation Filtration Plant - 2nd Stage	-	-	-	-	-	-	-	-	-	-	-
	TOTAL CENTRAL POOL AUGMENTATION *(Filtration Projects)*	**3,507.2**	**19,486.9**	-	-	-	-	-	-	-	-	**22,994.1**
5-0516-31	Perris Filtration Plant	-	-	-	-	-	-	-	-	-	-	-
5-5800-71	Perris Filtration Plant - Study and Advance Land Acquisition	-	19,387.4	-	-	-	-	-	-	-	-	19,387.4
	TOTAL PERRIS FILTRATION PLANT	-	**19,387.4**	-	-	-	-	-	-	-	-	**19,387.4**
	SUBTOTAL FOR WATER TREATMENT PROJECTS	**98,070.4**	**176,610.2**	**162,581.1**	**92,106.3**	**80,236.9**	**109,136.0**	**72,901.8**	**9,821.2**	**559.7**	**587.5**	**802,611.1**
	TOTAL PROPOSED CAPITAL IMPROVEMENT PROGRAM	**416,077.6**	**789,804.7**	**928,782.0**	**711,641.3**	**444,408.5**	**412,530.5**	**215,420.8**	**77,686.5**	**70,641.2**	**69,162.7**	**4,136,155.7**

Program No	Title	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
	SUPPLY, DISTRIBUTION, AND STORAGE PROJECTS										
5-0413-63	All Facilities - Security Systems Improvements	-	-	-	-	-	-	-	-	-	-
5-6070-11	All Pumping Plants - Discharge Pipelines and Pump Buildings, Seismic Modifications	-	-	-	-	-	-	-	-	-	-
5-6230-11	All Pumping Plants and Reservoirs - Install Hypochlorination	-	-	-	-	-	-	-	-	-	-
5-6890-22	Automatic Meter Reading System/Water Information System (WIN)	-	-	-	-	-	-	-	-	-	-
5-0500-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1995-96	-	-	-	-	-	-	-	-	-	-
5-6310-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1991-92	-	-	-	-	-	-	-	-	-	-
5-6450-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1992-93	-	-	-	-	-	-	-	-	-	-
5-6610-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1993-94	-	-	-	-	-	-	-	-	-	-
5-6930-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1994-95	-	-	-	-	-	-	-	-	-	-
5-Z035-81	Capital Suspense Accounts	-	-	-	-	-	-	-	-	-	-
5-6750-11	Colorado River Aqueduct - Supervisory Control and Data Acquisition (SCADA) System	-	-	-	-	-	-	-	-	-	-
5-5840-43	Data and Digital Microwave Network - Communication System Upgrade	-	-	-	-	-	-	-	-	-	-
5-0312-42	Digital Microwave Services To Plants and Desert Facilities	-	-	-	-	-	-	-	-	-	-
5-6720-22	Distribution System - Metro Green Line Electrolysis Monitoring Stations	-	-	-	-	-	-	-	-	-	-
5-5770-42	Distribution System - Replacement Of Area Control Systems	-	-	-	-	-	-	-	-	-	-
5-6850-63	Etiwanda Cavitation Test Facility	-	-	-	-	-	-	-	-	-	-
5-5280-21	Etiwanda Pipeline and Control Facility	-	-	-	-	-	-	-	-	-	-
5-0601-91	Future System Reliability Projects FY 1996/97	-	-	-	-	-	-	-	-	-	-
5-0701-91	Future System Reliability Projects FY 1997/98	-	-	-	-	-	-	-	-	-	-
5-0801-91	Future System Reliability Projects FY 1998/99	-	-	-	-	-	-	-	-	-	-
5-0901-91	Future System Reliability Projects FY 1999/00	-	-	-	-	-	-	-	-	-	-
5-2000-91	Future System Reliability Projects FY 2000/01	-	-	-	-	-	-	-	-	-	-
5-2001-91	Future System Reliability Projects FY 2001/02	-	-	-	-	-	-	-	-	-	-
5-2002-91	Future System Reliability Projects FY 2002/03	-	-	-	-	-	-	-	-	-	-
5-2003-91	Future System Reliability Projects FY 2003/04	12,827 5	-	-	-	-	-	-	-	-	-
5-2004-91	Future System Reliability Projects FY 2004/05	25,655 1	13,468.9	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2005/06	12,827 5	26,937.8	14,142 4	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2006/07	-	13,468.9	28,284.7	14,849 5	-	-	-	-	-	-
	Future System Reliability Projects FY 2007/08	-	-	14,142.4	29,699 0	15,592.0	-	-	-	-	-
	Future System Reliability Projects FY 2008/09	-	-	-	14,849 5	31,183.9	16,371 6	-	-	-	-
	Future System Reliability Projects FY 2009/10	-	-	-	-	15,592.0	32,743 1	17,190 1	-	-	-
	Future System Reliability Projects FY 2010/11	-	-	-	-	-	16,371 6	34,380 3	18,049 6	-	-
	Future System Reliability Projects FY 2011/12	-	-	-	-	-	-	17,190 1	36,099.3	18,952 1	-
	Future System Reliability Projects FY 2012/13	-	-	-	-	-	-	-	18,049.6	37,904.3	19,899.7
	Future System Reliability Projects FY 2013/14	-	-	-	-	-	-	-	-	18,952 1	39,799.5
	Future System Reliability Projects FY 2014/15	-	-	-	-	-	-	-	-	-	19,899.7
	Future System Reliability Projects FY 2015/16	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2016/17	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2017/18	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2018/19	-	-	-	-	-	-	-	-	-	-
	Future System Reliability Projects FY 2019/20	-	-	-	-	-	-	-	-	-	-
5-6400-21	Garvey Reservoir Repair	-	-	-	-	-	-	-	-	-	-
5-6830-11	Implementation of the Drainage Water Quality Management Plan	-	-	-	-	-	-	-	-	-	-
5-6340-43	Information Systems Strategic Plan - Implementation	-	-	-	-	-	-	-	-	-	-
5-6840-22	Insulating Joint Test Station	-	-	-	-	-	-	-	-	-	-
5-7110-99	Iron Mountain Rip/Rap Quarry	-	-	-	-	-	-	-	-	-	-
5-0001-63	La Verne Construct Office and Warehouse Storage	-	-	-	-	-	-	-	-	-	-
5-0594-63	La Verne Facilities - Mortar Lining and Gunite Coating Facil	-	-	-	-	-	-	-	-	-	-
5-6780-61	La Verne Facility Auto Repair and Utility Shop Bldg. Seismic	-	-	-	-	-	-	-	-	-	-
5-0510-11	Lake Mathews - Construct Outlet Facility	-	-	-	-	-	-	-	-	-	-
5-6620-11	Lake Mathews - Valves and Appurtenances, Refurbishment Progr	-	-	-	-	-	-	-	-	-	-
5-6790-53	Lake Mathews and Temescal Power Plants - Install 34.5-KV Cir	-	-	-	-	-	-	-	-	-	-
5-0408-61	Lake Mathews Auto and Heavy Equipment Shop.	-	-	-	-	-	-	-	-	-	-
5-0404-61	Lake Mathews Multi-Purpose Building	-	-	-	-	-	-	-	-	-	-
5-0405-61	Lake Mathews Warehouse and Tool Crib Extension	-	-	-	-	-	-	-	-	-	-
5-0143-11	Lake Perris Pumpback Improvement	-	-	-	-	-	-	-	-	-	-
5-6410-21	Lake Skinner - Bypass Pipeline No. 2, Screen Installation	-	-	-	-	-	-	-	-	-	-
5-5730-21	Lake Skinner Facilities - Outlet Tower and Bypass Pipelines	-	-	-	-	-	-	-	-	-	-
5-0104-21	Lakeview Pipeline - Airstack Installation	-	-	-	-	-	-	-	-	-	-
5-5160-22	Lower Feeder - Air Release	-	-	-	-	-	-	-	-	-	-
5-6490-21	Lower, Middle, and West Coast Feeders - Cathodic Protection	-	-	-	-	-	-	-	-	-	-
5-0108-22	Middle Feeder - Rio Hondo Pressure Control Structure - Repla	-	-	-	-	-	-	-	-	-	-
5-5670-43	Operations Control Center at Eagle Rock	-	-	-	-	-	-	-	-	-	-
5-0506-61	Record Drawing Restoration	-	-	-	-	-	-	-	-	-	-
5-7100-99	Retrofit 28 Manhole-Risers on the Santa Monica Feeder	-	-	-	-	-	-	-	-	-	-
5-7000-42	Rolm 8000 CBX Network	-	-	-	-	-	-	-	-	-	-
5-5970-11	San Jacinto Tunnel, West Portal - Seismic Modifications	-	-	-	-	-	-	-	-	-	-
5-6960-42	Strategic Operations and Maintenance Management System	-	-	-	-	-	-	-	-	-	-
5-6880-61	Union Station Long-Term Headquarters Facility	-	-	-	-	-	-	-	-	-	-
5-0512-43	Upgrade and Replacement of Two-Way Radio System with New Wire	-	-	-	-	-	-	-	-	-	-
	TOTAL RELIABILITY / REHABILITATION / ADMINISTRATIVE FACILITIES	**51,310.2**	**53,875.7**	**56,569.5**	**59,397.9**	**62,367.8**	**65,486.2**	**68,760.5**	**72,198.6**	**75,808.5**	**79,598.9**
5-0507-21	Allen-McColloch Pipeline Parallel (S4B/S5 Reach)	-	-	-	-	1,014 4	2,785 0	3,813 4	23,286 1	42,675.0	-
5-6690-21	Allen-McColloch Pipeline Purchase	-	-	-	-	-	-	-	-	-	-
5-5710-21	South (Orange) County Pipeline - Joint Participation and Purchase	-	-	-	-	-	-	-	-	-	-
	TREATED WATER DISTRIBUTION	**-**	**-**	**-**	**-**	**1,014.4**	**2,785.0**	**3,813.4**	**23,286.1**	**42,675.0**	**-**
5-5600-11	Eastside Reservoir Project	-	-	-	-	-	-	-	-	-	-
	TOTAL EASTSIDE RESERVOIR PROJECT	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
5-5590-11	Inland Feeder	-	-	-	-	-	-	-	-	-	-
	TOTAL INLAND FEEDER	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
5-5580-21	San Diego Pipeline No. 6	-	-	-	-	-	-	-	-	-	-
	TOTAL SAN DIEGO PIPELINE NO.6	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
5-5990-71	West Valley Area Study	-	-	-	-	-	-	-	-	-	-
5-0229-21	West Valley Project	-	-	-	-	-	-	-	-	-	-
	West Valley Interconnection	1,628 9	6,841.4	-	-	-	-	-	-	-	-
	TOTAL WEST VALLEY	**1,628.9**	**6,841.4**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
5-0141-21	Central Pool Augmentation Tunnel & Pipeline	5,267 8	5,644 8	13,985.3	14,054.9	18,799 0	166,109 0	167,995.0	173,389 0	116,434.4	-
	Central Pool Augmentation Conveyance Extension Project	-	-	-	-	-	-	-	-	-	-
	TOTAL CENTRAL POOL AUGMENTATION (Supply, Distribution, & Storage Projects)	**5,267.8**	**5,644.8**	**13,985.3**	**14,054.9**	**18,799.0**	**166,109.0**	**167,995.0**	**173,389.0**	**116,434.4**	**-**
5-3990-11	Chino Basin Groundwater Storage Program	-	-	-	-	-	-	-	-	-	-
5-6580-71	Foothill Area Study	-	-	-	-	-	-	-	-	-	-
5-0517-11	Local Groundwater Storage Agreements	9,583 3	9,583 3	9,583 3	5,750 0	-	-	-	-	-	-
	TOTAL CONJUNCTIVE USE / GW STORAGE	**9,583.3**	**9,583.3**	**9,583.3**	**5,750.0**	**-**	**-**	**-**	**-**	**-**	**-**
5-5810-71	San Bernardino / Riverside Area Study	-	-	-	-	-	-	-	-	-	-
	TOTAL SAN BERNARDINO / RIVERSIDE AREA STUDY	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
5-6040-11	Desalination Demonstration Project	-	-	-	-	-	-	-	-	-	-
	TOTAL DESALINATION	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	SUBTOTAL FOR SUPPLY, DISTRIBUTION, AND STORAGE PROJECTS	**67,790.2**	**75,945.2**	**80,138.1**	**79,202.8**	**82,181.3**	**234,380.3**	**240,569.0**	**268,873.7**	**234,917.8**	**79,598.9**

Program No	Title	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
	WATER TREATMENT PROJECTS										
5-6270-61	All Facilities - Discharge Elimination	-	-	-	-	-	-	-	-	-	-
5-6030-31	All Filtration Plants and Distribution System - Chemical Spill Containment	-	-	-	-	-	-	-	-	-	-
5-0122-33	Diemer - Relocate Front Entrance Gate and Install Lighting, Sec Camera and Gate Control	-	-	-	-	-	-	-	-	-	-
5-6810-31	Diemer and Weymouth Install Emergency Generators	-	-	-	-	-	-	-	-	-	-
5-6820-31	Diemer Chemical Feed Pumps Relocation	-	-	-	-	-	-	-	-	-	-
5-6760-31	Diemer Filtration Plant - Chlorination System Modifications	-	-	-	-	-	-	-	-	-	-
5-0503-31	Diemer Filtration Plant - Construct Sedimentation Basin Spillway	-	-	-	-	-	-	-	-	-	-
5-0509-31	Diemer Filtration Plant - Domestic Water System Improvement	-	-	-	-	-	-	-	-	-	-
5-6570-31	Diemer Filtration Plant - Mixing and Settling Basin No. 8 - North Slope Remediation	-	-	-	-	-	-	-	-	-	-
5-0501-31	Diemer Filtration Plant - New Finished Water Reservoir	-	-	-	-	-	-	-	-	-	-
5-0502-61	Diemer Filtration Plant - New Maintenance Building	-	-	-	-	-	-	-	-	-	-
5-6990-11	Diemer Filtration Plant - Upgrade Flocculator Drives	-	-	-	-	-	-	-	-	-	-
5-5500-31	Diemer Filtration Plant Modifications and Washwater Reclamation *Plant Enlargement*	-	-	-	-	-	-	-	-	-	-
5-6640-31	Diemer Land Acquisition and Habitat Conservation Plan	-	-	-	-	-	-	-	-	-	-
5-0520-31	Diemer, Weymouth & Skinner Filtrations Plants - Oxidation Retrofit Program	-	-	-	-	-	-	-	-	-	-
5-6080-32	Filt.Plts., Distr. System, and *Colorado River Aqueduct - Backflow Prevention Assemblies*	*616 9*	646 6	642.9	-	-	-	-	-	-	-
5-6100-31	Jensen & Mills Filtration Plants - Oxidation Retrofit Program	-	-	-	-	-	-	-	-	-	-
5-5270-31	Jensen Filtration Plant - Expansion No 1	-	-	-	-	-	-	-	-	-	-
5-0508-31	Jensen Filtration Plant - Repair Roof at Reservoir No. 1	-	-	-	-	-	-	-	-	-	-
5-5820-32	Jensen Filtration Plant - Replace Filter Media	-	-	-	-	-	-	-	-	-	-
5-6980-32	Jensen Filtration Plant - Sludge Handling Study	-	-	-	-	-	-	-	-	-	-
5-6860-31	Jensen Plant - Chemical Tank Farm Modifications	-	-	-	-	-	-	-	-	-	-
5-0112-63	La Verne Facilities - Construct a Utility Shop Building	-	-	-	-	-	-	-	-	-	-
5-0317-61	La Verne Facilities - Electrical Service Upgrade	-	-	-	-	-	-	-	-	-	-
5-6550-61	La Verne Facility - Hazardous Waste Staging Area	-	-	-	-	-	-	-	-	-	-
5-5570-31	Mills Filtration Plant - Expansion No. 2	-	-	-	-	-	-	-	-	-	-
5-0111-31	Mills Filtration Plant - Landfill	-	-	-	-	-	-	-	-	-	-
5-5610-21	San Joaquin Reservoir - *Improvement*	-	-	-	-	-	-	-	-	-	-
5-7010-11	San Joaquin Reservoir - Slope Repair (Met's Share)	-	-	-	-	-	-	-	-	-	-
5-6280-33	Skinner - Relocate Front Entrance Gate and Fencing, and Construck New Parking Lot	-	-	-	-	-	-	-	-	-	-
5-6110-31	Skinner Filtration *Plant - Emergency Power* Generating System	-	-	-	-	-	-	-	-	-	-
5-6660-31	Skinner Filtration Plant - Filter Media Replacement	-	-	-	-	-	-	-	-	-	-
5-0515-31	Skinner Filtration Plant - Flocculator Replacement in Modules 1 & 2	-	-	-	-	-	-	-	-	-	-
5-0304-31	Skinner Filtration Plant - Install Effluent Adjustable Weir	-	-	-	-	-	-	-	-	-	-
5-0410-31	Skinner Filtration Plant - Modules 4, 5, and 6 Sedimentation Basin	-	-	-	-	-	-	-	-	-	-
5-6510-31	Skinner Filtration Plant Monofill	-	-	-	-	-	-	-	-	-	-
5-6920-31	Skinner Modules 1-3 Electrical Conduit and Wireways Replace	-	-	-	-	-	-	-	-	-	-
5-0402-61	Warehouse and Storage Building At Mills Filtration Plant	-	-	-	-	-	-	-	-	-	-
5-0514-31	Water Quality - Cryptosporidium Action Plan	-	-	-	-	-	-	-	-	-	-
5-6590-31	Water Quality - Demonstration-Scale Testing	-	-	-	-	-	-	-	-	-	-
5-0401-61	Water Quality Lab - Inductively Coupled Plasma Mass Spectrometer	-	-	-	-	-	-	-	-	-	-
5-6350-63	Water Quality Laboratory Building Expansion	-	-	-	-	-	-	-	-	-	-
5-6910-32	Weymouth Filtration Plant - Sludge Handling Facility	-	-	-	-	-	-	-	-	-	-
5-6530-31	Weymouth Filtration Plant- Ferric Chloride Retrofit and Storage Augmentation	-	-	-	-	-	-	-	-	-	-
5-0002-32	Weymouth Replace Existing Asphalt Paving	-	-	-	-	-	-	-	-	-	-
	TOTAL WATER QUALITY AND TREATMENT (EXISTING PLANTS)	**616.9**	**646.6**	**642.9**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
5-5560-71	Central Pool Augmentation and Water Quality Project - Study and Land Acquisition	-	-	-	-	-	-	-	-	-	-
5-0221-32	Central Pool Augmentation Filtration Plant	13,602 3	16,219 6	15,209 6	15,370.8	73,900.0	100,864 5	104,654.3	98,341.2	-	-
	Central Pool Augmentation *Filtration Plant - 2nd Stage*	-	-	-	-	-	-	-	-	-	1,797 1
	TOTAL CENTRAL POOL AUGMENTATION (Filtration Projects)	**13,602.3**	**16,219.6**	**15,209.6**	**15,370.8**	**73,900.0**	**100,864.5**	**104,654.3**	**98,341.2**	**-**	**1,797.1**
5-0516-31	*Perris Filtration Plant*	-	-	2,528 4	2,654.8	11,150.2	11,707.8	92,198.6	96,808.5	101,649 0	-
5-5800-71	Perris Filtration Plant - Study and Advance Land Acquisition	-	-	-	-	-	-	-	-	-	-
	TOTAL PERRIS FILTRATION PLANT	**-**	**-**	**2,528.4**	**2,654.8**	**11,150.2**	**11,707.8**	**92,198.6**	**96,808.5**	**101,649.0**	**-**
	SUBTOTAL FOR WATER TREATMENT PROJECTS	**14,219.2**	**16,866.2**	**18,380.9**	**18,025.6**	**85,050.3**	**112,572.2**	**196,853.0**	**195,149.8**	**101,649.0**	**1,797.1**
	TOTAL PROPOSED CAPITAL IMPROVEMENT PROGRAM	**82,009.4**	**92,811.3**	**98,519.0**	**97,228.4**	**167,231.5**	**346,952.5**	**437,422.0**	**464,023.5**	**336,566.8**	**81,396.1**

Program No	Title	2015-16	2016-17	2017-18	2018-19	2019-20	95/96-19/20 Total	Program Costs w/o Cont.	Cont.	Total Program Costs With Cont.
	SUPPLY, DISTRIBUTION, AND STORAGE PROJECTS									
5-0413-63	All Facilities - Security Systems Improvements	-	-	-	-	-	2,482.3	2,592.6	453.7	3,046.3
5-6070-11	All Pumping Plants - Discharge Pipelines and Pump Buildings, Seismic Modifications	-	-	-	-	-	7,479.8	10,793.7	2,066.6	12,860.4
5-6230-11	All Pumping Plants and Reservoirs - Install Hypochlorination	-	-	-	-	-	1,859.2	6,840.1	-	6,840.1
5-6890-22	Automatic Meter Reading System/Water Information System (WIN)	-	-	-	-	-	2,814.3	3,969.4	439.6	4,408.9
5-0500-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1995-96	-	-	-	-	-	2,449.8	2,454.0	546.0	3,000.0
5-6310-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1991-92	-	-	-	-	-	14.6	3,031.0	5.7	3,036.7
5-6450-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1992-93	-	-	-	-	-	272.6	892.5	107.5	1,000.0
5-6610-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1993-94	-	-	-	-	-	605.9	1,398.6	101.4	1,500.0
5-6930-61	Capital Program For Projects Costing Less Than $250,000 For Fiscal Year 1994-95	-	-	-	-	-	1,646.0	2,712.1	287.9	3,000.0
5-Z035-81	Capital Suspense Accounts	-	-	-	-	-	1,471.6	1,471.6	-	1,471.6
5-6750-11	Colorado River Aqueduct - Supervisory Control and Data Acquisition (SCADA) System	-	-	-	-	-	5,528.9	5,724.3	851.8	6,576.1
5-5840-43	Data and Digital Microwave Network - Communication System Upgrade	-	-	-	-	-	6,045.0	11,160.6	228.4	11,389.0
5-0312-42	Digital Microwave Services To Plants and Desert Facilities	-	-	-	-	-	684.2	684.2	-	684.2
5-6720-22	Distribution System - Metro Green Line Electrolysis Monitoring Stations	-	-	-	-	-	175.4	309.8	50.2	360.0
5-5770-42	Distribution System - Replacement Of Area Control Systems	-	-	-	-	-	8,794.4	12,615.9	1,384.1	14,000.0
5-6850-63	Etiwanda Cavitation Test Facility	-	-	-	-	-	337.0	570.3	87.2	657.5
5-5280-21	Etiwanda Pipeline and Control Facility	-	-	-	-	-	606.3	105,956.8	15,342.4	121,299.2
5-0601-91	Future System Reliability Projects FY 1996/97	-	-	-	-	-	34,749.4	34,749.4	-	34,749.4
5-0701-91	Future System Reliability Projects FY 1997/98	-	-	-	-	-	36,486.9	36,486.9	-	36,486.9
5-0801-91	Future System Reliability Projects FY 1998/99	-	-	-	-	-	38,311.2	38,311.2	-	38,311.2
5-0901-91	Future System Reliability Projects FY 1999/00	-	-	-	-	-	40,226.8	40,226.8	-	40,226.8
5-2000-91	Future System Reliability Projects FY 2000/01	-	-	-	-	-	42,238.1	42,238.1	-	42,238.1
5-2001-91	Future System Reliability Projects FY 2001/02	-	-	-	-	-	44,350.0	44,350.0	-	44,350.0
5-2002-91	Future System Reliability Projects FY 2002/03	-	-	-	-	-	46,567.5	46,567.5	-	46,567.5
5-2003-91	Future System Reliability Projects FY 2003/04	-	-	-	-	-	48,895.9	48,895.9	-	48,895.9
5-2004-91	Future System Reliability Projects FY 2004/05	-	-	-	-	-	51,340.7	51,340.7	-	51,340.7
	Future System Reliability Projects FY 2005/06	-	-	-	-	-	53,907.8	53,907.8	-	53,907.8
	Future System Reliability Projects FY 2006/07	-	-	-	-	-	56,603.1	56,603.1	-	56,603.1
	Future System Reliability Projects FY 2007/08	-	-	-	-	-	59,433.3	59,433.3	-	59,433.3
	Future System Reliability Projects FY 2008/09	-	-	-	-	-	62,405.0	62,405.0	-	62,405.0
	Future System Reliability Projects FY 2009/10	-	-	-	-	-	65,525.2	65,525.2	-	65,525.2
	Future System Reliability Projects FY 2010/11	-	-	-	-	-	68,801.5	68,801.5	-	68,801.5
	Future System Reliability Projects FY 2011/12	-	-	-	-	-	72,241.6	72,241.6	-	72,241.6
	Future System Reliability Projects FY 2012/13	-	-	-	-	-	75,853.6	75,853.6	-	75,853.6
	Future System Reliability Projects FY 2013/14	20,894.7	-	-	-	-	79,646.3	79,646.3	-	79,646.3
	Future System Reliability Projects FY 2014/15	41,789 4	21,939 5	-	-	-	83,628.6	83,628.6	-	83,628.6
	Future System Reliability Projects FY 2015/16	20,894 7	43,878.9	23,036 4	-	-	87,810.1	87,810.1	-	87,810.1
	Future System Reliability Projects FY 2016/17	-	21,939.5	46,072 9	24,188.2	-	92,200.6	92,200.6	-	92,200.6
	Future System Reliability Projects FY 2017/18	-	-	23,036 4	48,376 5	25,397 7	96,810.6	96,810.6	-	96,810.6
	Future System Reliability Projects FY 2018/19	-	-	-	24,188.2	50,795 3	74,983.6	74,983.6	-	74,983.6
	Future System Reliability Projects FY 2019/20	-	-	-	-	25,397.7	25,397.7	25,397.7	-	25,397.7
5-6400-21	Garvey Reservoir Repair	-	-	-	-	-	18,386.7	25,828.5	2,171.5	28,000.0
5-6830-11	Implementation of the Drainage Water Quality Management Plan	-	-	-	-	-	20,402.0	21,409.9	3,290.1	24,700.0
5-6340-43	Information Systems Strategic Plan - Implementation	-	-	-	-	-	7,599.2	27,210.4	-	27,210.4
5-6840-22	Insulating Joint Test Station	-	-	-	-	-	729.4	849.6	170.3	1,020.0
5-7110-99	Iron Mountain Rip/Rap Quarry	-	-	-	-	-	1,577.4	1,729.1	223.2	1,952.3
5-0001-63	La Verne Construct Office and Warehouse Storage	-	-	-	-	-	4,235.9	4,235.9	661.1	4,897.0
5-0594-63	La Verne Facilities - Mortar Lining and Gunite Coating Facil	-	-	-	-	-	1,090.7	1,112.3	108.1	1,220.3
5-6780-61	La Verne Facility Auto Repair and Utility Shop Bldg Seismic	-	-	-	-	-	252.1	426.2	83.9	510.1
5-0510-11	Lake Mathews - Construct Outlet Facility	-	-	-	-	-	126,045.9	126,228.1	18,771.9	145,000.0
5-6620-11	Lake Mathews - Valves and Appurtenances, Refurbishment Progr	-	-	-	-	-	136.1	1,284.5	2,635.4	3,919.9
5-6790-53	Lake Mathews and Temescal Power Plants - Install 34.5-KV Cir	-	-	-	-	-	218.9	300.7	86.3	387.1
5-0408-61	Lake Mathews Auto and Heavy Equipment Shop.	-	-	-	-	-	4,432.4	4,432.4	567.6	5,000.0
5-0404-61	Lake Mathews Multi-Purpose Building	-	-	-	-	-	1,103.3	1,103.3	156.7	1,260.0
5-0405-61	Lake Mathews Warehouse and Tool Crib Extension	-	-	-	-	-	376.7	376.7	8.3	385.0
5-0143-11	Lake Perris Pumpback Improvement	-	-	-	-	-	491.4	599.1	80.9	680.0
5-6410-21	Lake Skinner - Bypass Pipeline No. 2, Screen Installation	-	-	-	-	-	197.5	1,848.8	355.9	2,204.7
5-5730-21	Lake Skinner Facilities - Outlet Tower and Bypass Pipelines	-	-	-	-	-	419.8	4,004.5	395.5	4,400.0
5-0104-21	Lakeview Pipeline - Airstack Installation	-	-	-	-	-	230.3	261.9	6.7	268.6
5-5160-22	Lower Feeder - Air Release	-	-	-	-	-	241.3	473.1	75.8	549.0
5-6490-21	Lower, Middle, and West Coast Feeders - Cathodic Protection	-	-	-	-	-	2,786.7	3,730.1	569.9	4,300.0
5-0108-22	Middle Feeder - Rio Hondo Pressure Control Structure - Repla	-	-	-	-	-	332.1	340.5	40.7	381.2
5-5670-43	Operations Control Center at Eagle Rock	-	-	-	-	-	2,398.6	3,120.9	440.1	3,561.0
5-0506-61	Record Drawing Restoration	-	-	-	-	-	6,511.6	6,511.5	763.7	7,275.2
5-7100-99	Retrofit 28 Manhole-Risers on the Santa Monica Feeder	-	-	-	-	-	323.8	730.8	68.1	798.9
5-7000-42	Rolm 8000 CBX Network	-	-	-	-	-	2,403.5	2,403.6	95.8	2,499.4
5-5970-11	San Jacinto Tunnel, West Portal - Seismic Modifications	-	-	-	-	-	1,873.9	2,173.8	276.2	2,450.0
5-6960-42	Strategic Operations and Maintenance Management System	-	-	-	-	-	1,711.4	1,917.4	396.9	2,314.3
5-6880-61	Union Station Long-Term Headquarters Facility	-	-	-	-	-	128,614.4	132,215.4	2,784.5	135,000.0
5-0512-43	Upgrade and Replacement of Two-Way Radio System with New Wire	-	-	-	-	-	1,012.5	1,012.5	143.4	1,155.8
	TOTAL RELIABILITY / REHABILITATION / ADMINISTRATIVE FACILITIES	83,578.9	87,757.8	92,145.7	96,753.0	101,590.6	1,818,017.7	1,989,464.3	57,381.0	2,046,845.3
5-0507-21	Allen-McColloch Pipeline Parallel (S4B/S5 Reach)	-	-	-	-	-	78,077.1	78,077.1	-	78,077.1
5-6690-21	Allen-McColloch Pipeline Purchase	-	-	-	-	-	6,108.6	66,067.4	288.3	66,355.7
5-5710-21	South (Orange) County Pipeline - Joint Participation and Purchase	-	-	-	-	-	142.4	69,547.2	-	69,547.2
	TREATED WATER DISTRIBUTION	-	-	-	-	-	84,328.1	213,691.7	288.3	213,980.0
5-5600-11	Eastside Reservoir Project	-	-	-	-	-	1,278,847.9	1,733,457.6	238,642.4	1,972,099.9
	TOTAL EASTSIDE RESERVOIR PROJECT	-	-	-	-	-	1,278,847.9	1,733,457.6	238,642.4	1,972,099.9
5-5590-11	Inland Feeder	-	-	-	-	-	854,391.3	894,397.7	132,602.4	1,027,000.1
	TOTAL INLAND FEEDER	-	-	-	-	-	854,391.3	894,397.7	132,602.4	1,027,000.1
5-5580-21	San Diego Pipeline No. 6	-	-	-	-	-	275,189.5	282,251.2	41,748.9	324,000.0
	TOTAL SAN DIEGO PIPELINE NO.6	-	-	-	-	-	275,189.5	282,251.2	41,748.9	324,000.0
5-5990-71	West Valley Area Study	-	-	-	-	-	19.4	2,776.0	-	2,776.0
5-0229-21	West Valley Project	-	-	-	-	-	-	-	-	-
	West Valley Interconnection	-	-	-	-	-	8,470.3	8,470.3	-	8,470.3
	TOTAL WEST VALLEY	-	-	-	-	-	8,489.7	11,246.2	-	11,246.2
5-0141-21	Central Pool Augmentation Tunnel & Pipeline	-	-	-	-	-	681,679.2	681,679.2	106,304.3	787,983.5
	Central Pool Augmentation Conveyance Extension Project	2,710 3	5,691.6	5,976.2	70,593 6	74,123.2	159,094.8	159,094.8	-	159,094.8
	TOTAL CENTRAL POOL AUGMENTATION (Supply, Distribution, & Storage Projects)	2,710.3	5,691.6	5,976.2	70,593.6	74,123.2	840,774.1	840,774.1	106,304.3	947,078.3
5-3990-11	Chino Basin Groundwater Storage Program	-	-	-	-	-	55.0	4,453.3	-	4,453.3
5-6580-71	Foothill Area Study	-	-	-	-	-	19.1	203.4	-	203.4
5-0517-11	Local Groundwater Storage Agreements	-	-	-	-	-	210,000.0	210,000.0	-	210,000.0
	TOTAL CONJUNCTIVE USE / GW STORAGE	-	-	-	-	-	210,074.1	214,656.7	-	214,656.7
5-5810-71	San Bernardino / Riverside Area Study	-	-	-	-	-	2,344.1	2,395.7	-	2,395.7
	TOTAL SAN BERNARDINO / RIVERSIDE AREA STUDY	-	-	-	-	-	2,344.1	2,395.7	-	2,395.7
5-6040-11	Desalination Demonstration Project	-	-	-	-	-	25,606.4	30,279.5	4,420.5	34,700.0
	TOTAL DESALINATION	-	-	-	-	-	25,606.4	30,279.5	4,420.5	34,700.0
	SUBTOTAL FOR SUPPLY, DISTRIBUTION, AND STORAGE PROJECTS	86,289.2	93,449.4	98,121.9	167,346.6	175,713.9	5,398,062.9	6,212,614.6	581,387.6	6,794,002.3

Program No	Title	2015-16	2016-17	2017-18	2018-19	2019-20	95/96-19/20 Total	Program Costs w/o Cont.	Cont.	Total Program Costs With Cont.
	WATER TREATMENT PROJECTS									
5-6270-61	All Facilities - Discharge Elimination	-	-	-	-	-	2,162.9	2,215.1	-	2,215.1
5-6030-31	All Filtration Plants and Distribution System - Chemical Spill Containment	-	-	-	-	-	10,289.1	29,416.3	9,583.7	39,000.0
5-0122-33	Diemer - Relocate Front Entrance Gate and Install Lighting, Sec Camera and Gate Control	-	-	-	-	-	779.0	780.7	110.8	891.5
5-6810-31	Diemer and Weymouth Install Emergency Generators	-	-	-	-	-	3,304.5	3,829.4	508.0	4,337.4
5-6820-31	Diemer Chemical Feed Pumps Relocation	-	-	-	-	-	894.0	1,231.1	216.0	1,447.1
5-6760-31	Diemer Filtration Plant - Chlorination System Modifications	-	-	-	-	-	2,634.2	3,515.0	320.9	3,836.0
5-0503-31	Diemer Filtration Plant - Construct Sedimentation Basin Spillway	-	-	-	-	-	2,831.8	2,831.8	416.3	3,248.1
5-0509-31	Diemer Filtration Plant - Domestic Water System Improvement	-	-	-	-	-	840.2	873.5	131.6	1,005.1
5-6570-31	Diemer Filtration Plant - Mixing and Settling Basin No 8 - North Slope Remediation	-	-	-	-	-	1,368.5	1,812.4	178.6	1,991.0
5-0501-31	Diemer Filtration Plant - New Finished Water Reservoir	-	-	-	-	-	53,664.7	53,705.9	7,813.4	61,519.3
5-0502-61	Diemer Filtration Plant - New Maintenance Building	-	-	-	-	-	3,837.1	3,837.1	548.5	4,385.6
5-6990-11	Diemer Filtration Plant - Upgrade Flocculator Drives	-	-	-	-	-	330.3	362.2	67.8	430.0
5-5500-31	Diemer Filtration Plant Modifications and Washwater Reclamation Plant Enlargement	-	-	-	-	-	1,869.3	27,840.3	659.7	28,500.0
5-6640-31	Diemer Land Acquisition and Habitat Conservation Plan	-	-	-	-	-	5,390.8	5,660.1	-	5,660.1
5-0520-31	Diemer, Weymouth & Skinner Filtrations Plants - Oxidation Retrofit Program	-	-	-	-	-	306,785.4	306,785.4	64,966.2	371,751.6
5-6080-32	Filt.Plts , Distr. System, and Colorado River Aqueduct - Backflow Prevention Assemblies	-	-	-	-	-	13,519.1	14,625.9	2,874.1	17,500.0
5-6100-31	Jensen & Mills Filtration Plants - Oxidation Retrofit Program	-	-	-	-	-	165,469.3	176,639.7	23,360.4	200,000.1
5-5270-31	Jensen Filtration Plant - Expansion No. 1	-	-	-	-	-	15,407.3	182,754.9	2,245.1	185,000.0
5-0508-31	Jensen Filtration Plant - Repair Roof at Reservoir No. 1	-	-	-	-	-	1,412.7	1,428.9	171.1	1,600.0
5-5820-32	Jensen Filtration Plant - Replace Filter Media	-	-	-	-	-	-	778.9	-	778.9
5-6980-32	Jensen Filtration Plant - Sludge Handling Study	-	-	-	-	-	302.8	314.3	35.7	350.0
5-6860-31	Jensen Plant - Chemical Tank Farm Modifications	-	-	-	-	-	147.9	390.9	60.7	451.6
5-0112-63	La Verne Facilities - Construct a Utility Shop Building	-	-	-	-	-	8,305.0	8,305.0	1,186.4	9,491.4
5-0317-61	La Verne Facilities - Electrical Service Upgrade	-	-	-	-	-	575.8	621.8	83.5	705.3
5-6550-61	La Verne Facility - Hazardous Waste Staging Area	-	-	-	-	-	2,017.1	2,052.2	260.3	2,312.5
5-5570-31	Mills Filtration Plant - Expansion No. 2	-	-	-	-	-	46,167.0	137,394.6	22,605.4	160,000.0
5-0111-31	Mills Filtration Plant - Landfill	-	-	-	-	-	7,589.8	7,596.6	-	7,596.6
5-5610-21	San Joaquin Reservoir - Improvement	-	-	-	-	-	21,316.0	24,641.2	3,128.8	27,770.0
5-7010-11	San Joaquin Reservoir - Slope Repair (Met's Share)	-	-	-	-	-	494.1	529.1	70.9	600.0
5-6280-33	Skinner - Relocate Front Entrance Gate and Fencing, and Construck New Parking Lot	-	-	-	-	-	239.8	322.3	69.3	391.6
5-6110-31	Skinner Filtration Plant - Emergency Power Generating System	-	-	-	-	-	1,816.6	2,291.1	362.9	2,654.0
5-6660-31	Skinner Filtration Plant - Filter Media Replacement	-	-	-	-	-	5,327.2	5,491.7	1,051.5	6,543.2
5-0515-31	Skinner Filtration Plant - Flocculator Replacement in Modules 1 & 2	-	-	-	-	-	1,504.2	1,504.2	185.8	1,690.0
5-0304-31	Skinner Filtration Plant - Install Effluent Adjustable Weir	-	-	-	-	-	691.7	691.7	98.8	790.5
5-0410-31	Skinner Filtration Plant - Modules 4, 5, and 6 Sedimentation Basin	-	-	-	-	-	39,198.4	39,198.4	5,599.8	44,798.2
5-6510-31	Skinner Filtration Plant Monofill	-	-	-	-	-	1,208.0	1,810.6	176.3	1,986.9
5-6920-31	Skinner Modules 1-3 Electrical Conduit and Wireways Replace	-	-	-	-	-	443.8	704.7	57.3	762.0
5-0402-61	Warehouse and Storage Building At Mills Filtration Plant	-	-	-	-	-	2,335.5	2,362.4	237.6	2,600.0
5-0514-31	Water Quality - Cryptosporidium Action Plan	-	-	-	-	-	5,033.6	5,033.6	503.2	5,536.8
5-6590-31	Water Quality - Demonstration-Scale Testing	-	-	-	-	-	5,091.6	9,133.0	131.4	9,264.4
5-0401-61	Water Quality Lab - Inductively Coupled Plasma Mass Spectrometer	-	-	-	-	-	294.4	301.0	28.5	329.5
5-6350-63	Water Quality Laboratory Building Expansion	-	-	-	-	-	11,964.8	12,906.5	1,905.0	14,811.5
5-6910-32	Weymouth Filtration Plant - Sludge Handling Facility	-	-	-	-	-	5,174.3	5,449.1	580.9	6,030.0
5-6530-31	Weymouth Filtration Plant- Ferric Chloride Retrofit and Storage Augmentation	-	-	-	-	-	1,311.2	1,355.6	222.2	1,577.8
5-0002-32	Weymouth Replace Existing Asphalt Paving	-	-	-	-	-	908.0	917.3	266.2	1,183.5
	TOTAL WATER QUALITY AND TREATMENT (EXISTING PLANTS)	-	-	-	-	-	762,135.9	1,092,243.8	153,080.7	1,245,324.5
5-5560-71	Central Pool Augmentation and Water Quality Project - Study and Land Acquisition	-	-	-	-	-	22,994.1	40,246.4	-	40,246.4
5-0221-32	Central Pool Augmentation Filtration Plant	-	-	-	-	-	438,162.4	438,162.4	59,214.8	497,377.1
	Central Pool Augmentation Filtration Plant - 2nd Stage	3,774.0	3,962.7	31,206.2	32,766.5	34,404.8	107,911.4	107,911.4	-	107,911.4
	TOTAL CENTRAL POOL AUGMENTATION (Filtration Projects)	3,774.0	3,962.7	31,206.2	32,766.5	34,404.8	569,067.9	586,320.1	59,214.8	645,534.9
5-0516-31	Perris Filtration Plant	-	-	-	-	-	318,697.4	318,697.4	41,327.0	360,024.3
5-5800-71	Perris Filtration Plant - Study and Advance Land Acquisition	-	-	-	-	-	19,387.4	20,555.2	-	20,555.2
	TOTAL PERRIS FILTRATION PLANT	-	-	-	-	-	338,084.7	339,252.6	41,327.0	380,579.5
	SUBTOTAL FOR WATER TREATMENT PROJECTS	3,774.0	3,962.7	31,206.2	32,766.5	34,404.8	1,669,288.5	2,017,816.4	253,622.4	2,271,438.9
	TOTAL PROPOSED CAPITAL IMPROVEMENT PROGRAM	90,063.2	97,412.1	129,328.1	200,113.1	210,118.7	7,067,381.4	8,230,431.1	835,010.0	9,065,441.1

SOUTHERN CALIFORNIA'S

INTEGRATED WATER RESOURCES PLAN

APPENDIX F:

IRPSIM MODEL DESCRIPTION

Report No. 1107

January, 1996

APPENDIX F:

IRPSIM MODEL DESCRIPTION

BACKGROUND

The primary goals of the modeling for the Integrated Resources Planning process were: (1) to determine the probability of regional water supply surplus or shortage, and (2) to define resources that could contribute to meeting a regional supply reliability goal. A simulation modeling technique was chosen to accomplish these goals, because simulation is highly effective in determining the probabalistic outcomes. In addition, simulation allows for flexibility in defining the variables needed for a scenario-based analysis over a long planning horizon, and provides a mechanism for including stochastic uncertainty in forecasts of supply and demand.

Specifically, the Integrated Resources Planning Simulation Model (IRPSIM) uses a sequentially-indexed Monte Carlo simulation algorithm to simulate future supply surplus/shortage conditions using correlated hydrologic variations in regional supplies and demands. In using this type of simulation algorithm, well defined operational rules for supply and storage operations are employed to meet the objectives of the simulation. The sequentially-indexed Monte Carlo process applies historical effects of hydrology and weather to forecasts of supplies and demands, generating a distribution of projected surplus/shortage conditions. This appendix contains definitions of the variables and ratios used in IRPSIM, the objectives of the IRPSIM algorithm, a description of the simulation processes (supply and demand, and storage operations), and an example of the storage algorithm used in IRPSIM.

VARIABLES AND RATIOS

Although many individual variables are used in IRPSIM, only the ones critical for understanding its algorithm will be defined.

Demand:	The aggregate retail-level demand for water.
Supply:	The aggregate water supply from all sources, local and imported.
Surplus/Shortage:	The contemporaneous surplus or shortage of water, *Supply-Demand*, before storage puts or takes. Surpluses are represented as positives, shortages as negatives.
Storage Device:	A groundwater basin or surface reservoir.

In-Lieu Conveyance:	The ceiling on the amount of in-lieu deliveries that a groundwater basin can and/or will take. In-lieu deliveries to a storage device are made by reducing groundwater pumping below safe yield for any single time step. The reduced pumping allows the basin to fill by accumulating natural runoff or regular replenishment.
Put/Take:	The put or take from a storage device, or aggregate of all storage devices. Puts are represented as positives, takes as negatives.
Net-Surplus/ Net-Shortage:	The surplus or shortage of water after storage puts and takes. Surpluses are represented as positives, shortages as negative.
Storage Capacity:	The total space in a storage device dedicated to storing water for regional purposes. Storage capacity can be defined for an individual storage device or for the aggregate of all storage devices.
Put Conveyance:	The physical spreading and/or injection capacity of a storage device.
Take Conveyance:	The physical pump or withdrawal capacity of a storage device. (for groundwater basins, this is derived as the maximum production capacity minus groundwater production).
Storage Level:	The total amount of water stored in a storage device at a particular time step.
Remaining Storage Capacity:	The *storage capacity* minus *storage level* for a storage device. Remaining storage capacity varies with time due to changes in storage level and storage capacity.
Put Ratio:	The minimum number of time steps required to fill the *Remaining Storage Capacity* of a storage device, provided there is enough water supply to maximize *Put Conveyance*. Mathematically, this variable is equal to *Remaining Storage Capacity* divided by *Put Conveyance*.
Overlying Demand:	The aggregate water demands of Metropolitan Water District's Member Agencies, Sub-Agencies, or Retailers, minus their respective local supplies, that overlies any single groundwater basin. This variable is interpreted as the maximum potential storage take for a groundwater basin, without export of the water to another region, or as the demand for imported water within the area of service for a groundwater basin.

Modified Take Conveyance:	The maximum *take conveyance* for which there is an *overlying demand.* This variable is equal to the lesser of *take conveyance* or *overlying demand.*
Take Ratio:	The minimum number of time steps required to empty a storage device given its *Storage Level,* provided there is enough water demand from which to maximize the *Modified Take Conveyance.* Mathematically this variable is equal to *Storage Level* divided by *Take Conveyance*.

OBJECTIVES

There are four objectives for the IRPSIM algorithm: (1) meet consumptive demands for water with coincident water production, (2) minimize the amount of wasted water; (3) efficiently use storage withdrawals to alleviate shortages; and (4) prioritize storage operations to fill storage: local (Groundwater & Surface), regional, and then outside service area. The four objectives split the IRPSIM algorithm into two separate parts; the production of supply and demand (objective 1), and the operation of storage (objectives 2-4).

Objective 1 has top priority in the IRPSIM algorithm, and also determines the supply surplus / shortage conditions used by the storage algorithm. Ideally, Objectives 2-4 would not be prioritized, so that all would carry the same importance. However, Objectives 2-4 are often in competition with each other. For example, in order to minimize wasted water, surplus water should be stored so as to maximize the likelihood of having remaining put conveyance in the future. In other words, when you have a choice between two groundwater basins to store surplus water, the groundwater basin with the lowest ratio of remaining storage capacity divided by its put conveyance should be used. This metric, called the *put ratio*, can help govern storage put decisions. In particular, the *put ratio* is interpreted as the number of future time steps required to fill the remaining storage, if there is ample water. Choosing where to store surplus water by *put ratio* assures that the maximum amount of put conveyance and remaining storage capacity is available in the future. However, this ratio conflicts with the objective of storing water to maximize future storage production. To accomplish this objective, surplus water should be stored in the basin with the lowest ratio of storage level divided by its take conveyance. This metric, called the *take ratio*, is interpreted as the number of time steps required to empty a storage device. These ratios can sometimes suggest alternative storage rules depending on the objective chosen. Therefore, objectives sometimes need to be prioritized.

The IRPSIM algorithm is most easily understood when broken into two parts: (1) The generation of future supplies and demands, and (2) the routing and balancing of storage.

SUPPLY AND DEMAND GENERATION

Future supplies and demands are generated by IRPSIM using equations specified in the variable definition (VARDEF) file. The VARDEF file is IRPSIM's primary source for data inputs and provides a flexible variable language for manipulating input data. IRPSIM is not a forecasting model. It is a tool for integrating supply and demand forecasts from several sources and creating an estimation of water supply reliability. The actual forecasts of supply and demand data must come from other models. IRPSIM uses an internal algorithm to cycle the effect of historical hydrologies on both supply and demand to estimate the impacts of weather variation on supply reliability. IRPSIM is also capable of generating and applying a random error term to both supplies and demands to reflect uncertainty in forecasted data.

IRPSIM equations allow for the combination of data from several non-integrated models. In this way, IRPSIM can leverage the information from multiple data sources. For example, MWD's long-range demand forecasting model, MWD-MAIN, produces weather normal forecasts, but does not have weather effects applied to its forecasts. However, weather effects are available from MWD's short-range demand forecast tool, MWD-FORE. By combining these two data sources, IRPSIM produces a "hybrid" demand forecast consisting of long-range trends and short-range weather variability in its demand projections. In this same way, IRPSIM combines data for all supply and demand data to create aggregate demand and supply.

IRPSIM uses an innovative approach called indexed-sequential monte-carlo simulation to evaluate supplies and demands. Indexed simulation means that imported supplies from Northern California and the Colorado River are indexed to the same historical year as local demand and supplies in Southern California. This methodology preserves the contemporaneous relationships between hydrology and climate effects on supply and demand. In other words, 1933's weather impact on Northern California's hydrology is matched with 1933's weather impact on demands and local supplies in Southern California and so forth for all supplies and demands. The indexing between supply and demand is critical because of the relationship between the two. The demand for water is inversely correlated with the supply. The same factors that tend to make demand increase (hot and dry weather), also tend to decrease supply availability.

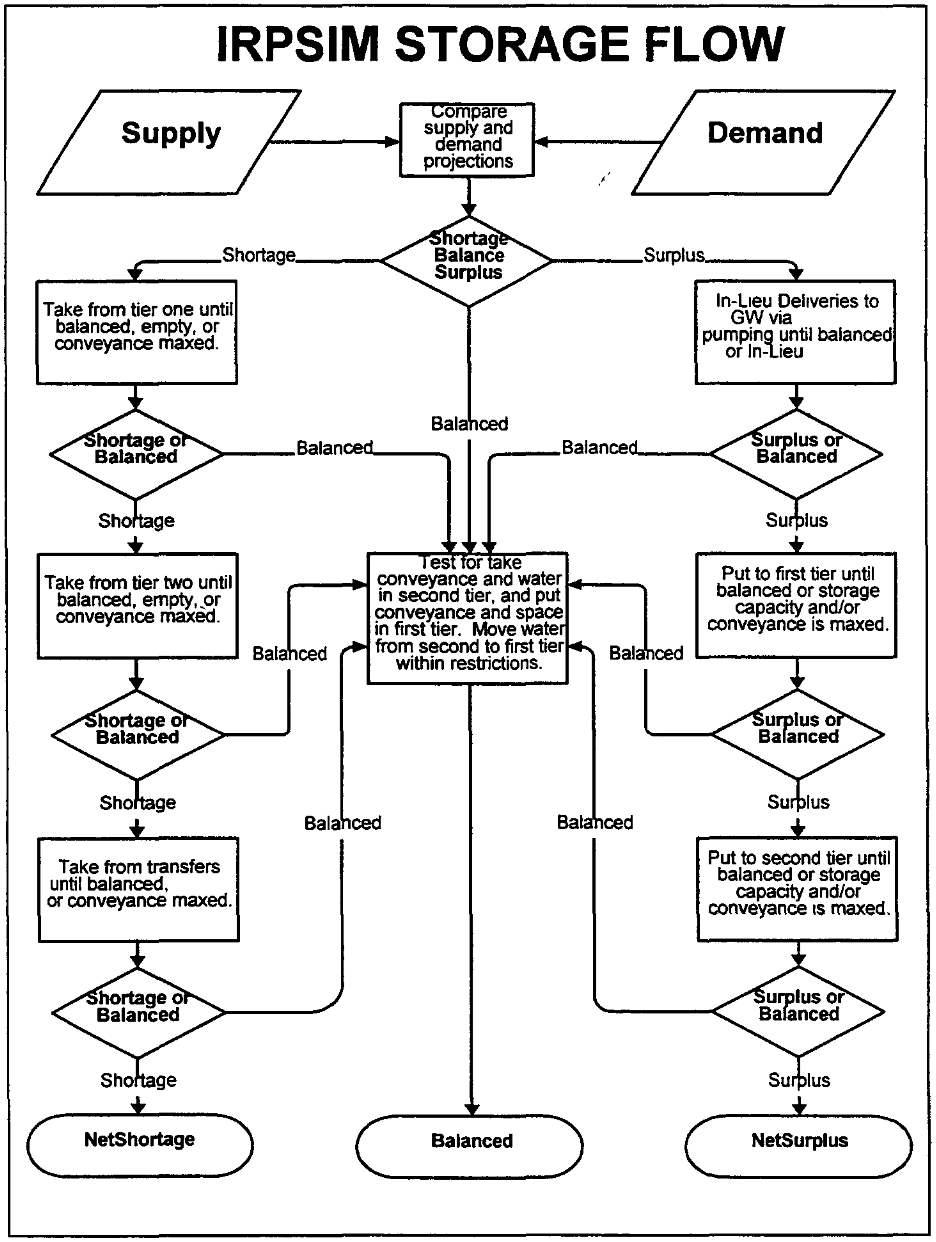
The simulation approach not only preserves the match between supply and demand, but also the sequence of years. Sequential simulation (preserving the order of the historical year's climate and hydrology) can identify the times in which demands exceed supplies and vice versa. This analysis is critical for determining storage needs. In addition, sequential simulation preserves the interrelationship of weather between years. Statistical models that are used to generate the weather effect on water demand, or hydrology effect on water supply, generally measure a multi-year effect. This means that the estimate of a weather effect on demand is based on the previous two or three year's weather. The same is true for hydrologic models of supply. Therefore, if 1987 were separated from 1984, 1985 and 1986 in the sequence, then the estimated weather or hydrology effect would not be valid.

The sequentially indexed monte-carlo method developed for IRPSIM is best described in its simplest form. Assume that water supply and demand come from independent distributions. Simply by taking a random draw from each distribution and subtracting them (supply minus demand), and repeating this hundreds of times, a distribution of shortage/surplus can be constructed. However, this simplified method is complicated by the negative correlation between supply and demand. Therefore, in order to determine supply reliability for water, matched pairs of supply and demand must be used to develop the distribution of shortage/surplus. Matching pairs of supply and demand, a low likelihood that a low demand observation gets paired with a low supply observation. IRPSIM combines the indexed-sequential simulation discussed earlier with Monte-Carlo probability analysis in order to obtain the final distribution of shortage/surplus used to estimate supply reliability. The model takes each of the unique 70 year climate/hydrology traces in the historical record (from 1922-1991) and draws about 28 different random non-weather related demands. This provides about 2,000 individual events for any specified time-step (usually monthly).

THE ROUTING AND BALANCING OF STORAGE

The basic flow rules for storage in IRPSIM are depicted in Figure F-1 below.

Figure F-1



In step one, total supply and demand are compared to determine if there is surplus or shortage. (or the unlikely outcome of exact balance). Based on this determination, water is either put to or taken from storage. If there is a surplus, water is delivered in-lieu to the groundwater basins until the surplus is depleted or until the in-lieu conveyance reaches its maximum. Any additional surplus water is put into tier one storage: groundwater basins[1], Lake Mathews, a San Diego surface reservoir, and Emergency Eastside Reservoir, up to the put conveyance or storage capacity of tier one. If surplus water remains, it is put into tier two storage: Non-Emergency Eastside Reservoir (the carryover portion). Any remaining surplus (net-surplus) is unusable in the Metropolitan Service Area, and is left as surplus on the State Water Project (or it could be used in yet undefined storage transfer facilities on the SWP). If the initial condition is shortage, then water is taken from tier one first (excluding Emergency Eastside Reservoir[2]). If shortage remains then water is taken from tier two storage. If shortages still exist then State Water Project Transfers are called. Finally, any remaining shortage (net-shortage) is true retail-level shortage and is counted against the region's reliability goal.

The linkage to the center line of the chart, the balanced path, represents an attempt to move water from Eastside Reservoir (Non-Emergency) into tier one storage. This movement of water, or storage shift, is attempted whenever there is surplus conveyance between Eastside Reservoir and tier one storage. Storage shift serves two purposes: (1) it transfers water closer to ultimate water demand off-peak, reducing the need for peak facilities; and (2) it frees up storage space in Eastside Reservoir to receive hydrologic or unexpected surpluses from the Colorado River Aqueduct or the State Water Project, reducing the overall likelihood of unused surplus water (net-surplus). In simulation, the storage shift rules allow groundwater basins to use their spreading basins in the winter for natural runoff while Eastside Reservoir fills, then receive deliveries from Eastside Reservoir in late spring or summer when there is spreading capacity available.

These gross flow rules handle a majority of the decisions for storage in IRPSIM. However, they do not address issues regarding the placement of water within a tier. For example, if there is only enough surplus to put water into a few tier one facilities, which facilities get the water? Conversely, if there is a shortage requiring storage takes from only a few tier one storage devices then which devices are used? In order to make these decisions, objectives of the storage algorithm had to be prioritized, and an optimal storage rule had to be developed[3].

As stated above, the objective of minimizing net-surplus and the objective of maximizing potential takes (which is equivalent to minimizing net-shortage), are sometimes in conflict. This conflict arises whenever a choice between tier one storage devices must be made. To fully understand this conflict, examine the following examples in which only two storage devices exist. In Example 1, shown in Table F-1, storage is balanced based on take ratios (putting and taking water from storage so that take ratios are as equal as possible across all storage devices within a tier). Balancing storage by take ratios maximizes the efficiency of future storage takes.

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[1] Metropolitan Water District to Member Agency connections, specifically designed for groundwater spreading and/or injection, allow groundwater deliveries over and above the ceiling of in-lieu deliveries. Additionally, the configuration of most Member Agencies precludes delivery of in-lieu water to portions of their retail demand, allowing a substantial remainder of groundwater conjunctive use potential to only be accessible through tier one (direct) deliveries.

[2] Emergency Eastside Reservoir never experiences a take unless a catastrophic emergency has occurred (an aqueduct severing earthquake).

[3] The Single Step Optimal Storage Rule documented below was developed for the MWD IRP process and is documented here for the first time.

By the end of six months, both storage devices have 3 months of maximum storage take available (storage level divided by modified storage take)[4]. Therefore, if three months of shortage were to occur, the storage devices would have enough water in storage and take conveyance to maximize takes. However, there is a drawback to this approach. If the next three months had large surpluses then storage device 2 would be full in 2.3 months. This would effectively

Table F-1

	Example 1					
Month	1	2	3	4	5	6
Supply	1200	1300	1200	1000	1000	1000
Demand	1000	900	1000	1100	1100	1200
Surplus/Shortage	200	400	200	-100	-100	-200
Net-Surplus/Net-Shortage	0	0	0	0	0	0
Device 1						
Storage Capacity	1000	1000	1000	1000	1000	1000
Storage Level	100	155	305	390	355	300
Remaining Storage Capacity	900	845	695	610	645	700
Put Conveyance	150	150	150	150	150	150
Take Conveyance	100	100	100	100	100	100
Overlying Demand	90	81	90	99	99	108
Modified Take Conveyance	90	81	90	99	99	100
Take Ratio	1.1	1.9	3.4	3.9	3.6	3.0
Put Ratio	6.0	5.6	4.6	4.1	4.3	4.7
Put/Take	55	150	85	-35	-55	-75
Device 2						
Storage Capacity	1200	1200	1200	1200	1200	1200
Storage Level	100	245	495	610	545	500
Remaining Storage Capacity	1100	955	705	590	655	700
Put Conveyance	300	300	300	300	300	300
Take Conveyance	250	250	250	250	250	250
Overlying Demand	140	126	140	154	154	168
Modified Take Conveyance	140	126	140	154	154	168
Take Ratio	0.7	1.9	3.5	4.0	3.5	3.0
Put Ratio	3.7	3.2	2.4	2.0	2.2	2.3
Put/Take	145	250	115	-65	-45	-125

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[4] Put and take ratio are actually beginning period variables, meaning that they are based on the actions of the previous period. Therefore, the ratio of true interest is calculated for month seven, and is not displayed in the chart. The balance that appears in month six is based on the actions of month 5.

Table F-2

	Example 2					
Month	1	2	3	4	5	6
Supply	1200	1300	1200	1000	1000	1000
Demand	1000	900	1000	1100	1100	1200
Surplus/Shortage	200	400	200	-100	-100	-200
Net-Surplus/Net-Shortage	0	0	0	0	0	0
Device 1						
Storage Capacity	1000	1000	1000	1000	1000	1000
Storage Level	100	250	400	550	550	533
Remaining Storage Capacity	900	750	600	450	450	467
Put Conveyance	150	150	150	150	150	150
Take Conveyance	100	100	100	100	100	100
Overlying Demand	90	81	90	99	99	108
Modified Take Conveyance	90	81	90	99	99	100
Take Ratio	1.1	3.1	4.4	5.6	5.6	5.3
Put Ratio	6.0	5.0	4.0	3.0	3.0	3.1
Put/Take	150	150	150	0	-17	-66
Device 2						
Storage Capacity	1200	1200	1200	1200	1200	1200
Storage Level	100	150	400	450	350	267
Remaining Storage Capacity	1100	1050	800	750	850	933
Put Conveyance	300	300	300	300	300	300
Take Conveyance	250	250	250	250	250	250
Overlying Demand	140	126	140	154	154	168
Modified Take Conveyance	140	126	140	154	154	168
Take Ratio	0.7	1.2	2.9	2.9	2.3	1.6
Put Ratio	3.7	3.5	2.7	2.5	2.8	3.1
Put/Take	50	250	50	-100	-83	-134

reduce the put conveyance of storage to that in storage device 1. The alternative, Example 2 (illustrated in Table F-2), is to balance storage by put ratios. Balancing storage by put ratios maximizes the efficiency of future storage puts. Therefore, if the next three months had large surpluses then there would be enough remaining storage capacity to maximize storage puts for all three months. The drawback of Example 2 is reflected in the take ratios. If there were three severe shortage months ahead, then device 2 would be empty in 1.6 months, effectively reducing overall take conveyance to that of device 1. The fundamental question is whether it is more important to minimize unused surplus or to minimize shortage. Since the IRP process was initiated to address supply reliability, it was decided to use the take ratio method and focus on minimizing shortage.

The take ratio rule is used at any point in the IRPSIM storage algorithm where there is less shortage than take conveyance and storage level available, or when there is less surplus than put conveyance of remaining storage capacity available. The take rule is applied whenever there is less storage shift than remaining put conveyance and remaining storage capacity in tier one. After storage has been resolved for all shortages and surpluses, there may be remaining ability for storage shift (movement of water from Eastside Reservoir to tier one storage). When this occurs, it may be necessary to prioritize this shift for tier one deliveries; if there is not enough water in storage shift from Eastside Reservoir to meet all the remaining put conveyance or remaining storage capacity in tier one.

A STORAGE EXAMPLE

The following, Table F-3, shows an example of the storage algorithm. Only three storage devices are assumed to exist: two tier one storage devices and one tier two storage device. For simplicity, no in-lieu conveyance is assumed. However, in-lieu operation can be surmised from the example. Supplies and demand are as given, and tier one is balanced using the take rule.

Table F-3

Month	1	2	3	4	5	6	7	8	9	10	11	12
Supply	1700	1700	1600	1500	1200	1100	1000	1050	1200	1300	1400	1500
Demand	900	800	1000	1100	1300	1400	1400	1300	1100	1000	900	900
Surplus/Shortage	800	900	600	400	-100	-300	-400	-250	100	300	500	600
Net-Surplus/Net-Shortage	0	100	0	0	0	0	0	0	0	0	0	0
TIER 1												
Device 1												
Storage Capacity	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Storage Level	100	250	400	550	700	725	710	710	642	722	842	992
Remaining Storage Capacity	1100	950	800	650	500	475	490	490	558	478	358	208
Put Conveyance	150	150	150	150	150	150	150	150	150	150	150	150
Take Conveyance	100	100	100	100	100	100	100	100	100	100	100	100
Overlying Demand	81	72	90	99	117	126	126	117	99	90	81	81
Modified Take Conveyance	81	72	90	99	100	100	100	100	99	90	81	81
Take Ratio	1.2	3.5	4.4	5.6	7.0	7.3	7.1	7.1	6.5	8.0	10.4	12.2
Put/Take	150	150	150	130	-60	-100	-100	-68	80	120	150	150
Storage Shift	0	0	0	20	85	85	100	0	0	0	0	0
Device 2												
Storage Capacity	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Storage Level	100	400	700	1000	1300	1425	1390	1290	1108	1128	1308	1608
Remaining Storage Capacity	1700	1400	1100	800	500	375	410	510	692	672	492	192
Put Conveyance	300	300	300	300	300	300	300	300	300	300	300	300
Take Conveyance	250	250	250	250	250	250	250	250	250	250	250	250
Overlying Demand	126	112	140	154	182	196	196	182	154	140	126	126
Modified Take Conveyance	126	112	140	154	182	196	196	182	154	140	126	126
Take Ratio	0.8	3.6	5.0	6.5	7.1	7.3	7.1	7.1	7.2	8.1	10.4	12.8
Put/Take	300	300	300	270	-40	-196	-196	-182	20	180	300	300
Storage Shift	0	0	0	30	165	161	96	0	0	0	0	0
TIER 2												
Device 1												
Storage Capacity	800	800	800	800	800	800	800	800	800	800	800	800
Storage Level	0	350	700	850	800	550	300	0	0	0	0	50
Remaining Storage Capacity	800	450	100	-50	0	250	500	800	800	800	800	750
Put Conveyance	350	350	350	350	350	350	350	350	350	350	350	350
Take Conveyance	250	250	250	250	250	250	250	250	250	250	250	250
Put/Take	350	350	150	0	0	-4	-104	0	0	0	50	150
Storage Shift	0	0	0	-50	-250	-246	-196	0	0	0	0	0

In month one, with a surplus of 800 AF, all storage is at its maximum put conveyance, and water is stored in all three devices apparently equally. Likewise in month two all put conveyance is utilized, but 100 AF is left as net-surplus. In month three it becomes apparent that tier one storage has preference for water over tier two, because its put conveyance is maximized, before tier two receives water. No balance rules have been used to this point, because there hasn't been a case when there wasn't enough water to maximize all tier one put conveyance. In month four the surplus is smaller than the combined put conveyance of tier one, so the take rule for balancing storage is applied[5]. Next, water is shifted from tier two to tier one. This is possible because the put conveyance of tier one has not been maximized by

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[5] Although the rule is named the Take Rule, it is applied during puts and takes. The rule name comes from the ratio it uses; not from when it is applied.

direct puts, and take conveyance of tier two has not been maximized by demand. Since there is enough water being shifted to maximize tier one puts (device 1: direct put of 130 AF and shift of 20 AF, and device 2: direct put of 270 AF and shift of 30 AF), storage balancing is not employed[6]. Month 5 has the first shortage month, and takes are balanced among tier one storage. The shift is balanced as well because tier one put conveyance is not maximized by the maximum tier two shift (equal to tier two's maximum take conveyance). The balancing that occurs is evidenced by the equal take ratios in month 6 (see footnote 4 above). Also in month 6, the modified take conveyance of device 2 forces a direct take from tier two. This implies that the shortage in month 6, although smaller than the overall take conveyance of tier one, was not distributed according to conveyance. Therefore, meeting this shortage solely out of tier one storage would require export facilities that are not assumed in the IRPSIM runs. Storage shift continues to keep tier one in balance until month 8, because tier two take conveyance never maximizes tier one put conveyance[7].

Although the example above is greatly simplified, having only two tier one devices and no in-lieu capabilities, it illustrates several important features of the storage algorithm. First, no water is put into tier two storage devices, unless it is unusable by tier one storage devices. Second, tier one is optimized for minimizing future shortages, using the heuristics of the take ratio rule. Third, storage is moved from tier two to tier one whenever possible. Fourth, tier one takes are restricted to meeting the demand for Metropolitan water that overlies the particular storage device.

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[6] It is also important to realize that any shift that maximizes put conveyance of tier one, negates the balancing that occurred for direct puts in that month. However, it is still necessary to balance direct puts whenever possible, because it is impossible to know a priori whether storage shift will maximize put conveyance.

[7] Following this logic it may seem impossible for a tier two storage device to ever maximize tier one storage (given the relative sizes and conveyances), but it can happen as preferred tier one storage devices fill, effectively decreasing the put conveyance of tier one.

SOUTHERN CALIFORNIA'S

INTEGRATED WATER RESOURCES PLAN

APPENDIX G:

SUPPLY RELIABILITY AND LEAST-COST PLANNING

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APPENDIX G:

SUPPLY RELIABILITY AND LEAST-COST PLANNING

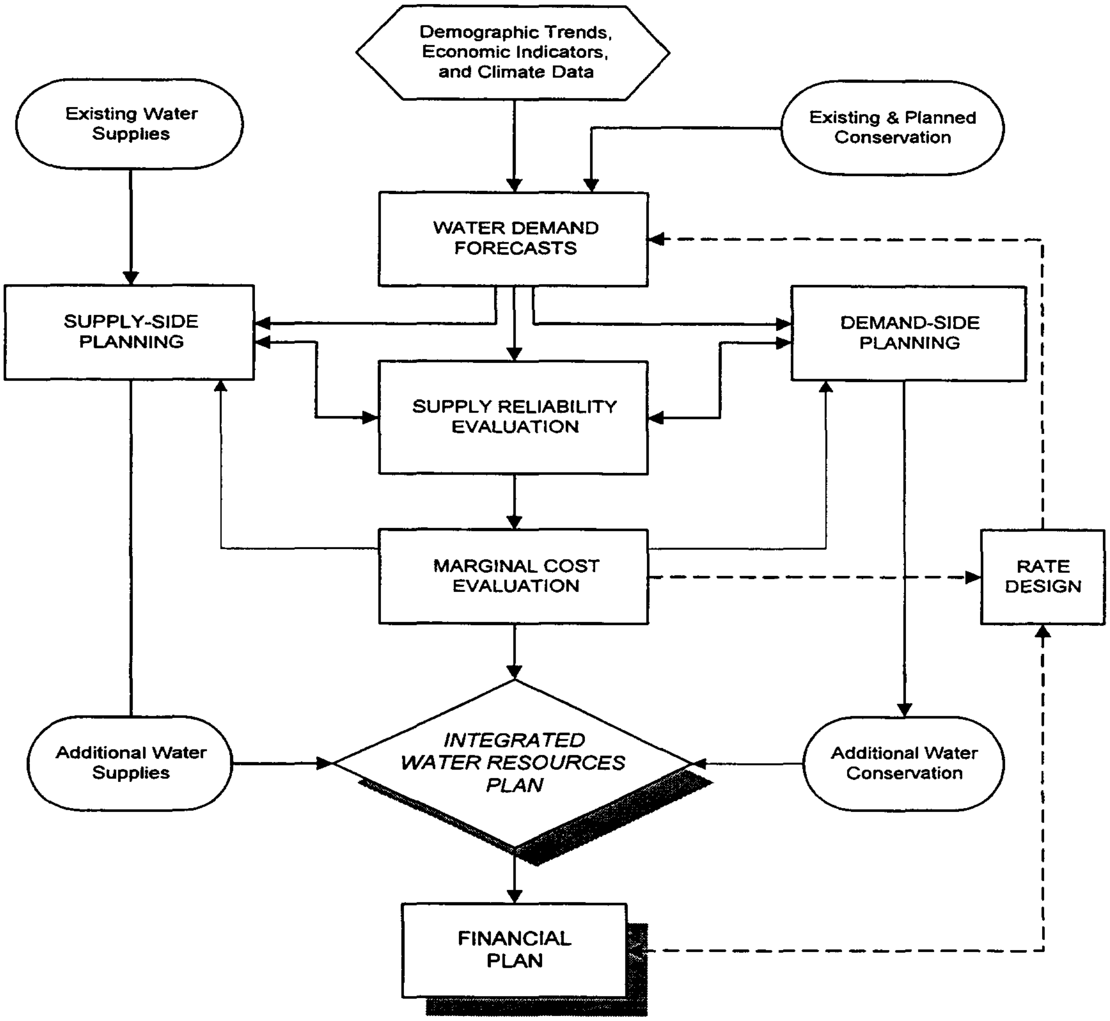
Traditionally, water supply planning has been fairly straightforward -- emphasizing the construction of supply projects such as surface reservoirs, treatment plants, wells and pipelines to meet growing demands. However, due to rising capital costs, increased environmental and water quality regulations, and attendant competition for new water supplies, different approaches to traditional supply planning must be used. These new planning approaches can be adapted from the techniques used by the power industry, such as least-cost planning (LCP) and integrated resource planning (IRP). In general, LCP is a procedure that compares the costs (resource development and environmental externalities) of traditional supply projects with demand-side management programs (conservation). Based on the principle of minimizing costs, the combination of supply options and demand-side management with the lowest overall cost should be pursued. IRP is a dynamic planning process which incorporates the basic principles of LCP, and explicitly considers other objectives such as environmental protection, sustainable growth, and the economy (Beecher, et al., 1991). Although traditional supply planning as often involved analysis of supply reliability, both LCP and IRP require detailed reliability evaluations which take into account non-traditional resources.

Even though IRP's will differ for each water utility due to the unique characteristics of its service area, there are some basic technical steps that should be followed:

1. Develop a Detailed Water Demand Forecast
2. Estimate Current and Future Water Supplies
3. Estimate the Variation in Demands and Supplies Due to Weather & Hydrology
4. Estimate the Effectiveness of Demand-Side Management
5. Estimate the Cost of Water Supplies and Demand-Side Management
6. Assess the Risk Associated with the Development of Supplies and Demand-Side Management

This technical appendix summarizes the analytical techniques used to analyze supply reliability and develop the appropriate resource targets for local and imported supplies. It details the theory and principles of supply reliability planning and least-cost planning that were used for the IRP. Figure G-1 presents a general flow chart of the technical evaluations that should be incorporated into an IRP.

Figure G-1
Technical Steps in Developing an IRP

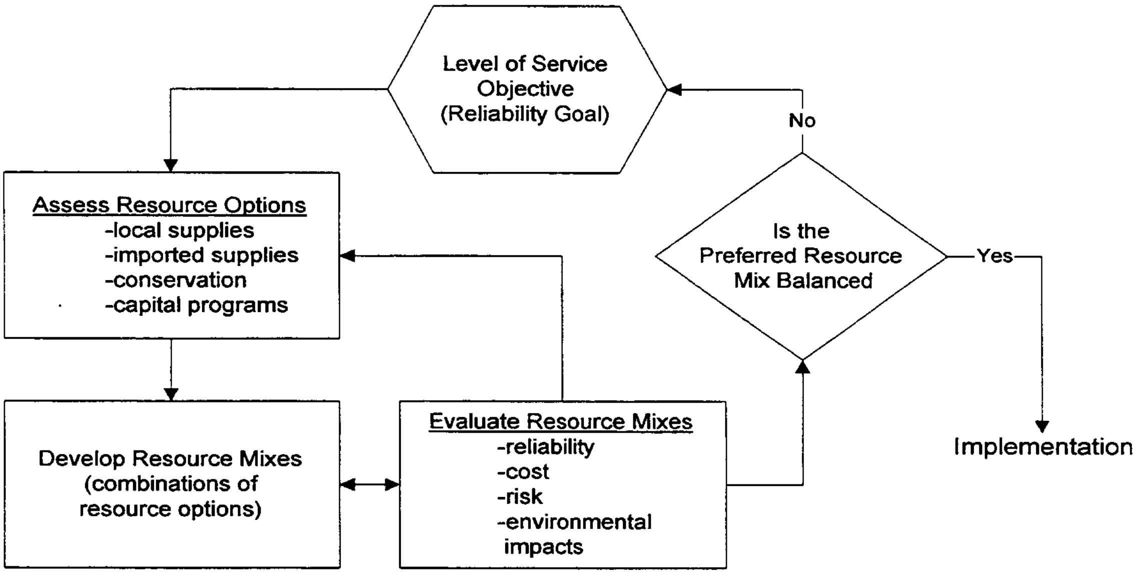


Metropolitan's IRP process started with the adoption of a water supply reliability goal, which states:

> *Through the implementation of the Integrated Resources Plan, Metropolitan and its member agencies will have the full capability to meet full serivce demands at the retail level under all foreseable hydrologic events.*

One of the major objectives of the IRP was to determine whether this goal was attainable and affordable. To determine whether the reliability goal was appropriate, a technical process was developed to analyze different resource strategies in a systematic fashion. Figure G-2 illustrates Metropolitan's IRP process. The process started with a level of service objective (reliability goal) and moved to the identification of resource options (imported supplies, local supplies, conservation, and capital improvements). After resource options were developed, combinations of these options were grouped to form resource mixes (or strategies) designed to meet the multiple objectives of the IRP. The resource mixes were then evaluated in terms of their reliability, cost and rate impacts, risk, and environmental impacts. The process allowed for some iterative movements back and forth. For example, if the selected resource mix resulted in unacceptable rate increases, then the process would return to the reliability goal for adjustment.

Figure G-2
Technical IRP Process



The discussion of supply reliability and IRP extends the technical work found in the power industry (see Wu and Gross, 1979; Booth, 1972; Hirst and Schweitzer, 1988; and Barakat & Chamberlin, 1994). However, the application of probability and simulation analyses and the rigorous evaluation of storage and other means of improving supply reliability represents an innovative and unique approach in the water industry.

NEEDS ASSESSMENT

A critical component to the assessment of supply reliability and development of an IRP is a credible and accurate water demand forecast. Much progress has been made in developing more advanced techniques for forecasting water demands. The use of econometric models that relate water use to major determinants such as housing type, family size, income, lot size, weather, and the price of water are increasing in the water industry. Metropolitan uses a customized version of the IWR-MAIN model which projects residential, commercial and industrial, and public water uses based on econometric models. Although this model does not use the simple per capita water use approach to demand forecasting (multiplying population by an assumed per person water usage factor), the resulting output explains why per capita water use increases or decreases over time. This ability to explain the effects that several factors have on demand is one of the strongest attributes of the IWR-MAIN model.

The model indicates that about 66 percent of the region's future urban water use will be in the residential sector, 17 percent in the commercial sector, 6 percent in the industrial sector, and the remaining 11 percent in public and other uses. Figure G-3 summarizes the resulting urban per capita water use estimates that were derived from the model. The model was also used to "backcast" demands in order to explain fluctuations in historical per capita use. For example, the large decreases in per capita use in 1977 and 1993 were both caused by drought conservation, economic recession, and wet/cool weather. The decrease in 1983 was due to extreme wet/cool weather. The model projects that normal-weather per capita use (without conservation) would increase in the future due to: (1) more families moving to the hotter and drier climate zones of the service area; (2) a greater standard of living due to a modest increase in income; and (3) employment growth in commercial sectors that use more seasonal water (Planning and Management Consultants Ltd., 1991). Based on the projected effectiveness of water conservation programs, it is anticipated that daily per capita use could be held down to a level of about 195 gallons.

Figure G-3

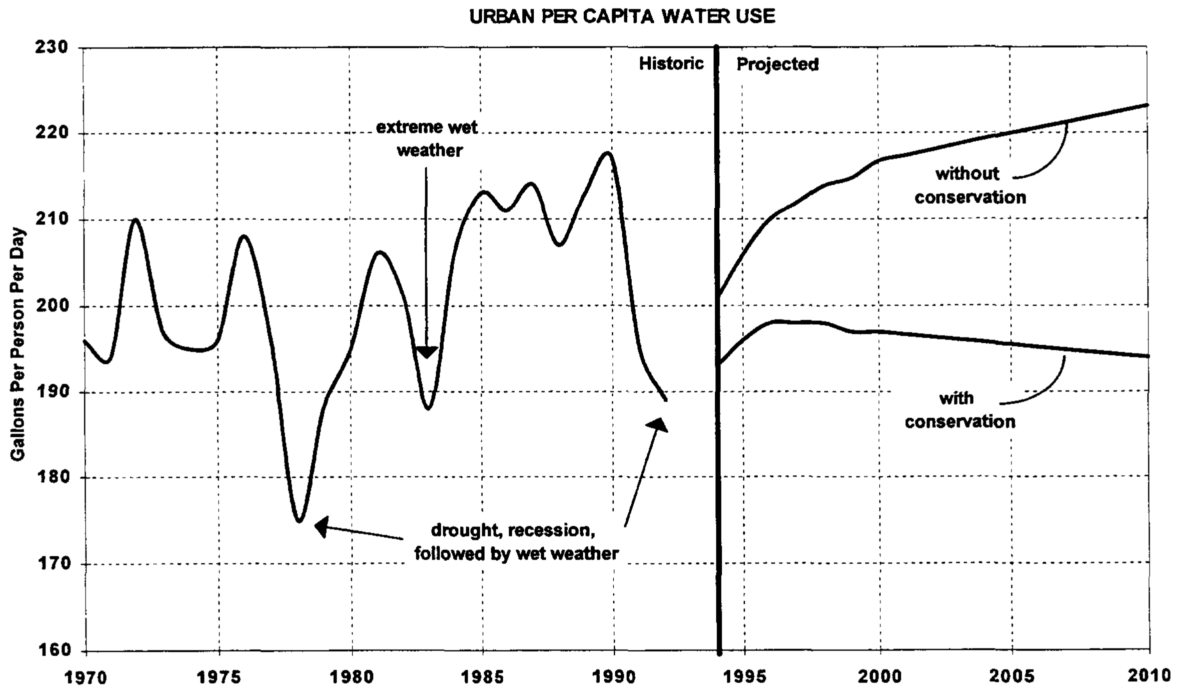
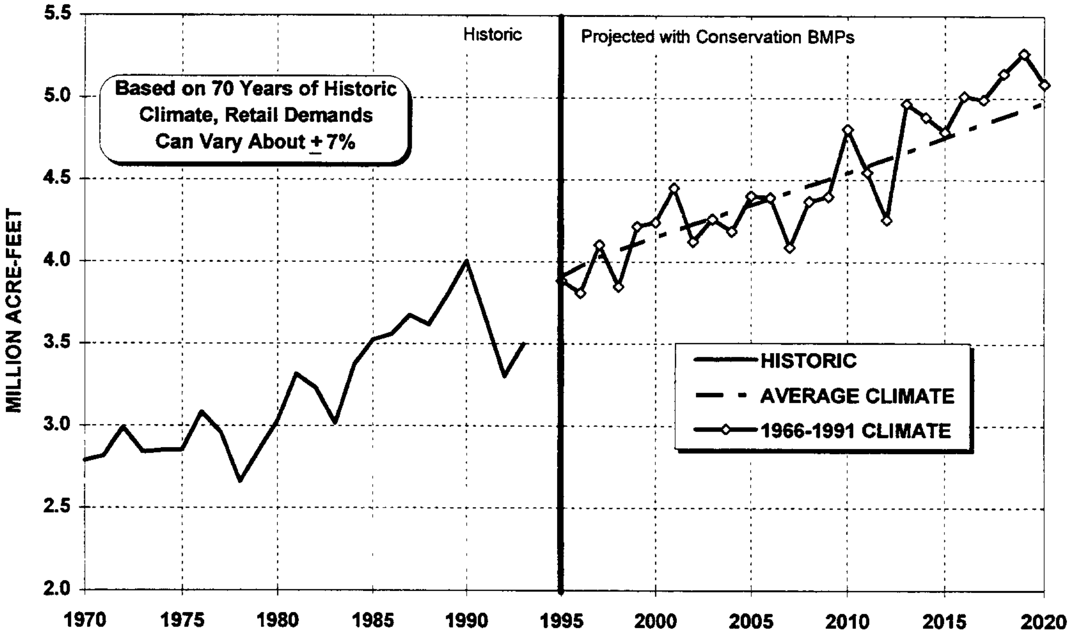


Figure G-4 presents the water demand projections in acre-feet per year, assuming the full implementation of conservation programs. The demand projections are first developed assuming normal weather. However, in order to estimate supply reliability, variations in future demands due to temperature and rainfall must be developed. To illustrate this variation, a climate trace from 1967 to 1991 was superimposed over the future demand projection. Wet and cool weather would result in lower-than-normal demands, while dry and hot weather would result in greater-than-normal demands. In the historic climate sequence, 1983 (a record wet year) falls on the projection year 2012 -- indicated by the lower-than-average projected demand. The recent six year drought (1986 to 1991) falls on the projection years 2014 to 2020 -- indicated by the greater-than-average projected demands. Based on 70 different historic climate sequences occurring in any given forecast year, the variation due to weather has been estimated to be about ± 7 percent at the 95 percent confidence level.

Figure G-4

RETAIL WATER DEMAND PROJECTIONS



In addition to the variations in water demands due to weather, the uncertainty in future demands due to demographic changes, economic growth and forecast error were also included in the reliability analysis. These uncertainties can add another ± 5 percent to the variation in future demands by the year 2020.

RESOURCE ALTERNATIVES

Based on the demand projections and assessment of existing firm water supplies available to the region during a drought, reliability evaluations indicated that about 2.2 million acre-feet of additional water supplies were needed to avoid water shortages that could occur at least 10 percent of the time. The possible local resource alternatives that could be used to meet the anticipated shortfall in supplies include: (1) increasing local groundwater production by storing excess imported water (available during wet and normal weather years) in underground aquifers, and pumping greater amounts of groundwater during dry years -- known as conjunctive use storage; (2) recovering contaminated brackish groundwater by desalination techniques -- thereby increasing production; and (3) developing reclamation projects that treat wastewater to high quality standards -- such that the water can be used for irrigation, groundwater recharge, and direct industrial uses. Moderate investments in local resource alternatives could produce 0.67 million acre-feet per year of additional supplies by 2020, while large investments could produce 1.10 million acre-feet per year of additional supplies by 2020.

In addition to the local resource options, the IRP identified several imported supply options that could be developed. These imported supply options include: (1) increasing firm supplies from the Colorado River; (2) enhancing supplies from the State Water Project; and (3) voluntary water transfers between willing sellers and buyers. About 1.2 million acre-feet of additional imported supplies could be developed by 2020 with moderate investments, while an additional 2.3 million acre-feet could be developed with large investments.

The IRP also assumed the implementation of long-term water conservation programs which are expected to permanently lower the demand for water into the future. These long-term programs were designed to minimize negative impacts to lifestyle. About 250,000 acre-feet of additional conservation is estimated to occur by year 2000 as a result of plumbing codes and landscape ordinances as well as programmatic demand-side management. By year 2020, it is expected that over 500,000 acre-feet of demand reduction will occur. These estimated savings were based on econometric studies, surveys, plumbing codes, and other studies.

RESOURCE EVALUATIONS

The next step in the IRP process was the grouping of local and imported resource alternatives into resource mixes. The resource mixes were developed and evaluated based on five major objectives:

1. Supply Reliability -- resource alternatives should be grouped such that, when combined, they achieve the desired reliability goal.

2. Cost -- resource alternatives which have the lowest overall unit costs (dollars per acre-foot) should be selected before more expensive options are developed.

3. Water Quality -- impacts to overall water quality need to be considered when selecting the resource alternatives.

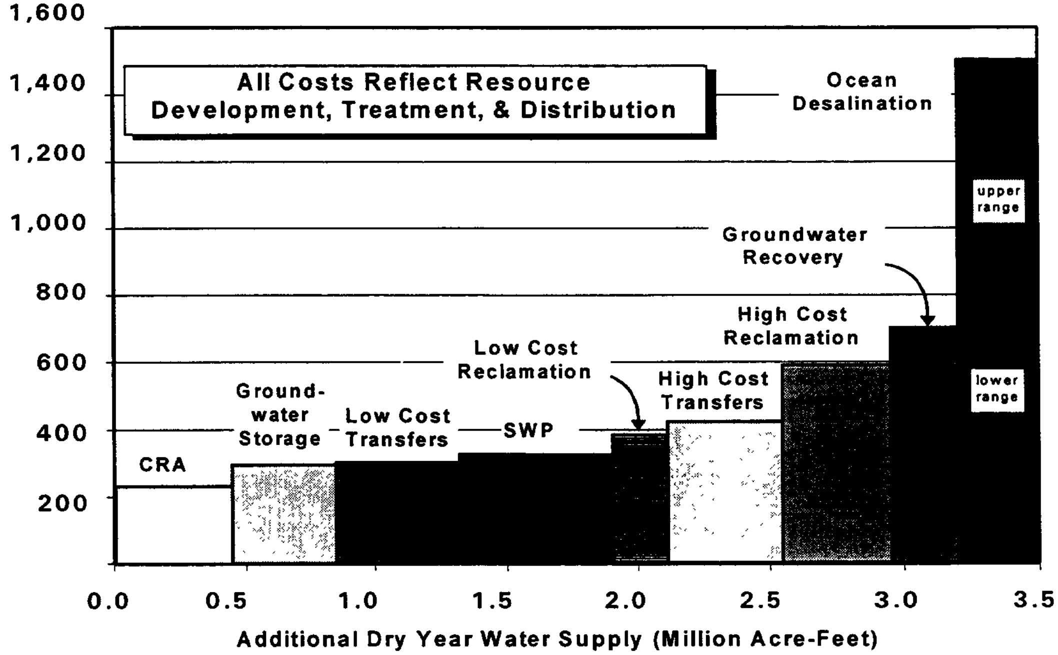
4. Flexibility and Diversity -- resource alternatives should be diversified in order to minimize the risks and uncertainties associated with developing the supply or conservation programs.

5. Institutional/Environmental -- institutional and environmental barriers or constraints to resource development should be considered.

Least-Cost Planning

Cost evaluations were based on estimated total project costs (capital and O&M) over the expected life of the project. The costs included developing and acquiring resources, capital investments, and operational and maintenance (O&M) costs for treating, storing, and distributing the supply. Capital costs were assumed to be financed at about 6 percent and future costs were inflated using a 3 to 4 percent annual escalation rate. Constraints were put on the available supply yield from these resource alternatives based on a risk assessment and incorporation of institutional/environmental constraints. The risk assessment and incorporation of institutional and environmental considerations were conducted over a one year period, during which water managers and resource experts were surveyed regarding the likelihood of success of resource development, the potential barriers to development, and means to overcome the barriers. Figure G-5 presents a summary of the unit cost and supply constraints that were used in the evaluations of the resource alternatives.

Figure G-5
UNIT COSTS OF RESOURCE OPTIONS ($/ACRE-FOOT)



The graph illustrates that about 3.5 million acre-feet of dry year water supply could be developed over the next 25 years. The resource alternatives are ranked by unit costs (dollars per acre-foot). Unit costs were estimated by taking the capital and O&M costs needed to develop the resources, divided by the anticipated water supply yield over the 25 year planning period. Generally, those resources with the lowest overall unit cost were selected first. However, water quality played an important role in the selection as well. For example, relying on imported water that is not sufficiently blended between Colorado River water (high in salinity content) and State Water Project or water transfers (low in salinity content) could prohibit the development of local resources (reclamation and groundwater storage). This is due to local groundwater basin water quality standards, and the fact that water high in salinity recycled through reclamation plants will result in extremely low quality water.

Storage Evaluation and Simulation

One of the major differences between the power and water industries is the ability to store water during times of excess (when supplies exceed demand) and to withdraw the water during times of need (when demands exceed supplies). Storage is critical to regions such as Southern California, which sometimes receive heavy rains and snowpack during wet years, yet may go many years between such events. In addition to providing drought benefits, storage also mitigates against catastrophic events such as earthquakes. All of the major imported water supply conveyance systems to Southern California cross the San Andreas Fault, where a major quake is long overdue. But, high costs and potential environmental impacts pose serious problems to developing large surface reservoirs. During the IRP, it became apparent that storing imported water in the large aquifers of the major groundwater basins in Southern California could help achieve the region's storage requirements. To evaluate the benefits of increased storage, a computer model called IRPSIM was developed that accounted for the availability of excess imported supplies, the total storage, the maximum monthly storage (putting water into storage) conveyance, and the maximum monthly withdraw (taking water from storage) conveyance.

An innovative approach called indexed-sequential simulation was used to evaluate the benefits and costs of storage. Indexed simulation means that imported supplies from Northern California and the Colorado River are indexed to the same year as local demand and supplies in Southern California. This methodology preserves the contemporaneous relationships between the hydrology and climate effects on supply and demand. In other words, 1933's weather impact on Northern California's hydrology is matched with 1933's weather impact on demands and local supplies in Southern California and so forth. This indexing between supply and demand is critical because of the relationship between the two. This relationship between supply and demand is another major difference between the power and water industries. Power demands are not necessarily correlated with the variation and uncertainties in power supplies. Outages in power can occur during times of low demand or high demand. Therefore, probability analysis of supply and demand for power reliability can generally be independent of each other. The demand for water, however, is generally correlated with the supply. The same factors that make demand increase (hot and dry weather), also tend to decrease supply availability.

The simulation approach not only preserves the match between supply and demand, but also the sequence of years. Sequential simulation (preserving the order of the historical year's climate and hydrology) can identify the times in which demands exceed supplies and vice versa. This analysis is critical for determining storage needs. In addition, sequential simulation preserves the interrelationship of weather between years. Statistical models that are generally used to generate the weather effect on water demand, or hydrology effect on water supply, measure a multi-year effect. This means that the estimate of 1987's weather effect on demand is, based on the previous two or three year's weather. The same is true for hydrologic models of supply.

Therefore, if 1987 were separated from 1984, 1985 and 1986 in the sequence, then the weather or hydrology effect estimated would not be valid.

Figure G-6 presents a simplified example of an indexed-sequential simulation, where 1967 to 1991 historical weather is mapped over a 1995 to 2020 projection of supplies and demand. The example summarizes the data into annual demands and supplies, and indicates the years in which shortages and surplus exist.

Figure G-6

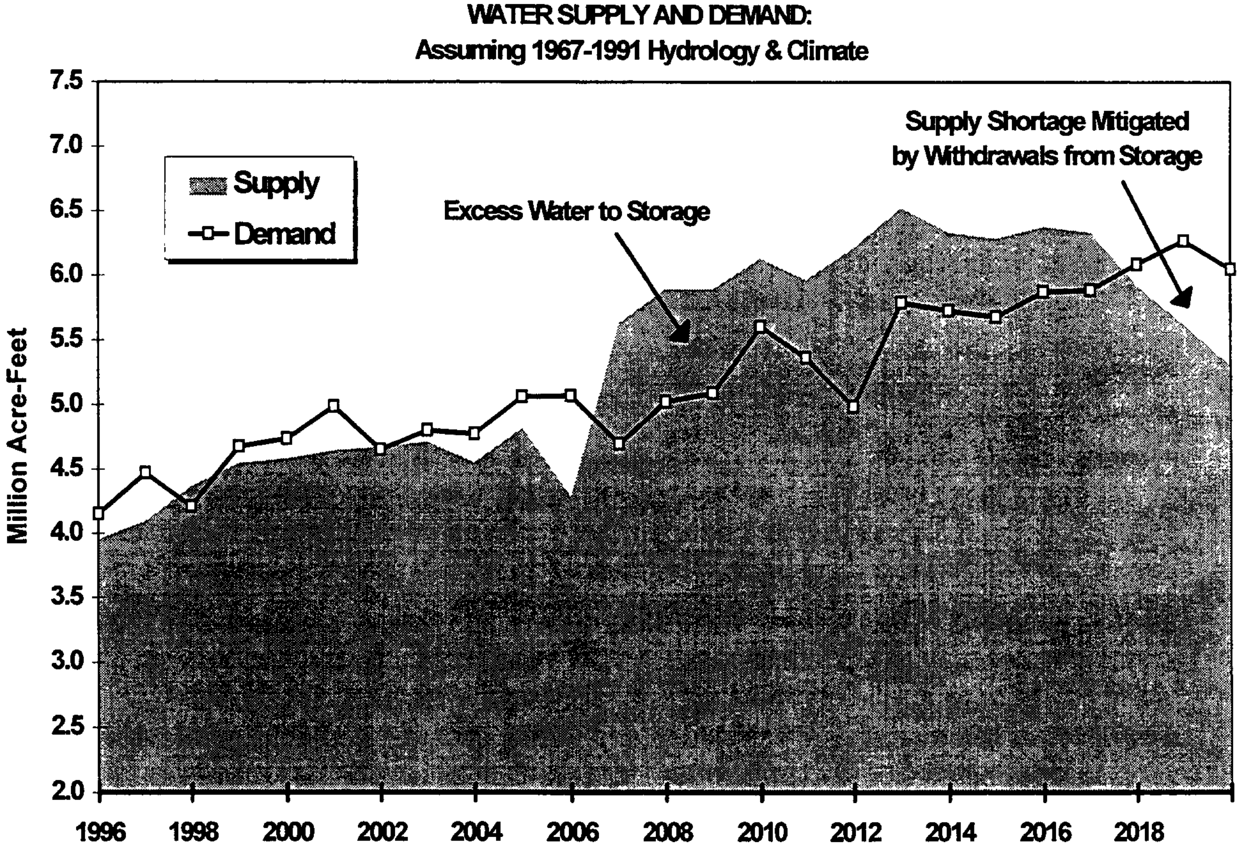
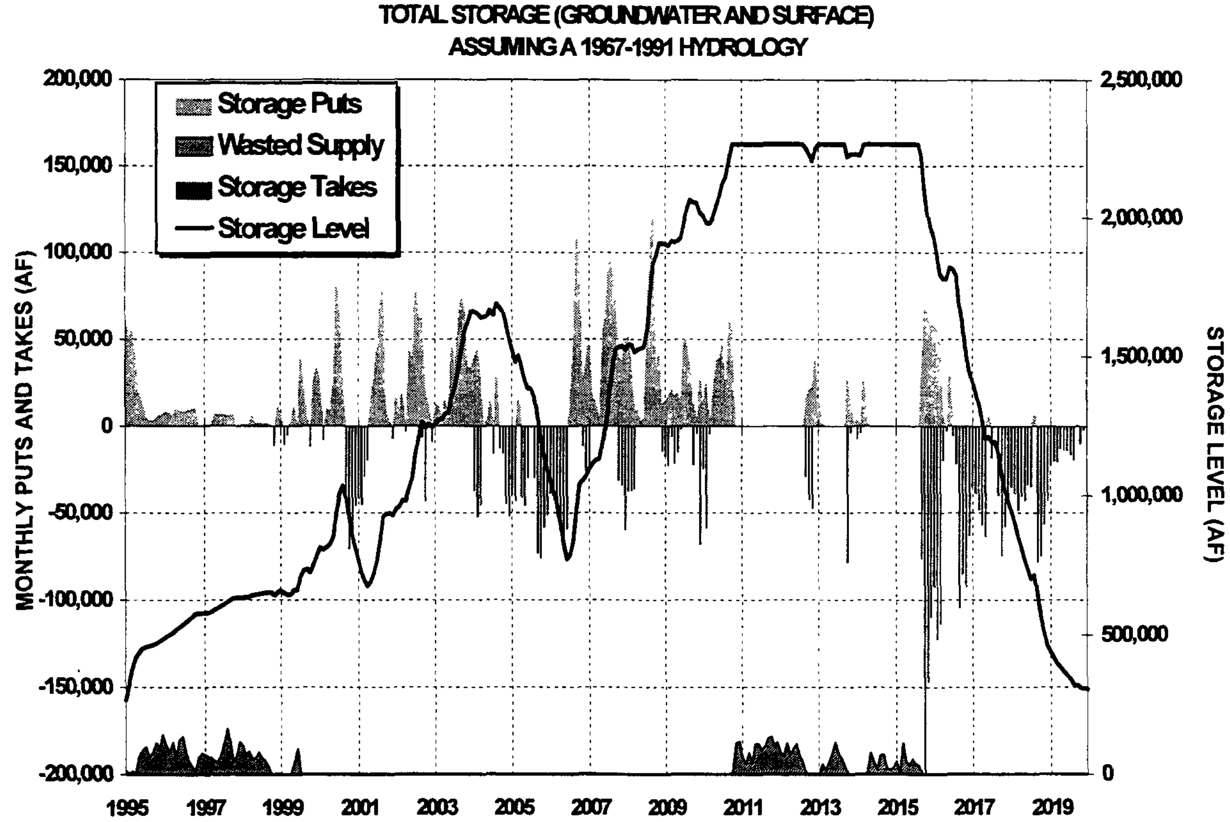


Figure G-7 presents the monthly simulation of storage assuming 1967-1991 historical hydrology and weather. The total storage level is measured by the solid black line, read from the right-hand vertical axis (ranging from 0 to 2.25 million acre-feet). The monthly puts into storage are measured by the light gray shaded area, read from the top portion of the left-hand vertical axis (ranging from 0 to +200,000 acre-feet). The monthly draws from storage are measured by the dark gray bars hanging down, read from the bottom portion of the left-hand vertical axis (ranging from 0 to -200,000 acre-feet). Finally, imported water which is available but cannot be stored (wasted supply) is shown as a gray-hatched shaded area at the bottom of the chart, read from the right-hand vertical axis.

Figure G-7



This particular 1967-1991 weather trace starts off wet, and imported water is stored as fast as the storage capacity can will allow. In the earlier years (before year 2000), only the groundwater basins provide significant storage potential. Because the physical spreading capabilities of the groundwater basins limit the storing of water, available imported water during this period is not fully used. After 1999, the Domenigoni Valley Reservoir Project (a planned 800,000 acre-foot surface reservoir) will be operational to store water for emergency and drought protection for the region. With its large monthly capacity for storing water, the slope of the total storage level increases dramatically and very little available imported water during wet years is unused. The 1976-77 drought (one of the worst on record) occurs in the 2005-06 projection year, as indicated by the heavy withdrawals from storage. The total storage level falls from 1.70 million acre-feet to about 0.70 million acre-feet in two years. The period following the 1976-77 drought was very wet and cool, allowing water to be quickly stored. Finally, the worst drought on record (1986 to 1991) occurs in the projection period of 2015 to 2020. This multi-year drought draws down the total storage level from 2.25 million acre-feet down to the emergency reserves of about 400,000 acre-feet over a five year period. This example represents only one such weather trace with a given demand growth. The storage benefits were evaluated using 70 historical weather traces and about 28 different demand scenarios.

SUPPLY RELIABILITY EVALUATION

In general, water supply reliability can be defined as: *the degree to which the performance of a supply system results in the delivery of water service to its customers in the amounts desired, within acceptable quality standards.* Evaluation of supply reliability is important because it provides a signal when additional resources and capital investments are required. Equally important, reliability planning determines when "enough is enough" -- that is, when additional resources or capital planning would constitute an over-investment in supply.

Supply reliability was measured using IRPSIM, an indexed-sequential and Monte-Carlo simulation computer model (Chesnutt and McSpadden, 1994). Supply reliability measures the likelihood and magnitude of supply shortages (when demand exceeds supply) and supply surplus (when supply exceeds demand). Supply reliability has major two components: (1) frequency -- how often does the supply shortage or surplus occur; and (2) magnitude -- how large is the supply shortage or surplus. Typically, reliability planning focuses on the shortage aspect, but it is also important to understand the surplus side of the equation. As discussed earlier, identification of surplus water supply conditions are critical for the evaluation of storage. Evaluation of surplus conditions also reveals the effectiveness of water supply and management investments.

Reliability Measurement

Measuring supply reliability can involve a great deal of analytical effort. Traditional methods of reliability analysis, borrowed from the power industry, were used as the basis for the analyses in the IRP. However, because power is not economically storable, the reliability evaluations had to be adapted for water. The simplest model for evaluating supply reliability in the power industry starts by estimating mean future demands and its potential distribution. A statistical demand model can have many predictors such as demographics, time of the year, and weather. However, even the best statistical predictions have remaining uncertainty or error.

Supply models also contain forecasting error and it is this combination of the variations in supply and demand that are used to estimate supply reliability. However, the distributions and interrelationships of supply and demand variables are often too difficult to derive by pure mathematical means. In order to avoid dealing with this computational problem, Monte Carlo simulation was used. By making random draws from distributions and mathematically manipulating them, a new distribution can be formed. In this way, distributions can be created one observation at a time without ever having to explicitly derive the mathematical formula for the new distribution.

The Monte-Carlo methods developed for IRPSIM are best described in their simplest form. Assume water supply and demand were independent normal distributions (see Figure G-8a). Simply by taking a random draw from each distribution and subtracting them (supply minus demand), and repeating this hundreds of times, a distribution (see Figure G-8b) of shortage/surplus can be derived.

However, this method is complicated by the negative correlation between supply and demand (see Figure G-9). For example, the same conditions that make demand increase (hot and dry weather), also tend to make supplies decrease.

Figure G-8a

Probability Distributions of Water Supply and Demand

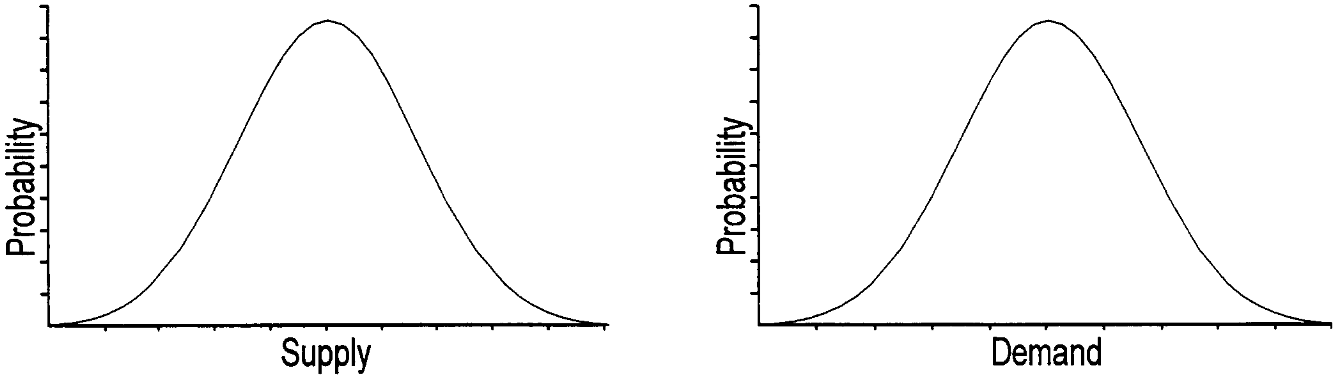


Figure G-8b

Probability Distribution of Water Supply Less Demand

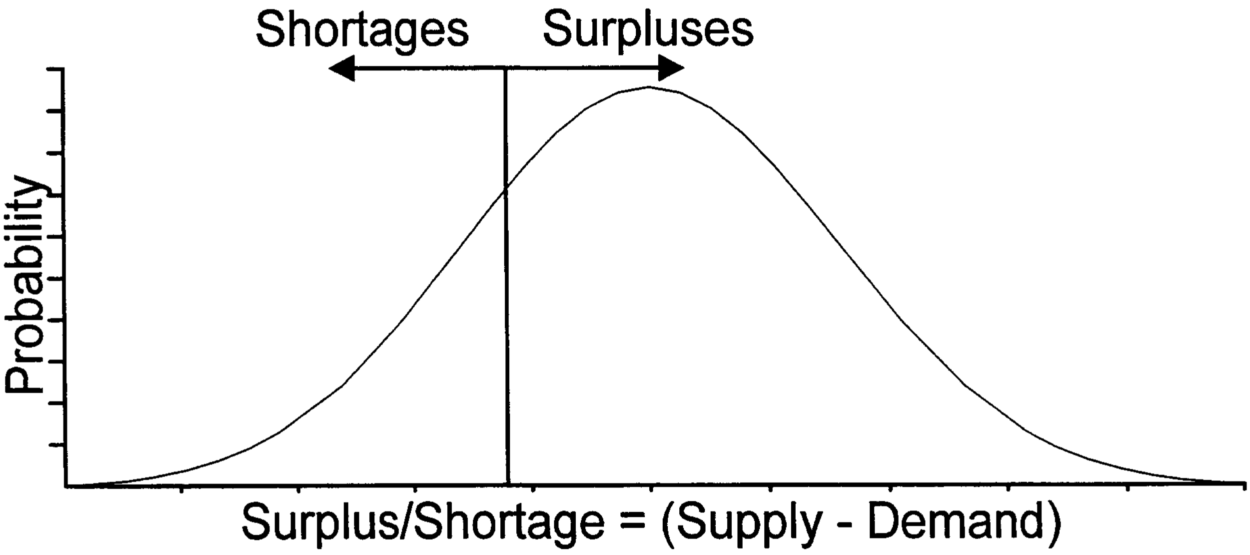
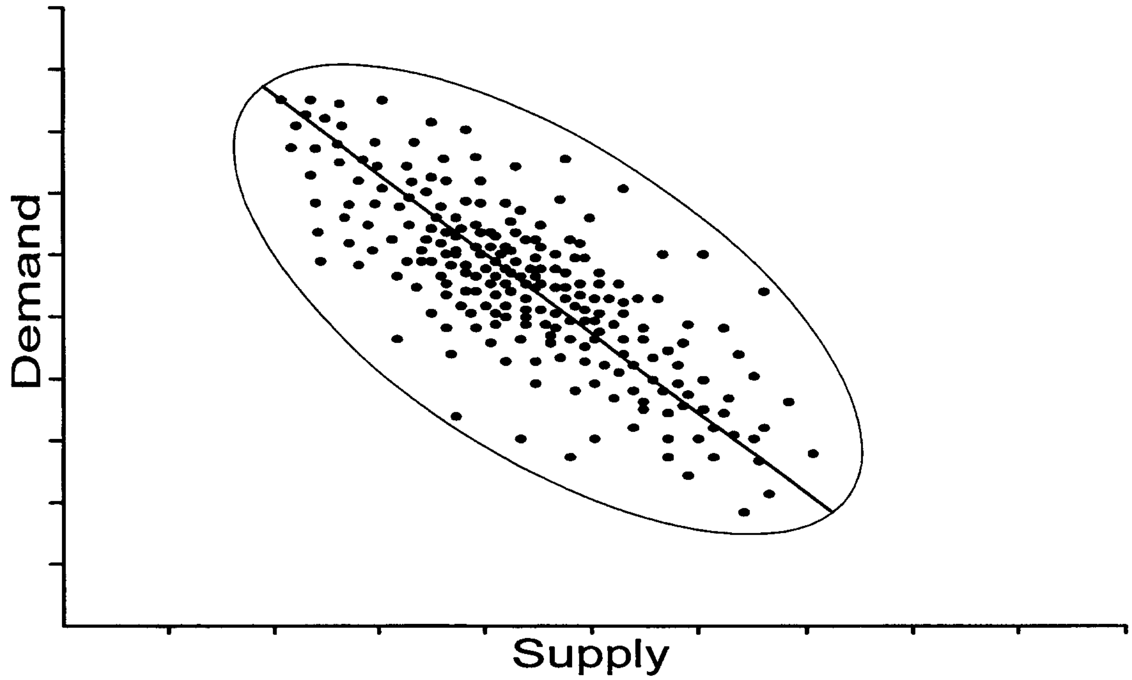


Figure G-9
Relationship Between Supply and Demand



Therefore, in order to determine supply reliability for water, matched pairs of supply and demand must be used to develop the distribution of supply less demand. In other words, there is a low likelihood that a low demand observation gets paired with a low supply observation. IRPSIM combines the indexed-sequential simulation discussed earlier with Monte-Carlo probability analysis in order to obtain the final distribution used to estimate supply reliability. The model takes each of the unique 70 year climate/hydrology traces (from 1922-1991) and draws about 28 different random non-weather related demands. This provides about 2,000 individual events for any specified time-step (usually monthly).

In order to estimate a reliability curve for any given time period, the distribution of supply less demand should not be displayed as a probability density function but as a cumulative probability distribution, by integrating the curve (see Figure G-10a). In this form, the probability of shortage or surplus can be read directly from the graph. But for further ease, this graphic can be rotated 90 degrees counter clockwise (see Figure G-10b). Now the likelihood (or frequency) of shortage or surplus is read on the horizontal axis and the magnitude of shortage or surplus is read on the vertical axis.

Figure G-10a
Cumulative Probability of Supply Shortage and Surplus

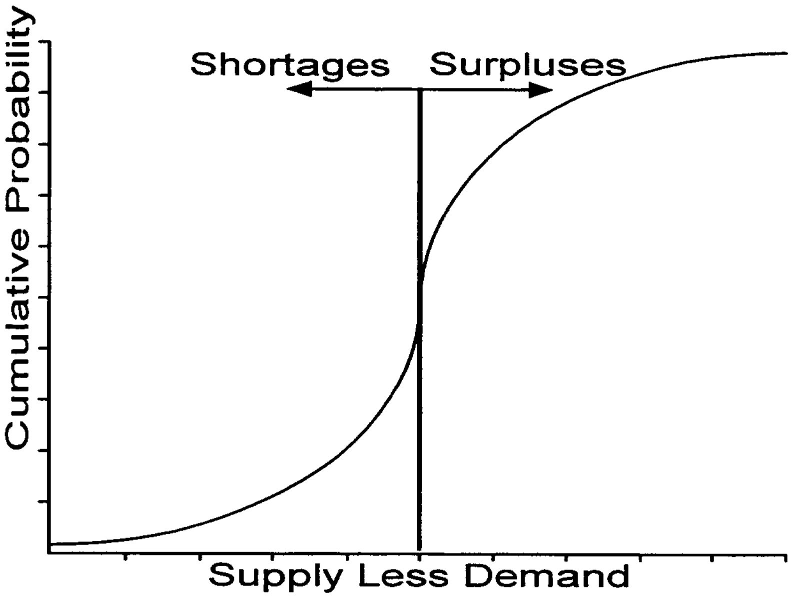
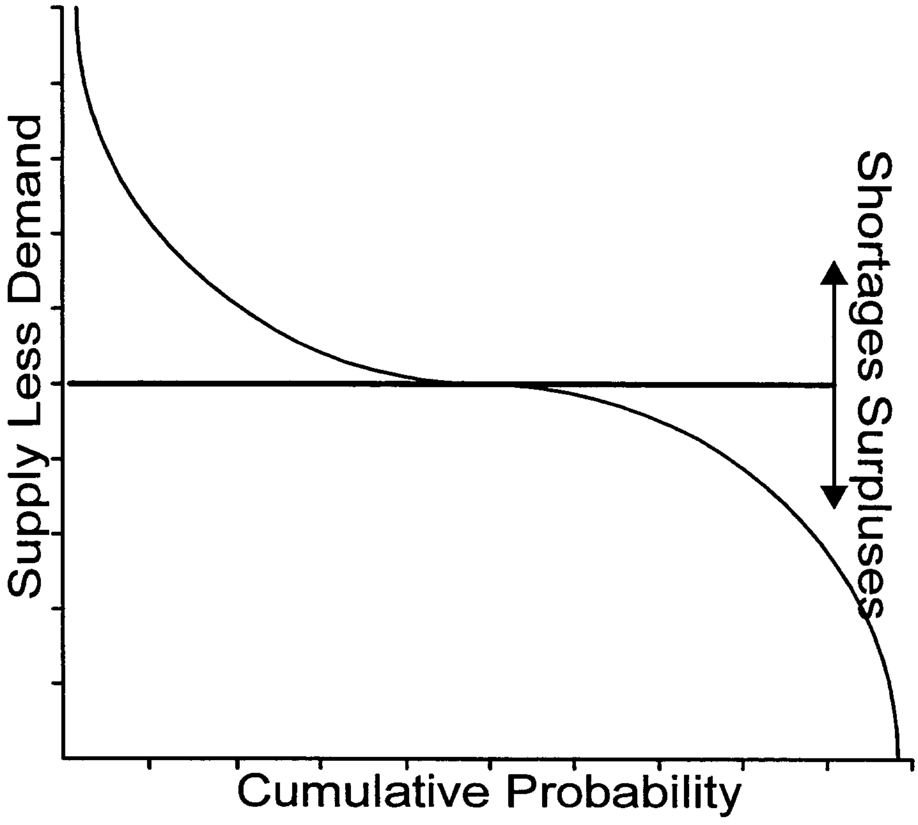


Figure G-10b
Rotated Cumulative Probability of Supply Shortage and Surplus



This example is greatly simplified because it does not include the impact of storage. To understand the impact of storage, it is instructive to illustrate how the reliability curve is affected by different supply enhancements. Supply reliability can be improved from basically three different types of water resource enhancements (or investments):

1. Core Supply -- investments are made for year round supply, whether they are needed in every year or not. Core investments *decrease* the likelihood and magnitude of water shortages, but at the same time *increase* the likelihood and magnitude of water surplus. Since capital expenditures do not vary with water supply yield, a portion of the core supply's cost will remain fixed even if the supply is not needed. For this reason, core supplies can be relatively expensive during wet years and normal years.

2. Storage -- investments are made to store excess water during times of plenty for use during times of need. Storage investments *decrease* the likelihood and magnitude of shortages and also *decrease* the likelihood and magnitude of surplus -- because they transfer surplus water to meet shortages. Storage investments may have relatively high unit costs in terms of total yield (because the supply yield is only used periodically), but may be cheaper than core supplies over the long term.

3. Swing Supply -- investments are made for water only when needed, such as option or spot market water transfers. These investments only *decrease* shortages and do not affect the frequency or magnitude of surplus water. Even if the dry year unit costs are higher than core supplies or storage, the average costs over time will likely be lower -- because the costs are paid only when the supply is used. However, flexible supplies can have a higher degree of uncertainty than core supplies or storage.

The following discussion illustrates how different water resource investments affect supply reliability. A core supply improvement (such as a reclamation facility) shifts the entire reliability curve downward (see Figure G-11a), because the supply is available under all hydrologic conditions. This can also be displayed as a shift to the right on the supply distribution curve (see Figure G-11b).

The evaluation of storage requires an evaluation of the raw reliability curve (see Figure G-11a) and the determination of a surplus or shortage condition. Based on this condition, water is either placed into or drawn from storage effectively reducing shortages and reducing surplus (see Figure G-12a). It also collapses the supply distribution from either side (Figure G-12b). Although the collapse of the supply distribution appears uniform in this example, the collapse is more likely to be skewed in either the right (if production capacity is less than storage capacity) or to the left (if storage capacity is less than production capacity). Only if storage operations were perfect (the same amount of water going into storage comes out of storage) would the collapse of the distribution curve be uniform.

Figure G-11a
Core Supply Improvement to the Supply Reliability Curve

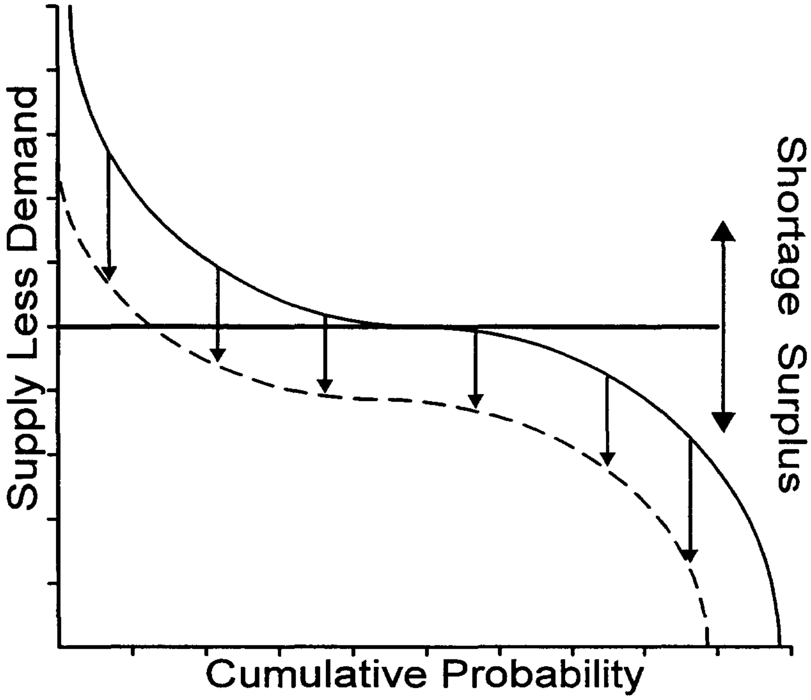


Figure G-11b
Core Supply Improvement to the Supply Distribution Curve

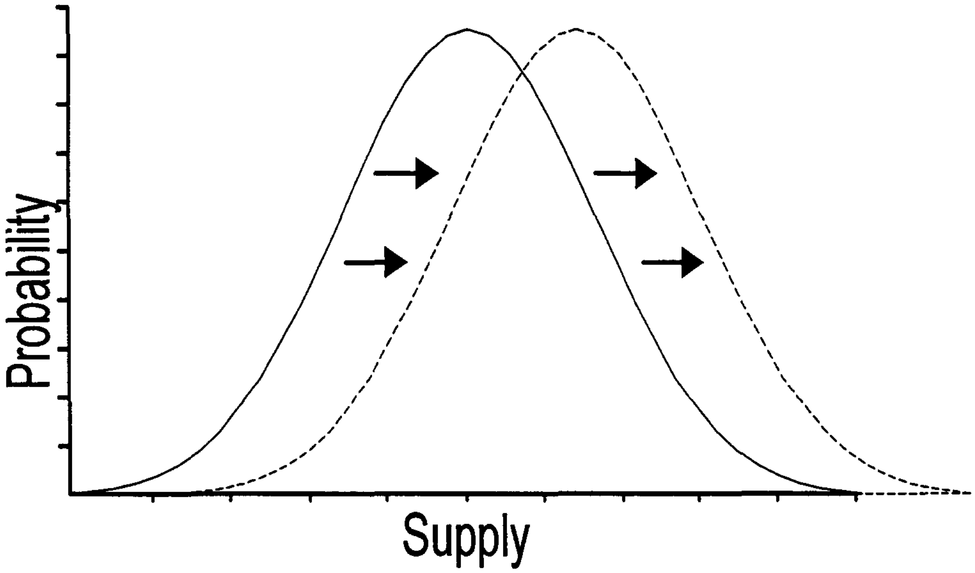


Figure G-12a
Storage Improvement to the Supply Reliability Curve

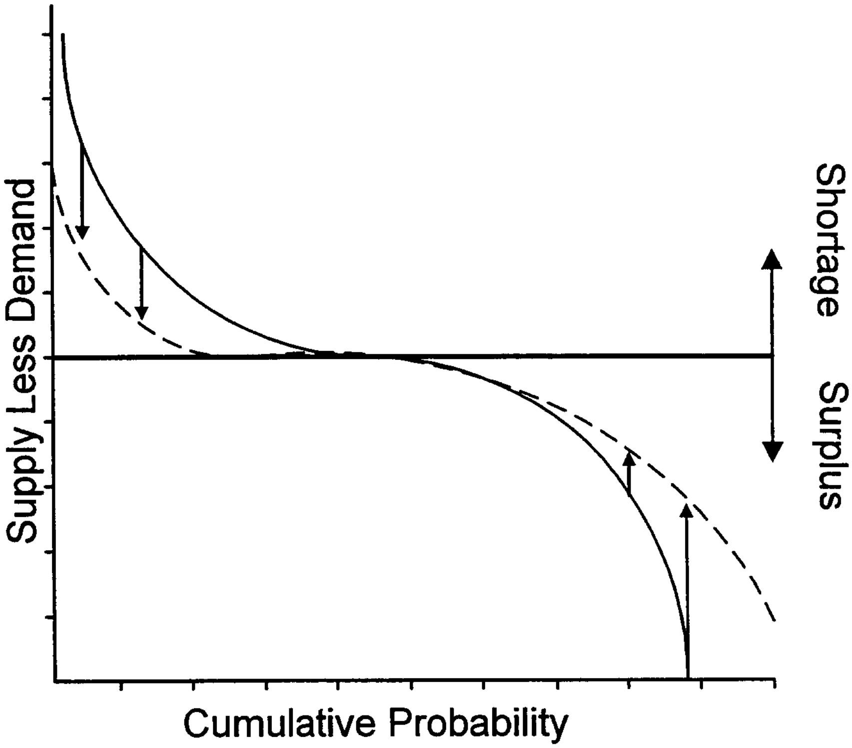
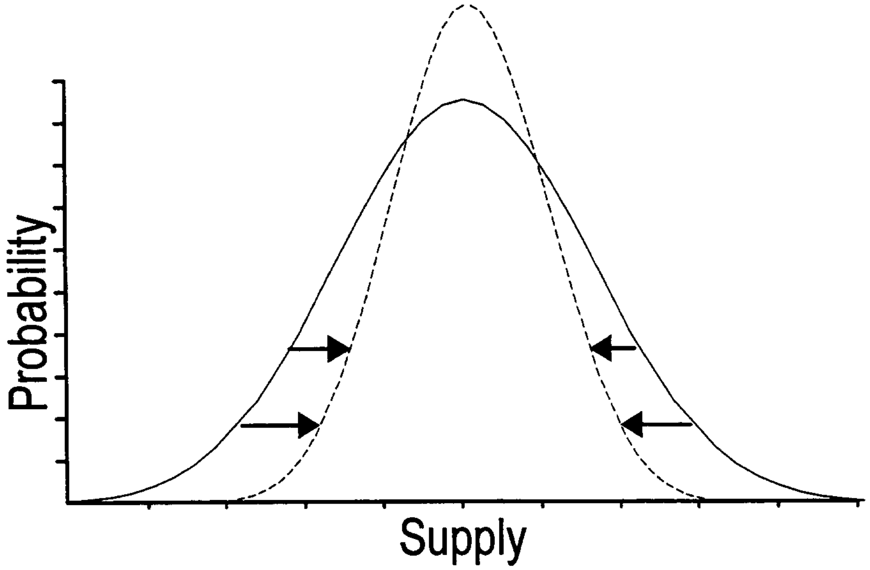


Figure G-12b
Storage Improvement to the Supply Distribution Curve



The actual measurement of the potential for storage to increase reliability depends on the inter-temporal nature of storage. The ability to put to or take from storage is dependent on the total storage capacity, conveyance constraints, availability of excess water, and the remaining storage capacity (or level) from the prior time period. Although theoretical models have been developed to predict weather in the short-term, no long-term forecast models have been used successfully. Because of this fact, the simulation used to evaluate supply reliability should maintain the sequence of the historical weather and hydrology.

Flexible supplies, such as water transfers, are used to help mitigate supply shortages. The augmentation of supply only occurs during the shortage, and for this reason, the supply curve is only shifted downward for the shortage, not the surplus (see Figure G-13a). The supply distribution is skewed rather than shifted as a result of a flexible supply (see Figure G-13b).

In reality, a diverse mix of core supplies, storage, and flexible supplies should be pursued. Based on detailed evaluations of different resource options, a diversified approach will tend to minimize overall costs, reduce wasted supply, and lower the overall risk in supply development. This notion of diversification of resources is consistent with the literature and studies conducted in the power industry (Hall and Thomas, 1984).

Figure G-14 presents an estimate of the retail level supply reliability for Metropolitan's service area in the year 2020 using the techniques described in this paper. The resource mix evaluated is a combination of cost effective local water supplies (reclamation, conservation, and groundwater), surface and groundwater storage, improvements to imported supply, and voluntary water transfers.

The top half of the graph depicts supply shortages, with the likelihood of shortages read from the top. The top portion of the left-hand axis measures the percent of full service retail demand that would not be met. For example, the reliability curves indicate that without future investments in supplies, shortages of about 30 percent could occur about 10 percent of the time. With core supply improvements, the shortages would be reduced to 15 percent, occurring about 10 percent of the time. Finally, with storage improvements, the shortages are further reduced to under 10 percent, occurring 10 percent of the time. The bottom half of the graph measures the likelihood and magnitude of supply surplus. No supply surplus would occur if no future investments are made by year 2020 (in other words, there is a 100 percent chance that some kind of water shortage would exist). When core supply investments are made, the shortages are reduced, but the surplus is about 10 percent, occurring 10 percent of the time. Storage reduces the surplus to about 5 percent, occurring 10 percent of the time.

Figure G-13a
Flexible Supply Improvement to the Supply Reliability Curve

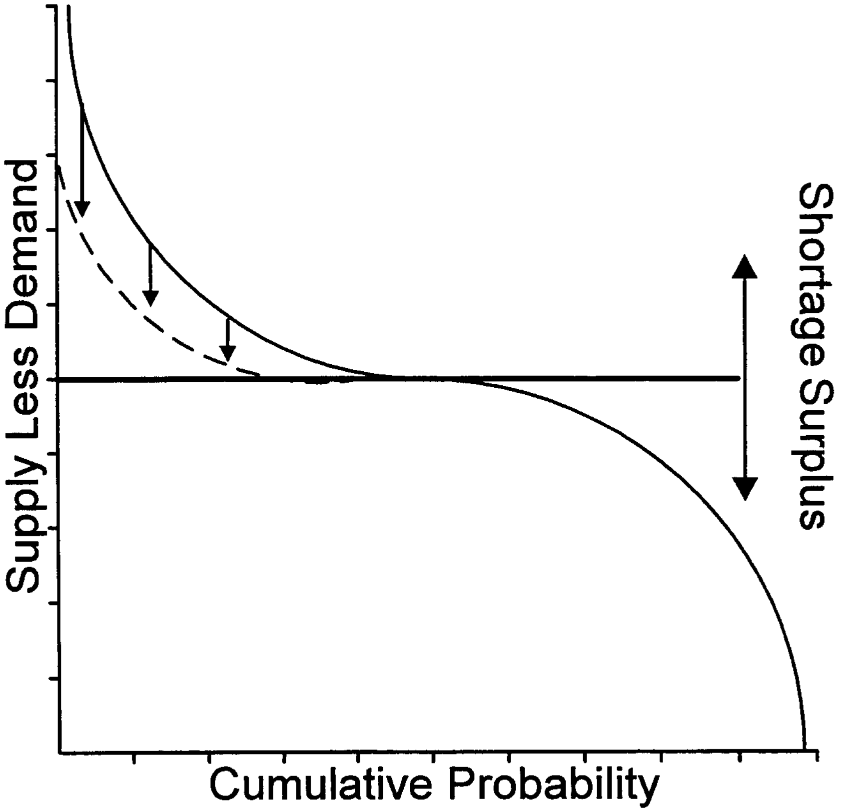


Figure G-13b
Flexible Supply Improvement to the Supply Distribution Curve

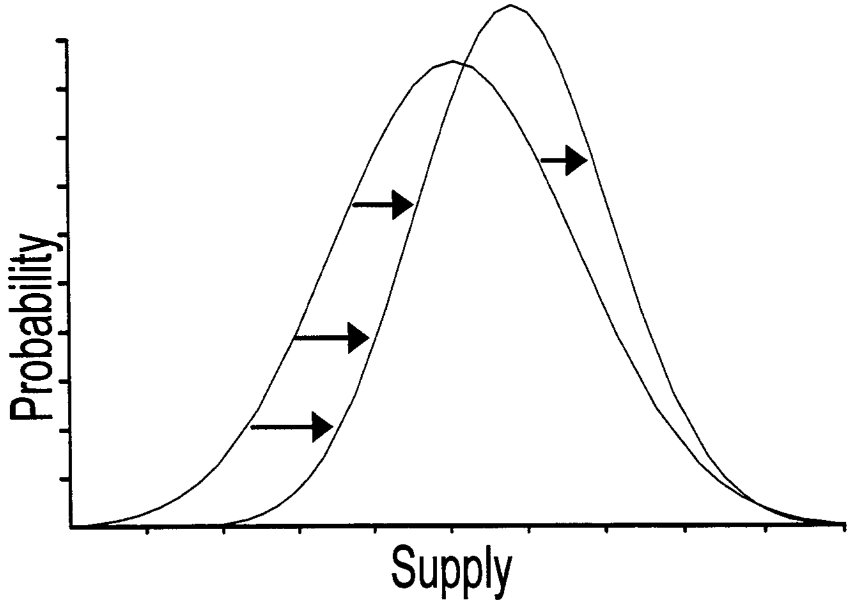
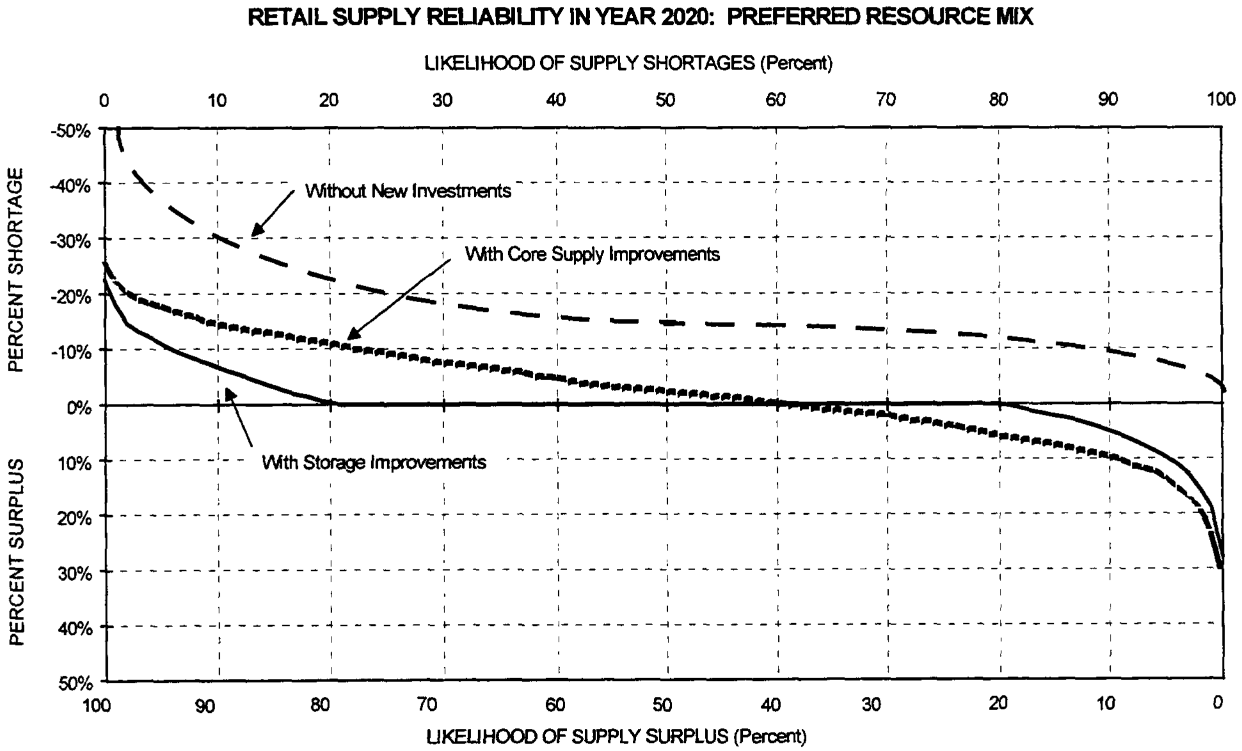


Figure G-14



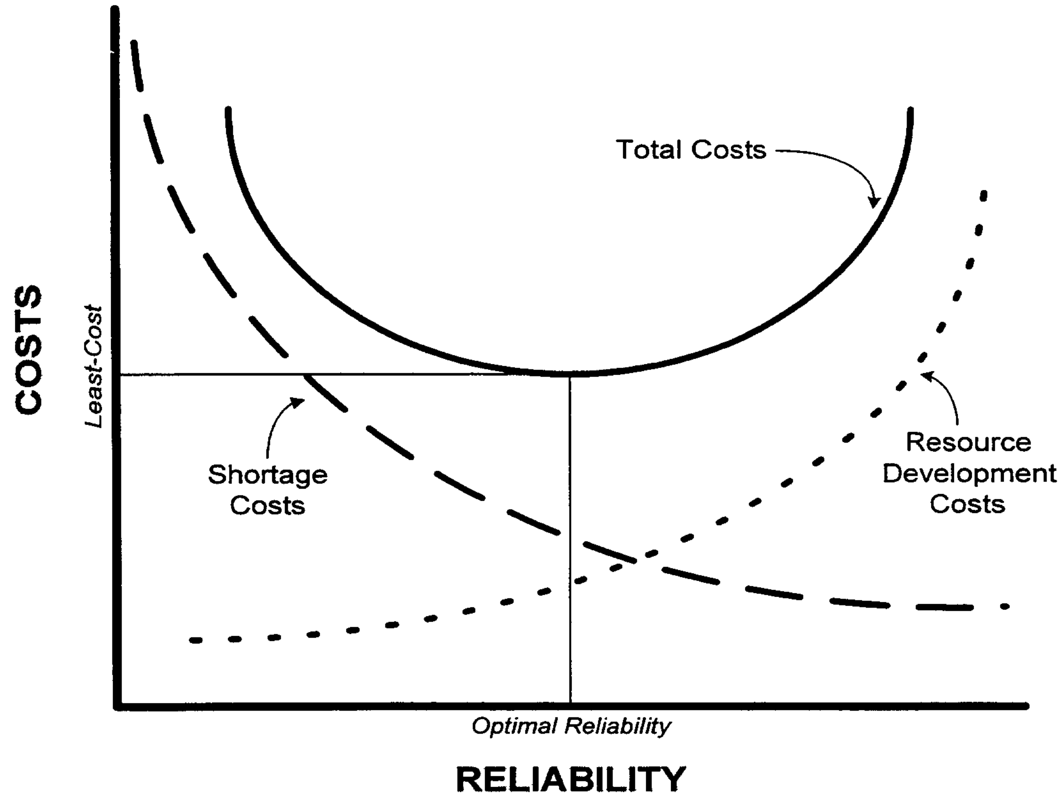
Metropolitan's wholesale supply reliability goal, translated into a retail goal, would imply that no shortage should be allowable 90 percent of the time, and that the maximum magnitude of the shortage should be less than 10 percent of full service retail demand. Although this evaluation indicated that the reliability goal could not be achieved with just core supply and storage improvements, water transfers could be used as a cost-effective supply to completely eliminate the remaining shortages. Based on the reliability evaluation, about 400,000 acre-feet of Central Valley water transfers would be needed about 10 percent of the time.

Costs and Benefits of Supply Reliability

The costs and benefits associated with supply development can also be determined by an extensive supply reliability evaluation. Ideally, the optimal level of reliability should be set to minimize total costs. Total costs should include all costs related to developing, treating, storing and distributing water, plus any environmental costs of development. The total costs should also include the adverse impacts to the region's economy and lifestyle that could occur if chronic water shortages exist. Figure G-15 presents a theoretical approach to setting the appropriate reliability.

The graph indicates that as reliability improves, the costs of resource development increase. If reliability decreases, the shortage costs (negative impacts to the economy and lifestyle) increase. The sum of these two cost curves (resource development and shortage costs) yields a total cost curve -- where optimal reliability is at the minimum point of the curve. In most cases, the construction of perfect cost curves will not be possible. Although resource development costs may be fairly easy to obtain for different levels of reliability, cost expenditures in the water industry are typically disjointed and "lumpy," rather than smooth curves.

Figure G-15
Least-Cost Reliability Planning



On the other hand, obtaining shortage costs for different levels of reliability is much more difficult. Measurement of the adverse impacts to the economy due to chronic water shortages can be obtained by examining actual case studies, but transference of the results may not be accurate. Statistical and economic input/output studies have been used to estimate the potential impact of supply shortages in the water sensitive manufacturing sector for California and can be helpful. Based on such studies, it has been estimated that a 15 percent shortage to the water sensitive industries in Southern California could cause about \$3.5 to \$4.3 billion in lost jobs and production (Spectrum Economics, 1991). However, most city councils and water boards are unlikely to short large commercial and industrial water customers for the fear of reducing economic output. Therefore, it is the residential customer that will most likely do without during shortages.

One way to measure impacts to residential users is by estimating their willingness to pay for decreased supply shortages. This can be done using contingent valuation analyses. This approach uses detailed surveys to determine willingness to pay for services that are typically difficult to measure (such as recreation, environmental protection, and resource reliability). Contingent valuation surveys completed in Southern California indicated that residential customers were, on average, willing to pay an additional $10 to $15 more per month in order to avoid varying levels of water shortages (Barakat & Chamberlin Inc., 1994).

Based on the results of the reliability evaluation, the costs of achieving the reliability goal specified in Metropolitan's IRP were estimated. These costs would result in a $3 to $5 increase in the average monthly water bill over the next 10 years for the region. Based on the economic studies and surveys of industry and residential water customers concerning supply shortages (as noted above), the costs for improved reliability are well below the costs associated with the chronic supply shortages that would exist without the new investments.

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