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ORANGE COUNTY WATER DISTRICT

STATE WATER RESOURCES CONTROL BOARD

OF THE STATE OF CALIFORNIA

In the Matter of State Water Resources Control Board Hearing on Water Rights Applications 31165 and 31370 of San Bernardino Valley Municipal Water District and Western Municipal Water District of Riverside County; Application 31174 of Orange County Water District; Application 31369 of Chino Basin Watermaster; Application 31371 of San Bernardino Valley Water Conservation District; and Application 31372 and Waste Water Change Petition WW-0045 of the City of Riverside.	Application No. 31174 DIRECT TESTIMONY OF ROY L. HERNDON, PG, CHG, ON BEHALF OF ORANGE COUNTY WATER DISTRICT FOR WATER RIGHTS APPLICATION 31174 Date: May 2, 2007 Time: 9:00 a.m. Location: Cal EPA Building Coastal Hearing Room

DECLARATION OF ROY L. HERNDON, PG, CHG

I, Roy L. Herndon, PG, CHG, declare and state as follows:

BACKGROUND AND QUALIFICATIONS.

1. I am the Chief Hydrogeologist of the Orange County Water District ("OCWD"), a position that I have held for approximately 15 years. My duties as Chief Hydrogeologist include the following: hydrologic analysis and preparation of the annual Santa Ana River Watermaster Report, numerical groundwater flow modeling, performance evaluation and improvement of two seawater intrusion barriers, basin-wide and local water level and water quality investigations and remedial projects, and the operation of a comprehensive water resources data management system for the Orange County groundwater basin. I also serve on the Alamitos Seawater Barrier Management Committee, the Orange County Well Standards Advisory Board, and the Marine Corps Air Station El Toro Restoration Advisory Board.

2. I hold an MS degree in hydrology and water resources from the University of Arizona (Tucson) and a BA degree in geology from the Colorado College (Colorado Springs), and am a California professional geologist and certified hydrogeologist.

3. I make this declaration as my direct testimony for the State Water Resources Control Board Hearing on Water Right Application 31174 of Orange County Water District ("OCWD"). This Declaration is Exhibit OCWD 3-1. My biography is Exhibit OCWD 3-2.

ASSESSMENT OF FUTURE SANTA ANA RIVER FLOWS BELOW PRADO DAM.

4. The following declaration was prepared by me, with the assistance of Environmental Science Associates. OCWD is applying for a permit to divert a wet-year maximum of 505,000 acre-feet annually ("AFA") of water from the Santa Ana River ("SAR"). With my assistance, OCWD has undertaken a water availability assessment to confirm that the water requested in OCWD's application will be available in the future. This assessment of water availability analyzes flow data collected by the SAR Watermaster

and finds that more than 505,000 acre-feet ("AF") of water has been recorded in the lower SAR in the recent past. The assessment goes on to develop future wet-year flow estimates, subtracting planned upstream diversions, to calculate a conservative future wet-year SAR flow estimate below Prado Dam. The assessment concludes that the 505,000 AFA requested in OCWD's application is reasonably foreseeable in future wet years downstream of Prado Dam.[1]

5. This conclusion is supported by two additional sets of data developed independently by the United States Army Corps of Engineers ("USACE") and the Santa Ana Watershed Project Authority ("SAWPA"). The USACE estimates future flow at Prado Dam through year 2052. The USACE estimates flows by year 2052 to be approximately 847,000 AF during a wet year. While the USACE does already account for <u>existing</u> upstream diversions and water recycling efforts, OCWD took a more conservative approach, assuming that <u>future</u> upstream diversion projects could decrease USACE's estimate. Even with this assumption, the water availability assessment shows that after additional planned upstream diversions are accounted for, 505,000 AFA is reasonably foreseeable during a future wet year at OCWD's Main River System diversion points.

6. The resulting assessment provides an estimate of minimum wet-year flow volume, assuming that 100 percent of diversions proposed upstream are actually implemented. In order to divert 100 percent of the proposed upstream diversions, maximum diversion rates need to occur for a period of several months. Since the river responds to episodic storm events, long periods of high flows are rare. More commonly, peak flows occur during storm events then decrease rapidly. During peak flow periods, the river flow rates exceed the diversion capacity of existing and proposed facilities. Therefore, it is likely that in most years, substantial volumes of storm flow would bypass diversion points and ultimately reach Prado Dam in quantities greater than predicted in this

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[1] Due to the annual variability of flows in the SAR, 505,000 AF will not be available in every year. Every year differs depending on the amount of precipitation experienced in the region.

water availability assessment.

7. Furthermore, depending on the ultimate uses of recycled water upstream, some fraction of the recycled water would return to the SAR, increasing the amount of water reaching Prado Dam to greater quantities than predicted in this water availability assessment.

DATA SOURCES.

8. This analysis incorporates information from the following data sources:

- Actual flow data from the 1991 through 2006 SAR Watermaster Annual Reports (Exhibit OCWD 3-3), including United States Geological Survey ("USGS") river flow gage data (Exhibit OCWD 3-4), and
- Hydrologic analyses prepared for the San Bernardino Valley Municipal Water District ("SBVMWD") and the Western Municipal Water District ("WMWD") SAR Water Rights Application Draft Environmental Impact Report (2004).
- SAR flow estimates prepared by USACE[2],
- SAR flow estimates prepared by SAWPA[3],

Future estimates of upstream water recycling (from SAWPA estimates) and proposed diversions (from pending applications) are subtracted from the USACE estimates of future flow to describe the minimum future SAR flow reaching Prado Dam and OCWD's Main River System during a wet year. This minimum wet-year flow represents the cumulative effect of reasonably foreseeable diversion projects on SAR hydrology.

BACKGROUND.

9. The District currently diverts water from the SAR to recharge the Orange County groundwater basin, which provides approximately 50 percent of Orange County's water supply. As urbanization continues in the upper SAR watershed, river flows have

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[2] USACE. 2005. *Prado Basin Water Conservation Feasibility Study Main Report with EIS/EIR* (Exhibit OCWD 1-27). The USACE operates Prado Dam and has estimated future SAR flows in order evaluate flood control and water conservation capabilities of the dam.

[3] SAWPA. 2004. *Santa Ana River Projected Flow Impacts Report* (Exhibit OCWD 3-5). SAWPA is a Joint Powers Authority that was created in 1969 to assist in regional water planning efforts and to participate in building facilities to protect water quality in the watershed.

increased dramatically. The two agencies with a direct need to evaluate future such flows, USACE and SAWPA, project that flows in the river will continue to increase.

10. The SAR is the largest river system in Southern California, originating in the San Bernardino Mountains and flowing over 100 miles southwesterly, with an outfall of intermittent winter storm flows at the Pacific Ocean between the cities of Newport Beach and Huntington Beach. As shown in Figure 1, the watershed encompasses 2,650 square miles in San Bernardino, Riverside and Orange Counties.

11. The river flows through a gap in the Santa Ana Mountains that separates the upper and lower watersheds. The OCWD encompasses the lower watershed on the coastal side of the Santa Ana Mountains below Prado Dam.

EXISTING FLOWS AT PRADO DAM.

12. The SAR Watermaster was created in 1969 as an outcome of the Orange County Judgment[4] to annually determine if the river flow obligations stipulated by the Judgment are met at the Riverside Narrows and Prado. The Watermaster is a committee composed of five members nominated by the five parties to the Judgment and appointed by the court. Each year, the Watermaster divides SAR flows reaching Prado Dam into three categories: base flow, storm flow, and non-tributary flow. Base flow in the SAR is created almost entirely by discharges of treated municipal wastewater upstream of Prado Basin (Burton et al., 1998)[5]. Storm flow results from runoff after storm events. Non-tributary flow includes water that originated outside the SAR watershed, as well as other water that the Watermaster has determined should be excluded from base flow and storm flow. Non-tributary flow is comprised primarily of water originating outside of the SAR watershed

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[4] *Orange County Water District v. City of Chino et al.* 1969. Orange County Superior Court No. 117628 (Exhibit OCWD 1-30).

[5] Burton, C.A., J.A. Izbicki, and K.S. Paybins. 1998. *Water Quality Trends in the Santa Ana River at MWD Crossing and below Prado Dam, Riverside County, California.* USGS Water-Resources Investigations Report 97-4173. References cited herein which are not included as exhibits are published and publicly available documents. If any reader is not able to obtain such material, OCWD is happy to assist.

that is purchased by OCWD for groundwater recharge.

13. The USGS maintains a river flow gage just downstream of Prado Dam (USGS Gage no. 11074000; see Figure 1). This gage provides information on the character, rate, and volume of flow entering the OCWD operations area, which is below the gage, downstream of Imperial Highway. Table 1 presents the annual volumes of the components of SAR flow downstream of Prado Dam from 1990 through 2005 as determined by the SAR Watermaster.

14. As shown in Table 1, the maximum flow volume between 1990 and 2005 occurred in water year 2004-05 when the USGS gage below Prado Dam recorded 638,513 AF. Base flow for the sixteen-year period averaged 135,934 AFA, trending upward for the period as a whole. As can be seen by comparing water year 2001-02 (very low rainfall) with water year 2004-05 (high rainfall), base flow is not correlated with rain; again, however, it is largely a product of and correlates very well to upstream wastewater releases, as shown on Exhibit OCWD 3-6.

15. Total annual SAR flow has varied year to year largely based on fluctuations in storm flows and annual precipitation in the watershed. Urbanization of former agricultural land in the watershed above Prado has created more impervious land cover and involved the concrete lining of storm channels to more efficiently convey storm flows to the SAR. A result of this is an increase in the amount of storm water runoff that arrives at Prado for a given storm event. A review of historical annual storm flows arriving at Prado and rainfall indicates an increase in the amount of storm water runoff arriving at Prado over the last 40 years. Figure 2 illustrates the increasing trend in the amount of storm flow at Prado per inch of rainfall. As urbanization continues in the upper watershed, storm flows arriving at Prado are expected to continue to increase and were taken into account by the USACE in its future flow projections at Prado, as described in the following sections.

PROJECTED WET YEAR FLOW BELOW PRADO DAM.

16. OCWD has prepared a water availability assessment to confirm that the

volume of water (505,000 AFA) requested by OCWD will be available in future wet years. This section explains the calculation of future water availability at OCWD's Main River System downstream of Prado Dam. Flow projections by the USACE and SAWPA are summarized and then adjusted to account for future cumulative conditions in the watershed. OCWD's analysis of future cumulative upstream conditions included existing water diversions, future diversions associated with water rights applications pending before the SWRCB, and planned recycled water and conservation programs. The conclusion of this assessment is that during wet years, 505,000 AFA is reasonably foreseeable at the OCWD Main River System points of diversion.

<u>USACE SAR FLOW ESTIMATES.</u>

17. In 2005, the USACE published a Feasibility Study to investigate the potential for additional water conservation at Prado Dam. As part of its study, the USACE predicted future annual flow variability at Prado Dam and at OCWD's operations area about nine miles below Prado Dam at Imperial Highway in the city of Anaheim (see Exhibit OCWD 1-27). A 39-year hydrologic base period (Water Year 1950 to 1988) was used as the basis for its projections. The total annual flow in the SAR at USGS gage 11074000 just below Prado Dam for each year of the hydrologic base period is shown in Figure 2. These total annual flow volumes include non-tributary flows. The maximum flow during this base period, which occurred in water year 1980, is similar in magnitude to the recent peak flows that occurred during water years 1993 and 2005.

18. The USACE estimated annual flow volume at Prado Dam and at OCWD's operations area for projected watershed conditions in 2052 (USACE Future). To predict future wet year and average year flow, the mean daily flow was adjusted for USACE Present conditions and USACE Future conditions. Under USACE Future conditions, storm water runoff and wastewater effluent volumes were adjusted as described below:

19. <u>Storm Water</u>. Adjustments were made to storm water runoff estimates according to the predicted increase in urbanization and its effect on runoff. This method

involved tabulation of Riverside and San Bernardino County population projections for the year 2052, and then estimating the change in impervious cover based on future population growth.

20. Wastewater Effluent. Daily contributions of wastewater from the major upstream dischargers (cities of San Bernardino and Colton RIX, City of Rialto WWTP, the Riverside RWQCP, IEUA, Western Riverside Regional WWTP, and City of Corona WWTP) were compiled for the base period. Increases were made to the effluent values based on year 2052 population estimates.

21. Figure 3 compares the projected annual flow variability expected under the USACE Future scenario (2052) at OCWD's Main River System to the historic flows recorded at the USGS gage no. 11074000 over the 39-year hydrologic base period. The figure demonstrates that by the year 2052, future flows will be greater than historic flows during each type of wet and dry year. The USACE projects that future annual flow at the District's operations area will fluctuate between approximately 300,000 AFA and 868,000 AFA. The modeled estimated peak annual flow of 868,000 AFA was attained twice within the period of record. These projections include a net contribution of 21,000 AFA from the nine miles of the SAR between Prado Dam and Imperial Highway. Table I in Exhibit OCWD 3-4 summarizes the USACE flow projection calculations.

SAWPA SAR FLOW ESTIMATES.

22. SAWPA has produced independent estimates of future SAR flows at Prado Dam for a shorter time range than did USACE, for the years 2010 and 2025 (see Exhibit OCWD 1-27). The estimates include base flow and storm flow for dry, average, and wet years. Table 2 summarizes the SAWPA flow estimates for the year 2025. Unlike the USACE estimates, SAWPA does not account for the effects of urbanization on storm flow, a significant omission, but rather assumes a storm flow volume based on the average historic peaks ranging from a low of 18,300 AFA to a high of 340,300 AFA. The SAWPA estimates include wastewater discharges to the river, but unlike the USACE projections,

reclaimed water volumes are already subtracted from SAWPA's estimated future base flow. In addition, unlike the USACE analysis, the SAWPA estimates account for additional flow contributions from: 1) the High Groundwater Mitigation Project, and 2) the program for Arundo removal.

SUMMARY OF USACE AND SAWPA FUTURE SAR FLOW ESTIMATES.

23. Table 3 and Figure 4 summarize the existing and SAWPA- and USACE-estimated future flow volumes in the SAR at Prado Dam.

24. The SAWPA future flow estimates are lower than the USACE estimates and project a future average flow similar to existing conditions for the following reasons: 1) they do not account for increased storm water flows during wet years caused by future upstream urbanization, 2) they subtract essentially all upstream wastewater recycling goals, and 3) they have projected for the year 2025 rather than 2052.

25. Neither SAWPA's nor USACE's future SAR flow projections took into account all of the post-1988 and pending applications for diversions. In order to be conservative, for the purposes of this water availability assessment, it became necessary to develop a projection of future SAR flows that builds upon SAWPA's and USACE's projections but subtracted all proposed diversions by upstream agencies in full, without accounting for return flows, as described below.

PENDING UPSTREAM DIVERSIONS.

26. The USACE estimated future flow in the SAR based on USGS data that spanned a 39-year hydrologic period (1950-1988). Water diversions in the upper SAR that occurred during the base period are thus accounted for in the USGS data and also are reflected in future flow estimates determined from this base period. However, diversions approved after 1988 and pending applications for additional appropriations are not reflected in USACE's projected flows in the SAR. To conservatively assess future flow volume at Prado Dam and OCWD's operations area, all existing and potential appropriations approved by and pending before the SWRCB since 1988 should be subtracted from

USACE flow estimates. Some pending applications, however, are for rights to water already being diverted from the river and, therefore, are accounted for and should not be subtracted from the USACE flow projections.

27. The following water rights were granted after 1988:

- Chino Basin Watermaster water right permit (no. 020753) for 27,000 AFA, issued in 1994. This amount was not accounted for and should be subtracted from USACE's flow projection.

- Elsinore Valley Municipal Water District water right permit (no. 021165) for 11,200 AFA, issued in 2004. This amount should not be subtracted from USACE's projected flows at Prado because this water originates within and is expected to be contained within the San Jacinto River watershed and, therefore, would not affect projected wet year-flow at Prado Dam.

28. The following water rights applications are pending before the SWRCB for diversions upstream of Prado Dam.

- SBVMWD/WMWD joint application (no. A031165 and A031370) for 200,000 AFA. The highest wet year flow recorded at the USGS Mentone Gage (no. 11051499) was 204,812 AF (SBVMWD/WMWD, 2004).[6] The following paragraph explains how this pending application was handled.
- San Bernardino Valley Water Conservation District ("SBVWCD") application (no. A031371) for 55,464 AFA from the SAR and the Mill Creek tributary. This application is for clarification of rights to water that the SBVWCD is already diverting—a maximum of 41,772 AFA from the SAR and a maximum of 19,800 AFA from Mill Creek. For purposes of this analysis, it is assumed that the proposed appropriation is not additive to the SBVMWD/WMWD application for 200,000 AFA, since the maximum flow at the proposed diversion location is assumed to be approximately 200,000 AFA based on the historical maximum flow. SBVMWD/WMWD has modeled the combined effects of their

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[6] SBVMWD/WMWD. 2004. Santa Ana River Water Right Applications for Supplemental Water Supply Draft EIR. Appendix A: Surface Water Hydrology. Page A-2-3.

pending diversions and SBVWCD pending diversions during a simulated wet 1993 water year (WY 1993). Under hydrologic conditions similar to WY 1993, both pending diversions remove all water from the SAR at Cuttle Weir. Due to hydrologic conditions, existing SBVWCD diversions, and channel losses, however, the net effect at Riverside Narrows is a 31,000 AFA reduction in flow volume. Therefore, this amount was subtracted from USACE's projected SAR flows.

- City of Riverside application (no. A031372) for 41,400 AFA. This application is for the right to divert, and appropriate, treated effluent that currently flows into the SAR just downstream of Riverside Narrows (SBVMWD/WMWD, 2004). This amount was not accounted for and should be subtracted from USACE's flow projection.
- Chino Basin Watermaster application (no. A031369) for 97,000 AFA. This application is for the right to divert flows from Deer Creek, Day Creek, Etiwanda Creek, San Sevaine Creek, Chino Creek, San Antonio Creek, and Cucamonga Creek, all of which are tributary to Prado reservoir and the SAR near Prado reservoir (SBVMWD/WMWD, 2004). The Chino Basin Watermaster already has a water rights permit issued by SWRCB in 1986 for 15,000 AFA. It is assumed that this pre-1988 diversion was accounted for in USACE's base period projection, and thus only the net additional flows of 82,000 AFA should be subtracted from USACE's projected flow.

29. The total volume of water associated with the aforementioned water rights approved since 1988 and pending water rights applications in the upper watershed is 432,226 AFA, as shown in Table 4. As explained above and shown in Table 4, after accounting for existing appropriations and diversions, the net potential new SAR diversions in the upper watershed could be as much as 181,562 AFA that were not accounted for in the USACE's future SAR flow projections.

PLANNED UPSTREAM RECYCLED WATER DIVERSIONS.

30. The SAWPA 2025 estimates for recycled water diversions assume that approximately 100,000 AFA of recycled water would be diverted from future SAR discharges. These estimates represent long term planning goals for 2025 that may not be achieved. Table 5 summarizes the wastewater recycling volumes planned for 2010, which provides an aggressive estimate for recycling programs in the region during a normal rainfall year. Assuming that customers will be available in the future to reliably accept the recycled water, this assessment includes a reduction of 64,540 AFA from wastewater discharges into the SAR. Although recycled water demand would likely decrease under wet year conditions, the aggressive recycled water demand used in this assessment is assumed to provide a conservative estimate.

SUMMARY OF WET YEAR WATER AVAILABILITY.

31. Existing Conditions. During water years 1993 and 2005, approximately 571,000 AF and 638,000 AF of water flowed out of Prado Dam (Table 1), respectively, illustrating that under existing conditions, at least 505,000 AF is available for diversion during wet years by OCWD at its Main River System. Using WY 1993 as an example, Figure 5 is a schematic of the SAR that shows the water available at key points along the river during a wet year, both with and without the implementation of pending diversion projects. Figure 6 illustrates the hydrograph at Prado Dam for WY 1993. Using the hydrologic conditions of WY 1993, after all future upstream diversions are realized, 449,000 AF would be available for diversion at OCWD's Main River System.

32. 2052 Conditions. In its projections, the USACE accounts for increased storm flows due to urbanization and therefore provides a realistic prediction of future wet weather flows in 2052. This assessment of water availability uses the USACE Future scenario, which projects a wet year flow volume of 847,000 AF at Prado Dam and 868,000 AF at OCWD's Main River System by the year 2052. Figure 7 is a schematic of the SAR

that shows future flow volume at key points along the river, from Seven Oaks Reservoir to the Pacific Ocean, both with and without implementation of pending projects. Figure 7 illustrates the projected water availability in the SAR under USACE Future wet-year conditions after accounting for the effects of existing diversions, future recycled water diversions (Table 5), pending water rights diversions, and additional flows due to conservation programs (Table 2). Table 6 summarizes the projected water availability at OCWD's Main River System after accounting for all existing and pending diversions and projects depicted in Figure 7. Total pending diversions (181,562 AFA) are incorporated in Figure 7 as the sum of Chino Basin diversions, Riverside diversions, and the net loss of 31,000 AFA attributable to SBVMWD/WMWD diversions. Assuming that 100 percent of these upstream diversions are subtracted from the total flow, estimated future wet-year flow volume arriving at OCWD's facilities on the SAR would be at least 654,698 AFA, based on USACE's projected volumes adjusted for future diversions and recycling. As shown in Figure 7, assuming 100 percent of planned diversions along the SAR are implemented, at least 262,000 AFA would flow to the ocean.

33. Additional water would reach the ocean during peak flow periods when river flow rates are greater than OCWD's diversion rate capacity. As noted previously, currently, river flows greater than 2,000 cfs generally bypass the OCWD diversion points and flow to the ocean. With OCWD's future projects, OCWD will be able to capture greater flows, but some flows still will reach to ocean.

AVERAGE YEAR WATER AVAILABILITY.

34. Using the USACE Future projections for 2052, the average flow at OCWD's diversion points would be 382,306 AF (see Table I in Exhibit OCWD 3-4). This projection is based on USACE's Future (2052) watershed conditions and estimates of population growth and urbanization in the watershed, including the contribution of runoff from the stretch of the river between Prado Dam and the OCWD points of diversion. Additionally, the USACE estimates show an 80% probability that average future flow volumes will

exceed 300,880 AF (see Table I in Exhibit OCWD 3-4). This does not account for future upstream pending diversions or recycled water diversions. Average year flows could be more or less depending on the amount of storm water diverted upstream and the amount of recycled water taken from the base flow. As shown in Table 2, the SAWPA projection at Prado Dam for an average water year in 2025 is 265,400 AF, which includes recycled water diversions but does not account for pending upstream diversions.

WATER AVAILABILITY ASSESSMENT CONCLUSIONS.

35. The wet-year annual flow in the SAR has already exceeded the 505,000 AF requested in OCWD's application three times in the last 30 years. Accounting for future upstream diversions, this water availability assessment estimates that a minimum of 654,698 AF is reasonably foreseeable during a future wet year at the OCWD points of diversion due to the projected increases in storm flow and base flow. This volume represents a minimum wet-year volume, assuming that 100 percent of diversions proposed upstream are actually implemented. If less water is diverted upstream of Prado Dam or if recycling efforts divert less water than planned, more water will reach Prado Dam during wet years. In addition, depending on the proposed uses of recycled water, some portion of the water may return to the SAR, increasing the amount of water reaching Prado Dam.

36. Therefore, it is reasonably foreseeable that under future cumulative river conditions, 505,000 AF will reach OCWD points of diversion during a wet year when considering the projected increases in base flow and storm flow and after accounting for planned diversions.

EFFECTS OF CLIMATE CHANGE ON WATER AVAILABILITY.

37. California water managers are becoming increasingly aware of the potential impacts of climate change on the state's water supplies. If projections of increased temperatures hold true, reduced Sierra Nevada snowpack and earlier runoff could have

serious consequences for the rivers and reservoirs in northern and central California.[7] While the Sierra snowpack is a dominant factor on river flows and reservoir storage in the northern portion of the state, flows of the Santa Ana River are largely controlled by continuous discharge of treated effluent from sewage treatment plants and rainfall-derived runoff.[8] Therefore, potential climate change effects on snowpack and snowmelt runoff are not expected to be significant for the Santa Ana River watershed.

38. In general, climate model projections show little change in total annual precipitation in California. Furthermore, among several models, precipitation projections do not show a consistent trend during the next century. As reported by the California Climate Change Center, the Mediterranean seasonal precipitation pattern is expected to continue, with most precipitation falling during winter from North Pacific storms.[9] The inconsistent projections of the current climate models do not provide a basis to support or detract from the methodology of the water available assessment summarized herein, but the broader message to be taken from these models is clear: Water managers will need to become more aware of and plan for potential climate-induced changes in hydrologic patterns with maximum reliance on local water supplies, as opposed to imported water, and increased recycling and reuse, both as contemplated by OCWD's application.

EVALUATION OF EFFECTS OF DIVERSION PROJECTS ON CONTAMINATED GROUNDWATER PLUMES.

39. While the quality of groundwater produced for potable supplies within OCWD's service area is very good, industrial contaminants such as volatile organic compounds ("VOCs") have been found in elevated concentrations in shallow aquifers in some areas of the groundwater basin. Areas impacted by VOCs in groundwater, or

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[7] California Department of Water Resources. 2006. *Progress on Incorporating Climate Change into Planning and Management of California's Water Resources*, Technical Memorandum Report.

[8] USACE. 2005 (Exhibit OCWD 1-27).

[9] California Climate Change Center. 2006. *Our Changing Climate – Assessing the Risks to California* (Exhibit OCWD 3-7).

"plumes," occur in the cities Anaheim and Fullerton, approximately 1 to 4 miles west and northwest of the Santa Ana River and OCWD's primary recharge facilities (see Figure 8). These plumes generally occur within the upper 200 feet of aquifer and overlie the zones principally drawn for potable supplies by production wells.

40. <u>VOC Remediation Project.</u> As part of its mission is to enhance the quality of basin water supplies, OCWD has initiated a groundwater cleanup project that will extract, treat, and reinject over three million gallons per day of VOC-impacted groundwater from within the plumes in Anaheim and Fullerton. The goal of this $50 million project is to hydraulically contain the VOC plumes and thereby reduce the potential that these compounds will further threaten drinking water supplies. The extraction wells will be designed and operated such that their flow rates can be adjusted higher or lower as needed to contain the VOC plumes. Because of the great investment in this VOC remediation project, OCWD would not want to develop recharge projects that would reduce the effectiveness of this project by detrimentally moving the VOC plumes.

41. <u>VOC Plume Movement Evaluation.</u> The velocity of groundwater and dissolved contaminants is a function of the aquifer permeability, stratigraphy, and the hydraulic gradient, which is in turn a function of the forces imposed on the aquifer such as pumping and recharge. If pumping and recharge change in the vicinity of the VOC plume, they can affect the gradient and thereby induce the plume to move faster and/or in a different direction. To evaluate current conditions, OCWD staff calculated the recent hydraulic gradient of the shallow aquifer impacted by the VOC plumes to be approximately 0.0025 (25 feet vertical to 10,000 feet horizontal) with a westerly flow direction, based on groundwater elevation contours of June 2006 groundwater level measurements. This gradient is consistent with other gradient calculations made in previous years for this area.

42. To evaluate the effect of the future diversion and recharge projects proposed by OCWD, the aforementioned empirically-derived gradient was compared to the results of future basin management scenarios simulated using OCWD's basin-wide numerical

groundwater model.[10] The model scenario selected for review was that with the greatest projected increases in recharge and pumping (above current conditions) and, therefore, was most likely to exhibit the greatest change in gradient within the plume area. The scenario was based on 2025 projections of groundwater demand and groundwater recharge projects that included approximately 450,000 AFA of basin-wide groundwater pumping (about a 50 percent increase above current pumping) and total recharge at OCWD's Anaheim and Orange recharge facilities of 377,000 AFA[11] (as compared to the current approximate 250,000 AFA recharge capacity). To balance the groundwater basin water budget for this model scenario, the remainder of the basin replenishment that was needed to equal the pumping consisted of recycled water injection for seawater intrusion and natural recharge.

43. The results of the modeling of this scenario indicate that groundwater within the shallow aquifer in the vicinity of the VOC plume would continue to flow in a westerly direction. The hydraulic gradient calculated by the model in this same vicinity under the increased pumping and recharge conditions was essentially the same as the current gradient condition. This finding is reasonable when considering that nearly all groundwater pumping in the Orange County groundwater basin occurs in aquifers 300 feet below ground surface and deeper – not the shallow aquifer that contains the VOC plumes. Because groundwater pumping is concentrated in the deeper aquifers, it induces steeper gradients to drive (or pull) the recharge water toward and into those deeper aquifers, rather than into the shallow aquifer where little pumping occurs. Hypothetically, if large-scale pumping were to occur in certain areas of the shallow aquifer, particularly if it were to occur immediately west (downgradient) of the VOC plumes, then this pumping could induce steeper gradients

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[10] The OCWD basin model was constructed by OCWD engineers and hydrogeologists under my direction and consists of three interconnected aquifer layers covering the entire groundwater basin and was calibrated until it closely matched historical groundwater level data. Once the model was calibrated, it was used as a predictive tool for future basin scenarios. OCWD. 2004. *Groundwater Management Plan* (Exhibit OCWD 3-8).

[11] This future amount of recharge in OCWD's recharge facilities compares closely with the USACE's projections of average SAR flows of 382,306 AFA by 2052 (Exhibit OCWD 1-27).

in the region which in turn could affect the movement of the VOC plumes.

44. In summary, OCWD modeled the effects of future recharge at OCWD's existing facilities and future facilities associated with the proposed SAR diversions and compared these to current groundwater flow conditions in the vicinity of known VOC plumes in the Anaheim/Fullerton area. Our comparison indicates that a condition of future projected recharge and pumping as of 2025 will not significantly affect the movement of shallow VOC plumes in this area.

Executed under the penalty of perjury under the laws of the State of California in Fountain Valley, California on April 11, 2007.

Roy L. Herndon, PG, CHG
Chief Hydrogeologist

TABLE 1
COMPONENTS OF ANNUAL SAR FLOW AT PRADO DAM (WY 1990 TO 2005)

Water Year	Rainfall (in)	Base Flow (ac-ft)	Storm Flow (ac-ft)	Non-Tributary Flow (ac-ft)	Total Flow[a] (ac-ft)
1989-90	8.53	119,149	24,314	1,354	144,817
1990-91	15.48	111,151	75,275	8,769	195,185
1991-92	16.54	106,948	82,729	8,603	198,280
1992-93	30.92	128,068	438,563	5,371	571,138
1993-94	11.62	111,186	41,622	5,889	159,560
1994-95	25.14	123,468	284,651	21,151	429,269
1995-96	11.92	131,861	58,692	26,607	217,160
1996-97	18.64	136,676	61,783	51,235	249,685
1997-98	33.41	155,711	298,915	8,007	462,646
1998-99	8.02	158,637	23,673	2,684	184,998
1999-00	11.09	148,269	40,269	19,945	207,850
2000-01	16.13	153,914	54,621	13,391	222,559
2001-02	5.08	145,981	10,615	18,372	174,968
2002-03	16.22	146,113	97,810	12,234	256,157
2003-04	10.80	143,510	57,317	13,275	214,102
2004-05	29.89	154,307	469,515	14,710	638,513

SOURCE: SAR Watermaster, Annual Reports (1991-2006)

[a]Total flow represents gaged outflow from Prado Dam and, therefore, does not include water stored behind the Dam at the end of the water year (generally a small volume).

TABLE 2
COMPONENTS OF 2025 SANTA ANA RIVER FLOW AS ESTIMATED BY SAWPA

Components of Santa Ana River Flow	Flows at Prado Dam (AFA)		
	Dry	Average	Wet
Municipal Discharges (including evaporation losses, infiltration losses, and recycled water diversions)	189,200	189,200	189,200
High Groundwater Mitigation Project	--	2,500	24,500
Arundo Removal	8,300	8,300	8,300
Total Base Flow Projections	**197,500**	**200,000**	**222,000**
Storm Flow	18,300	65,400	340,300
Total Base Flow and Storm Flow	**215,800**	**265,400**	**562,300**

SOURCE: SAWPA, 2004.

TABLE 3

SUMMARY OF HISTORIC AND PROJECTED FUTURE AVERAGE ANNUAL SAR FLOW REACHING PRADO DAM

Water Years /Time Period	SAR flow at Prado Dam (AFA)	
	Average	Wet Year[d]
USGS Gage 1950-1988[a]	120,257	536,174
USGS Gage 1989-2003[a]	255,646	571,138
SAWPA Estimates 2025[b]	265,400	562,300
USACE Estimates 2052[c]	374,436	847,000

SOURCE:
a USGS Gage no. 11074000
b SAWPA, 2004
c USACE, 2005
d Flow value is a maximum annual total over the indicated period.

TABLE 4
SUMMARY OF PENDING WATER RIGHTS APPLICATIONS

Water Rights Approved Since 1988	**Total Pending New Diversion Rights (AFA)**	**Net Pending Wet Year Diversions (AFA)**
Chino Basin Watermaster	27,000	27,000
Ganahl (private)	81	81
Gunnoe (private)	30	30
Elsinore Valley Municipal Water District	11,200	0[1]
<u>**Pending Water Rights Applications**</u>		
Kirtley (private)	25	25
Quiroz (private)	26	26
San Bernardino Valley Water Conservation District (SBVWCD)	55,464[2]	0[3]
San Bernardino Valley Municipal Water District/ Western Municipal Water District (Muni/Western)	200,000[2]	31,000[3]
Chino Basin Watermaster	97,000	82,000[4]
City of Riverside	41,400	41,400
Total	**432,226**	**181,562**

SOURCE: California Water Rights Information Management System, http://www.waterrights.ca.gov/

[1] The total also does not include 11,200 afy for Elsinore Valley Municipal Water District because contributions from the San Jacinto watershed to the SAR are infrequent and would not affect projected wet year flow at Prado Dam significantly.

[2] SBVWCD and SBVMWD/WMWD would be in competition for diversions at a common point on the river, below Mentone Gage. The combined total of these two applications is 200,000 af.

[3] According to SBVMWD/WMWD, during a future wet year similar to 1992-1993, one of the wettest years on record since 1950, the effect of both SBVMWD/WMWD and SBVWCD diversions would result in total diversions of 125,000 afy, resulting in a total net loss of 31,000 afy at Riverside Narrows. See Figure 4 and SBVMWD/WMWD (2004) for further explanation.

[4] Chino Basin Watermaster already has a permit to divert 15,000 afy from the SAR using detention basins built prior to 1988. Therefore, net pending actual diversions do not include this existing diversion amount.

TABLE 5
ESTIMATED FUTURE WASTEWATER RECYCLING VOLUMES

Wastewater Treatment Provider	Projected Recycled Water Demand (AFA)	Notes
City of Rialto WWTP	70	70 afy is the volume of water that the City of Rialto recycled in 2001-2002. Facility expansion plans are not anticipated before 2010.
Riverside RWQCP	2,000	Currently, the City of Riverside is in the design phase for construction of a new pump station to develop 2,000 afy of recycled water. Additional recycled water projects by the City have been accounted for as part of the City's pending 41,400 afy diversion application.
City of San Bernardino/Colton RIX Facility	5,000	The City of San Bernardino/Colton RIX Facility indicates that up to 18,000 afy of recycled water could be diverted from their SAR discharge. However, no recycled water is currently being diverted. Although SAWPA 2025 estimates do not include RIX diversions, for purposes of this analysis 5,000 afy has been assumed.
Inland Empire Utilities Agency	43,100	IEUA's Wastewater Facilities Master Plan (Plan), August 2002, calls for increased water recycling. The later phases of the Plan are scheduled for 2005-06, 2006-08, and 2008-10, and call for an additional 43,100 afy of recycled water from all IEAU treatment plants.
Western Riverside Regional WWTP	5,200	The Western Riverside Regional WWTP did not recycle any of its tertiary effluent in 2001-2002. Plans call for increasing plant capacity and developing recycled water; these plans, however, are only in the preliminary discussion stage and it is not anticipated that any expansion will be completed before 2010. SAWPA estimates assume 5,200 afy by 2025.
City of Corona	9,170	Based upon current construction and permitting schedules, SAWPA staff projects that approximately 70% of the City of Corona's recycled water goal will be met by 2010 (the recycled water goal is 13,100 afy by the year 2025). 9,170 afy represents 70% of 13,100 afy and is considered a reasonable amount given the uncertainties of permitting requirements and recycled water demand reliability.
Total Projected Recycled Water	**64,540**	

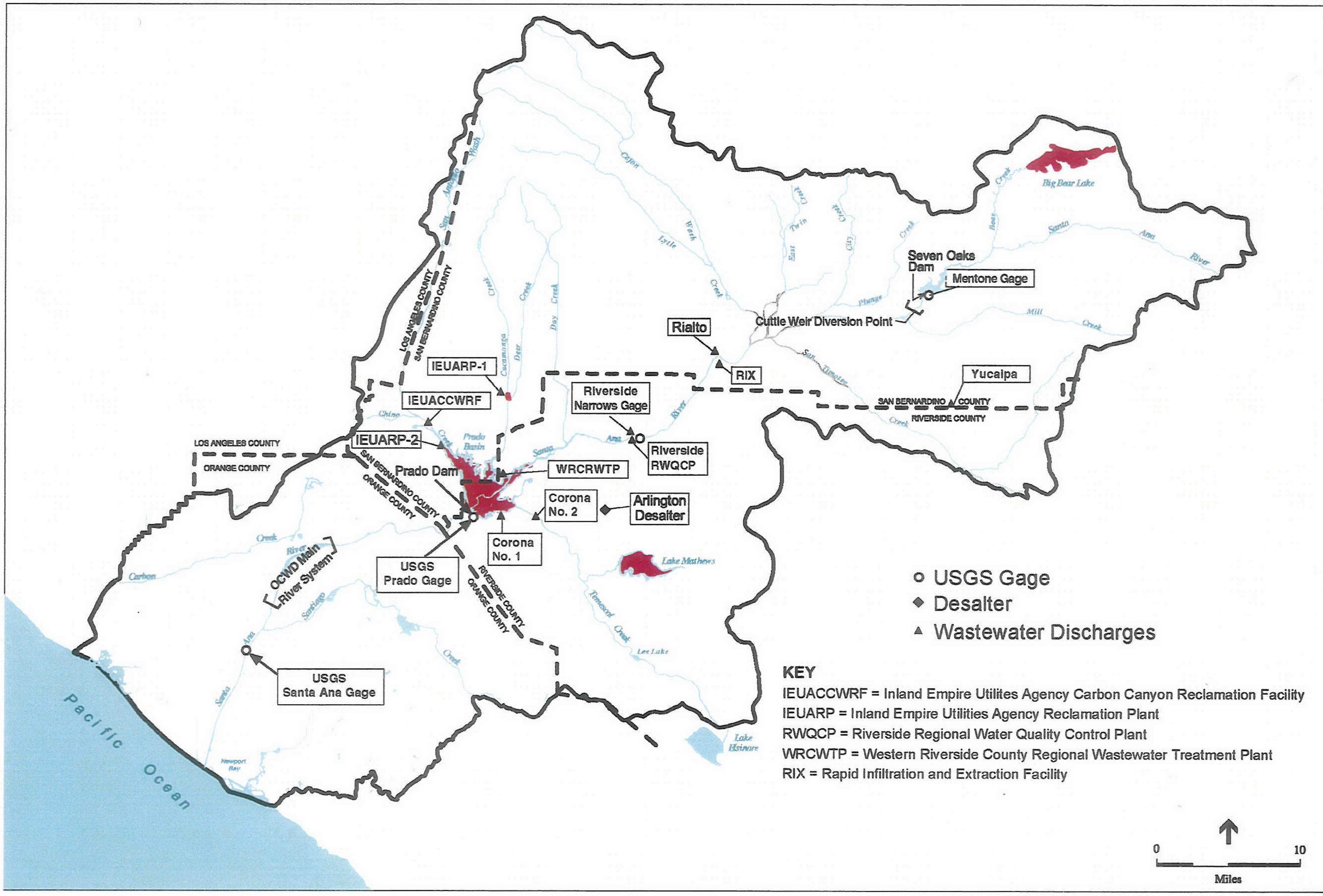
SOURCE: SAWPA, 2004.

Note: Values are estimates presented by SAWPA based on planned recycled water development.

TABLE 6
SUMMARY OF NET PEAK WET YEAR FLOWS UNDER FUTURE RUNOFF CONDITIONS ARRIVING AT OCWD'S OPERATIONS AREA (AFA)

	A Max. Annual Future Supply Estimates	B Total Pending New Water Diversion Applications	C Estimated Recycled Water Volume	D Estimated Additional Flows	Total Flows (A-B-C+D)
USACE under 2052 conditions	868,000	181,562	64,540	32,800	654,698

SOURCE:
(A) USACE, 2005, including estimated inflow from tributaries between Prado Dam and Imperial Highway.
(B) See Table 4.
(C) SAWPA, 2004 Also see Table 5.
(D) Includes SAWPA estimates for Arundo Removal and High Groundwater Mitigation Projects.



SOURCE: Santa Ana River Watermaster, 2005

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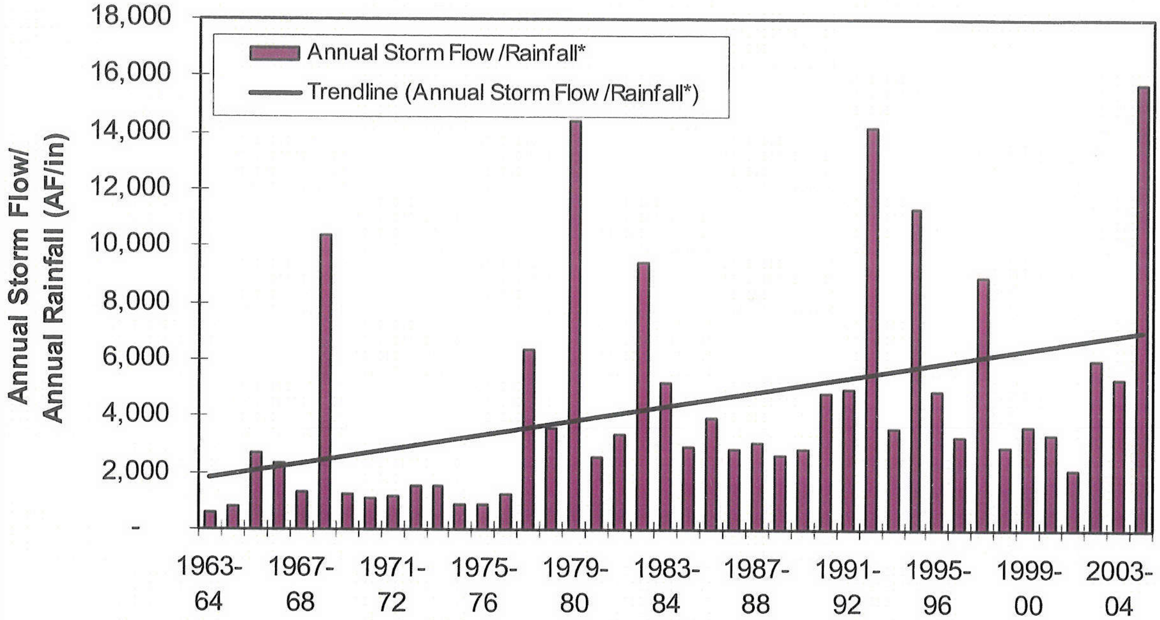
Figure 1
Appendix D-Diversion Points on SAR

Figure 2: SAR Storm Flow/Rainfall Trend at Prado



* Sources: For years 1963-66, "Appendix 'A' Basic Data, Volume I, OCWD v. Chino, Joint Engineering Committee, 1968"; 1967-68, "Analysis of Components of Flow of the SAR below Prado Dam for Water Year 1967-68"; 1968-69, "Prado Scalping 1968-69 Based on Inflow Adjusted Using New Reservoir Contents Table Based on Survey of September 1969"; 1970-2006 SAR Watermaster Annual Reports

Figure 3: SAR Flow Variability for Historical Base Period and as Adjusted by the USACE for 2052 Conditions

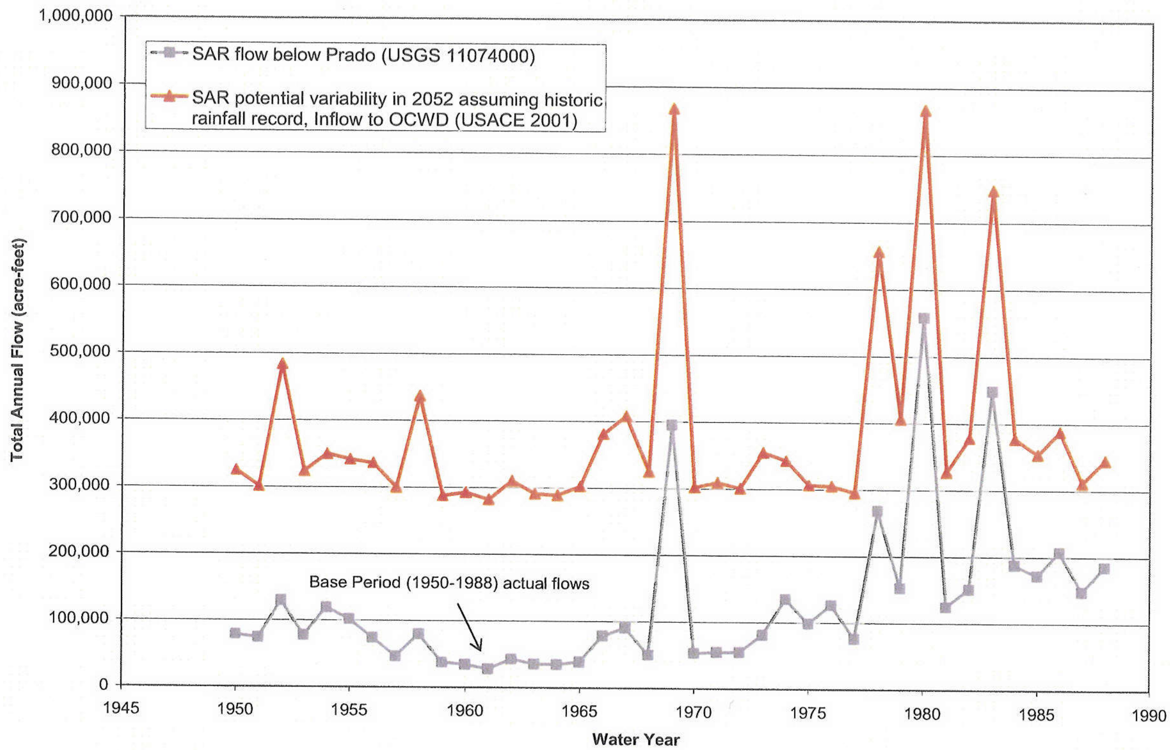
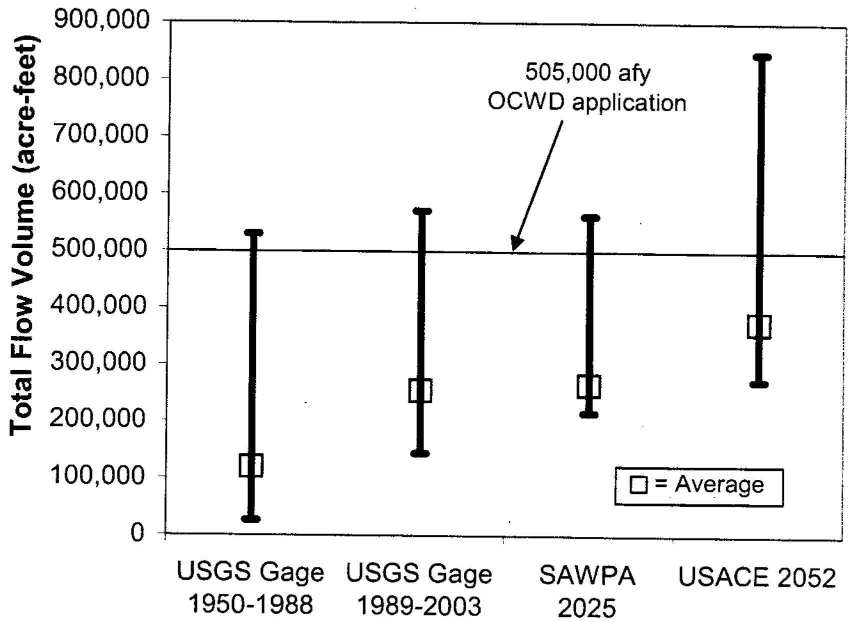
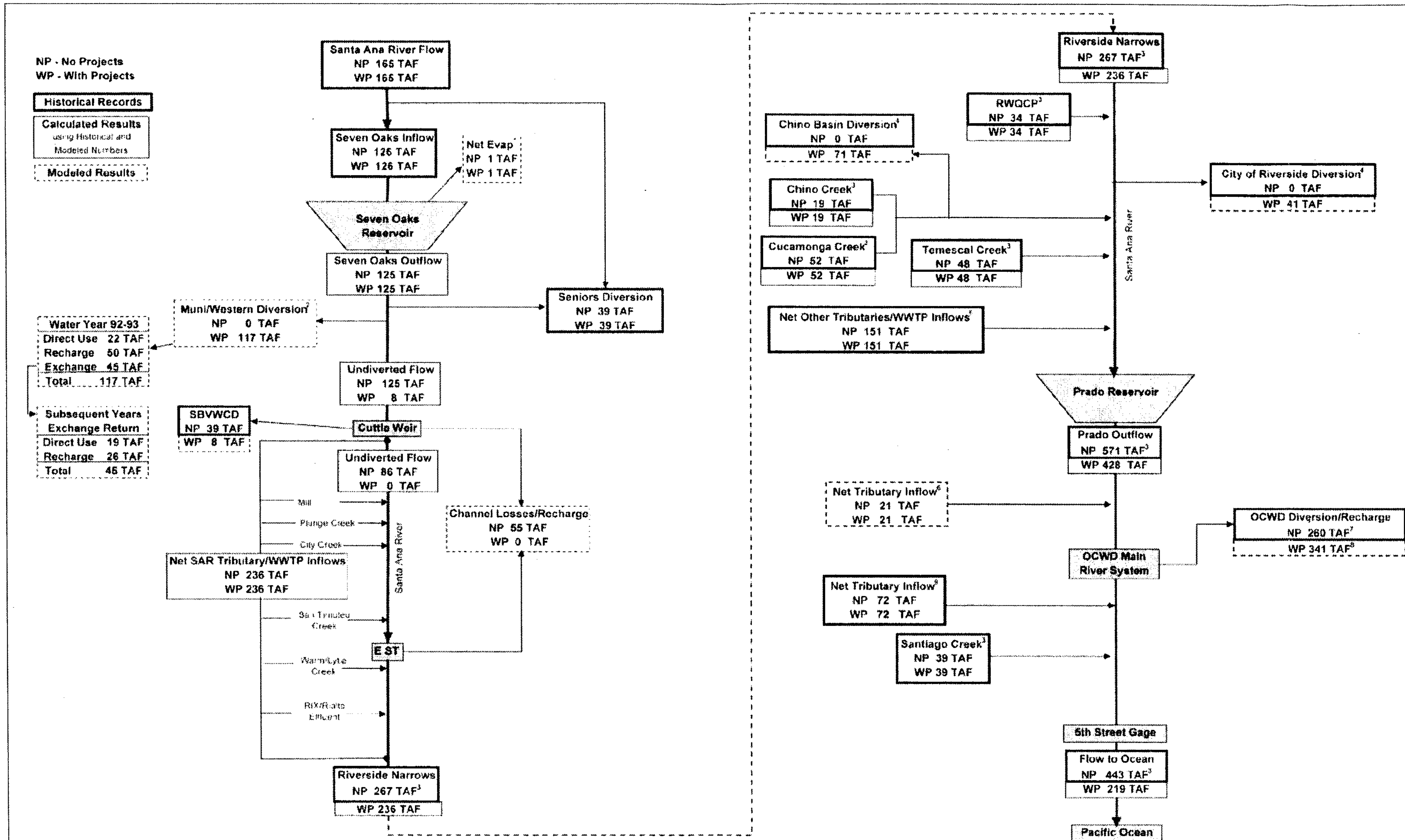


Figure 4. Actual and Estimated Range of SAR Flow





Note: Water Year 92-93 is the 3rd wettest year in the period from WY 1961-62 to 1999-2000. The probability of a similar wet year occurring in any future year is 5%.

[1] Modeled value estimate at 0.2 TAF but 1 TAF used for illustrative purposes

[2] Muni/Western Diversion based on modeled Project Scenario A.

[3] Flow volume based on USGS gage data for Water Year 1992-1993

[4] Diversions assume water rights applications are accepted and approved by SWRCB. Chino Basin Watermaster (IEUA) has 27 TAF of water rights approved in 1994 and is applying for an additional 97 TAF. In simulated WY 1993, 71 TAF is available for diversion

[5] Flow volume calculated as the difference between gaged river flow above and below Prado Dam net of evapotranspiration and channel losses

[6] USACE estimate of inflow to the Santa Ana River between Prado Dam and OCWD Main River System. (Prado Conservation Feasibility Study EIS. 2004)

[7] OCWD diversions for Water Year 1992-1993. (See OCWD Water Rights DEIR, Appendix D, Attachment A, Table A)

[8] This represents OCWD's estimate of diversions during a simulated WY 1993, based on daily flow rates below Prado Dam at USGS Gage No. 11074000. OCWD assumes 108 TAF of water bypasses its points of diversion when the river is flowing over 3,500 cfs

[9] Flow volume calculated as the difference between Prado (11074000), 5th Street (11078000) and Santiago Creek (11077500) gages and OCWD Diversions for Water Year 1992-1993

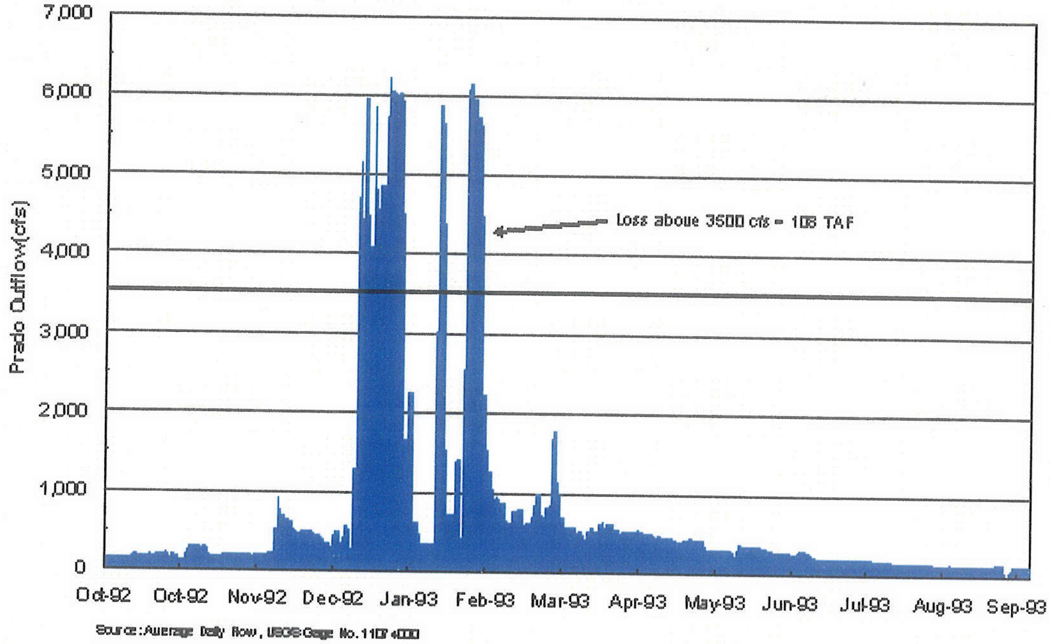
SOURCE: OCWD, ESA 2005

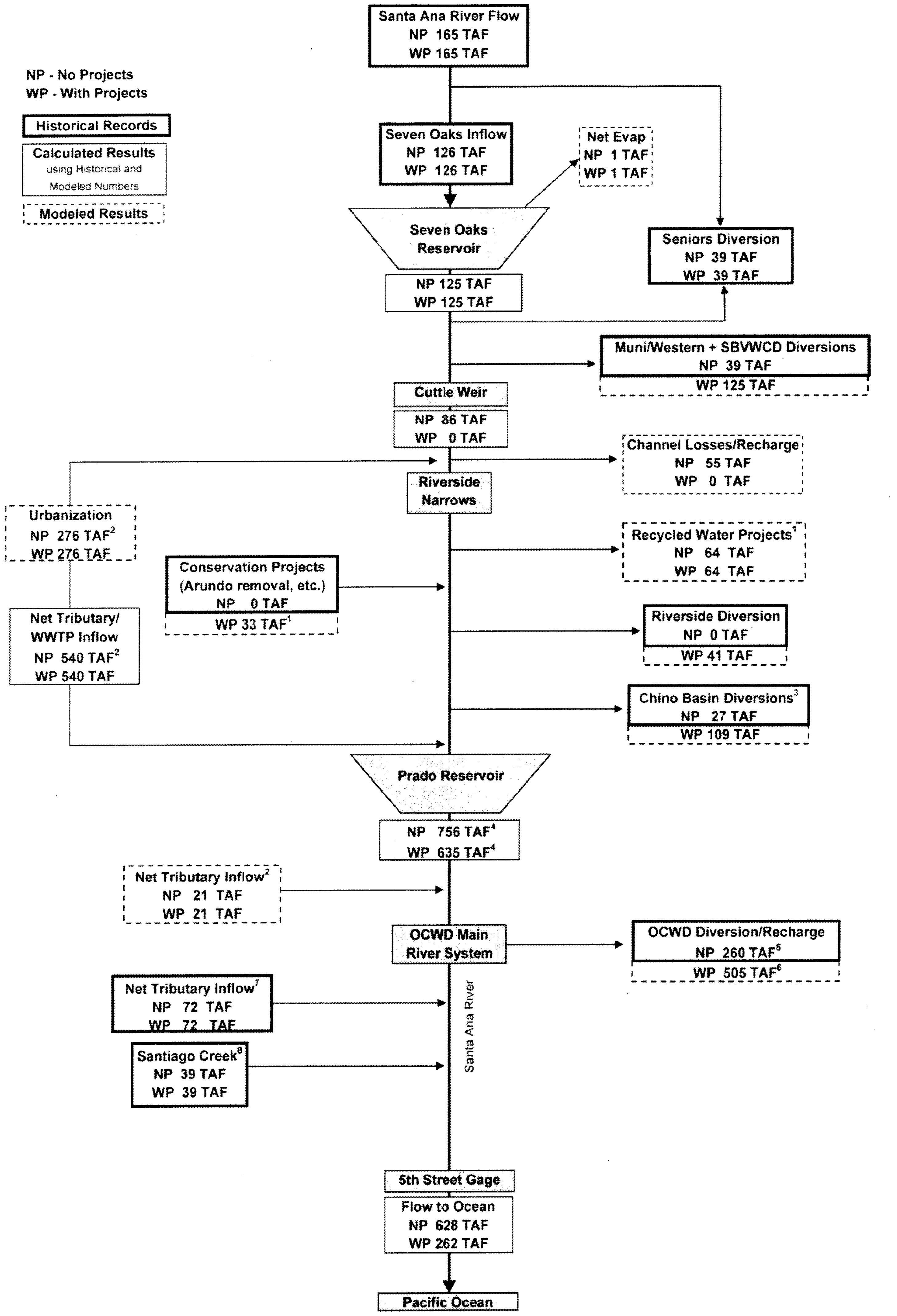
OCWD . 202291

Figure 5

Schematic of Santa Ana River Flows and Diversions
Simulated Repetition of Water Year 1992-93 Hydrology (TAF / Year)
Proposed Projects from Seven Oaks Dam to the Pacific Ocean

Figure 6. Water Year 1992-93 Daily Outflow at Prado Reservoir





[1] OCWD and SAWPA estimates (OCWD Water Rights DEIR, Appendix D).

[2] USACE projection of inflow to the Santa Ana River above Prado Dam (847 TAF) and between Prado Dam and OCWD Main River System (21 TAF) when accounting for urbanization in the SAR watershed (Prado Conservation Feasibility Study, 2004). Urbanization increases total flow volume at Prado Dam by 276 TAF during a year similar to the 1992-1993 Water Year.

[3] Flow volume includes Chino Basin Watermaster (IEUA) water rights approved since 1988 (27 TAF) and net pending water rights (82 TAF).

[4] **NP:** USACE 50-year projection for Prado Dam outflow for a wet year (847 TAF) minus proposed recycling projects (64 TAF) and Chino Basin (IEUA) approved diversions (27 TAF). **WP**: USACE 50-year projection for Prado Dam outflow for a wet year (847 TAF) minus proposed recycling projects (64 TAF), plus conservation projects (33 TAF), minus proposed upstream diversions (31 TAF, 41 TAF, 109 TAF).

[5] OCWD diversions for Water Year 1992-1993. (See OCWD Water Rights DEIR, Appendix D, Attachment A, Table A)

[6] This represents a theoretical diversion equal to the total water rights being requested from the SWRCB.

[7] Flow volume calculated as the difference between Prado (11074000), 5th Street (11078000), and Santiago Creek (11077500) gages and OCWD Diversions for Water Year 1992-1993. Urbanization will not affect future (2052) flows in this portion of the watershed.

[8] Flow volume based on USGS Gage No. 11077500 for Water Year 1992-1993. Urbanization will not affect future flows in Santiago Creek.

SOURCE: OCWD, 2005

Figure 7

Schematic of Santa Ana River Annual Flows and Diversions
Simulated Repetition of Water Year 1992-93 with Urbanization (TAF / Year)
Proposed Projects from Seven Oaks Dam to the Pacific Ocean

Figure 8.

OCWD Recharge Facilities and Areas of Chlorinated VOC Groundwater Contamination