TESTIMONY OF ROBERT G. BEEBY

Before the

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

Relative to

SANTA ANA RIVER WATER RIGHT APPLICATIONS FOR SUPPLEMENTAL WATER SUPPLY

May 2007

Summary of Testimony

1. I was retained in 1997 by the San Bernardino Valley Municipal Water District (Muni) and the Western Municipal Water District of Riverside County (Western) to prepare an analysis of the water in the Santa Ana River (SAR) System that might be conserved by means of additional storage capacity made available by Seven Oaks Dam.

2. In 1999 I testified before this Board that, based on my analyses, in some years Muni and Western could divert and put to beneficial use up to the 100,000 acre-feet (af) that was applied for in their joint application filed in 1991. I also testified that my analyses indicated that an additional 100,000 af could also be diverted and put to beneficial use and that I would recommend that Muni and Western augment their original application for a total of 200,000 af. Shortly after the 1999 hearing, Muni and Western filed a second petition and application for an additional 100,000 af and now have two applications pending before this Board requesting a permit to divert and put to beneficial use up 200,000 af in years when that amount is available.

3. Extensive analyses conducted since 1999 on the hydrology of the Santa Ana River System and on the environmental impacts of diverting up to 200,000 af in some years confirm my earlier analysis.

4. These analyses were conducted using a suite of computer models developed by SAIC and GEOSCIENCE who worked cooperatively in model development and in evaluating the results.

5. The computer models had two basic objectives. The first was to estimate the amounts of potential capture of unappropriated water from the Upper Santa Ana River for a range of scenarios; the second objective was to evaluate the effects of such capture on the downstream channel hydrology and hydraulics.

6. Sixteen Project Scenarios were developed based on a number of variables and five scenarios were analyzed in detail because they represented the high and low range of capture amounts for diversion rates of 500 cubic feet per second (cfs) and 1,500 cfs.

7. The high and low ranges of potential capture by Muni/Western established “bookends” that were used to identify and evaluate environmental impacts resulting from Project implementation.

8. The largest effects on the Santa Ana River channel, in terms of flowrate, depth and area inundated will be in the segments from Seven Oaks Dam to the confluence with Mill Creek. Downstream from the confluence with Mill Creek the effects of Muni/Western diversions become less when compared to the No Project condition because of the influence of tributary inflow and discharges from the existing wastewater treatment plants.

Downstream from Riverside Narrows, the effects of Muni/Western diversions are so small they cannot be accurately measured.

9. The additional analyses show that by using the regulatory and perhaps conservation storage created by Seven Oaks Dam, Muni/Western could divert from 10,000 to 27,000 acre-feet per year (afy) on average depending on Project Scenario.

10. In some years, up to 198,300 af can be captured by Muni/Western.

11. This can be accomplished without affecting downstream obligations under the various judgments and with recognition of the rights of local senior water right holders to divert water from the Santa Ana River.

12. The roughly 200,000 af of water captured by Muni/Western in the maximum year of the hydrologic base period is distributed to beneficial uses in the Muni/Western service areas as listed: (1) 20,313 af to direct use in the Muni Service Area; (2) 3,900 af to groundwater recharge in the San Bernardino Basin Area; (3) 26,852 af to groundwater recharge in the Muni Service Area; and, (4) 147,254 af for exchange to be returned to Muni/Western as soon as practicable following the maximum runoff year.[1]

13. Such conservation and beneficial use of the local water supplies justifies the State Water Resources Control Board granting permits for Application No. 31165 and Application No. 31370 for a combined maximum annual diversion of 200,000 af.

Background and Qualifications

14. I have over 35 years of experience in planning and management of water resource projects. I have directed numerous studies relating to technical and economic feasibility of water projects for agriculture, have developed regional water management plans, have participated as an expert on technical advisory committees for adjudication of Mojave, Santa Maria and Antelope Valley ground water basins and have managed the design and construction of major water resource facilities. I also have provided expert witness testimony in numerous proceedings related to land use, water use and water rights. I have testified before this Board, before a Special Master appointed by the Supreme Court in *Arizona v. California* (1980), and before judicial and quasi-judicial bodies. A more detailed description of my qualifications is contained in my resume, which is attached as Muni/Western Exhibit 5-2.

15. My current position is Vice President – Engineering Services with Science Applications International Corporation (SAIC). In that capacity I serve as principal-in-charge and senior project manager for projects relating to water resources planning and management. My specific activities are related to regional water planning, development of physical solutions,

1 Exchange water could be put to beneficial use within the Muni/Western service areas if Muni/Western determines it is not desirable to enter into an exchange with Metropolitan. See Paragraph 99 of this testimony.

evaluation and implementation of water banking and exchange programs, agricultural land and water use and litigation support related to rights to use surface and ground water resources. I also serve on the Board of Directors of SAIC Engineering, Inc., a wholly owned subsidiary of SAIC.

16. I continue to provide professional services to clients in the region, and in addition to the work related to the Muni/Western water right applications, which are the subject of my testimony before this Board, I am involved in the preparation of an integrated regional water management plan for the area.

Project History

17. In 1991, Muni submitted Application No. 31165 (“First Application”) to the State Water Resources Control Board on behalf of itself and Western to appropriate up to 100,000 afy from the Santa Ana River. However, in 1989 and again in 1998, the State Water Resources Control Board included the Santa Ana River in its Declaration of Fully Appropriated Streams. In accordance with these Declarations, the Santa Ana River was considered fully appropriated year-round. In 1989, the State Water Code prevented the State Water Resources Control Board from accepting any new applications to appropriate water from watercourses listed in the Declarations. In April 1993, the State Water Resources Control Board adopted procedures for reviewing the fully appropriated stream status of the Santa Ana River and Muni/Western subsequently submitted a petition to revise the Declaration of Fully Appropriated Stream Status for the Santa Ana River, together with the 1991 application.

18. Muni/Western provided evidence the during hearings held by the State Water Resources Control Board in December 1999 when my testimony and that of other experts demonstrated that flows in the Santa Ana River watershed had increased due to urbanization and the attendant increased runoff and increased releases of treated wastewater. Additionally, completion and subsequent operation of Seven Oaks Dam would increase availability of water during wet years. Based on evidence in the hearing record, the State Water Resources Control Board amended the Declaration in Order WR 2000–12, to allow for the processing of the water right applications submitted by Muni/Western and Orange County Water District.

19. In May 2001 Muni and Western jointly submitted Application No. 31370 to appropriate 100,000 af of water annually ("Second Application") in addition to the 100,000 af per year previously requested under the First Application, along with a second petition to revise the Fully Appropriated Streams Declaration for the Santa Ana River ("Second Petition"). The Second Petition and Second Application were based on updated hydrologic analyses prepared by SAIC and were submitted to the State Water Resources Control Board during

the 1999 hearings which indicated that, in certain years, there is in excess of 200,000 af of water available for appropriation in the Santa Ana River.

SAIC Role in Project

20. I was retained by Downey Brand on behalf of Muni/Western in 1997 when I was an employee of Bookman-Edmonston Engineering, Inc. I joined SAIC in August of 1998 and Downey Brand subsequently entered into a contract with SAIC for professional services. I serve as the Principal-in-Charge and direct all SAIC activities related to the professional services agreement between Downey Brand and SAIC and the activities of my staff.

21. The type of professional services SAIC provides to Muni/Western fall into three general categories: (1) Analyses that relate to the quantity of water that can be captured and diverted from the SAR by Muni/Western and put to beneficial use in their service areas; (2) Analyses that relate to the effects of those diversions on the channel of the SAR; and, (3) working on the groundwater modeling effort led by GEOSCIENCE.

22. The work was generally performed using computer models developed by SAIC to simulate hydrologic conditions based on a repetition of historical hydrology. The computer models were used to analyze:

    a. The fully appropriated stream status.

    b. The amounts of unappropriated flow in the Santa Ana River (SAR) that can be captured and put to beneficial use by Muni/Western.

    c. The effects that capture of the unappropriated flow in the SAR by Muni/Western would have on the hydrology and hydraulics of the SAR channel.

    d. The effects of various proposed settlement alternatives.

SAIC engineers and technical staff also worked closely with the modeling staff at GEOSCIENCE to assure that the surface water modeling efforts and groundwater modeling efforts were coordinated and consistent with each other. This will be explained later in my testimony and in the testimony of Dr. Dennis Williams.

Santa Ana River System

23. The Santa Ana River is the largest stream system in southern California. It begins in the San Bernardino Mountains and flows over 100 miles southwesterly where it discharges to the Pacific Ocean between Newport Beach and Huntington Beach. A complete description of the SAR watershed is presented in the Draft EIR, pages 3.1-1 to 3.1-11 (See Muni/Western Exhibit 4-3). The SAR watershed and its relationship to the Muni/Western service areas are illustrated in Muni/Western Exhibit 5-3.

24. The main features of the SAR System are described below:

a. **Bear Valley Dam and Lake** – Big Bear Dam, which forms Big Bear Lake, is the only major dam that affects runoff into Seven Oaks Dam. I will discuss the agreements affecting the releases from Big Bear Dam to Bear Creek, a tributary to the SAR, later in my testimony.

b. **Diversions Upstream from Seven Oaks Dam** - Water diverted at a number of points of diversion upstream of Seven Oaks Dam is used for power generation as it is conveyed through the existing Southern California Edison (SCE) Canal for delivery to Senior Water Rights Claimants. The Senior Water Rights Claimants are discussed in the Draft EIR, page 3.1-19. The upstream diversion points and other facilities in the vicinity of the Dam are shown on Muni/Western Exhibit 5-4 and Muni/Western Exhibit 5-5.

c. **Seven Oaks Dam** - The flow in the SAR is constrained by Seven Oaks Dam, which was completed in December 1999. The Seven Oaks Dam is a 550-foot high earth/rock-fill dam with a gross storage capacity of 147,970 af at spillway crest. About one mile downstream from Seven Oaks Dam, the SAR emerges from the upper SAR canyon and flows through the San Bernardino Valley. The watershed above Seven Oaks Dam drains approximately 177 square miles.

d. **Francis Cuttle Weir** - The Francis Cuttle Weir (“Cuttle Weir”) was built in 1932 by what is now known as the Conservation District to divert flow in the SAR for groundwater recharge. The weir is located approximately one mile downstream from the Seven Oaks Dam. Water diverted from the SAR is conveyed to the Santa Ana River Spreading Grounds by the Conservation District Canal. The capacity of the canal is roughly 300 cfs.

e. **Wastewater Treatment Facilities** - Proceeding downstream, there are 14 publicly owned wastewater treatment plants (WWTP) located above Prado Dam in the Upper SAR watershed. Nine of these plants contribute to surface flow of the SAR. Between 1970 and 2000, the total volume of wastewater contributions to SAR flows increased from 44,000 afy to 169,000 afy (see Muni/Western Exhibit 4-3, Draft EIR page 3.1-4).

f. **Groundwater Recharge Facilities** - Groundwater recharge facilities have been a component of the SAR System since 1912 with the formation of what is now known as the Conservation District, created to percolate natural runoff from the SAR. Details of the operations of the Conservation District are covered in the Draft EIR, pages 3.1-19 to 3.1-20 (See Muni/Western Exhibit 4-3). Artificial recharge of imported water began in 1972.

25. The Santa Ana River System and more specifically, the flow characteristics of the channel itself, vary widely from its headwaters in the San Bernardino Mountains to its mouth at the

Pacific Ocean. These characteristics are best understood by subdividing the SAR into seven reaches or segments. Each specific segment of the river is delineated using criteria (e.g., locations at which US Geological Survey (USGS) gage data are available, locations at which river flow changes due to large inflow or large diversion, and locations specific to water rights agreements and judgments) that have important implications for the analysis of Project-related impacts. For the purposes of this Project, and my testimony, the segments have designations A through G that have important implications for the analysis of Project-related impacts. See Muni/Western Exhibit 5-6.

a. **Segment A** – Upstream of Seven Oaks Dam (above River Mile [RM] 70.93) - The watershed above Seven Oaks Dam drains approximately 177 square miles. The average gradient of the river above Seven Oaks Dam is 300 feet per mile, but tributaries have gradients ranging from 600 feet per mile to 1,900 feet per mile, which illustrate the steep topography of this area. Features in Segment A include Bear Valley Dam and Lake and the diversion facilities for SCE and the Senior Water Rights Claimants.

b. **Segment B –** Seven Oaks Dam to just above Cuttle Weir (RM 70.93 to RM 70.46 – Releases from Seven Oaks Dam control the flow in this segment of the river. A minimum of 3 cfs is continuously released from Seven Oaks Dam into the Plunge Pool or Plunge Pool bypass pipeline. This release becomes surface flow diverted by the Auxiliary Diversion into the Division Box for use by the Senior Water Rights Claimants. Water released from Seven Oaks Dam can enter the Redlands Tunnel by infiltration and is also used by the Senior Water Rights Claimants. The other major water diversions in this segment are those made by the Conservation District through the intake structure adjacent to Cuttle Weir. I have prepared Muni/Western Exhibit 5-7 to show the various facilities in the vicinity of Seven Oaks Dam.

c. **Segment C** – Cuttle Weir to just above the confluence with Mill Creek (RM 70.46 to RM 68.59) - There are no major tributaries or water control features in this segment of the SAR. Like its upstream segment, the SAR slope is fairly steep and bed material is generally coarse throughout. Downstream of the Cuttle Weir, the SAR exits the upper SAR canyon and enters the the Santa Ana Wash. At the Greenspot Road Bridge the SAR channel is approximately 250 feet wide. Throughout this segment, the river floodplain is wider and is no longer confined by the upper SAR canyon walls. Stream flows in this reach are ephemeral.

d. **Segment D** – Mill Creek confluence to just above "E" Street (RM 68.59 to RM 57.7) - This river segment receives a substantial amount of tributary inflow from Mill Creek, City Creek, Plunge Creek, Mission Zanja Creek, San Timoteo

Creek, and East Twin Creek. Mill Creek is one of the largest tributaries to the SAR in the Project area, with a drainage basin of approximately 49 square miles (Muni/Western 2004). Flow in Mill Creek depends largely on storm precipitation, with a general reduction in stream flow during the dry summer and fall months. At the upper end of this river segment, river bed material is generally coarse, whereas the downstream portion of this river segment consists of a soft-bottom channel with uncompacted earthen berms on both banks. In the upper end of this river segment the channel is about 1,800 feet wide. In this downstream portion, the river is part of a broad wash up to 5,000 feet wide, which includes part of the floodplain for City Creek and Plunge Creek. Segment D includes multiple areas that could be subject to overbank flooding.

e. **Segment E –** "E" Street to just above RIX and Rialto Effluent Outfall (RM 57.7 to RM 53.5) - River Segment E receives a substantial amount of tributary inflow from Lytle Creek and Warm Creek. From November to April, this segment generally has baseflow along its entire length, however, from May to October the streambed typically dries out at approximately RM 54.5 and downstream until the RIX and Rialto Effluent Outfall. Throughout Segment E, the SAR has been largely channelized to confine flows and protect bridges and other structures.

f. **Segment F –** RIX and Rialto Effluent Outfall to just above Riverside Narrows (RM 53.5 to RM 45.2) - The SAR in Segment F receives significant inflow from wastewater discharges from the RIX and Rialto WWTPs. Generally, this river segment has year round flow, attributable to the effluent discharge, rising water, and inflow from urban and agricultural runoff.

g. **Segment G –** Riverside Narrows to Prado Dam (RM 45.2 to RM 35.5) - Stream flow is perennial throughout Segment G due to inflow from WWTPs and groundwater influences.

Gages and Measurement

26. Runoff records provide information on the characteristics of flow in the SAR and its tributaries. Such records are available for a number of stream gaging stations located on the mainstem of the SAR and throughout the watershed. The location of these gages is shown on Muni/Western Exhibit 5-8. There are three USGS gaging stations located within the SAR canyon upstream of Seven Oaks Dam that were used to estimate the flows in the SAR. These gages are listed as follow:

a. The Southern California Edison (SCE) Canal Gage (USGS Gage 11049500 SCE SANTA ANA R CN AB PP3 NR MENTONE CA) records flow that is diverted into the SCE Canal above Seven Oaks Dam;

b. The Auxiliary Canal Gage (USGS Gage 11051502 SAR SUPP GAGE NR MENTONE CA) records flow diverted from the SAR into the Auxiliary Canal above Cuttle Weir which ultimately enters the Division Box; and,

c. The Mentone Gage [USGS Gage 11051499 SANTA ANA R NR MENTONE (RIVER ONLY)]. (Note: The "(RIVER ONLY) part of the official USGS label for this physical gage site should not be confused with "River Only Mentone Gage" defined as USGS record 11051500 in Paragraph 27 and as used throughout this testimony.) This gage is located on the SAR at RM 69.96, just upstream of Cuttle Weir, accounts for water flowing in the SAR just below Seven Oaks Dam.

27. The combination of all three gages (referred to as the "Combined Flow" Mentone Gage [USGS record 11051501 SANTA ANA R NR MENTONE CN + CN CA]), represents the sum of stream flow recorded in the river at the Mentone Gage, in addition to flow that would have been in the river at this location had it not been diverted upstream for use in the SCE hydroelectric system and at other points of diversion. The "River Only" Mentone Gage (USGS record 11051500 SANTA ANA R NR MENTONE CA) is the sum of the Mentone Gage and Auxiliary Canal Gage and is representative of SAR flow near Seven Oaks Dam. For use in the analysis described in my testimony following, the daily values for USGS record 11051500 were calculated by adding the daily values for USGS gage 11051499 and USGS gage 11051502. The daily values for USGS record 11051501 were calculated by adding the daily values for USGS gage 11051499, USGS gage 11051502 and USGS gage 11049500.

28. There are two other USGS gaging stations located downstream of Seven Oaks Dam, but within the upper SAR basin: the "E" Street Gage (USGS Gage 11059300 SANTA ANA R A E ST NR SAN BERNARDINO CA) located in the City of San Bernardino at RM 57.69; and the MWD (Metropolitan Water District) Crossing Gage (USGS Gage 11066460 SANTA ANA R A MWD CROSSING CA) located at RM 45.2 near Riverside Narrows.

29. It is noted that stream flow gaging stations function by recording the stage or depth of flow that is passing by the particular point in the river where the gage is located. The cross sectional area of the point is determined by USGS hydrologists. A calibration curve is prepared that relates the depth of flow to the rate of flow, which is usually expressed in cubic feet per second. What is reported in the USGS records is the average daily flowrate which is then converted to a volume, usually expressed in acre-feet.

30. The USGS rates the accuracy of their stations using the terms Excellent, Good, Fair and Poor. Accuracy of the USGS measurements is a function of the hydraulic conditions at the rated section including, but not limited to: (1) the stability of the channel bed where the gage is located; (2) the slope of the channel upstream and downstream; (3) the hydraulic roughness of the channel; (4) existence of vegetation in the channel. The USGS gaging

stations in the portion of the SAR affected by the Project are rated “Fair”, largely due to the fact that the channel is somewhat unstable and irregular. Because these stations are rated as “Fair”, the accuracy is defined by the USGS as plus or minus 15 percent (see page 2-35 of Final EIR, Muni/Western Exhibit 4-4). That is to say that if the flow is reported to be 100 af on a particular day, the actual flow would be in the range of 115 to 85 af for that day.

Institutional Considerations

31. The right to use water from the SAR has been the subject of a number of court judgments and State Water Resources Control Board (SWRCB) orders which are described in the Draft EIR at pages 3.1-16 to 3.1-19 (See Muni/Western Exhibit 4-3). Two court judgments, referred to as the *Orange County* Judgment and the *Western* Judgment, provide the overall framework for the division of rights and responsibilities for water users in the SAR basin. These judgments and SWRCB orders have been described in testimony submitted by Mr. Robert Reiter, one of the Watermasters for the *Orange County* and *Western* Judgments, and former General Manager and Chief Engineer of Muni. The purpose of including discussion of these institutional considerations is to explain how the administration of these judgments is reflected in the computer modeling developed by SAIC.

a. ***Orange County* Judgment** - The *Orange County* Judgment imposes a physical solution that requires parties in the upper SAR watershed to deliver a minimum quantity of water to points downstream including Riverside Narrows and Prado Dam. A provision of the *Orange County* Judgment related to conservation establishes that, once the minimum quantity requirements are met, the Upper Area parties “may engage in unlimited water conservation activities, including spreading, impounding, and other methods, in the area above Prado Reservoir.”

b. ***Western* Judgment** - the *Western* Judgment generally provides for:

- A determination of safe yield of the San Bernardino Basin Area (SBBA);
- Establishment of specific amounts that can be extracted from the SBBA by plaintiff parties equal in aggregate to 27.95 percent of safe yield;
- An obligation of Muni to provide replenishment for any extractions from the SBBA by non-plaintiffs in aggregate in excess of 72.05 percent of safe yield;
- An obligation of Western to replenish the Colton and Riverside basins if extractions for use in Riverside County in aggregate exceed certain specific amounts; and
- An obligation of Muni to replenish the Colton and Riverside basins if the average water level is lower than a specific water level elevation in specified wells.

The principal objective of the Muni/Western Project is to capture water that can be conserved upstream of Prado Dam and put that water to beneficial use in the Muni/Western Service Areas. To accomplish this objective, all obligations imposed by the *Western* Judgment and the *Orange County* Judgment on the upstream water users had to be built in to the SAIC modeling effort. One of the key features in the *Western* Judgment incorporated in the model was the use of credits that had accumulated in the "water account" of Muni. Consultation with Muni resulted in utilization of the criteria that the accumulated credits could not be reduced below 100,000 af. Currently the accumulated credit in the Muni "water account" is roughly 275,423 af.

32. **Source of Replenishment Calculations** - For purposes of the replenishment obligation, Muni acts on behalf of all defendants dismissed from the *Western* Judgment, and similarly, Western acts on behalf of the Plaintiffs and other dismissed parties within Western. Plaintiff parties have specific rights to produce 27.95 percent of the safe yield from the SBBA. The computer models developed by SAIC and by GEOSCIENCE were designed to compute the balance between local water supplies and groundwater production from the SBBA. In years where production exceeded the local supply, the computer model was used to estimate the amount of water to be imported to maintain the safe yield of the SBBA. The source of the imported water supply is the California State Water Project (SWP) through the contract Muni has with the State of California Department of Water Resources (DWR) for an annual Table A allocation of 102,600 af.

33. **Senior Water Rights Claimants** - The Senior Water Rights Claimants are a group of purveyors who claim pre-1914 water rights on the SAR. They are Bear Valley Mutual Water Company (and shareholders including City of Redlands), Lugonia Water Company, North Fork Water Company (and shareholders including East Valley Water District), and Redlands Water Company. The Senior Water Rights Claimants receive all of their SAR water via diversions made from the SAR at the Redlands Tunnel, the New SCE Conduit, Old SCE Conduit, and the smaller Auxiliary River Pickup. Please refer back to Muni/Western Exhibit 5-5 prepared to illustrate the existing facilities in the vicinity of the Dam.

34. **Seven Oaks Accord** - The Senior Water Right Claimants protested the applications by Muni/Western to appropriate water from the SAR but on July 21, 2004, Muni, Western, and the Senior Water Right Claimants signed a settlement agreement known as the Seven Oaks Accord. The Seven Oaks Accord calls for Muni/Western to not object to the diversion of up to 88 cfs from the natural flow of the SAR. In exchange, the water users agree to withdraw their protests to the Muni/Western water right applications. Consequently, the analysis and computer modeling conducted for the Project and for the environmental documentation is based on implementation of the Accord.

35. **Santa Ana River-Mill Creek Cooperative Water Project Agreement** - This agreement (informally known as the Exchange Plan), is an agreement among ten agencies and private water companies in the East San Bernardino Valley, executed in May 1976. The ten eligible entities (or members):

a. Bear Valley Mutual Water Company

b. City of Redlands

c. Crafton Water Company

d. East Valley Water District

e. Lugonia Water Company

f. North Fork Water Company

g. Redlands Water Company

h. San Bernardino Valley Municipal Water District

i. San Bernardino Valley Water Conservation District

j. Yucaipa Valley Water District

36. Under the Exchange Plan, the parties have agreed to the exchange of water from the SAR, Mill Creek, and the SWP. The agreement is described as a "bucket for bucket exchange," whereby a party to the agreement provides a "bucket" of their water to a second, higher elevation, party and the second party provides a "bucket" of water from an alternate, lower elevation, source back to the original party. To facilitate exchanges, parties to the agreement share their existing facilities. However, specific facilities (called Cooperative Water Project facilities) were built and are operated by Muni, in part, to accommodate Exchange Plan deliveries. The effect of the Exchange Plan, such as banking water in the Santa Ana River Spreading Grounds by the Conservation District, has been incorporated into the computer models to the extent possible. In this regard, records of water spreading operations provided by the Conservation District did not include the amounts of water spread on behalf of Exchange Plan members. In the context of this hearing and my testimony, this point is now moot because of the Seven Oaks Accord and the settlement reached with the Conservation District.

37. **Big Bear Lake Operations** - Because tributary flow to the SAR includes releases and spills from Big Bear Lake located at the headwaters of Bear Creek, and because operations of this lake have changed in recent years, gage data and related runoff estimates have been revised to better estimate what inflow to Seven Oaks Dam would have been had current Big Bear Lake operations been in effect during the entire hydrologic base period. Historically, releases for irrigation were made from Big Bear Lake to meet the demand of Bear Valley Mutual Water Company and the lake spilled only during extremely wet years.

Although most of the irrigation releases were diverted into the SCE Canal, at times some water remained in the SAR and contributed to historical SAR flow. Irrigation releases made from Big Bear Lake during dry periods sometimes resulted in low water levels in the Lake, to the detriment of recreational uses of the Lake. As recreational uses increased, litigation ensued and was resolved through a settlement in 1977. In addition, a revised lake operating policy implementing that settlement was enacted in 1987. In accordance with the revised lake operating policy, Bear Valley Mutual Water Company receives SWP water from time to time (from Muni) in lieu of water from Big Bear Lake. The resulting decrease in releases from Big Bear Lake has helped stabilize lake elevations but has, at the same time, generally reduced the amount of water that Big Bear Lake contributes to flow in the SAR and the SCE Canal. Runoff estimates used for the Project within OPMODEL (discussed later in my testimony) account for these changes in the operation of Bear Valley Dam and SAR hydrology through the use of a "synthesized hydrology." In the synthesized hydrology, for flows prior to 1987, a monthly water balance model developed by Mr. Don Evenson, a consultant to Big Bear Municipal Water District, was used to estimate the change from historical outflow from Big Bear Lake. This change in operational criteria at Big Bear Lake occurred during the hydrologic base period (discussed later in my testimony) chosen for the analyses of potential capture by Muni/Western. The gaged records of the USGS had to be "synthesized" to estimate what the gage readings and flow would have been if the operational agreement had been in place throughout the period of record. See Muni/Western Exhibit 5-10 for an illustration of Gage Data with and without synthesized data.

38. **<u>San Bernardino Valley Water Conservation District</u>** - The Conservation District holds two licenses issued by the SWRCB to divert water from the SAR (Licenses 2831 and 2832). License 2831 grants the Conservation District the right to divert and spread 8,300 af of water annually during the period January 1 to May 31. License 2832 grants the Conservation District the right to divert and spread 2,100 af annually from October 1 to December 31. The total of the two licenses is 10,400 afy. The Conservation District diverts water directly from the SAR, just upstream of the Cuttle Weir. Diversions are measured below the North Fork Box and include the total of diversions made at the Cuttle Weir and waters from the North Fork Box. The current capacity of the Conservation District's conveyance canal is estimated at 300 cfs and historical diversions have averaged 9,847 afy over the period of record.

Santa Ana River – Surface Water Hydrology

39. This section of my testimony provides a description of surface water hydrology of the region and explains the selection of a portion of the period of record to use as a base period for the analyses of potential capture by Muni/Western. Presented later in my testimony are additional details on the surface water modeling tools used to estimate the potential capture

by Muni/Western and to analyze downstream flow conditions resulting from implementation of the Project. Changes to the surface water hydrology can influence groundwater characteristics such as depth to groundwater, interactions with contaminant plumes, and groundwater quality. Such potential interactions will be addressed by Dr. Dennis Williams in his testimony.

40. In the SAR Watershed, winter storms usually occur from December through March. They originate over the Pacific Ocean as a result of the interaction between polar Pacific and tropical Pacific air masses and move eastward over the watershed. These storms, which often last for several days, reflect orographic (i.e., land elevation) influences and are accompanied by widespread precipitation in the form of rain and, at higher elevations, snow.

41. Local storms cover small areas, but can result in high intensity precipitation for durations of approximately 6 hours. These storms can occur any time of the year, either as isolated events or as part of a general storm, and those occurring during the winter are generally associated with frontal systems (a “front” is the interface between air masses of different temperatures or densities). Summer storms can occur in the late summer and early fall months in the San Bernardino area, although they are infrequent. The large portion (73 percent) of average annual precipitation occurs during December through March and rainless periods of several months are common in the summer.

42. Urbanization taking place in the valley areas of the SAR watershed has resulted in increased responsiveness of the SAR to rainfall. The increase in impervious surfaces (such as roofs, roads, parking lots, etc.) and constructed drainages to remove surface water from urban areas has resulted in decreased groundwater infiltration and increased runoff from urban areas. These actions have reduced the lag-time between peak rainfall and peak runoff (i.e., constructed drainage systems move water from the urban areas to the SAR faster than this water would move if the land was not developed).

43. Compared to a basin without the influence of urbanization, the same rainfall occurring over an urbanized segment of the watershed will result in higher peak discharges, a shorter lag-time to the peak discharge, and an overall larger volume of water entering the local drainage channels. For example, as shown in Muni/Western Exhibit 5-11, the cumulative departure from the average annual runoff in WY 1926-27 and again in WY 1942-43 is roughly 700 percent. This indicates that the years leading up to both these peaks had higher than average stream flow. Such above average stream flows, in the context of current urbanization, would result in greater departures from the average. Because the SAR watershed is experiencing rapid growth, increased urbanization of the basin is expected to continue, and therefore, this trend in increased discharge and decreased lag-times between peak rainfall and peak stream flow is expected to continue in the future.

44. I am not an expert in global climate change science but I am familiar with the July 2006 Technical Memorandum Report by the California Department of Water Resources (DWR) entitled "Progress on Incorporating Climate Change into Management of California's Water Resources, which summarizes the potential impacts of a change in climate on water resources in California. Given the uncertainties inherent in California's water resource liability now, and in the future, and in particular the possibility of severe drought, it is essential that water agencies diversify their water supply portfolios to manage these uncertainties. This strategy to enhance water supply reliability is discussed further in testimony by Mr. Macaulay.

45. **Base Period** - A hydrologic base period is the period of time over which a water balance (hydrologic budget) is evaluated. Selection of a base period that represents long-term hydrologic conditions is a necessary step prior to conducting surface water and groundwater modeling of the SAR and SBBA, respectively. The time period selected to use as the base period should have the following characteristics:

- Average precipitation of the base period is approximately equal to the average precipitation of the entire period of record;
- Average runoff of the base period is approximately equal to the average runoff of the entire period of record;
- Contain periods of wet, dry, and average hydrologic conditions;
- Be sufficiently long (typically a 20- to 30-year period) to contain data representative of the averages, deviations from the averages, and extreme values of the entire historical period;
- Contain a dry trend at both the beginning and end of the period in order to minimize the difference between the amount of water in transit in the soil at either end of the base period; and,
- Be representative of recent environmental and cultural conditions (e.g., land use, extent of urbanization, urban runoff) for the purpose of using the base period in forecasting models.

46. **1999 Testimony** - When I testified before this Board in December of 1999, I used surface runoff records measured at various points along the SAR over a 20-year base period from Water Year 1971-72 through Water Year 1990-91. This period was selected because it was long enough to contain representative data and had several wet and dry periods. A longer base period (from Water Year 1969-70 through Water Year 1995-96) was considered for use in the earlier testimony but was not used because it contained two very wet years that caused the average flow at Mentone (Combined Flow) to be overstated compared to the base period used in 1999. In addition, the objective of the earlier testimony was to demonstrate that water was available and that the SAR was not fully appropriated. I also

testified in 1999 that if I were charged with determining the amount of water that might be available for appropriation at the USGS Mentone Gage, use of the longer base period from Water Year 1969-70 through Water Year 1995-96 would be appropriate because that longer base period would provide the best estimate of actual long-term water availability at Mentone.

47. **2007 Testimony** - Additional analyses by SAIC of surface runoff, and analysis by GEOSCIENCE of the precipitation component, led to the selection of the alternative base period of WY 1961-62 through 1999-2000 (a 39-year period) to best represent average hydrologic conditions. One of the key factors in this decision was the availability of additional data that allowed the selection of a base period that closely matches the long-term runoff and rainfall in the Project area. Dr. Williams will provide testimony later in this hearing describing the technical analyses of precipitation data conducted by his firm to further support the use of the selected base period.

48. The runoff data from the USGS Combined Flow Mentone River Gage (USGS Gage Number 11051501) for the period WY 1913-14 to 2000-01 form the basis for determining the base period used in my testimony and in the environmental documents. These flow records represent the historic measurement of flows in the SAR near Seven Oaks Dam.

49. Muni/Western Exhibit 5-11 illustrates the cumulative departure from the long-term average using data from the Combined Flow Mentone River Gage for the period WY 1913-14 to WY 2000-01. This record includes data from three gages near the Seven Oaks Dam site that, together, best describe flows in the SAR near Seven Oaks Dam.

50. Over the period WY 1962-63 to WY 2000-01, the graph in Muni/Western Exhibit 5-11 oscillates above and below zero percent. The beginning and ending points of the base period are slightly above zero percent and the cumulative departure from the average of the beginning and end points of the base period is six (6) percent. This indicates an approximately equal number of above-average and below-average periods of runoff during this period. This period more accurately duplicates the long term average than the 20-year period utilized for my 1999 testimony.

51. Annual Unimpaired Flow, as defined by the SWRCB, "…is the total volume of water, on average, that would flow past a particular point of interest on an annual basis if no diversions (impairments) were taking place in the watershed above that point." For the purposes of this analysis the point of interest is immediately downstream of the Cuttle Weir. This location was chosen as the point of interest because it is the furthest downstream diversion point identified in the proposed applications. Gage data and the resulting synthesized hydrology were used to estimate the annual unimpaired flow. It should be noted that the synthesized hydrology used in the estimate assumes no diversions but does assume current operations of Big Bear Lake and current operations of Seven Oaks

Dam. Data from the "Combined Flow" Mentone Gage [USGS record 11051501]), which represents the sum of stream flow recorded in the river at the Mentone Gage, in addition to flow that would have been in the river at this location had it not been diverted upstream for use in the SCE hydroelectric system, were modified for the period water year 1961-62 through 1986-1987 to account for changes in operation of Big Bear Lake. The surface water hydrology values reported in the balance of my testimony are based upon analyses of flow conditions for the selected base period of WY 1961-62 through 1999-2000. Presented in Muni/Western Exhibit 5-12 is a graphical representation of historical flow at Seven Oaks showing diversions by the Senior Water Rights Claimants and the Conservation District and the residual amount of unappropriated water.

52. **Current No Project SAR Hydrology** - The existing Seven Oaks Dam, although not a component of the Muni/Western Project, has substantially altered the natural hydrology of the SAR, with the largest changes occurring during and after periods of high stream flow (i.e., flood flows). These changes have been extensively evaluated by the U. S. Army Corps of Engineers (USACE). The findings of these USACE studies are used to establish the No Project condition for the SAR as described in this portion of my testimony.

53. Overall, the completion of Seven Oaks Dam has altered the discharge rate, depth, velocity, and volume of flow in the SAR and, hence, has affected flood magnitude and the extent of overbank flooding, along with the erosional and depositional characteristics in the overbank area. The dam operates in "pass through" mode (inflow equals outflow) from June through October of each year. From the beginning of November to the end of May all flows except 3 cfs are stored until a target debris pool storage of approximately 3,000 af is met at elevation 2,200 NGVD. Once debris pool target storage is obtained, the reservoir is operated so that outflow equals inflow. In the event of a flood, Seven Oaks Dam is operated in conjunction with Prado Dam. Releases at Seven Oaks Dam are held at 500 cfs or less until peak water surface elevation has passed at Prado Dam. Following a flood, water is released from Seven Oaks Dam at up to 7,000 cfs until target storage is again reached. However, the outlet works are sized to pass a slightly larger discharge to provide flexibility and a factor of safety; releases as great as 8,000 cfs are possible through the outlet works under emergency operating conditions. Releases greater than 8,000 cfs can only be made utilizing the dam spillway, which is dependent on water levels in the reservoir exceeding the invert elevation of the spillway. Beginning in June, releases are made to empty the debris pool by the end of September.

54. Flood events are the predominant factor in shaping the overbank or floodplain areas through erosion and deposition of sediment. The largest recorded flood is that of 1862, which had an estimated discharge rate of 317,000 cfs at Riverside Narrows. A more detailed description of flood events is found in the Draft EIR, pages 3.1-6 to 3.1-8 (see Muni/Western Exhibit 4-3).

55. USACE projections of instantaneous peak flows at various locations along the mainstem of the SAR downstream from Seven Oaks Dam under pre- and post-dam conditions are provided in Muni/Western Exhibit 5-13. The effect of the Seven Oaks Dam on flow regulation in the SAR becomes attenuated further downstream from the dam, with the largest changes in peak discharge for a given frequency seen closest to the Dam and the smallest changes seen in inflow to Prado Dam, which is located about 40 miles downstream of Seven Oaks Dam. Under 100-year flood conditions SAR flow downstream of the confluence with Mill Creek has been reduced by about 67 percent, from 75,000 cfs prior to the construction of Seven Oaks Dam to 25,000 after the dam's construction. At Prado Dam, due to the effects of tributaries and other inflows to the river, the effect of Seven Oaks Dam is much less pronounced. Under 100-year flood conditions, inflow to Prado Dam has been reduced by about 15 percent, from 230,000 cfs to 195,000 cfs.

56. The Seven Oaks Dam has caused changes in flood flows below the dam that result in changes to the area adjacent to the downstream channel subject to overbank flooding, as well as changes to sediment transport within the SAR Wash. Water velocity and depth, both in the channel and in overbank areas under pre- and post-dam conditions, are shown in Muni/Western Exhibit 5-14.

57. The Seven Oaks Dam will store and release flows to the upper SAR according to its operating criteria and the operating criteria specified for Prado Dam because the operation of both dams will be coordinated by the operating agencies. Generally during a flood event, inflows to Seven Oaks Dam of less than or equal to 500 cfs are passed through whereas flows in excess of 500 cfs are stored behind Seven Oaks Dam until Prado Flood Control Basin can accommodate the additional water. With Seven Oaks Dam in place there would be flows downstream in the 1,000 cfs to 4,000 cfs range for longer periods than would have occurred historically because of this flood water storage and later release from Seven Oaks Dam. Data indicate that, with operation of Seven Oaks Dam, there is consistently an approximately 15 percent increase in the frequency of flows in the SAR downstream in the 500 to 4,000 cfs range, and a decrease of approximately 25 percent in the frequency of flows over 4,000 cfs. According to recent sediment transport analysis discussed in the Final EIR (see Muni/Western Exhibit 4-4 at p. 2-38), it is flows over 4,000 cfs that mobilize gravel and cobbles in the SAR, whereas flows in the 500 to 4,000 cfs range transport sand.

58. Information presented in Muni/Western Exhibit 5-14 demonstrates that Seven Oaks Dam will decrease the extent of the areas likely to experience overbank flooding. Based on results of modeling performed as part of its Biological Assessment (BA) for Seven Oaks Dam, the USACE determined that there are three major areas where 100-year floods could result in overbank flows under post-Seven Oaks Dam conditions:

- The north bank between the Mill Creek Confluence and RM 65.41 where the 100-year flood could overtop the existing low flow channel banks and create continuous, separate, and parallel overbank flood flows within this approximately 4-mile stretch;
- Between RM 64.90 and RM 63.78 flood flows could break out into the north overbank area and inundate a large active sand and gravel mining operation; and
- Just upstream of the railroad bridge between RM 59.12 and RM 59.17, approximately 1,200 cfs of the post-dam 100-year flood flows (of 33,000 cfs) could break out into the north overbank (cited in Muni/Western 2004). Model results indicate that the flooding in this area would amount to less than 6 inches of shallow sheet flow.

59. USACE estimates that with Seven Oaks Dam in place, the acreage of overbank flood areas will decrease by between 25 to 27 percent, relative to pre-dam conditions (though other estimates also by USACE put the reduction in overbank flow acreages as high as 39 percent). Not only will overbank flood areas be reduced in size but the velocity and flood depth will be altered and this in turn will alter the sediment transport and scour experienced in these areas. Water velocity in the overbank flood areas would be reduced (under 100-year flood conditions) from between 3.5 and 7.0 feet per second (ft/s) to between 2.0 and 3.0 ft/s, while average flood depth would be decreased from between 2.5 to 5.0 feet to between 1.0 to 2.5 feet. Generally, it is my understanding that in the overbank flood areas, sands become mobilized at water velocities of about 2 to 3 ft/s, gravels at about 6 ft/s, and boulders at 10 ft/s. It is also my understanding that vegetation can resist short-duration velocities up to 6 to 8 ft/s, but will be uprooted at higher velocities and/or longer duration flows based on my review of USACE documents. As discussed in the Final EIR, under post-dam conditions, velocities within the river channel are sufficient to transport sand- to boulder-sized material, and sand deposition would be expected in overbank flood areas adjacent to the river.

60. There are numerous tributaries that contribute flow to the mainstem of the SAR in the Project area including Mill Creek, City Creek, Plunge Creek (a tributary of City Creek), Mission Zanja Creek (located upstream of San Timoteo Creek), San Timoteo Creek, East Twin Creek, Warm Creek, and Lytle Creek (a tributary of Warm Creek). The flow (under 100-year flood conditions) contributed by each of these tributaries is provided in Muni/Western Exhibit 5-15. Based on data from a USACE 1988 report, during a 100-year flood event, Seven Oaks Dam would release up to 5,000 cfs (see Muni/Western Exhibit 4-3, Draft EIR page 3.1-4).

61. As I noted earlier in my testimony, flow in the SAR is highly variable from year to year. Also, flow in the SAR increases downstream from Seven Oaks Dam due to inflows from tributaries, rising water, and effluent from wastewater treatment plants. SAR flows at the “E” Street Gage include flows from Mill Creek and San Timoteo Creek but not from Lytle and Warm creeks, which enter the SAR below the “E” Street Gage. SAR flows at the

MWD Crossing include inflows from Lytle and Warm creeks, two large public WWTPs, and rising water.

62. **Wastewater Treatment Plants (WWTP) along SAR** - Three WWTPs (Redlands, Beaumont, and Yucaipa) discharge to the SAR and its tributaries upstream of the City of San Bernardino, but these discharges generally do not flow continuously in the SAR to "E" Street. Two plants, the Rapid Infiltration and Extraction (RIX) WWTP in the City of Colton, and the Rialto WWTP in the City of Rialto discharge directly to the SAR through a discharge channel at RM 53.46 (approximately 4 miles below "E" Street and more than 7 miles upstream of Riverside Narrows). Wastewater discharges from these plants maintain hydraulic continuity to the SAR above Riverside Narrows. As can be seen in Muni/Western Exhibit 5-16, combined wastewater discharge from these two plants has risen from around 22,000 afy in WY 1970-71 to 57,750 afy in WY 2000-01. The combined wastewater discharge is expected to increase to about 59,000 afy with both facilities operating at their respective design capacities as shown on Muni/Western Exhibit 5-16. There are seven WWTPs (Riverside, Corona, Inland Empire Utilities Agency [IEUA] Regional Plant 1, IEUA Regional Plant 2, IEUA Regional Plant 4, IEUA Carbon Canyon, and Western Riverside County) that contribute wastewater discharges to the SAR between Riverside Narrows and Prado Dam. In WY 2000-01 these discharges totaled 110,852 af. Prior to April 1996, the San Bernardino Water Reclamation Plant discharged to the SAR above "E" Street. Since April 1996, effluent from the San Bernardino Water Reclamation Plant has been sent to the RIX facility and is ultimately discharged downstream of "E" Street (Santa Ana River Watermaster 2003 as cited in the Draft EIR). The Pre-Seven Oaks Dam flow at "E" Street is the average daily flow recorded by the "E" Street Gage and includes effluent once discharged by the San Bernardino Water Reclamation Plant. Estimated flows under No Project conditions (described later) at "E" Street are synthesized by taking the historical "E" Street Gage data, less inflows attributable to the San Bernardino Water Reclamation Plant which no longer discharges effluent upstream of this location, plus the effect that Seven Oaks Dam has on flows at "E" Street. Under Project scenarios (described later), flow at "E" Street is estimated using one of the computer models (DOP) output for flows at Cuttle Weir reduced by 40 percent to account for losses through percolation in the stream channel and evaporation. The methods used to estimate flow losses from Cuttle Weir to "E" Street are discussed below.

63. **Mill Creek** - The USGS maintained several stream gages on Mill Creek to measure stream flow that provided flow measurements for the period 1948-1986. Average discharge for this 39-year period is 37.6 cfs and the maximum 1-day discharge during the period of record was 5,310 cfs (occurring on January 25, 1969). The highest estimated flows on record occurred on March 26, 1938, producing an instantaneous discharge of 18,100 cfs. In general, flows in Mill Creek tend toward the extreme, with either excessive, or minimal, amounts of water present. These extremes are attributable to the absence of reservoirs and

very steep terrain in the Mill Creek watershed. The only existing flood control structure on Mill Creek is a levee system comprised of embankments and masonry and concrete walls. The USACE completed the Mill Creek Levee modifications portion of the Santa Ana River Mainstem Project in 1998. These modifications consisted of construction of a floodwall on top of the existing levees and extension of the riprap toe of the existing levees. The flood control structure on Mill Creek now consists of a vertical reinforced concrete floodwall, beginning 2 miles upstream of the SAR and Mill Creek confluence, 2.4 miles long and approximately 6 feet high, on the waterside edge of the levee berm. These modifications restored the original standard project flood protection level of 33,000 cfs contained within the banks.

64. **Lytle Creek** - Lytle Creek runs along the eastern end of the San Gabriel Mountains in a southeasterly direction and is joined by Cajon Creek before finally reaching its confluence with the SAR near Colton. The Lytle Creek drainage basin is approximately 186 square miles (USGS 1999)(see Muni/Western Exhibit 4-3, Draft EIR Appendix A, page A-2-5). Combined annual flows average 43.8 cfs (as measured at USGS Gage No. 11062001 LYTLE+BRLNE+COND+INF – W27 CA, the Lytle Creek Gaging Station). The maximum peak flow measured over the period 1899-2000 was 25,200 cfs and mean annual runoff during that period was 31,720 af.

65. The following few paragraphs summarize the general hydrologic flow conditions on the SAR without the Muni/Western Project.

66. The “Combined Flow” Mentone Gage [USGS record 11051501], represents the sum of stream flow recorded in the SAR at the Mentone Gage, in addition to flow that would have been in the river at this location had it not been diverted upstream for use in the SCE hydroelectric system and at other points of diversion. The Combined Flow demonstrates the highly variable nature of SAR flow, with large flood events taking place in some years and other years of extremely low flows. I have prepared Muni/Western Exhibit 5-12 to illustrate this characteristic by plotting the Combined Flow, in acre-feet, for each year of the hydrologic base period, adjusted for Big Bear Lake reoperation.

67. Working downstream from Mentone, annual flows at the River Only Mentone, “E” Street, and MWD Crossing gages are summarized in Muni/Western Exhibit 5-17. As shown in this figure, flow in the SAR is highly variable from year to year. Additionally, flow in the SAR increases as one progresses downstream due to inflows from tributaries, rising water, and inflow from wastewater treatment plants (WWTPs). SAR flows at the “E” Street Gage include flows from Mill Creek and San Timoteo Creek but not from Lytle and Warm creeks, which enter the SAR below the “E” Street Gage. SAR flows at the MWD Crossing include inflows from Lytle and Warm creeks, two large public WWTPs, and rising water.

68. Muni/Western Exhibit 5-18 illustrates probability of exceedance curves based on gage records for the River Only Mentone, "E" Street, and MWD Crossing locations. These curves demonstrate the percentage of time that certain flows are met or exceeded. As shown in this figure, large annual flows in the upstream areas can be expected quite infrequently, but the probability of the same flow occurring downstream is greater. For example, flows in excess of about 70,000 afy have a frequency of occurrence of only 10 percent at the River Only Mentone Gage, whereas this same flow has a frequency of occurrence of over 60 percent at the MWD Crossing Gage. Additionally, in the upstream areas, minimum annual stream flows are generally much smaller than minimum annual flows in the downstream areas.

69. Turning to a monthly timestep, Muni/Western Exhibit 5-19 represents monthly flows in the SAR as recorded at the River Only Mentone Gage for the period of record. The largest monthly flows typically occurred in February and March and the lowest monthly flows typically occurred between August and October. Although stream flow increases downstream, the timing of flows (i.e., when the monthly maximums and minimums occur) is similar to the timing of flows observed at the River Only Mentone Gage. A wet year, compared to an average year, shows both greater monthly flows and earlier onset.

70. Muni/Western Exhibit 5-19 shows the median flow of each month and total monthly flow for different types of water years (e.g., dry, average, and wet years). Muni/Western Exhibits 5-20 through Muni/Western Exhibit 5-23 show the probability of a given flow being exceeded within a given month at the River Only Mentone Gage. These figures demonstrate the variability in flow among different types of water years and variability between months, but also illustrate some consistent trends. For example, the largest monthly flows typically occur in February and March, and the lowest monthly flows typically occur August through October.

71. **Hydrology of River Segments** - The characteristics of the seven river segments used in the environmental documentation and analyzed from the hydrologic standpoint were described earlier in my testimony. The hydrology of these segments is presented in the following portion of my testimony to illustrate the characteristics of flow with Seven Oaks Dam but without the Muni/Western Project. Detailed descriptions of the hydrology of the specific SAR segments are presented in the Draft EIR Appendix A, pages A-2-22 to A-2-27 (See Muni/Western Exhibit 4-3).

   a. **Segment A, Upstream of Seven Oaks Dam** - Upstream from Seven Oaks Dam water is diverted at concrete diversion dams on the SAR and its tributaries of Bear Creek, Breakneck Creek, Keller Creek, and Alder Creek. These diversion dams and the SCE conduit are capable of withdrawing and conveying water at a maximum rate of 93.3 cfs, which is conveyed in the SCE conduit through the SAR 1 Powerhouse to the SAR 2/3 Powerhouse. Historic flows recorded at the

USGS Gage 11049500 on the SCE Canal are shown in Muni/Western Exhibit 5-24. Median annual diversions into the SCE Canal for WY 1914-15 through 1999-2000 are 29,101 af.

b. **Segment B, Seven Oaks Dam to Just Above Cuttle Weir** - The probability of exceedance curves for flow above Cuttle Weir are shown in Muni/Western Exhibit 5-25. It is evident from this figure that prior to the construction of Seven Oak Dam, more than 30 percent of the time there was no flow in this segment. With the dam in operation, mean daily discharge is at least 3 cfs, and about 55 percent of the time discharge is greater than 3 cfs.

c. **Segment C, Cuttle Weir to just above the Confluence of Mill Creek** - Muni/Western Exhibit 5-26 shows probability of exceedance curves for flow downstream of Cuttle Weir. Prior to the construction of Seven Oak Dam, more than 65 percent of the time there was no flow in this segment. With the dam in operation, approximately 78 percent of the time there is no discharge in this river segment.

d. **Segment D, Mill Creek Confluence to just above "E" Street** - I have prepared Muni/Western Exhibit 5-15 to show the relative contributions of each of the tributaries to SAR flow. Muni/Western Exhibit 5-27 shows probability of exceedance curves for flow below the confluence of Mill Creek. This figure shows that prior to the construction of Seven Oaks Dam, about 56 percent of the time there was no flow in this segment. With the dam in operation, flows are similar to those of pre-dam conditions, demonstrating that the inflow from Mill Creek lessens the influence of flows from the Project area in this segment and approximately 53 percent of the time there is no discharge in this river segment.

e. **Segment E, "E" Street to just above the RIX and Rialto Effluent Outfall** - In the same fashion as the other exhibits, Muni/Western Exhibit 5-28 presents probability of exceedance curves for flow downstream of "E" Street. Prior to the construction of Seven Oak Dam, about 5 percent of the time there was no flow in this segment; flows above 10 cfs occurred approximately 90 percent of days; and flows above 100 cfs occurred approximately 13 percent of the time. Since December 1999 (with the dam in operation), flows are consistently lower than pre-dam conditions, but this effect is due largely to the loss of WWTP effluent that, prior to 1996, was discharged in this river segment but has since been discharged in Segment F. Currently, approximately 54 percent of the time there is no discharge in this river segment; flows above 10 cfs are equaled or exceeded approximately 33 percent of the time; and for flows of 100 cfs and higher, the frequency drops to about 12 percent.

f. **Segment F, RIX and Rialto Effluent Outfall to just above Riverside Narrows** - These WWTPs discharged 57,750 af in WY 2000-01 and in the future could discharge as much as 59,000 afy. Muni/Western Exhibit 5-29 presents probability of exceedance curves downstream at the RIX and Rialto Effluent Outfalls. These curves are synthesized from gage data and effluent discharges of the WWTPs. This varies from the curves shown for the upstream segments and illustrates the presence of higher and more sustained flows below the RIX and Rialto Effluent Outfalls. This figure shows that prior to the construction of Seven Oak Dam, flows equaled or exceed 10 cfs at all times. Since December 1999 (with the dam in operation), flows are consistently higher than pre-dam conditions, but this effect is due largely to the addition of WWTP effluent that, prior to 1996, was discharged in Segment E. Since 1999, discharge in this river segment has equaled or exceed 60 cfs at all times.

g. **Segment G, Riverside Narrows to Prado Dam** - Segment G extends from Riverside Narrows at RM 45.7 to Prado Dam at RM 30.5. This river segment falls entirely within SARWQCB Reach 3 and is within USACE Sub-Area 3. Stream flow is perennial throughout Segment G due to inflow from WWTPs and groundwater influences.

Project Description and Facilities

72. The principal purpose of the Muni/Western Project is to capture local water, mainly during flood events that would otherwise flow to the Pacific Ocean because the channel of the SAR would be saturated and percolation to the underlying groundwater basins would be minimal. The object of the Project is to capture these flows, subject to diversions by the prior holders of rights to use water from the SAR, and to do so with minimal impacts to the environment.

73. The Project includes: (a) applications that seek to directly divert or divert to storage a maximum annual 200,000 af of water from the SAR in the vicinity of Seven Oaks Dam; and (b) placing water diverted from the SAR to beneficial use. Beneficial uses would include deliveries to: water treatment plants; groundwater recharge of the San Bernardino Basin Area (SBBA); groundwater recharge outside the SBBA but in the Muni service area; and possibly exchange with other agencies. Diversions are proposed during the season of October through September each water year.

74. The Project is designed to achieve the following objectives:

- Increase water supply reliability by reducing dependence on imported water;
- Develop and deliver a new, local, high quality, long-term water supply that is needed to meet part of anticipated future demands; and

- Expand operational flexibility by adding infrastructure and varying sources of water, thereby providing Muni/Western with greater capability to match varying supply and demand.

75. Institutional arrangements would be put in place, in addition to those already existing, to achieve the goals for implementation. These arrangements would provide for (1) Sharing of the conveyance capacity of existing facilities; (2) Joint use of existing spreading grounds; and, (3) Possible additional water exchange agreements.

76. **<u>Need for Long-range Planning</u>** - Muni and Western have long recognized the need for long-range planning to meet the growing water demands in their respective service areas. The concept of the current Muni/Western Project was developed in the late 1960s when the need for a flood control facility in the upper portion of the SAR watershed became apparent and continues to the present. A Regional Integrated Groundwater Management plan is currently being prepared by Muni.

77. **<u>Water Demands</u>** - Water demands within the Muni/Western service areas have increased significantly with the growing population. The population is projected to continue to grow by the Southern California Association of Governments (SCAG) as well as local water purveyors. For purposes of the Muni/Western Project, water demands for the study period were estimated using available data from SCAG and from Urban Water Management Plans prepared by water purveyors. The estimates of future water demands are essential to the modeling efforts by both SAIC and GEOSCIENCE because they drive the potential for direct deliveries from the Muni/Western Project as well as the groundwater extractions from the SBBA. The potential uses of water captured by the Project will be discussed later in my testimony on modeling.

78. **Water Conservation -** Water conservation activities are part of all water resource planning in Southern California. Purveyors in the Muni and Western service areas are employing various conservation practices that will be discussed in the testimony of Mr. Macaulay. Assumptions regarding the level of water conservation that will be implemented during the study period for the Muni/Western Project are important because those assumptions affect projections of future water demands discussed above. Estimates of future water demands for the study period of the Muni/Western Project are based on an 8-10 percent improvement in water conservation, and savings in water demands, when compared to current levels. The basis for the 8-10 percent improvement is a study prepared by the Santa Ana Watershed Project Authority entitled Santa Ana Integrated Watershed Plan dated 2002 (as cited by Muni/Western 2004).

79. **Conveyance Facilities** - The Project would be located in the Muni and Western service areas. Diversions for the Project would occur in the vicinity of Seven Oaks Dam located in the lower part of the Santa Ana Canyon about 8 miles northeast of the City of Redlands, in San Bernardino County, California. The Project calls for the delivery of diverted water,

utilizing existing conveyance facilities, for potential use by water agencies in Southern California. SAR water could be delivered directly to users or to a number of groundwater storage basins, both within and outside the Muni/Western service area. These facilities are either part of local agency conveyance systems that deliver water to retail providers and to spreading facilities for groundwater storage, or are part of regional water supply and distribution systems operated by entities such as DWR.

80. Presented in Muni/Western Exhibit 5-4 is the Seven Oaks Dam and the diversion points in close proximity to the Dam. Muni/Western Exhibit 5-4 shows the points of diversion (PODs) upstream of Seven Oaks Dam where water is diverted and conveyed (after being used for power generation) through the existing SCE Canal for delivery to Senior Water Right Claimants. Detailed descriptions of existing and proposed Project facilities are presented in the Draft EIR Chapter 2 and Draft EIR Appendices A and C. These Project-related facilities are located in four areas, listed below and briefly described in the following paragraphs of my testimony.

- The Seven Oaks Dam and Reservoir Area. This includes the intake structure of Seven Oaks Dam and the access road to the intake structure. To achieve the desired level of conservation storage, these infrastructure elements require modification.
- The Santa Ana River Construction Area includes the following proposed new facilities: Plunge Pool Pipeline; Low Flow Connector Pipeline; and Morton Canyon Connector II Pipeline.
- The Devil Canyon Construction Area adjacent to the Devil Canyon Power Plant and Afterbays of the SWP will accommodate the new Devil Canyon By-Pass Pipeline.
- The Lytle Creek Construction Area includes the new Lower Lytle Creek Pipeline and Cactus Basins Pipeline.

81. **Seven Oaks Dam and Reservoir Area** - To accommodate seasonal conservation storage at Seven Oaks Dam, it would be necessary to modify/rebuild the intake structure, maintenance deck, and bulkhead of the dam, as well as the bridge and road used to access the intake structure. See Muni/Western Exhibit 5-30.

82. **Santa Ana River Construction Area.** Most of the water captured from the SAR and released from Seven Oaks Dam would be conveyed through the proposed Plunge Pool Pipeline and Low Flow Connector Pipeline, all located in the Santa Ana River Construction Area. The Santa Ana River Construction Area would accommodate diversion structures and three new proposed pipelines:

- Plunge Pool Pipeline;
- Low Flow Connector Pipeline; and,
- Morton Canyon Connector II Pipeline. See Muni/Western Exhibit 5-31.

a. **Plunge Pool Pipeline** - The Plunge Pool Pipeline would be constructed in three phases. Ultimately the pipeline would connect the plunge pool located immediately below Seven Oaks Dam to both Muni's existing Foothill Pipeline and Metropolitan's Inland Feeder Pipeline. Construction of each of the three phases would depend on funding, water demand, and other variables. Descriptions of the anticipated construction phases follow.

i. **Phase I** consists of a 15-foot diameter eastward extension of the existing Foothill Pipeline to a point in the Santa Ana River channel just west of the existing Cuttle Weir. The extension would initially convey up to 500 cfs. Under Phase I, flows of up to 500 cfs would be diverted. However, due to capacity limitations, no more that 300 cfs of diverted water can be conveyed through the existing Foothill Pipeline (in reverse flow). An additional quantity of diverted water (up to 70 cfs) could be conveyed through the Santa Ana River Crossing (SARC) Pipeline with the remaining water (up to 130 cfs) conveyed through the Conservation District Canal to the Santa Ana River spreading grounds.

ii. **Phase II** would be the construction and extension of the 15-foot diameter pipe constructed in Phase I westward to the intertie with the Foothill Pipeline and Inland Feeder Pipeline near Cone Camp Road. This section of pipe would be approximately 2 miles long. The completion of Phase II would enable Muni/Western to convey up to 1,500 cfs from the Santa Ana River.

iii. **Phase III** would be to connect those portions of the pipeline developed in Phases I and II to the plunge pool of Seven Oaks Dam. The Phase III segment consists of a 15-foot pipeline, extending 2,980 feet from the southeast quadrant of the plunge pool to a point on the west bank of the SAR approximately 1,600 feet downstream of Cuttle Weir. An intake structure to the Plunge Pool Pipeline would be built within the plunge pool.

83. In addition to the phased construction of the major pipeline facilities discussed above, alternative routes for distributing captured flows from the SAR are briefly described below and summarized in the following tabulation. These conveyance routes include either existing pipes, pipes currently under construction, or pipelines included as part of the Project. In the future, other conveyance routes may become available, such as pipelines proposed as part of the East Branch Extension (EBX) – Phase II.

Conveyance Facility	***Capacity (cfs)***	***Comments***
Foothill Pipeline (Reverse Flow)	200	The capacity of the Foothill Pipeline (Reverse Flow) is 300 cfs from the Santa Ana River crossing Pipeline westward to the inter-tie with the Inland Feeder
Foothill Pipeline (Normal Flow)	288	
Santa Ana Low Turnout	288	
Greenspot Pipeline	70	
Inland Feeder (South)	1,000	
Inland Feeder (North)	300	Estimated completion date of 2010
Lytle Pipeline	55	
Santa Ana River Crossing Pipeline	70	
Morton Canyon Connector Pipeline	70	
Lytle Pipeline	120	Muni currently contracts for 55 cfs of capacity, but under certain conditions the entire 120 cfs conveyance capacity is available to Muni

84. **Groundwater Recharge Facilities** - The Project would include the recharge of unappropriated SAR water through the utilization of selected existing spreading basins. Groundwater recharge could also be accomplished indirectly through the delivery of surface water in lieu of groundwater pumping. The location of spreading grounds, their proximity to existing and proposed conveyance facilities, and their relationship to underlying groundwater basins are shown in Muni/Western Exhibit 5-32. As shown, all but one of the 12 groundwater recharge facilities proposed for use under the Project are within Muni's service area. These recharge facilities overlie the Lytle Creek and Bunker Hill groundwater basins (collectively known as the San Bernardino Basin Area [SBBA]), the Rialto-Colton Basin, San Timoteo Basin, and Yucaipa Basin. Existing turnouts serve each recharge facility with the exception of the Cactus Spreading and Flood Control Basins, which would be served by the proposed Cactus Basins Pipeline. Characteristics of selected spreading grounds are summarized in Muni/Western Exhibit 5-33. A more complete explanation of the groundwater recharge facilities that could be used as part of the Project is found in Draft EIR Appendix B Chapter 3 (see Muni/Western Exhibit 4-3).

Project Scenarios

85. Estimates of the quantities of unappropriated water are influenced by a number of factors, the most critical of which are listed below.

- Diversions by Senior Water Rights Claimants;

- Diversions by the Conservation District;
- Releases designed to accomplish habitat restoration as prescribed by the terms of the Biological Opinion (BO) for the operation of Seven Oaks Dam; and
- Operation of Seven Oaks Dam for flood control only or flood control with seasonal water conservation storage.

86. The treatment of these four parameters in the analyses can have major impacts on the amount of water from the SAR potentially captured and put to beneficial use. The significance of each parameter is described in the following paragraphs. Various combinations of these critical parameters were used to develop the scenarios analyzed to estimate the potential capture by Muni/Western. These scenarios are described following the discussion of each parameter.

87. **Diversion Rate for Senior Water Rights Claimants** - Future diversions by the Senior Water Right Claimants could vary from historical diversions up to 88 cfs. During the period Water Year 1961-62 to Water Year 1999-2000, average annual Senior Water Right Claimant diversions are estimated at approximately 26,600 afy. However, the Senior Water Rights Claimants assert pre-1914 water rights of more than this amount. In July 2004, Muni, Western, and the Senior Water Right Claimants signed a settlement agreement known as the Seven Oaks Accord. As a result of this Accord, Muni/Western have agreed not to object to diversions by the Senior Water Right Claimants of up to 88 cfs. In the future it is anticipated that the amount of water taken by the Senior Water Rights Claimants will vary between their historical amount and 88 cfs (or about 36,323 afy on average).

88. **Conservation District** - Future diversions by the San Bernardino Valley Water Conservation District could vary between their licensed right and their historical diversions. The Conservation District holds two licenses issued by the SWRCB to divert water from the SAR as discussed earlier. In addition to these licensed diversions, the Conservation District also claims pre-1914 water rights and has diverted water in excess of 10,400 af in some years. For example, from Water Year 1969-70 to 1999-2000 diversions averaged 14,299 af per year. Accordingly and for purposes of analysis, a set of scenarios was based on diversions limited by the licensed right and another set was based on the Conservation District's actual historical diversions to the SAR Spreading Grounds.

89. **Biological Opinion Flows** - The USACE prepared a "Biological Assessment" (BA) that indicated a certain flowrate be released from Seven Oaks Dam to maintain habitat immediately downstream from the Dam by causing overbank flooding and to aid in fluvial processes. To respond to this requirement, Muni/Western used the Operations Model (discussed later in my testimony) to determine the appropriate duration and rate of releases. The modeling allowed Muni/Western to conclude that releases of SAR surface water from Seven Oaks Dam to accommodate habitat restoration at flowrates up to 1,000 cfs for 2 days, when water is available, would accommodate habitat restoration.

90. **Seasonal Storage -** To optimize the beneficial use of unappropriated water in the SAR, the criteria under which Seven Oaks Dam is currently operated would be changed to accommodate conservation storage in addition to its current use for regulatory flood storage. After the designated flood control season (October through February), up to 50,000 af of water could be impounded in Seven Oaks Reservoir in seasonal water conservation storage. With or without the Project, Seven Oaks Dam will be operated for flood control benefits during the period October through February, with seasonal water conservation storage beginning in March and ending in September.

91. Using the same approach as with the other parameters, one set of scenarios was run with conservation storage and another without.

92. **Analytical Approach –** The basic analytical approach was to develop and evaluate scenarios that represented the high and low range of capture amounts to establish "bookends" so that other alternative scenarios would be covered by the environmental impact expected at both the high bookend and the low one. The computer modeling effort discussed in the next main section of my testimony was designed to be used to evaluate the potential capture of unappropriated SAR water using any combination of all four parameters and two rates of diversion, 500 cfs and 1,500 cfs. As was noted in the discussion of the parameters, there are high and low estimates for each. For example, habitat restoration plans under the BO are still under development. Ultimate habitat restoration plans may use large volumes of water released from Seven Oaks Dam or may rely on other treatments that use little or no water. Likewise scenarios were developed to reflect either licensed or historical Conservation District diversions. The combination of high and low estimates for each of the four factors results in 16 different "scenarios."

93. Of the 16 scenarios, five were carried forward for detailed analyses: Project Scenarios A, B, C, and D as well as the No Project Scenario. They represent the maximum quantity of SAR water appropriated by Muni/Western with a 1,500 cfs diversion rate (Scenario A); the maximum quantity of SAR water appropriated by Muni/Western with a 500 cfs diversion rate (Scenario B); the minimum quantity of SAR water appropriated by Muni/Western with a diversion rate of 1,500 cfs (Scenario C); and, finally the minimum quantity of SAR water appropriated by Muni/Western with a diversion rate of 500 cfs (Scenario D); and the scenario representative of No Project conditions (No Project Scenario).

94. To summarize this section of my testimony, based on the range of values for the four most critical parameters, estimates the amount of water available for Muni/Western appropriation can be made using the computer models described in the following section. Presented on Muni/Western Exhibit 5-34 are 16 different "scenarios" created by the different combinations of these four assumptions.

Computer Modeling

95. The computer modeling of surface water hydrology by SAIC is designed to estimate a range of potential water capture amounts by Muni/Western under the Project and to evaluate the effects of that capture on downstream channel hydrology and hydraulics. The computer modeling of groundwater conditions was done by GEOSCIENCE and will be described by Dr. Williams in his testimony.

96. Water appropriated from the SAR will be put to beneficial use in the Muni/Western service area through direct use, groundwater recharge, and/or exchange. Muni/Western have developed a set of analytic techniques and models which allows a demonstration of the manner in which groundwater and surface water resources in their region can be conjunctively used.

97. Under the Project, Muni/Western have several options available to them for conveying and distributing SAR water. The water can be put to direct use or stored in groundwater basins within the Muni/Western service area for later extraction and use. Muni/Western's analytic techniques and models also demonstrate how Muni/Western can allocate water for maximum beneficial use through direct delivery, spreading to underground storage, or exchange.

98. **Priorities for Water Allocation –** The computer modeling of the surface water hydrology, specifically the Allocation Model (which I will describe later), operates under a set of priorities of uses for Muni/Western capture and delivery of SAR water are made to beneficial uses. These priorities are described in detail in Drat EIR Appendix A page A-5-2 to A-5-5 and summarized below.

   a. **Direct Use – Priority 1** - I have prepared Muni/Western Exhibit 5-35 to list the six direct uses proposed to receive SAR water under the Project. In total, direct uses represent 155 cfs of absorptive capacity in most months. The demand for SAR water delivered by Muni/Western to West Valley, City Creek, Hinckley, and Tate WTPs is set to zero from September through May because during these months other local water supplies are delivered to these treatment plants. In the Allocation Model, demand by the Yucaipa WTP increases over the 39-year base period to reflect increasing use of the new facility and fluctuates to reflect the seasonality of demands. The absorptive capacity of each beneficial use and the conveyance capacity of the delivery system are accounted for in the computer modeling described later.

   b. **Groundwater Recharge in the San Bernardino Basin Area – Priority 2 –** Under the Project, nine existing spreading grounds that overlie the SBBA would receive captured SAR water. These are also shown on Muni/Western Exhibit 5-35. In total, these spreading grounds have 239 cfs of available absorptive capacity but this full capacity is not generally used because of limited amounts of SAR supplies.

c. **Other Groundwater Recharge in the Muni Service Area - Priority 3 -** Groundwater recharge outside the SBBA but within Muni's service area is the third priority use for captured SAR water. As shown in Muni/Western Exhibit 5-35, three spreading grounds outside of the SBBA would receive SAR water under the Project. In total, these spreading grounds have 57 cfs of available absorptive capacity based on reasonable monthly recharge rates and assuming year-round use.

d. **Exchange - Priority 4** - Exchange is the lowest priority use for captured SAR water. There are four potential exchange partners that have been identified, including The Metropolitan Water District of Southern California (Metropolitan); San Gabriel Valley Municipal Water District (SGVMWD); San Gorgonio Pass Water Agency (SGPWA); and the California Department of Water Resources (DWR). These agencies have access to SWP water and are agencies to which Muni can physically deliver water. Potential deliveries to exchange partners are limited by the conveyance capacity available. It is assumed that there is adequate demand or reservoir storage capacity on the part of the exchange partners to accept captured SAR water in the amounts proposed in Muni/Western Exhibit 5-35. For conveyance to exchange partners, the total absorptive capacity is 1,371 cfs.[1]

99. The Draft and Final EIRs included as an element of the Project the exchange of SAR water in excess of immediate needs of the Muni/Western service area during wet years with The Metropolitan Water District of Southern California (Metropolitan). Mr. Jack Safely will present testimony demonstrating that an exchange with Metropolitan is not necessary in order for Muni/Western to put most of the 200,000 af requested in the applications to reasonable and beneficial use in their service areas in a single year. If the SWRCB grants Muni/Western permits to divert water and it becomes desirable to enter into an exchange with Metropolitan, Muni/Western would only implement such an exchange in full compliance with applicable laws.

100. The estimates of future potential capture of SAR flows by Muni/Western and the impact analysis methodology require that future surface water conditions be forecast. The first model, Operations Model (OPMODEL), is used to estimate the quantities of unappropriated water potentially available on a monthly basis for diversion from the SAR. Daily Operations Model (DOP) was developed to evaluate potential deliveries on a daily

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[1] Exchange water could be put to beneficial use within the Muni/Western service areas if Muni/Western determines it is not desirable to enter into an exchange with Metropolitan. See Paragraph 99 of this testimony.

basis. The next model (Allocation Model) is used to evaluate how the monthly supplies derived using OPMODEL could be distributed among a number of beneficial uses. With information on the amount of potential diversions and allocation of water, Groundwater Model(s) are used to determine a variety of effects on the groundwater system. Next, River Analysis is used to evaluate the potential effects that daily diversions may have on hydrologic processes in the SAR, particularly instream flows and overbank flooding. Daily River Analysis Model (DRAM) is used to evaluate the potential effects that daily diversions may have on hydrologic processes in the SAR. The different models and their interactions are illustrated in Muni/Western Exhibit 5-36.

101. The Operations Model, referred to as OPMODEL, is a spreadsheet modeling tool used to estimate the quantity of unappropriated SAR water available for diversion by Muni/Western after accounting for diversions by prior rights holders and other uses. This model simulates monthly releases that could be made from Seven Oaks Dam under the set of factors described earlier in my testimony and again in this section for ease of reference.

102. The initial input to OPMODEL is an estimate of inflow to Seven Oaks Reservoir. There is no gage to directly measure this quantity so estimates of SAR surface water inflow for the base period are based primarily on USGS historical data recorded at the "River Only" Mentone Gage, modified to reflect current operating conditions of Bear Valley Dam located upstream of Seven Oaks Dam. An annual estimate of reservoir evaporation, resulting from operation of Seven Oaks Dam, was subtracted to account for the current operations of Seven Oaks Dam. The calculated flows for the base period were shown in Muni/Western Exhibit 5-12. Variations between these values illustrate how average annual No Project flows vary from year to year.

103. A monthly time-step was chosen for OPMODEL because of data availability and because a volumetric estimate of the amount of water available for Muni/Western diversion is needed. Synthesized flow for the SAR based on the re-operation of Big Bear Lake and diversions by the Conservation District are available on a monthly basis. Output from OPMODEL is used in the Allocation Model, which also uses a monthly time-step.

104. The results of OPMODEL that are most pertinent to the environmental documentation are estimates of: (i) unappropriated water available to Muni/Western for diversion; and (ii) water remaining un-diverted and contributing to flow in the SAR. This output from OPMODEL is used as input to two other models employed in analyses: the Allocation Model and the Groundwater Model.

105. The four main parameters or conditions discussed earlier are incorporated in OPMODEL and influence model results. Depending on the combination of parameter values, a range of unappropriated SAR surface water is potentially available for diversion by

Muni/Western. The main parameters that affect the quantity of water available for diversion by Muni/Western were described earlier but are listed below for clarity.

- Diversions by senior water rights claimants (ranging between their historical diversions and up to 88 cfs);
- Diversions by the Conservation District (historical or licensed);
- Releases of SAR surface water from Seven Oaks Dam to accommodate habitat restoration (up to 1,000 cfs for 2 days when water is available); and,
- Operation of Seven Oaks Dam for flood control or seasonal water conservation storage.

106. The following sections provide a detailed description of the logic used in OPMODEL and provide details regarding: (i) model structure; (ii) model input, parameters, and assumptions; (iii) model application; and (iv) model results.

107. Presented in Muni/Western Exhibit 5-37 is a flowchart illustrating the structure of OPMODEL. The Senior Water Rights Claimants take water above Seven Oaks Dam through the SCE Canal and the Redlands Tunnel and the Auxiliary Diversion below the dam. Storage of surface water inflow is augmented by up-welling groundwater that is intercepted by the grout curtain underlying Seven Oaks Dam and is reduced by evaporation from the reservoir surface. Releases and release rates from Seven Oaks Dam depend on the resulting reservoir storage and whether the dam is operated for flood control purposes or for a combination of flood control and seasonal water conservation storage. The major structure of OPMODEL is outlined in Muni/Western Exhibit 5-38. The details of the various pieces of the structure are described in Draft EIR Appendix A Chapter 4 (See Muni/Western Exhibit 4-3).

108. The historical inflow to Seven Oaks Dam is estimated under two different assumptions regarding diversions by Senior Water Rights Claimants using OPMODEL. When the model is configured for historical diversions, estimates of the SAR flow entering Seven Oaks reservoir are based on historical records derived from flows measured by the “River Only” Mentone Gage. When the model is configured to use an assumed diversion rate of up to 88 cfs, monthly inflow to Seven Oaks Reservoir is calculated as the monthly historical SAR flow as measured at the “Combined Flow” Mentone Gage minus the assumed 88 cfs allotted to Senior Water Rights Claimants. Of this total of 88 cfs allotted to the Senior Water Rights Claimants, 3 cfs is comprised of sub-surface flow that is intercepted by Seven Oaks Dam and subsequently released for pick up by the Redlands Tunnel. The 85 cfs of the Senior Water Rights Claimants diversions is diverted from the SAR upstream of the Seven Oaks Dam and delivered to the SCE Canal.

109. Seven Oaks Reservoir Evaporation - Water losses from the surface of the reservoir due to evaporation are accounted for in OPMODEL. The estimated reservoir surface area is

multiplied by an evaporation rate to estimate the net average monthly volume of water lost through evaporation. Presented in Muni/Western Exhibit 5-39 is the area/capacity curve for Seven Oaks Reservoir. Evaporation rates are taken from monthly pan evaporation rates observed at the San Bernardino County Flood Control District facility.

110. Releases from Seven Oaks Dam - The difference between average monthly storage and the end-of-month target storage quantities are used in OPMODEL to calculate the release of water from Seven Oaks Dam. The end-of-month target depends on whether or not the dam is to be operated with or without seasonal water conservation storage. As can be seen in Muni/Western Exhibit 5-40, target-storages and hence, releases, are identical for the months September through February. From March through August, without seasonal water conservation storage, all water in excess of that contained in the debris pool is released from the dam. With seasonal water conservation storage, target storages are much higher from March through August.

111. Historical Conservation District Diversions of SAR Water - Occasionally the monthly volume of water recorded in the Conservation District spreading record for the SAR spreading grounds exceeds the estimated flow in the SAR. The historical diversions of the Conservation District are included in OPMODEL as the minimum of (1) recorded historical monthly spreading, or (2) simulated monthly release from Seven Oaks Dam. This method approximates water available for diversion by Muni/Western because some of the water listed in the historical Conservation District spreading records is water that had been historically diverted from sources other than the SAR. The data are inadequate for a more refined analysis.

112. The timing of licensed diversions (October through May) by the Conservation District is important when considered in conjunction with the Seven Oaks Dam target storages. With or without seasonal water conservation storage, the dam begins storing water in November to fill the debris pool to 2,966 af and holds that storage through at least June. With seasonal water conservation storage, water in the debris pool is held until August. The debris pool is filled during the Conservation District's licensed seasonal diversion period and released outside of that period. When OPMODEL is configured to use licensed Conservation District diversions, the model logic considers that due to the timing of filling and draining of the debris pool, water from the debris pool is not available to the Conservation District

113. The diversion rate for the Conservation District use of SAR water is 300 cfs for purposes of the modeling analyses for the Project. Use of this capacity results in all historical diversions to be delivered.

114. Environmental Habitat Releases from Seven Oaks Dam - Environmental restoration activities designed to mitigate impacts from flood control operations of Seven Oaks Dam

are proposed in the US Army Corps of Engineers Biological Assessment (2000) and US Fish & Wildlife Service Biological Opinion (2002) (as cited in the Draft EIR Appendix A). One of the methods suggested to accomplish habitat restoration is through periodic release of water from the dam. Assuming operations with habitat releases, once all prior rights and diversions have been met, OPMODEL is used to determine if there is enough reservoir storage remaining to allow a release with sufficient velocity and magnitude to implement effective habitat restoration.

115. Related variables in the model that can be specified by the user include a release rate, duration, and interval for the environmental habitat releases. The BA suggests (in Table 38 of the document) a magnitude for the habitat release of between 1,000 cfs and 2,000 cfs for a few days occurring every 5 to 10 years for 10-acre parcels. Construction of the necessary dikes would take 3 to 5 months; this implies that habitat releases must be made at least 6 months apart.

116. OPMODEL was run under various assumptions to determine the appropriate duration (in days) of environmental habitat releases. Based on these analyses, it was determined that to have an environmental habitat release every 5 to 10 years, the volume of water associated with the release would have to be 1,000 cfs for 2 days (4,000 af) or less, and Seven Oaks Dam would have to be operated to allow for temporary or seasonal water conservation storage. Based on these findings, OPMODEL was configured to simulate environmental habitat releases of 1,000 cfs for duration of 2 days, with at least 6 months elapsed time between releases. The OPMODEL logic further assumes a habitat release is made only when: (1) there is a sufficient volume of water available above that needed for Conservation District diversions; (2) when reservoir elevation is great enough to sustain the specified release rate (1,000 cfs); and (3) when there has not been a release within the specified interval, i.e., the past 6 months.

117. Seasonal Water Conservation Storage - After the flood season has ended in any given water year, reservoir storage space, up to a specified target pool level elevation, could be used to allow controlled releases for downstream uses while providing conservation storage of SAR flows. Therefore, OPMODEL has been designed to simulate Seven Oaks Dam operations under two different assumptions – operations with seasonal water conservation storage and operations without seasonal storage. These assumptions affect dam operations, including target storage and Seven Oaks Dam releases. It is important to note that Muni/Western intend that Seven Oaks Dam be operated to provide both regulatory and seasonal water conservation storage. With seasonal water conservation storage in the months when Seven Oaks Dam operations would allow it (March through August), Muni/Western diversions are limited to the volume which Muni/Western can beneficially use in the short-term (direct-uses). Water in excess of short-term beneficial use is left in seasonal water conservation storage in Seven Oaks reservoir for release at a later time. An

estimate of the amount of water to be released for short-term beneficial use in the Muni/Western service areas is derived, on a monthly basis, from the Allocation Model.

118. Seven Oaks Reservoir Target Storage Capacities - Based on the USACE operating criteria, inflow to Seven Oaks Dam, reservoir storage behind the dam, and outflow from the dam are determined by using OPMODEL. Outflow from the dam or releases are determined, in part, by setting or using an end-of-month target reservoir storage volume for each month. Two different sets of monthly reservoir storage targets depending on whether or not seasonal water conservation storage is specified are used in OPMODEL. These are described in Draft EIR Appendix A page A-4-6 to A-4-7. End-of-month target storage capacities, both with and without seasonal water conservation storage, are summarized in Muni/Western Exhibit 5-40.

119. ALLOCATION MODEL - The Allocation Model is designed to account for and simulate how diversions from the SAR by Muni/Western would be put to a variety of beneficial uses. The priorities assigned to Muni/Western diversions of SAR water have been described earlier in my testimony. These priorities reflect the desirability of minimizing energy costs (direct delivery is less expensive than groundwater pumping) and the desirability of utilizing high quality SAR water locally.

120. General Description and Purpose of Allocation Model - The Allocation Model provides a tool for estimating the quantities of captured water delivered to different beneficial uses under No Project and Project (Scenarios A through D) conditions. OPMODEL and Allocation Model are used together to make forecasts, based on a repetition of historical hydrologic conditions of the period WY 1961-62 through WY 1999-2000. Allocation Model operates on a monthly time-step as does OPMODEL. To take account of future conditions with and without the Project, assumptions concerning future water demand, future groundwater pumping, future capacity of conveyance and treatment facilities, and future water management actions are incorporated in the logic used to construct Allocation Model.

121. Deliveries of SAR water diverted as part of the Project, deliveries of SAR and imported water to meet the requirements of the *Western* Judgment, and deliveries of SWP water returned from exchange programs are tracked in Allocation Model. These deliveries are tracked to locations within the Muni service area that are inside and outside the SBBA.

122. Allocation Model is integrated with other models developed to support the SAR water rights applications and the environmental documentation. The output from OPMODEL serves as the input to Allocation Model. These inputs include:

- Monthly amounts of SAR water that could be diverted by Muni/Western;
- Monthly amounts of SAR water that would be diverted by the Conservation District and delivered to the Santa Ana River Spreading Grounds for recharge; and,

- Annual amounts of environmental habitat releases that contribute to deep percolation in the river channel.

123. Allocation Model and the Groundwater Model are evaluated and work "iteratively" to provide estimates of reasonable deliveries to spreading grounds. The iterative process is necessary since deliveries of water to spreading grounds are not only limited by delivery constraints such as available conveyance route capacities and absorptive capacities of spreading facilities, but also by groundwater levels and the location of groundwater contamination plumes in the SBBA. The results of the Allocation Model are summarized annually for use in the groundwater model.

124. The iterative process between the Allocation Model and the Groundwater Model starts with the initial estimate of annual deliveries to each spreading ground developed by Allocation Model as the input to Groundwater Model. The effects of these initial delivery estimates on groundwater levels are evaluated by GEOSCIENCE and manual adjustments are made by SAIC to the recharge targets used in the Allocation Model. The iterative process is repeated until an acceptable recharge target is identified that meets the groundwater management objectives.

125. The logic upon which Allocation Model is structured is shown on Muni/Western Exhibit 5-41. Allocation to each beneficial use is limited by:

- The amount of water remaining after deliveries to a higher priority use;
- Available conveyance capacity;
- Available absorptive capacity of a given beneficial use; and,
- Consideration of groundwater levels using groundwater targets

126. Allocation Model is based on the fact that, when it is not possible for SAR water diverted by Muni/Western to be used for direct uses or for groundwater spreading in the SBBA or other locations in the Muni/Western service areas, as a last priority, SAR water could be exchanged with other agencies and an equal amount of water could be returned at a later date. If water were exchanged outside of the Western Service area, as shown in Muni/Western Exhibit 5-41, water returned as part of an exchange would be put to beneficial use, again with the first priority being direct use, second to groundwater spreading in the SBBA, and lastly to groundwater spreading in other areas of the Muni/Western service areas.[1]

127. The annual quantity of water needed to fulfill Muni's groundwater replenishment obligations for the SBBA under the *Western* Judgment is estimated using Allocation Model.

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[1] Exchange water could be put to beneficial use within the Muni/Western service areas if Muni/Western determines it is not desirable to enter into an exchange with Metropolitan. See Paragraph 99 of this testimony.

128. The logic of Allocation Model is designed to simulate how water captured from the SAR could be put to beneficial use while, at the same time, meeting the following objectives. These objectives include:

- Meeting the Muni recharge obligations of the SBBA under the *Western* Judgment;
- Avoiding high groundwater conditions;
- Avoiding deterioration of groundwater levels in the Pressure Zone of the SBBA; and,
- Not adversely affecting groundwater contamination plumes.

129. To meet these various objectives, Allocation Model tracks deliveries of SAR water diverted as part of the Project, deliveries of imported water to meet the requirements of the *Western* Judgment, and deliveries of SWP water returned from exchange programs. These deliveries are tracked to locations within Muni's service area that are inside and outside the SBBA. The objectives of avoiding high groundwater conditions and avoiding deterioration of groundwater levels in the Pressure Zone are met through an iterative process using both Allocation Model and the Groundwater Model as was stated earlier.

130. As noted earlier, the logic built into Allocation Model recognizes the priority of beneficial uses described earlier with the following constraints.

   a. Direct use is constrained by the demands within the areas served by the various water treatment facilities.

   b. Groundwater recharge in the SBBA is constrained by the absorption capacity of the various spreading grounds and impacts on the groundwater.

   c. Groundwater recharge in the balance of the Muni is constrained by the absorption capacity of the various spreading grounds and impacts on the groundwater.

   d. Water delivered for exchange is constrained by conveyance capacity but there was no constraint imposed by storage capacity outside Muni/Western. It is assumed that there is adequate demand or reservoir storage capacity on the part of the exchange partners to accept captured SAR water in the amounts proposed in Muni/Western Exhibit 5-42. For conveyance to exchange partners, the total absorptive capacity used is 1,371 cfs.

131. Return of Imported Water from Exchanges - The amount of imported water delivered in exchange for prior deliveries of SAR water is estimated in Allocation Model. Allocation Model accounts for deliveries to, and returns from, exchange partners, and the corresponding "account" balance with each partner. The Allocation Model returns water to Muni/Western as soon as possible, subject to the following constraints:

- No water is returned to Muni/Western in months that Muni/Western takes delivery of SAR water; and

- The total water returned from exchange in a month is estimated based on the absorptive capacities of the beneficial uses and the conveyance capacities. The conveyance capacity limitations used in the analysis are the same as those used to evaluate deliveries of diverted SAR water.
- The total capacity for return from exchange was assigned a limit of 288 cfs within the Allocation Model. This limit corresponds to the maximum conveyance capacity of the Foothill Pipeline. Based on this set conveyance limit the Allocation Model indicates return of exchange water can be made within about 10 years or less for Scenarios A and B and about 5 years or less for Scenarios C and D, and it is all brought back within the 39-year period.[1]

132. Future Demands in the Muni Service Area Including Exports - Estimates are made of future water demands and sources of water supply for purveyors within Muni's service area and purveyors exporting from the Muni service area. Estimates of water demand are derived on a production basis and are an integral part of the Allocation Model analysis. As an example, in Allocation Model logic, Yucaipa WTP is assumed to accept SAR water year-round. For this reason a monthly demand pattern was developed for this WTP. Other WTPs are available only over one season and for these WTPs demand was set at a constant rate for the season. Spreading grounds are assigned long-term absorptive capacities for the potential delivery of captured SAR water and are not varied seasonally since recharge can follow a different pattern than the ultimate monthly or seasonal demand for water.

133. Projected year 2020 annual water demands for municipal Non-Exporters were obtained from the Urban Water Management Plans (UWMPs) for each purveyor when available or from the Muni Regional Water Facilities Master Plan if UWMPs were not available. Projected water demand through year 2039, the end of the Allocation Model base period, was estimated by applying anticipated water demand increases obtained from either the Santa Ana Integrated Watershed Plan (2002) or by extrapolation using the year 2020 estimates. Projected changes in agricultural water demand in the Muni service area through year 2015 were obtained from the Regional Water Facilities Master Plan.

134. The Master Plan estimated a 15 percent decrease in agricultural demand every five years. This same trend was applied to estimate agricultural demands as part of the projected water demands used for the Allocation Model. It is anticipated that some portion of the existing agricultural uses will transfer to urban uses as development occurs.

135. As shown in Muni/Western Exhibit 5-43, municipal and industrial production demands are estimated to increase by about 34 percent (including allowances for water conservation and recycling). Agricultural demand is expected to decrease by about 48 percent between the years 2000 and 2020. The resulting annual net increase in production demand of 3,380 afy

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[1] Exchange water could be put to beneficial use within the Muni/Western service areas if Muni/Western determines it is not desirable to enter into an exchange with Metropolitan. See Paragraph 99 of this testimony.

for 2000 to 2020 was used for the first 20 years and for the projected replenishment calculations. Lower annual growth rates of 740 afy were assigned for the final 19 years of the 39-year base period based on information contained in SAWPA planning reports indicating build-out of the Muni service area and allowing for no additional extractions to meet growth in demand by Exporters.

136. Constraints to Allocation of SAR Water - SAR water captured by Muni/Western and water imported for replenishment are distributed to twenty-two specific beneficial uses within four general categories using Allocation Model as illustrated in Muni/Western Exhibit 5-34. The following constraints are applied within Allocation Model to simulate deliveries of water to each of the 22 beneficial uses: (1) the conveyance capacity of the delivery route (including the turnout capacity); (2) the monthly available absorptive capacity of the receiving beneficial use; and (3) annual recharge targets set (applicable only to spreading grounds). Descriptions of constraining factors are provided in the sections that follow. These facilities are shown in Muni/Western Exhibit 5-35 and within Allocation Model each beneficial use is assigned an available absorptive capacity, such as the capacity at buildout, to represent a reasonable rate at which water can be absorbed, or used, over a specific period. There are seasonal variations in the absorptive capacity of the beneficial uses. This is reflected in Allocation Model by assigning a "demand factor" to each beneficial use. The "demand factor" can take a value between zero and one for each month of the analysis. A value of zero indicates that, in a given month no delivery of captured SAR water is made. A value of 1 signifies that in that month the full absorptive capacity of the beneficial use is available for SAR water delivery. A value of 0.5 signifies that in that month half of the assigned absorptive capacity of a beneficial use is available to take Project water. For example, in the months of September through February many of the spreading grounds are assigned demand factors of zero, because during these months it is assumed that the absorptive capacity of the spreading grounds is dedicated to control of local runoff and no additional space is available for SAR water. Likewise, demand factors for water treatment plants (with the exception of the Yucaipa Water Treatment Plant) are set to zero from September through May, reflecting the fact that in those months other local or imported water supplies meet demands and these WTPs have no available capacity to take captured SAR water.

137. Constraints to Allocation of Water for Groundwater Recharge - Each of the groundwater spreading facilities in the SBBA. Based on the results of groundwater modeling, each spreading ground in the SBBA was assigned a "recharge target" for each year of the analysis. The recharge target is an estimated volume of spreading. These targets do not represent optimum groundwater management but provide a guideline on how much water could be spread to avoid adverse affects.

138. Replenishment Obligations - The Muni replenishment obligation is estimated within Allocation Model. The replenishment obligation is based on the provisions of the *Western* Judgment as described above, in addition to forecasted supplies and demands within the SBBA. Parameters used to determine the annual replenishment obligation include:

- Natural safe yield;
- Water demand by Non-Plaintiffs (production to meet demand includes SBBA groundwater extractions, SBBA surface water diversions, plus imported water delivered as direct delivery within the SBBA);
- SAR water diverted as part of the Project and delivered within Muni's Service area; and
- SBBA groundwater extractions by Plaintiffs.

139. Natural Safe Yield - The Western-San Bernardino Watermaster has determined the natural safe yield of the SBBA is 232,100 afy. Of the 232,100 afy natural safe yield, 72.05 percent, or 167,238 afy, is the defined portion of natural safe yield available to the Non-Plaintiffs because of the Western Judgement. The Plaintiffs' portion of the defined natural safe yield (27.95 percent) is 64,862 afy, of which 63,435 afy may be exported for use outside the SBBA and 1,427 afy is for use within the SBBA. Natural safe yield and estimated future water demands are described in the Draft EIR Appendix A pages A-5-17 to A-5-19 (see Muni/Western Exhibit 4-3).

140. Water Demand by Non-Plaintiffs - For purposes of Allocation Model a projected increase in water demand by the Non-Plaintiffs over the base period, which recognizes some water conservation and recycling to meet future demands is used. Within the Allocation Model there are three sources of water available to meet Non-Plaintiff demands: imported water (SWP); local surface water diversions; and groundwater pumping. The estimated amount of water used from each of these sources affects the replenishment obligation estimated by the Allocation Model. SWP deliveries to Non-Plaintiffs are estimated within Allocation Model based on SWP deliveries reported by the Western-San Bernardino Watermaster for year 2000, but with yearly increases to account for increasing demand. Based on OPMODEL, non-Plaintiff local surface water diversions are based on historical diversions by Senior Water Rights Claimants (applicable to analyzing the No Project and Scenarios A and B) up to a diversion capacity of 88 cfs (applicable to analyzing Scenarios C and D) output. The amount of surface water available to the Non-Plaintiffs is dependent upon the forecasted hydrology. Estimates of available surface water, in turn, affect projected groundwater pumping.

141. A key criteria incorporated in Allocation Model is that any water demands that are not met by SWP water or local surface water supplies will be met by groundwater pumping. These estimates of groundwater pumping from Allocation Model become input to the

groundwater model. The Allocation Model applies the assumptions used in the groundwater modeling that all water pumped from groundwater or used for direct delivery in the basin has a 30 percent return flow. Since the natural safe yield quantities established by the Western-San Bernardino Watermaster accounted for return flows, only the 30 percent return from extractions above the natural safe yield reduce the replenishment obligation as calculated within the Allocation Model.

142. SAR Water Diverted by the Project - The net increase in SAR water diverted and made available for beneficial use by the Project is considered "new conservation" and, in the terms of the Western Judgment, 27.95 percent of this newly conserved water will be available to the Plaintiffs if they pay their proportionate share of the costs. Accordingly, Allocation Model assumes that the Plaintiffs can increase groundwater extractions within the SBBA to use their share (27.95 percent) of any new conservation.

143. SBBA Water Extractions by Plaintiffs - One of the criteria in Allocation Model is that direct deliveries would not be made to Western's service area. Instead, increased groundwater spreading in the Muni service area would support increased groundwater pumping for export to users in Western's service area. Allocation Model uses the assumption that, at a minimum, Plaintiffs will pump and export their adjudicated safe yield, and will increase pumping to appropriate their share of any new conservation (27.95 percent). Further, Allocation Model is based on the criteria that Plaintiffs will increase pumping to export their share of new conservation within five years from the year in which new water is captured by the Project. When SAR water is captured and exchanged, water is returned to the Muni service area within a reasonable period.

144. Calculating Replenishment Obligation - The annual replenishment obligation under the *Western* Judgment is initially estimated in the Allocation Model as the difference between the Western-San Bernardino Watermaster-determined natural safe yield of the SBBA and extractions from the SBBA by Plaintiffs and Non-Plaintiffs. The Allocation Model calculation of the annual replenishment obligation considers eight adjustments to the initial estimate that are described in Draft EIR Appendix A pages A-5-19 to A-5-20. It is noted that the Plaintiffs' adjusted pumping is input to the groundwater model.

145. Availability of SWP Water - A projection of the amount of SWP deliveries available to Muni in any given year is made and used as an input to Allocation Model. A portion of Muni's SWP water is committed to direct deliveries and for use in areas outside of the SBBA but within Muni's service area. Allocation Model assumes that the remaining SWP water is available for replenishment. The projections of the available SWP water for delivery to Muni were derived from results of CALSIM II modeling by DWR (2002) described in Draft EIR Appendix A page A-5-20.

146. Relationship Between Replenishment Obligation and Recharge Target - As described earlier, Muni can meet replenishment obligations by delivering captured SAR water, importing SWP water, purchasing water that can be imported through the SWP, or by using existing credits. In years when recharging water to meet the replenishment obligation would be inconsistent with the groundwater recharge target, Muni can use credits instead of undertaking groundwater recharge. In 2001, the Western-San Bernardino Watermaster reported Muni credits of approximately 270,000 af. In accordance with the direction of the Western-San Bernardino Watermaster, Allocation Model uses the following criteria to balance recharge targets and replenishment obligation annually:

- When Muni's accumulated credit is greater than 270,000 af, then credit is used in lieu of undertaking groundwater replenishment.
- When Muni's accumulated credit is more than 100,000 af and less than 270,000 af and the recharge target is more than the replenishment obligation, then Muni's available Table A water supplies are used to try and meet the recharge target, thus restoring used credit and adding to the credit balance.

147. Other criteria in Allocation Model are that credit cannot be used when Muni's accumulated credit is less than 100,000 af and no more credit can be used in any given year than the lesser of 25,000 af or the amount of Muni's accumulated credit in excess of the 100,000 af reserve limit.

148. Allocation Model analyzes five scenarios: A, B, C, and D, and the No Project condition as do the other hydrology models.

149. GROUNDWATER MODEL - The term Groundwater Model, as used in my testimony, relates to a group of groundwater models that will be described by Dr. Williams in his testimony. The Groundwater Model developed by GEOSCIENCE integrates with surface water hydrology model components.

150. RIVER ANALYSIS - River Analysis is a collection of analytical techniques designed to assess the effects that potential diversions by Muni/Western could have on the flow regime of the SAR. Analysis is conducted for two sets of conditions:

- Storm flow conditions where attention is focused on overbank flooding; and
- Non-storm flow conditions where attention is focused on changes in channel flow.

151. The detailed discussion of River Analysis is presented in Draft EIR Appendix A Chapter 6 and summarized in the following paragraphs. The basic purpose of the River Analysis Model is to evaluate the effects of Muni/Western diversions on the SAR channel for Storm Flows and Non-Storm Flows are described in the following sections.

152. Storm Flows - Storm flow analysis utilizes the public domain model HEC-RAS Version 3.1.1. Water surface profiles are calculated using HEC-RAS based on steady, gradually

varied flow in a river reach or a full network of channels. The analysis for the Project used channel geometry data and instantaneous flow rates for various return periods (e.g., 50-year flood, 100-year flood, etc.) used by the USACE in the Biological Assessment for the Seven Oaks Dam. The output of the HEC-RAS model allows for a comparison of water velocity, depth of water in the channel, wetted area in the river channel, velocity of water in overbank areas, and depth of water in overbank areas between the No Project and Project scenarios (Scenarios A through D) for different types of storm/flood events. As mentioned earlier in my testimony Scenarios A through D will be described later.

153. Non-Storm Flows - The non-storm flow analysis was conducted through the use of a daily version of the monthly OPMODEL, referred to as the Daily Operations Model (DOP), and a river analysis model referred to as the Daily River Analysis Model (DRAM). These modeling tools are discussed later in this section of my testimony. The goal of the non-storm flow analysis, under both No Project and Project scenarios, is to simulate, or synthesize, hydrological flows at specific locations along the river channel. The hydrologic impacts of the Project diversions are greater, percentage-wise for non-storm flows compared to storm flows.

154. Description and Purpose of Storm Flow Analysis - This section presents estimates of the potential effects that Muni/Western diversions could have on flood flow and channel characteristics for segments of the SAR between the plunge pool and Prado Reservoir. The characteristics are:

- Areas subject to overbank flooding during storm flows (peak flows), particularly in the area of the alluvial fan;
- Sedimentation and scour;
- Flow depth, velocity, and other hydraulic properties; and,
- Groundwater recharge.

155. Hydrologic and hydraulic effects associated with the operation of Seven Oaks Dam are described in the BA. Estimates of these potential effects were derived using the public domain water surface profile-model HEC-RAS Version 3.1.1. The potential effects of the diversions by Muni/Western on the area subject to overbank flooding were also estimated using the HEC-RAS model.

156. HEC-RAS Model Structure Assumptions - A number of assumptions are made and criteria used during the process of estimating the effects of the Muni/Western diversions on peak flows.

- The effects of the environmental habitat releases on the river are not analyzed because they are a mitigation measure for a previously implemented project and they are not planned to occur during peak flows that are analyzed in this section. Environmental habitat releases, and subsequent diversion to portions of the overbank channel, are planned after a peak has passed and diversion levees have been constructed.

- Habitat releases are assumed to have a higher priority than Muni/Western diversions.
- USACE estimates of peak flow from Mill Creek, Plunge Creek, and other tributaries are included for each respective flood event frequency.
- Historical locations of contributing stream confluence points along the main stem of the SAR used by USACE were adopted for the analysis undertaken here.
- Estimates of changes in flow depths and velocities are consistent with modeling performed for the BA (USACE 2000a) as cited in the Draft EIR.
- Estimates of the scour and sediment transport contained in the BA were adopted.
- For the flow profiles, it was assumed that the channel is saturated during the peak flow and that infiltration is minimal.

157. HEC-RAS Model Input is described in Draft EIR Appendix A page A-6-4. Inflow from tributaries is included in the analysis but cross-sections and flow within tributaries were not modeled. Several wastewater treatment plants contribute to the flow in the river. However, these flows are assumed to be included in the increasing quantities of flow as one proceeds downstream.

158. HEC-RAS Model Results - It was verified that the HEC-RAS data provided by the USACE could be used to replicate results contained in the BA. The verified model was then used to illustrate the potential effects on such variables as water velocity, water depth, and area of inundation in the overbank (floodplain) areas that could result from implementation of the Project, i.e., Muni/Western diversions of up to 1,500 cfs.

159. The time-steps in the modeling efforts include annual (for Groundwater Model), monthly for OPMODEL and Allocation Model and daily for modeling efforts that required this level of detail and when the data were available.

160. A daily time-step is used in River Analysis for the following reasons: (1) historical storm and non-storm categorization does not fit a monthly pattern; (2) the Santa Ana River Watermaster categorizes storm and non-storm periods on a daily basis; and (3) flow data is available from the USGS on a daily basis at various sites along the SAR. Assumptions are made in both DOP and DRAM to account for some data limitations as described for each model in detail below.

161. DAILY OPERATIONS MODEL (DOP) - DOP is a spreadsheet model used to simulate the release of water from Seven Oaks Dam on a daily time step. The model is based on similar input parameters and computational criteria to those used in the monthly OPMODEL. Results from DOP become input data to DRAM, which is discussed in later in my

testimony. Although DOP and OPMODEL are both based on similar logic, parameters, and criteria, they do possess differences as described below.

- Daily average flow rate (cfs) is used as the basis for DOP computations whenever possible as opposed to the volumetric method (af/month) used in the monthly OPMODEL.
- In calculations involving storage and Conservation District diversions, the daily average flow rate (cfs) was converted to a volume (af) for computational purposes.
- Rising and falling conditions of Prado Reservoir are incorporated into the operational criteria for Seven Oaks Dam to compute the release rate from Seven Oaks Dam in DOP. This logic simulates the tandem operations of both dams to control storm flows.
- Hydrologic records of flow at the USGS Combined Flow Mentone Gage are not adjusted to reflect re-operation of Big Bear Lake in DOP. Big Bear Lake operations have little effect on non-storm flow days because non-storm day releases from Big Bear Lake would be diverted before reaching Seven Oaks Dam.
- Seasonal water conservation storage is post-processed by limiting Seven Oaks Dam releases during the seasonal water conservation storage period to ensure all releases are diverted by either the Conservation District or Muni/Western.

162. Selected results from DOP become input data to DRAM and include: (1) historical and up to 88 cfs diversions by Senior Water Rights Claimants; (2) historical or licensed diversions by the Conservation District; (3) environmental habitat releases or no environmental habitat releases; (4) diversions by Muni/Western as represented by Scenarios A, B, C, and D; and (5) undiverted SAR flow. These outputs are combined with estimated SAR inflows (tributary and WWTP) and outflows (evaporation and infiltration losses) to provide the hydrologic basis for flow downstream from Seven Oaks Dam under various operational scenarios. The following discussion provides descriptions of the major assumptions contained in the DOP model.

163. End-of-Day Storage in Seven Oaks Dam - The end-of-day storage is the previous day's storage plus inflow less: (a) losses due to evaporation and (b) the release from the dam (including the 3 cfs released for groundwater recharge). The inflow to Seven Oaks reservoir is estimated as the historical surface flow in the river, less the Senior Water Rights Claimants diversion. This SAR surface water flow rate, plus 3 cfs of groundwater flow intercepted by the dam, is converted to acre-feet and added to the previous day's end-of-day storage to compute the beginning-of-day storage in the reservoir. Water loss through evaporation from the reservoir surface area is calculated using standard pan evaporation rates less average precipitation.

164. The daily release rate to the plunge pool is based on the stage/discharge rating curve for Seven Oaks Dam. It is also determined by consideration of other factors such as time of

the year (flood season or not), reservoir condition at Prado (storm or non-storm), water in the reservoir compared to target storage, and criteria relating to the debris pool. During the months of July and August when the debris pool is drained, releases are limited to a rate equal to inflow plus an additional 20 cfs.

165. Diversions by the Conservation District – The diversions by the Conservation District have been described previously in my testimony for purposes of OPMODEL and the same criteria are used in DOP. Historical Conservation District diversions used in the model are based on daily data when available and any data gaps are in-filled using interpolated monthly data. Daily Conservation District diversion data (measured as cfs) are available for WY 1966-67 through WY 1977-78 and were, therefore, used in DOP for that time period. The remainder of the record (from October 1961 through September 1966, and from October 1977 through September 2000) was in-filled using monthly diversion records provided by the Conservation District.

166. The DOP model includes the criterion that the Conservation District diverts all flows released from the dam up to 300 cfs on a daily basis until monthly historical volumes are met. The daily diversions are converted to acre-feet and cumulated to compare to the monthly records. Once the historical monthly volume is met, DOP model logic prevents further diversion for the remainder of the month. Any shortfalls in meeting the historical monthly diversions are carried over to be met the next month, if possible. When the daily record is available, the minimum of the Conservation District daily record or the flow released from the dam is considered in DOP model to represent the daily diversion by the Conservation District. This logic is based on the assumption that the Conservation District diversion originates solely from water released from the dam. This approach was used because of limited data, and this method ensures that all Conservation District demands are met, prior to unappropriated SAR water being made available for Muni/Western diversion.

167. Environmental Habitat Releases – SAR inflow to Seven Oaks in excess of the Senior Water Rights Claimants and Conservation District diversions is available for potential environmental habitat releases. The DOP modeling is based on these releases being made only if there is sufficient water in the reservoir to make an environmental release for at least two days at the desired rate and sufficient time (6 months) has passed since the last environmental habitat release. This logic was incorporated in DOP to recognize conditions set forth in the BA. For modeling purposes, a release at a rate of 1,000 cfs is made for 2 days.

168. DAILY RIVER ANALYSIS MODEL (DRAM) – In addition to using daily analyses to evaluate the effects of the Project as Seven Oaks Dam using DOP, the effects on downstream channel conditions also required analyses on a daily basis. This was accomplished by developing DRAM to simulate downstream channel conditions and how they would be affected by the Project. DRAM is a spreadsheet model designed to simulate

daily river flow rates for non-storm days at six specific locations along the mainstem of the SAR between Seven Oaks Dam and Riverside Narrows. The locations are (1) upstream of Cuttle Weir; (2) immediately downstream of Cuttle Weir; (3) immediately downstream of the Mill Creek confluence; (4) at "E" Street in the City of San Bernardino; (5) immediately downstream of the outfalls of the RIX and Rialto WWTPs; and (6) at the MWD Crossing Gage at Riverside Narrows. In addition to the output from DOP, DRAM uses a number of data sources to compute or simulate flows at specific locations on the SAR, including estimated SAR inflows from tributaries, discharges from WWTPs, and losses attributable to evaporation and infiltration. Additional detail on DRAM and the data used in it is provided in Appendix A.

169. Collectively, the results from DOP and DRAM provide a comparison of average non-storm daily flows and the number of zero flow days for the No Project and Project scenarios.

170. The three sets of hydrologic and hydraulic conditions represented are:

- Prior to the construction and operation of Seven Oaks Dam;
- Under No Project conditions (i.e., with the operation of Seven Oaks Dam); and,
- Project implementation (i.e., with Muni/Western diversions taking place). The methodology used to simulate the SAR flow rates at these six locations is described below.

171. The generic structure of DRAM presented in Muni/Western Exhibit 5-44 and helps illustrate the components of the estimated flows and data sources. Rectangular shapes represent input data sources, e.g., USGS gages or treatment plant outflow records, while hexagonal shapes represent major model products, i.e., interpolated hydrology at specific locations. Losses from the main channel vary and are shown as triangles in the illustration. Losses occur in the channel through percolation and through evaporation. Diversions are shown with diamond shapes.

Surface Water Computer Models and Results

172. As was explained earlier in my testimony, a "bookend" approach was used to identify the "maximum" and "minimum" amounts of unappropriated water that could be captured and put to beneficial use by Muni/Western through implementation of the Project. This approach is based on the identification of the extreme values resulting from this range of potential combination of conditions (scenarios) that can affect the quantity of unappropriated water that could be captured and put to beneficial use by the Project. This range is identified for the two potential diversion rates that might be utilized by Muni/Western are 500 cfs and 1,500 cfs.

173. There were 16 scenarios identified, of which five have been carried forward for detailed analyses and to provide "bookends" to represent the high and low range of diversions by Muni/Western for evaluation of the potential environmental impacts.

174. The bases underlying each of these five scenarios are described as follows:

- **Scenario A (Scenario 15 at 1,500 cfs)** Scenario A represents the maximum potential appropriation by Muni/Western at a diversion rate of 1,500 cfs and is the result of assuming (i) historical diversions by senior water rights claimants, (ii) licensed diversions by the Conservation District, (iii) environmental restoration without releases from the dam, and (iv) seasonal water conservation storage at Seven Oaks Dam;
- **Scenario B (Scenario 15 at 500 cfs)** Scenario B is based on the same parameters as Scenario A, except the proposed Muni/Western diversion rate is set at 500 cfs instead of 1,500 cfs used in Scenario A.
- **Scenario C (Scenario 2 at 1,500 cfs)** Scenario C represents the minimum potential appropriation by Muni/Western at a diversion rate of 1,500 cfs and is the result of assuming (i) 88 cfs diversions by senior water rights claimants, (ii) historical diversions by the Conservation District, (iii) releases for environmental restoration, and (iv) no seasonal water conservation storage at Seven Oaks Dam.
- **Scenario D (Scenario 2 at 500 cfs)** Scenario D is based on the same parameters as Scenario C, except the proposed Muni/Western diversion rate is set at 500 cfs instead of the 1,500 cfs used in Scenario C.
- **No Project Scenario (Scenario 10)** The No Project Scenario is based on (i) historical diversions by senior water rights claimants; (ii) historical diversions by the Conservation District; (iii) releases for environmental restoration; and, (iv) no seasonal water conservation storage at Seven Oaks Dam.

175. Scenarios A through D span the range of possible operations of Seven Oaks Dam, the range of possible releases from Seven Oaks Dam, and the range of potential diversion by Muni/Western. Evaluating Scenarios A through D encompasses all possible scenarios and negates the need to analyze each of the 16 scenarios individually.

176. As I previously noted, the computer modeling efforts by SAIC were conducted to: (1) Determine the amount of potential capture of SAR water that could be put to beneficial use by Muni/Western; and, (2) the hydrologic and hydraulic effects of that capture on the downstream channel characteristics.

177. The results of the evaluation the hydrologic and hydraulic effects of that capture on the downstream channel characteristics are discussed in Paragraphs 174 through 198. Paragraphs 199 through 209 will discuss capture amounts.

178. Modeling results provide information on changes to both storm-flows and non-storm flows in the SAR that could result with implementation of the Project. Storm and non-storm days

are defined by the Santa Ana River Watermaster each year based on rainfall and flow in the SAR channel at Riverside Narrows and at Prado. The storm flow analysis provides information on peak storm discharges within different river reaches, velocity of flood flows in the channel and in overbank areas, and depth of water in the channel and in overbank areas. This information can be directly applied to determine potential changes in fluvial processes or changes in the extent of area inundated during a flood event.

179. Project-related effects under high flows (such as 50-year and 100-year events) and lower flows (more frequent 5- and 10-year events) in USACE Sub-Area 2 (RM 70.93 to RM 61.5) are presented in Muni/Western Exhibit 5-45. As shown, there is no overbank flooding in the Upper Reach portion of Sub-Area 2 and the effects of the Project would be limited to changes in flow in the main channel. In the Middle Reach portion of Sub-Area 2, the change in overbank velocity and depth is minor. Overall, in Sub-Area 2 inundation would be reduced by 3.8 percent and 2.4 percent, for the 50-year and 100-year flood events, respectively. Mill Creek, Plunge Creek, City Creek, and other tributaries would not be affected by the diversion. This is the worst-case reduction in flood flows; with a 500 cfs diversion rate, changes to flood flows would be less pronounced. In Sub-Area 3 (RM 61.5 to 35.5), the effects of Muni/Western diversions were analyzed for the 100-year flood scenario for key cross sections. No flow data for the 50-year event or other frequency events in Sub-Area 3 were available from the USACE dataset. Model results reveal an overall decrease of inundated area for Sub-Area 3 of about 11 acres (0.2 percent of total area inundated) for the 100-year flood scenario associated with the Project.

180. Zero-Flow Days - Zero-flow days are defined as days in which the channel is dry. Non-storm days are based on a determination of the Santa Ana River Watermaster and comprised 8,375 (67 percent) of the total 12,419 days contained in the period of record used in this analysis.

- Above Cuttle Weir - Over the base period, prior to the construction of Seven Oaks Dam, it is estimated that there were 4,014 days (or approximately 32 percent of the time) in which there was no flow in the channel, i.e. zero-flow days. Under No Project and Project conditions (with both the dam in place and Project diversions) there are no zero-flow days in this segment. This is attributable to a constant 3 cfs release from the dam. These flow data are presented in Muni/Western Exhibit 5-46.

- Below Cuttle Weir - Over the base period, prior to the construction of Seven Oaks Dam, it is estimated that there were 5,813 days (or approximately 47 percent of the time) without flow in this segment of the river. Under No Project conditions with the Seven Oaks Dam in place, the number of zero-flow days increases to 6,506 (50 percent of the total days). With implementation of the Project diversion (regardless of capture scenario), the number of zero-flow days increases to 8,374, or 67 percent of total days in the period Muni/Western Exhibit 5-47.

- Mill Creek Confluence - Over the base period, prior to the construction of Seven Oaks Dam, it is estimated that there were 5,679 zero-flow days (approximately 47% of the time) at the Mill Creek confluence. With Seven Oaks Dam in place, the number of zero-flow days is 5,624, about 47 percent of the total days for the period. With the Project diversion in place, the number of days with no flow increases to 6,436 days, about 53 percent of the total days Muni/Western Exhibit 5-48.
- "E" Street Gage – As shown in Muni/Western Exhibit 5-49, over the base period, prior to the construction of Seven Oaks Dam, it is estimated that there were 521 zero-flow days, about 4 percent of the total days in the period at "E" Street based on the historical record. Under No Project conditions, which reflect relocation of upstream WWTPs, the number of zero-flow days increases to 5,930 (48 percent of the total days). The increase in zero-flow days with Seven Oaks Dam in place is due, in large part, to the filling of the debris pool in the early winter months and maintenance target storage. With implementation of Scenario C or D, the number of zero-flow days increases to 5,004 (48 percent of total days). This increase is attributable to most dam releases being diverted by Muni/Western instead of flowing downstream. With implementation of Scenario A or B, there is a greater frequency and volume of Muni/Western diversions and the number of zero-flow days increases to 6,120 (49 percent of total days).
- RIX and Rialto and Riverside Narrows- Over the base period, prior to the construction of Seven Oaks Dam, it is estimated that there were no zero-flow days below either the RIX and Rialto or Riverside Narrows. The same condition exists with or without the Project. These conditions are shown on Muni/Western Exhibit 5-50 and Muni/Western Exhibit 5-51.

181. Non-Storm Days - The availability of necessary flows has been evaluated for all days in the period of analysis and separately for non-storm days, days when flow is not directly attributable to runoff events. Non-storm flows are the predominant condition on the SAR with approximately 70 percent of all days classified as non-storm flow days. Because non-storm flow days generally exhibit low flows, diversions on non-storm days are more likely to have a measurable impact.

182. The hydrologic models used to assess changes in non-storm flows use USGS gage data as input. This gage data has a margin of measurement error estimated to be ± 15 percent as discussed earlier. When the difference between non-storm flows under No Project conditions and corresponding flows under Project scenarios, as determined using the model, differs by less than this error margin, it is unclear whether the difference is a true change or due to the error of measurement inherent in the gage readings used in the model. When the difference between the No Project and Project scenarios is greater than the error of measurement, then the difference is attributed to the Project and this is considered a measurable change.

183. Non-Storm Flow Analysis - The non-storm flow analysis was conducted through the use DOP and DRAM, both described earlier in my testimony. The goal of the non-storm flow analysis, under both No Project and Project scenarios, is to simulate, or interpolate, flows at specific locations along the river channel for each river segment.

184. The daily analysis of Seven Oaks Dam operations shows that releases from the dam rarely exceed 500 cfs on non-storm days. Therefore, the effect of Project diversions on SAR flows during non-storm periods is essentially identical for both the 500 cfs and 1,500 cfs Muni/Western diversion rates. Scenario A and Scenario B both represent the maximum potential appropriation by Muni/Western. Therefore, because the diversion rate makes virtually no difference when dealing with non-storm flows, Scenario A will have the same effect on non-storm flows as Scenario B. Scenario C and Scenario D both represent the minimum potential appropriation by Muni/Western and differ only in terms of the assumed Muni/Western diversion rate. Again, because the diversion rate makes little or no difference when dealing with non-storm flows, Scenario C will have similar impacts on non-storm flows as Scenario D. Therefore, when discussing potential impacts on non-storm flows, the results for Scenarios A and B are identical and are presented together as are the results for Scenarios C and D.

185. Monthly flow summaries for non-storm days are presented for each of the six locations: (1) above Cuttle Weir; (2) below Cuttle Weir; (3) at the Mill Creek confluence; (4) at "E" Street Gage; (5) at the RIX and Rialto Effluent Outfall; and (6) at Riverside Narrows. For each location, the number of zero-flow and flow days and daily flows are determined on a monthly basis under each of the following conditions and are summarized on Muni/Western Exhibit 5-52.

- Pre-Seven Oaks Dam (historical);
- No Project; and,
- Project scenarios.

186. A probability of exceedance curve is a graphic comparing the frequency of an event with its magnitude. These curves can aid in the presentation and interpretation of Project-related effects on flows under all conditions (Scenarios A through D). The information presented in Muni/Western Exhibit 5-53 through Muni/Western Exhibit 5-58 compare Project scenarios with No Project and Pre-Seven Oaks Dam flow for non-storm days.

187. The characteristics of flow above Cuttle Weir are shown on Muni/Western Exhibit 5-53. Prior to Seven Oaks Dam, flow occurred in this segment only 50 percent of the time. Under both Project and No Project conditions, a constant flow of 3 cfs occurs. This is attributable to the release from Seven Oaks Dam that is diverted by the senior water rights claimants. Under the No Project and Scenarios C and D, a sustained flow at 27 cfs is noticeable. This is due to the draining of the debris pool which causes a sustained release

of 20 cfs in the late summer months plus inflow to Seven Oaks Dam and the 3 cfs for diversion by the Senior Water Rights Claimants. Under Scenarios A or B, the flows attributable to the draining of the debris pool are captured by the Project diversion.

188. The probability of daily discharge below Cuttle Weir is shown on Muni/Western Exhibit 5-54. Prior to Seven Oaks Dam, flow only occurred in this segment about 30 percent of the time. Under No Project conditions flows only occur in this segment about 22 percent of the time. Under both Project scenarios, flows do not occur in this segment. Any flows released by Seven Oaks Dam in excess of senior water rights claimants and Conservation District requirements are captured by the Project diversion.

189. The probability of daily discharge at the Mill Creek confluence is shown on Muni/Western Exhibit 5-55. Prior to Seven Oaks Dam, flow occurred in this segment about 24 percent of the time. Under No Project conditions, flows exist about 29 percent of the time. A sustained flow of 10 cfs occurs due to the annual draining of the debris pool in the late summer months. On non-storm days, under all Project conditions (Scenarios A through D), SAR flows do exist and resemble the Pre-Seven Oaks Dam flow regime.

190. The probability of daily discharge at the "E" Street Gage is shown on Muni/Western Exhibit 5-56. Prior to Seven Oaks Dam flow occurred in this segment about 93 percent of the time. This is attributable to the San Bernardino Water Reclamation Plant which historically discharged effluent upstream of the Gage. Currently, the San Bernardino Water Reclamation Plant effluent is conveyed to the RIX facility and this has substantially decreased flows in this segment. Under the No Project condition, flows occur in this segment only about 29 percent of the time. When comparing No Project and Project conditions, a noticeable difference in flows only occurs for flow less than 100 cfs. Scenarios A or B would create lower flows at all times compared to the Scenarios C or D and No Project conditions.

191. The probability of daily discharge at the RIX and Rialto Effluent Outfall is shown on Muni/Western Exhibit 5-57. Under all Project scenarios (Scenarios A through D), flows occur in this segment 100 percent of the time. The estimated Project flows are higher than the historical flows because they include effluent from both the RIX and Rialto facilities operating at plant capacity. A difference of less than 1 percent is noticeable when comparing No Project, and Scenarios A, B, C, and D.

192. The probability of daily discharge at Riverside Narrows is shown on Muni/Western Exhibit 5-58. No difference is seen when comparing Pre-Seven Oaks Dam, No Project and Project scenarios. Because there was no discernable difference between the No Project and Project scenarios below Riverside Narrows, this location was the furthest downstream location studied in the analysis.

193. Analysis of Maximum Daily Flow Events - DOP results were used to identify the possible timing and number of days that a flow of 1,500 cfs (the maximum Muni/Western diversion rate) or greater would occur. An evaluation was also conducted, based on the delivery constraints within the Allocation Model, to identify how a peak diversion of 1,500 cfs would be allocated. This evaluation approximates the daily maximum delivery rate and the total amount of captured water that would not be diverted or delivered to beneficial uses during periods of peak diversions.

194. Based on DOP results, peak unappropriated flows of 1,500 cfs are available within the months of December, January, February, and March. Since seasonal water conservation storage begins in March, all available SAR water can be captured and delivered in this month. The likely available absorptive capacity for each of the priorities during the months December, January, and February is listed below and totals roughly 1,400 cfs.

Direct Delivery (Priority 1)	5 to 10 cfs
Groundwater Recharge within SBBA (Priority 2)	0 cfs
Groundwater Recharge Muni/Western Service Area (Priority 3)	21 cfs
Exchange (Priority 4)	1,371 cfs

195. Based on the DOP results, during the months of December, January, and February, over the 39-year base period, there would be 14 days with a peak unappropriated flow of 1,500 cfs given the assumptions of Scenario A or B, and 8 days where a peak unappropriated flow of 1,500 cfs would occur given the assumptions of Scenario C or D. With a maximum absorptive capacity of 1,400 cfs available during these 3 months, 100 cfs (approximately 200 af per day) would not be diverted or delivered to beneficial uses during these days, or approximately 1,600 af and 2,800 af, over the base period. Thus the potential reduction in Muni/Western diversion, based on the above conditions, ranges from 1,600 af to 2,800 af over the 39-year base period (or 41 to 72 afy). In both cases, at least half of the potential reduction occurred in the month of February.

196. Median Monthly Flows for Non-Storm Days - The information presented in Muni/Western Exhibits 5-46 to 5-51, shows that the river segment most affected by the Project is downstream of Cuttle Weir, while segments further downstream are progressively less affected. This is because the downstream segments have other flows contributing to the river. Descriptions of flow above Cuttle Weir and the downstream segments are summarized below:

- Above Cuttle Weir - Flows in this segment have a median annual value of 4 cfs for the base period under the No Project condition as is shown in Muni/Western Exhibit 5-46 and Muni/Western Exhibit 5-59. Median flows in the spring months, up to 8 cfs in the month of April, are due to rainfall in these months. In the late summer months a median flow of 26 cfs occurs due to the draining of the debris pool, which is limited to a rate of 20 cfs plus inflow to the dam. Generally median flows are small under the Project Scenarios A, B, C, and D, generally about 3 cfs attributable to the 3 cfs release of captured groundwater. The greatest difference in median flows in this segment between the No Project and Project Scenarios A, B, C, and D occurs in the summer months of July through September; under the No Project in these months this reach would receive water drained from the debris pool, but with the Project (assuming Phase III of the Plunge Pool Pipeline is completed and diversions occur upstream at the plunge pool) this water would be diverted.

- Below Cuttle Weir - Under No Project conditions, median flows in this segment are zero cfs for all months. Under No Project conditions, all dam releases are diverted by Senior Water Rights Claimants or the Conservation District at Cuttle Weir. Median flow is also zero in this river segment under all Project scenarios as is shown on Muni/Western Exhibit 5-47 and Muni/Western Exhibit 5-60.

- Mill Creek Confluence - Under No Project conditions, the median flow on non-storm days for this segment is 0 cfs over the base period, a median flow of 12 cfs occurs in the months of July and August due to the draining of the debris pool. A reduction of flows to zero cfs due to the Project occurs in the late summer months of July and August as is shown on Muni/Western Exhibit 5-48 and Muni/Western Exhibit 5-61.

- “E” Street Gage – Under No Project and Project conditions, the median flows for this segment is 0 cfs over the base periods. See Muni-Western Exhibits 5-49 and 5-62.

- RIX and Rialto Effluent Outfalls - Change in non-storm day median daily flow at the RIX and Rialto Effluent Outfall is still more attenuated as can be seen from the information presented in Muni/Western Exhibits 5-50 and 5-63. The difference in median daily flows between No Project and Scenarios A or B is the greatest in the months of June and July with a reduction of 1 percent from 74 cfs under No Project to 73 cfs for Scenarios A or B. There are no zero-flow days in the river channel under either historical, No Project, or Project conditions. This is attributable to the effluent discharged by the RIX and Rialto WWTPs, and tributary inflow along the SAR on Muni/Western Exhibit 5-50.

- Riverside Narrows - A slight reduction in flow at this location occurs in the months of February, July, and August and October when comparing No Project conditions to Scenario A or B. The maximum change in flows for these months is a drop from 78 cfs in February under No Project conditions to 75 cfs under Scenario A or B, a reduction of 4 percent. No change from the No Project was detected with Scenarios C or D as is shown on Muni/Western Exhibit 5-51 and Muni/Western Exhibit 5-64.

- Riverside Narrows - There are also no zero-flow days in the river channel under either historical, No Project, or Project conditions at Riverside Narrows as shown on Muni/Western Exhibit 5-52. This is attributable to effluent being discharged upstream from the RIX and Rialto WWTPs and the Riverside Water Quality Control Plant effluent discharged immediately above this gaging point.

197. Statistics regarding the annual flow quantities for the upper SAR are presented in Muni/Western Exhibit 5-65 through Muni/Western Exhibit 5-69.

198. **Bypass Flow Analysis –** During the negotiations with the California Department of Fish and Game, SAIC was asked to investigate the "hydrologic feasibility" of providing Bypass Flows. Bypass Flows were defined as the amount of unappropriated SAR water not captured by the Muni/Western Project that could be left in the SAR channel to maintain hydraulic connectivity downstream.

199. Accordingly, an investigation was undertaken by Muni/Western to determine:

- The possibility of creating bypass flows sufficiently large to produce hydrologic connectivity (a continuous flow) from the proposed point of diversion to various points downstream;
- The biological benefits that might be derived from such bypass flows; and
- Implications to the amount of unappropriated water captured by the proposed Project of implementing such bypass flows.

200. I will be addressing bullet points one and three. In order to study the feasibility of bypass flows, an assessment of flow loss between Seven Oaks Dam and the RIX-Rialto Outfalls, focusing on groundwater infiltration, was conducted. The RIX-Rialto Outfalls were chosen as the furthest downstream point for the analysis because: (1) downstream of the RIX-Rialto Outfall the Santa Ana River has flow year round, attributable to the effluent discharge in addition to rising water, and urban and agricultural runoff; and (2) physical changes in flow in the SAR due to Project diversions are not detectable downstream of this location.

201. The base period for the bypass flow analysis is 1966-67 through 1999-2000, 34-years, the period of available data for the "E" Street stream flow gage.

202. The detailed discussion of the Bypass Flow requirements are found in the Final EIR, page 2-118 to page 2-134 (see Muni/Western Exhibit 4-4). In summary, to establish hydraulic connectivity would require a release of 4 cfs downstream from Cuttle Weir, another 34 cfs to reach "E" Street, and another 3 cfs to reach the RIX and Rialto Outfalls, for a total minimum release of 41 cfs to maintain hydraulic connectivity between the Dam and the RIX and Rialto Outfalls.

203. From this analysis, I conclude that only in the years with the highest runoff years could hydraulic connectivity been maintained in the SAR channel and in most years water is unavailable to create a bypass flow.

204. This section presents model results describing the quantities of captured SAR water allocated to each of the beneficial uses under different Project scenarios. Attention is given first to initial deliveries to the four general beneficial users (direct, recharge of the SBBA, groundwater recharge outside the SBBA, and exchange) followed by initial deliveries to the specific beneficial uses. This is followed by an examination of ultimate deliveries to the same beneficial uses, i.e., the deliveries once all exchange water has been returned.

205. **Capture by Muni/Western -** For each of the 16 potential scenarios described earlier in my testimony, a quantity of unappropriated SAR water is shown to be available for capture by Muni/Western.

206. Muni/Western Exhibit 5-70 illustrates OPMODEL results assuming that Phase I of the Plunge Pool Pipeline, with a conveyance capacity limited to 500 cfs, is implemented. Presented in Muni/Western Exhibit 5-71 provides corresponding results with implementation of Phase II or later phases of the Plunge Pool Pipeline when a conveyance capacity of 1,500 cfs is available. Results under the No Project conditions are also shown. The cumulative amount of SAR water available for capture by Muni/Western over the 39-year period could vary from a low of about 400,600 af (Scenario D) to a high of about 1,054,648 af (Scenario A). Diversion by Muni/Western at 500 cfs (as per Scenarios B and D) would still result in unappropriated water remaining in the channel, but under a 1,500 cfs diversion (as per Scenarios A and C) no unappropriated water would remain in the channel. The median annual quantity of water captured by Muni/Western could range from about 0 af to 3,265 af.

207. Projected initial median annual deliveries to the four priorities under different project scenarios are illustrated in Muni/Western Exhibit 5-72. Initial deliveries refer to those deliveries of water made to beneficial uses directly after their diversion from the SAR. They do not account for water ultimately allocated in later years when exchange water is returned to the Muni/Western service area. As can be seen from the information presented in Muni/Western Exhibit 5-72, in the majority of years deliveries would be small, ranging from no water under Scenario C or D to approximately 3,265 af under Scenario A or B. With median annual capture, all water would be devoted to Direct Uses (Priority 1). Because the amount of median annual diversions is small, no water would go to Priorities 2 through 4. However, water would go to these priorities during large flow years, as can be seen in the information presented in Muni/Western Exhibit 5-73 and Muni/Western Exhibit 5-74. As demonstrated by these figures, under any of the four Project scenarios, in the maximum year and cumulatively over the base period, the largest share of captured water would be allocated to exchange (Priority 4). In a maximum year, between 56,270 af and 88,438 af would be allocated to combined Priorities 1 through 3 and thereby remain in the Muni/Western service area and between 69,289 af and 147,254 af would go to exchange. Cumulatively over the 39-year base period, between 213,224 af and 661,559 af would be allocated to combined Priorities 1 through 3 and thereby remain in the Muni/Western service area and between 157,452 af and 427,510 af would go to exchange.[1]

208. As indicated in Muni/Western Exhibit 5-73 and Muni/Western Exhibit 5-74, with other assumptions being the same, changing the diversion rate from 500 cfs to 1,500 cfs (i.e.,

[1] Exchange water could be put to beneficial use within the Muni/Western service areas if Muni/Western determines it is not desirable to enter into an exchange with Metropolitan. See Paragraph 99 of this testimony.

Scenario A vs. Scenario B or Scenario C vs. Scenario D) increases the quantity of water delivered to exchange, but does not substantially change deliveries to direct uses or groundwater spreading. When diversion capacity is limited to 500 cfs conveyance is limited and it is necessary to spread water in the SAR spreading grounds, regardless of whether the recharge targets set in the Allocation Model indicate high water table elevations may result from these deliveries. While this is undesirable, for the purposes of preventing high groundwater in the pressure zone, spreading water in the SAR spreading grounds (which will, after a lag, reach the pressure zone) is preferable to leaving water in the SAR because of the immediate influence on groundwater levels. Thus, initial deliveries of captured SAR water to spreading in the SBBA (Priority 2) are greater under the 500 cfs diversion rate than the 1,500 cfs diversion rate for each Project scenario (Scenario B rather than Scenario A, Scenario D rather than Scenario C).

209. A comparison of median annual Muni/Western deliveries Muni/Western Exhibit 5-72 to maximum annual deliveries Muni/Western Exhibit 5-73 demonstrates that, in those infrequent high flow years, large quantities of water are available, even under the constraints of Scenarios C and D. Direct deliveries (Priority 1) under Scenarios C and D have a median value of zero, but in the maximum year almost 18,000 af would be allocated to direct delivery.

210. The deliveries that would be made to specific beneficial uses under Scenario A are shown in Muni/Western Exhibit 5-75. The first priority for delivery is direct uses, and within this category the Yucaipa WTP would receive the largest delivery relative to the other WTPs. This large quantity is based on the assumption that the Yucaipa WTP can accept SAR water throughout the year, whereas other WTP can accept SAR water only during the period June through August. Under Scenario A, spreading grounds in the SBBA would receive Project deliveries (Priority 2); however, water would also be allocated to spreading grounds outside of the SBBA (Priority 3). This demonstrates the influence that recharge targets have on the amount of SAR water delivered to spreading basins in the SBBA. Consistent with Muni/Western Exhibit 5-73 and Muni/Western Exhibit 5-74, the greatest amount of SAR Project water is allocated to exchange (Priority 4).[1]

211. The deliveries that would be made to specific beneficial uses under Scenario B are shown in Muni/Western Exhibit 5-76. This figure shows that Scenario B would have very similar deliveries to Scenario A, albeit with less water going to each beneficial use, the exceptions being increased deliveries to the Santa Ana River Spreading Grounds and increased exchanges with San Gorgonio Pass Water Agency.

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1 Exchange water could be put to beneficial use within the Muni/Western service areas if Muni/Western determines it is not desirable to enter into an exchange with Metropolitan. See Paragraph 99 of this testimony.

212. Under Scenarios C and D, deliveries to specific beneficial uses are as illustrated in Muni/Western Exhibit 5-77 and Muni/Western Exhibit 5-78. The majority of time there is no water diverted by the Project under Scenario C or D (see Muni/Western Exhibit 5-72), but in years when water is diverted the first priority for delivery is direct use. Quantities allocated to direct uses (Priority 1) are similar to those observed under Scenarios A and B with the Yucaipa WTP receiving the largest water delivery relative to the other WTPs. Spreading grounds in the SBBA would receive Project deliveries, but diverted water is also allocated to spreading grounds outside of the SBBA. Most deliveries are to exchange (Priority 4).

213. With a repeat of base period hydrologic conditions, projected initial deliveries to each of the four groups of beneficial uses under Scenario A or B would be as shown in Muni/Western Exhibit 5-79 and Muni/Western Exhibit 5-80. Under Scenario A or B, water would be diverted in all but 2 of the 39 years shown.

214. A comparison of initial deliveries under Scenario A or B (Muni/Western Exhibit 5-79 and Muni/Western Exhibit 5-80) and Scenario C or D (Muni/Western Exhibit 5-81 and Muni/Western Exhibit 5-82) for each year in the future base period demonstrates that not only is more water delivered under the Scenario A and B, but that water is delivered more frequently. Since water is available more frequently under the Scenarios A and B, it is possible to allocate more water to direct use (Priority 1), spreading in the SBBA (Priority 2), and other groundwater spreading in the Muni service area (Priority 3) than under Scenarios C and D. This condition is evident from the information presented in Muni/Western Exhibit 5-81 and Muni/Western Exhibit 5-82, where capture of SAR water under Scenarios C or D would occur in only 8 of the 39 years with intervening periods between diversions lasting as long as 10 years.

Conclusions

215. Hydrologic analyses by Muni/Western indicate that, after Senior Water Right Claimants, the Conservation District and environmental needs are accounted for, seasonal water conservation at Seven Oaks Dam can provide a water supply sufficient to help meet projected demand within the Muni/Western service area and significantly reduce the need to increase the use of imported water. This will, in turn, improve the reliability of regional water supplies and allow for effective conjunctive use of groundwater and surface water supplies. This supplemental water has the added benefit of making water that is not imported by Muni/Western available to help meet the needs of other areas that depend on the SWP and Colorado River water.

216. Approval of the two applications by the SWRCB and implementation of the Muni/Western Project will result in an average capture of unappropriated flows in the SAR of between 10,000 and 27,000 af of water annually with a repetition of the hydrologic base period.

217. Extensive analyses of the hydrology of the SAR System and of potential beneficial uses using computer models to simulate repetition of the hydrologic base period shows that up to 198,300 af can be captured and beneficially used, confirming almost exactly the amount determined by SAIC in the late 1990s. I have prepared Muni-Western Exhibit 5-83 to illustrate how the capture by Muni/Western will be beneficially used over the base period.

218. In simple terms, the intent of the Project is to capture unappropriated SAR water that would otherwise flow to the ocean in wet years when this capture would have negligible effects on other users. This is why Muni/Western should be issued a permit to appropriate up to 200,000 af. Presented in Muni-Western Exhibit 5-84 is a graphic showing the importance of wet year capture to the Project. For example, there are only four years when historical flow of the Dam was on the order of 100,000 af or more, yet these four years account for over 50 percent of the total capture for the 39-year base period.

219. Presented in Muni/Western Exhibit 5-85 is a schedule representing annual flow of various points in the SAR system for the third wettest year of the base period, 1992-93. What is illustrated is that under No Project conditions, total flow of the Dam would be on the order of 125,000 af. For that same year, more than 400,000 of water would flow to the ocean. Implementation of the Muni/Western Project as a result of receiving a permit from this Board would allow 117,000 af to be put to beneficial use by Muni/Western and still nearly 220,000 of water would flow to the ocean because of lack of absorptive capacity. (See Figure 2.5-1 of the Final EIR for the detailed schematic.)

220. Lastly, in addition to reducing the quantity of water that would flow to the Pacific Ocean during a wet year like 1992-93, the Project will improve the reliability of supplies to Muni/Western. Muni/Western Exhibits 5-86 and 5-87 show the comparison of runoff in the Sacramento Valley and in the Santa Ana River watershed. Exhibit 5-86 shows a comparison between the total runoff in the Sacramento Valley and the total runoff in the Santa Ana River watershed; Exhibit 5-87 shows a comparison between the Sacramento Valley Rivers (American, Yuba, Feather and Sacramento) and the Santa Ana River near Mentone. Exhibit 5-88 plots the correlation coefficient between Sacramento Valley Rivers runoff and Santa Ana River runoff near Mentone, showing that the r^2 is 0.235. These exhibits show that the hydrology of the Sacramento Valley Rivers (the source of SWP supplies) and the hydrology of the Santa Ana River near Mentone are largely independent. Obtaining the ability to take water from both sources, as would be the result of granting the Applications, would therefore improve water supply reliability for Muni/Western.