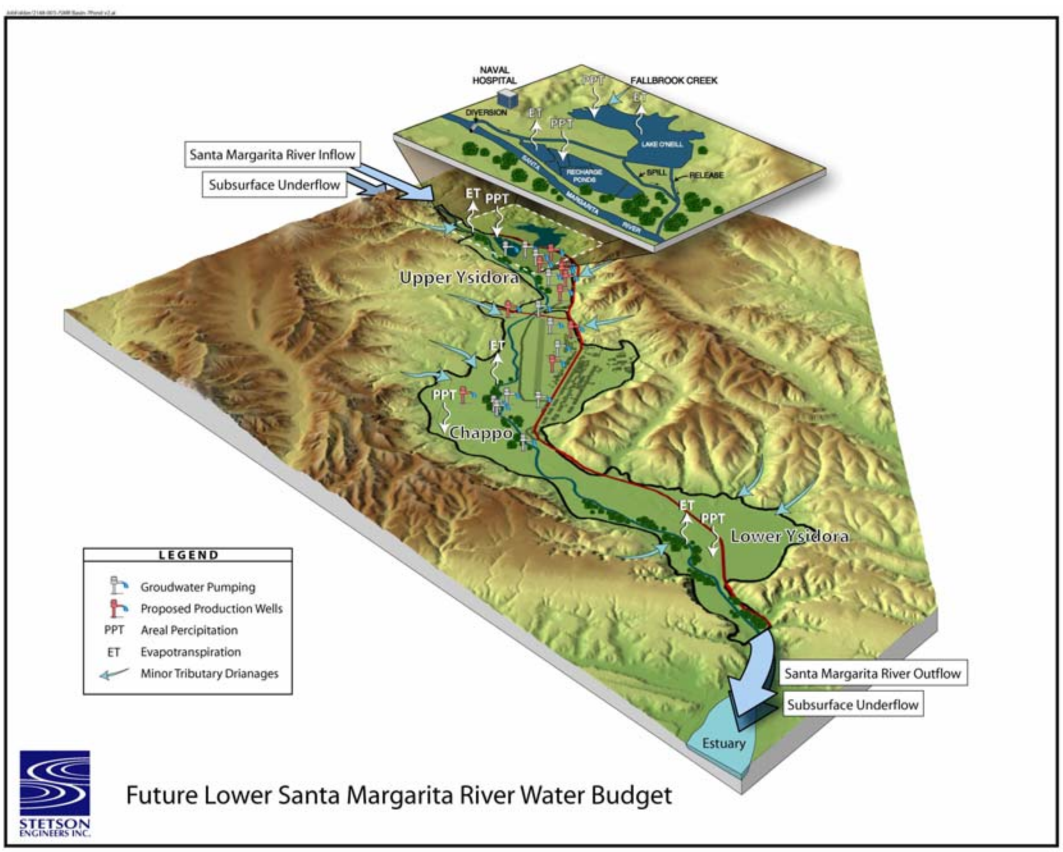
RECLAMATION
Managing Water in the West

Final Technical Memorandum No. 2.2

Santa Margarita River Conjunctive Use Project Volume I



U.S. Department of the Interior
Bureau of Reclamation

April 2007

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Final Technical Memorandum No. 2.2

Santa Margarita River Conjunctive Use Project Volume I

Surface Water and Groundwater Modeling Analysis to Determine Santa Margarita River Conjunctive Use Project Yield

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Prepared for:

Bureau of Reclamation
Southern California Area Office

U.S. Department of the Interior
Bureau of Reclamation

April 2007

ABSTRACT

The Bureau of Reclamation (Reclamation) is currently investigating the development of the Santa Margarita River Conjunctive Use Project (CUP) to enhance local water supplies available to the United States Marine Corps Base Camp Pendleton (Camp Pendleton) and the Fallbrook Public Utility District (FPUD). The purpose of the project is to perfect existing water rights permits previously issued by the State of California and to provide a possible physical solution to the *United States* v. *Fallbrook PUD* litigation. In order to perform this task, Reclamation has assembled a team of engineers, hydrologists, environmental specialists, and program managers to conduct a feasibility study and complete the supporting environmental documentation.

Stetson Engineers has been working with hydrologists and engineers from Reclamation's Denver Technical Service Center to identify and describe the yield from the proposed Santa Margarita River CUP. Initiated in October 2005, Phase I of the investigation described the availability of surface water that could be developed by the CUP. The results of this study were presented in Technical Memorandum 1.0 (TM 1.0), issued in January 2006. Concepts introduced in TM 1.0 included the availability of surface water at the proposed point of and various physical characteristics of the watershed system.

Technical Memorandum 2.2 (TM 2.2) continues to build upon the characterization of the Santa Margarita River Basin's water resources by developing the 2006 groundwater model (2006 Model). Originally developed by Camp Pendleton in February 2001, the purpose of the model was to characterize the total groundwater yield from Camp Pendleton's aquifers in the lower Santa Margarita River watershed. In order to provide useful information to engineers and decisionmakers, 12 management scenarios were developed to estimate impacts on basin yield as a result of variations in Santa Margarita River CUP components and management strategies. TM 2.2 is presented in two volumes—the first volume includes the background and summary results, and the second volume includes 18 technical attachments that support these results.

Conclusions drawn from the surface and groundwater analyses to support the Santa Margarita River CUP indicate that the total basin yield of Camp Pendleton's aquifers may be optimized through the implementation of proposed operational parameters. These operational parameters include the development of enhanced or new diversion works for both storage and direct use of water diverted from the Santa Margarita River. Limited by physical and environmental constraints, the total increase in average annual groundwater yield from Camp Pendleton's aquifers is approximately 4,800 acre-feet per year, when compared to Baseline conditions. The average annual surface water yield for direct use may potentially total 2,100 acre-feet per year, compared to zero direct use diversions

under Baseline conditions. The potential average annual increase in surface and groundwater yield above Baseline conditions, as identified from the 12 model runs which were investigated, may incrementally add up to 6,900 acre-feet per year water production from the Santa Margarita River Basin.

The results of all 12 model runs reflect the total basin yield from Camp Pendleton's aquifers, not the project yield from the Santa Margarita River CUP. As recommended in the conclusions, the technical study team should investigate the relevance of perfected and unperfected water rights as they pertain to total basin yield. Annual diversion rates, water applied to beneficial use, places of diversion, and other relevant issues related to both existing and future water rights should be clearly addressed.

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Executive Summary

Stetson Engineers developed and completed surface water and groundwater modeling analyses of the Lower Santa Margarita River Basin in order to determine the potential yield of the Santa Margarita River Conjunctive Use Project (CUP). The groundwater model was initially developed by Camp Pendleton as part of the 2001 Permit 15000 Study (Stetson Engineers, 201) and was then later applied in 2002 and 2003 to investigate the benefits of wastewater recycling and constructed treatment wetlands, respectively. Following extensive aquifer and soils testing by Stetson Engineers during the summer of 2005, the groundwater model was refined to provide a higher degree of confidence in its results. Most recently during the fall of 2005, Camp Pendleton used the groundwater model to identify optimal locations for the replacement of groundwater production wells.

The development and execution of the first six model runs to support the feasibility study of the Santa Margarita River CUP were initially funded by the Bureau of Reclamation (Reclamation) in February 2006. The results from these six model runs were then presented to the Santa Margarita River CUP Planning Team (Planning Team) in July 2006 as Draft TM 2.0. Preliminary results and recommendations from the these runs established the need to develop four additional model runs that focused on evaluating environmental concerns and the yield of the most recently proposed Santa Margarita River CUP action. The results from the groundwater analysis of the first ten model runs were then presented to the Planning Team as Draft Technical Memorandum (TM) 2.1 in September 2006. Lastly, following the Planning Team's review of Draft TM 2.1, two additional model runs were executed to simulate total basin yield under a combination of new operational parameters. TM 2.2 presents the findings from the 12 model runs and incorporates the Planning Team's comments that were issued for Draft TM 2.0 and Draft TM 2.1.

Model Runs 1 through 10 were developed to simulate the impact to total basin yield from the change of a single operational parameter. Typical in model development, only one parameter is changed at a time, so the model development team may estimate that absolute impact to the model from the parameter. This methodology allows the technical team to make informed decisions on how

limited resources should be expended on future model runs. Beginning with Model Runs 11 and 12, multiple operational parameters are simultaneously changed to provide decisionmakers with probable future conditions and total basin yield. TM 2.2 reports on the impact of changing single operational parameters (Model Runs 1 through 10) as well as combining multiple operational parameters that may potentially simulate probable project conditions (Model Runs 11 through 12).

At the initiation of the surface water availability at the Santa Margarita River CUP point of diversion investigation in October 2005, a technical team was formed to direct work on both the surface and groundwater modeling studies described in this series of TMs. Mr. Thomas Bellinger and Mr. Robert Talbot from Reclamation's Denver Technical Service Center led the technical team that provided peer review, guidance, and support through e-mail, meetings, and weekly conference calls. Mr. Doug McPherson and Mr. Jeff Baysinger, both from Reclamation, provided environmental and facility design expertise that further supported and enhanced results from the groundwater model. The surface and groundwater modeling were performed by Ms. Jean Moran, Ms. Dawn Taffler, Ms. Molly Palmer, and Ms. Natalie Schommer of Stetson Engineers in San Rafael, California. Finally, Mr. Del Holz, Mr. Stephen Reich, and Ms. Meena Westford provided project management and coordination functions for Reclamation's and Stetson's technical teams, respectively.

Coinciding with the development of TM 2.2, the groundwater model underwent peer review by Reclamation. During the peer review process, refinements to the understanding of aquifer properties, tributary inflow, and recharge components were completed to further improve the level of confidence provided by the current model (2006 Model). Sensitivity analyses were also performed to refine the model's representation of hydrogeologic properties that control the occurrence and movement of groundwater through the aquifers in the Lower Santa Margarita River Basin. Using the results from the peer review process and professional judgment to interpret the results, the technical team was able to raise the confidence level and accuracy of the model to enhance its usefulness as a tool for making management decisions regarding the Santa Margarita River CUP.

Groundwater yield for each of the 12 management scenarios has been maximized through the conjunctive use of surface and groundwater delivered from the Santa Margarita River. The conjunctive use of surface and groundwater is accomplished by drawing down groundwater levels prior to winter storm events to divert and store high flow surface water flows before they reach the ocean. Historical groundwater pumping data from Camp Pendleton indicate that maximum pumping occurred during the summer months when water demand peaked, creating available aquifer storage with no imminent source of water for replenishment. The conjunctive use of surface and groundwater described in TM 2.2 relies on shifting the maximum pumping demand 6 months to the wintertime when elevated surface flows are available to replenish aquifer storage. High streamflow events that would normally flow to the ocean were also diverted and stored as groundwater, effectively increasing the sustainable yield of Camp Pendleton's aquifers. Subsequently following the winter months, simulated groundwater levels and groundwater in storage recovered to support hydrologic and riparian demands from reduced groundwater pumping during the summer months. The summary of basin yield (table ES-1) provides the average and median yield of the Baseline and future management Runs 1 through 12. A brief explanation of the table properties and results is presented in the remainder of this section.

Table ES-1. Basin Yield of Management Runs 1 Through 12 (Acre-Feet Per Year)

		Total Basin Yield			
				Planning Range[1]	
Run	**Description**	**Average**	**Median**	**Min Median**	**Max Median**
Baseline	Baseline	7,300	8,300	5,300 -	8,800
Run 1	Project	11,100	11,300	5,400 -	16,800
Run 2	3-Basin	11,700	11,700	5,400 -	16,700
Run 3	Mitigation	12,100	12,100	6,300 -	17,700
Run 4	No CWRMA	9,300	9,300	5,000 -	13,800
Run 5	Title 22	11,900	12,300	6,100 -	17,600
Run 6R[2]	Alt 2 – FPUD Sump[3]	13,800	13,200	5,100 -	16,100
Run 7	Mitigate 7-Yr Drought	12,100	12,200	7,100 -	16,600
Run 8	Proposed Action[3]	12,200	11,900	5,100 -	16,500
Run 9	Maximize Chappo	11,700	11,300	5,700 -	17,600
Run 10[4]	Diversion Bypass	11,100	10,900	5,400 -	16,800
Run 11	Two Direct Use Diversions[3]	13,100	12,600	5,300 -	21,500
Run12	Two Direct Use Diversions with Options[3]	14,200	13,500	6,300 -	22,900

[1] The "Planning Range" is based on ED conditions to represent the minimum median and VW conditions to represent the maximum median annual groundwater pumping.

[2] R: revised model run updated from Draft Technical Memorandum 2.0.

[3] Yield represents groundwater pumping and diversions for direct use.

[4] Values presented for Run 10 represent the average pumping of maintaining a variable bypass at the Diversion Point. Detail of specific bypass is presented in the text.

The columns labeled as "planning range" are intended to provide economists and feasibility study engineers with the expected yield of the Santa Margarita River CUP during the driest and wettest hydrologic conditions. The minimum value provided in the planning range is the median annual yield of the Santa Margarita River CUP that would be expected to occur during the driest of conditions. The maximum value is the quantity of water that can be produced from the project during consecutively wet hydrologic years. Run 12 provides the highest average and median annual Santa Margarita River CUP yields of 14,200 acre-feet per year and 13,500 acre-feet per year, respectively. Run 12 simulates combined operational parameters, including two diversions for direct use and one diversion for storage. Throughout TM 2.2, the term "diversion for direct use" is consistent with the State of California's definition for direct diversion in which surface waters are applied to immediate and beneficial use. If not specifically stated in TM 2.2, all other references to "diversions" are considered to be for diversion to underground storage. Note that all model results reported throughout TM 2.2 have been rounded to the nearest 100 acre-feet.

The 2006 Model simulated the maximum monthly groundwater production rates which ranged between 30 and 39 cubic feet per second (cfs) in Runs 1 through 12. Runs 6, 11, and 12 include a 25-cfs diversion for direct use at the Fallbrook Sump. Runs 8, 11, and 12 include a 10-cfs diversion for direct use at a point downstream from recharge pond #2 on Camp Pendleton. All model runs include diversion to surface storage in Lake O'Neill and diversion to groundwater storage in the Santa Margarita River aquifers on Camp Pendleton. The maximum groundwater yield for each of the 12 management runs occurred in January of consecutive Very Wet (VW) hydrologic years. The minimum groundwater production from Camp Pendleton's aquifers occurred in July of consecutive Extremely Dry (ED) years. (Note: VW and ED hydrologic years describe the extreme ends of a four category system used to describe hydrologic conditions for each year of the modeling effort. More descriptive information is provided in the "50-Year Simulation Period" section).

Results from the simulation of different operational parameters discussed throughout TM 2.2 indicate that the yield of the Santa Margarita River CUP is highly dependent upon the Santa Margarita River streamflow and recharge. The 2006 Model simulated a 50-year hydrologic period, including the driest period of record between 1956 and 1962, resulting in the development of a Dry-Year Management Scenario that reduces the groundwater pumping to maintain water levels along the riparian corridor. The median groundwater yield identified in the 2006 Model for the proposed action (Run 8) is 11,900 acre-feet per year, but as discussed throughout TM 2.2 and illustrated in Run 12, is greater if extreme dry periods are mitigated.

The 2001 Model developed in the Permit 15000 Study estimated yield from a project similar to that described in Run 1. A comparison of the 2001 and 2006 Models indicated that the yield of the Santa Margarita River CUP has increased 2,600 acre-feet per year due to the development of a Wet Year

Table ES-2. Summary of Santa Margarita River CUP Model Runs

Operational Parameter	Baseline[1]	Run 1 Project	Run 2 3-Basin	Run 3 Mitigate	Run 4 No CWRMA	Run 5 Title 22	Run 6R Alt 2	Run 7 Mitigate Drought	Run 8 Proposed Action	Run 9 Max Chappo	Run 10 Diversion Bypass	Run 11 Two Direct Div.	Run 12 Two Direct Div. w/ Options
Pre-Project Pumping	n/a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
UY/CH Pumping	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
LY Pumping	✓		✓			✓							
CWRMA	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Additional Outside Water Supplies[2]								✓					✓
3-cfs Bypass	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Title 22						✓							
VOC Constraint	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	
Riparian Water Level Constraint	✓	✓	✓	*	✓	✓	✓	✓	✓	✓	✓	✓	*
Direct Use Diversion							✓[3]		✓			✓[4]	✓[4]
Basin Yield (AFY)	7,300	11,100	11,700	12,100	9,300	11,900	13,800	12,100	12,200	11,700	11,100	13,100	14,200
Change in Average Basin Yield from Baseline (AFY)	n/a	+3,800	+4,400	+4,800	+2,000	+4,600	+6,500	+4,800	+4,900	+4,400	+3,800	+5,800	+6,900
Change in Average Basin Yield from Run 1 (AFY)	n/a	n/a	+600	+1,000	-1,800	+800	+2,700	+1,000	+1,100	+600	0	+2,000	+3,100

[1] Baseline pumping is based on 8,800 AFY under normal conditions. Given the simulated 7-year drought conditions, the 50-year average pumping is 7,300 AFY.

[2] CWRMA Emergency Release may be used to supplement water needed to mitigate drought conditions.

[3] FPUD diversions for direct use in Run 6R are not constrained by surface water flow to the estuary.

[4] Runs 11 and 12: Run 8 water delivery priorities met before FPUD direct use diversion is operated. FPUD direct use diversions are constrained by surface water flow to the estuary.

* Water level constrained by compaction and salt water intrusion only.

Algorithm and the refinement of the hydrogeologic parameters. If the results from the 2006 Model Run 1 are compared to those of the older 2001 Permit 15000 Study for the same hydrologic period, the median groundwater yield increased to 16,200 acre-feet per year, as compared to 14,100 acre-feet per year, during the same 20-year simulation period from 1980 to 1999.

TM 2.2 presents the results of all 12 model runs in detail, as well as results from other management scenarios investigated during the course of this investigation. Recommendations to investigate other management scenarios for the Santa Margarita River CUP include: incorporating results from the economic analysis, refinement of environmental flow bypasses, sensitivity analysis of the instantaneous diversion rate, and supporting water rights issues. These recommendations, as well as other results and conclusions, are discussed in detail following the presentation of the 2006 Model and the management scenarios.

SURFACE AND GROUNDWATER MODELING ANALYSES TO DETERMINE SANTA MARGARITA RIVER BASIN TOTAL YIELD, INCLUDING IMPACTS FROM THE PROPOSED SANTA MARGARITY RIVER CONJUNCTIVE USE PROJECT YIELD

Introduction of Management Scenarios

The Lower Santa Margarita River Basin is located on Camp Pendleton in San Diego County, immediately upstream of the mouth of the Santa Margarita River to the Pacific Ocean (figure 1). The Lower Santa Margarita River Basin includes three subbasins identified as the Upper Ysidora, Chappo, and Lower Ysidora. The physiographic and geologic description of this area is well defined in previous reports including the Permit 15000 Study (Stetson, 2001), the Fallbrook Public Utility District Recycle and Reuse Project (Stetson, 2002) and the Constructed Treatment Wetland Report (Stetson, 2003). The purpose of Technical Memorandum (TM) 2.2 is to establish and report the groundwater yield of the Santa Margarita River Conjunctive Use Project (CUP) by building upon the previous modeling efforts, including the most up-to-date hydrologic and hydrogeologic datasets available.

TM 2.2 has been organized to provide an overview of the modeling effort to planners and decision makers while providing detailed data that support all findings, conclusions, and recommendations. The main body of TM 2.2 outlines and presents the Peer Review Process, Groundwater Model Calibration, Management Runs, Conclusions, and Recommendations. Attachments A through S to TM 2.2 provide summary statistics, budget calculations, groundwater level hydrographs, simulated pumping information, and other pertinent data and memoranda developed by the technical team in support of this study. Attachment A provides the reader with a list of acronyms, a color code key to hydrographs and budget data, a brief description of the tables and figures presented in the attachments, and well naming convention for reference to abbreviations and maps provided throughout TM 2.2. Attachment S contains the Response to Comment matrix for the Study Team's review of Draft TM 2.0 and Draft TM 2.1.

The conclusions, findings, and recommendations of TM 2.2 are the products of a collaborative team effort between the Bureau of Reclamation (Reclamation) and Stetson Engineers. This collaboration was supported by 5 technical and planning meetings, 23 conference calls, and numerous data exchanges between Reclamation and Stetson Engineers. Reclamation also provided their National Environmental Protection Act (NEPA) expert and consultant (North State

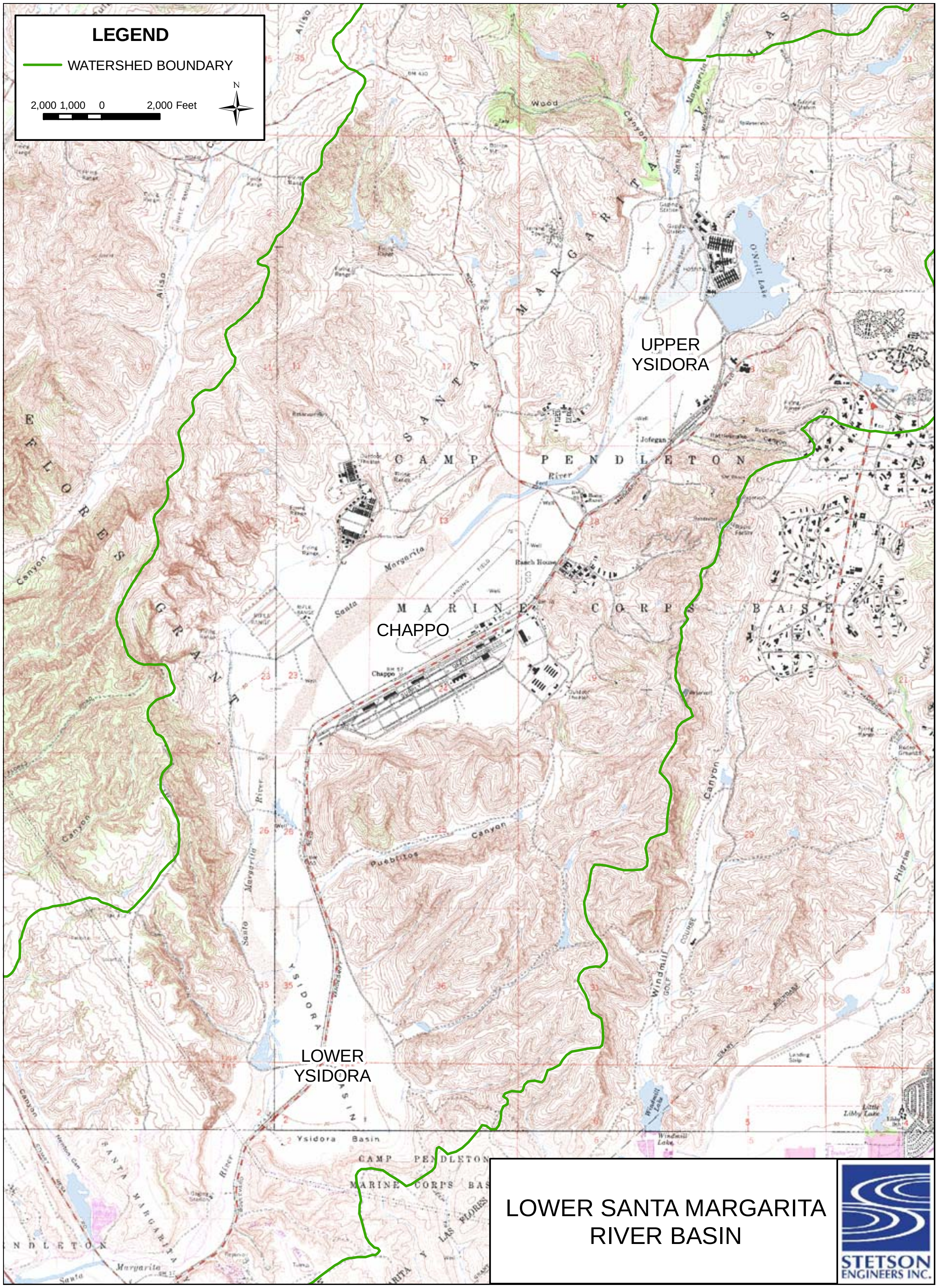

Figure 1. Lower Santa Margarita River Basin.

Resources) to review the environmental limitations and constraints that were followed to develop the groundwater yield during the model simulation of the 12 management runs. The meeting and conference call notes are included in Attachment B.

For each of the model runs presented in the Management Scenario Results section, a surface water and groundwater hydrologic budget has been introduced. Each budget has three main categories: Inflow, Outflow, and Change in Storage.

Inflow numerically describes the amount of water that enters the model boundary by surface flow, subsurface flow, and areal precipitation. Outflow describes the amount of water flowing out of the 2006 Model's boundary including losses to riparian vegetation, surface and subsurface flow toward the Santa Margarita River estuary, and extractions by groundwater wells. The difference between Inflow and Outflow is identified as simulated Change of Groundwater in Storage and represents the quantity of water that is removed from or added to the aquifer in order to balance the Inflow and Outflow from each Management Scenario. Statistically meaningful numbers that describe average annual and median conditions for four hydrologic conditions are presented for each of the three categories to allow for a meaningful comparison between model runs.

Before the 12 management scenarios were executed, both Calibration and Baseline model runs were completed. The Calibration model run was used to test the hydrologic variability of the 2006 Model to historical data, while the Baseline was completed to establish "no project" conditions. While the Calibration run simulated historical conditions between 1980 and 2004, the Baseline established 50-year future conditions based on physical constraints established by historical water levels and hydrologic conditions. A summary of the Calibration, Baseline, and 12 management runs is provided in table 1.

All model runs included groundwater pumping in the Upper Ysidora and Chappo Subbasins, while only the Calibration, Run 2 and Run 5 simulations included groundwater pumping in the Lower Ysidora Subbasin. Streamflow constraints included augmentation to the Santa Margarita River from either the Cooperative Water Resources Management Agreement (CWRMA) or Title 22 releases, while flow-through at the diversion structure included bypass flows to meet downstream riparian needs. Two levels of CWRMA drought emergency releases have been accounted for in Runs 1 and 8 to provide results that consider the uncertainty of actual releases that might occur in the future. Other constraints included water quality and environmental conditions that limited the impact of pumping on the aquifer and riparian vegetation. The predominant water quality constraint was to not exacerbate the migration of regulated contaminants. Constraints not listed in the summary, table 1, but applied to all model runs, included prevention of seawater intrusion and compaction (subsidence) to the groundwater aquifer.

Table 1. Summary of Santa Margarita River CUP Model Run Operations and Constraints

Run #	Name	Location of Pumping		Streamflow			Constraints[3]	
		UY/CH	LY	CWRMA[2]	Bypass	Title 22	WQ	Environment[1]
Calibration	Historical	✓	✓		✓		✓	✓
Baseline	Baseline	✓		✓	✓		✓	✓
Run 1	Project	✓		✓	✓		✓	✓
Run 2	3-Basin	✓	✓	✓	✓		✓[4]	✓
Run 3	Mitigation	✓		✓			✓	
Run 4	No CWRMA	✓			✓		✓	✓
Run 5	Title 22	✓	✓	✓	✓	✓LY	✓[4]	✓
Run 6R	Alt 2 – FPUD Sump	✓		✓	✓		✓	✓
Run 7	Mitigate 7-Yr Drought	✓		✓	✓		✓	✓
Run 8	Proposed Action	✓		✓	✓		✓	✓
Run 9	Maximize Chappo	✓		✓	✓			✓
Run 10	Diversion Bypass	✓		✓	varies		✓	✓
Run 11	Two Direct Use Diversions	✓		✓	✓		✓	
Run 12	Two Direct Use Diversions with Options	✓		✓	✓			

[1] Environmental constraints for all runs, unless otherwise specified, include maintaining water level drawdown within historical limitations in riparian zone.

[2] Sensitivity analysis was performed on the reliability of CWRMA Emergency Flows for Runs 1 and 8 (see text).

[3] All runs considered constraints for prevention of salt water intrusion and aquifer compaction.

[4] In addition to regulated contamination, TDS is considered a constraint when pumping occurs in the Lower Ysidora Subbasin.

50-Year Simulation Period

The groundwater yield of each model scenario is presented using a variety of statistical formats, all of which may be considered meaningful to planners and decisionmakers. For example, the average groundwater yield represents the average yield that could be expected from a project over a given time frame. The median yield represents the amount of water that would be expected to occur at least 50 percent (%) of the time during a given timeframe. Common in Southwestern United States hydrology and consistent with the results of the Santa Margarita River CUP groundwater modeling, the median and average deviate due to the large variability associated with extreme dry and extreme wet conditions. To accurately describe the results of the Santa Margarita River CUP groundwater modeling study, the median yield during four different hydrologic cycles is presented. Based on each hydrologic condition, the percent of time exceedance for achieving that level of yield is shown. Additionally, the average groundwater yield is provided so that planners and engineers may calculate the total yield over a given life span of the project.

Stetson Engineers Technical Memorandum 1.0 identified the variability of the Santa Margarita River streamflow under different hydrologic conditions. Four hydrologic conditions were established in order to characterize the river system: Extremely Dry (ED), Below Normal (BN), Above Normal (AN), and Very Wet (VW). ED, BN, AN, and VW conditions are characterized by recurrence intervals of greater than 76%, 50-76%, 19-50%, and less than 19%, respectively. Because of the extreme variability of the Santa Margarita River system, each of these hydrologic conditions do not occur one-fourth of the time. Rather, Extreme Dry and VW conditions occur less frequently while BN and AN occur more often. The groundwater yield for each of the 12 management runs is presented for each of the 4 hydrologic conditions.

A 50-year time cycle representing hydrologic conditions that occurred between 1952 and 2001 was chosen to simulate the Baseline and 12 management scenarios. Hereafter referred to as Model Years (MY), the 50-year model period is intended to simulate future hydrologic conditions during various model years based on historically recorded hydrologic conditions. The purpose of choosing this extended time period was to adequately represent the historical 81-year period of record available for the watershed. The 50-year period of record included both extreme dry and extreme wet conditions that have occurred during the period of historically recorded hydrologic data. While the 25-year calibration period was chosen based on the availability of streamflow, groundwater pumping, and water level data, the 50-year hydrologic period applied to management scenarios was chosen in order to identify the yield of the project that would be expected during the life of the project. (Note: The 2001 Permit 15000 Study and the 2002 Recycle and Reuse Study simulated a 20-year period of record from 1980 to 1999, which did not include an extended dry period or drought.)

Calibration and Baseline Model Runs

Results from the 25-year Calibration model run indicated historical streamflow and water level conditions were accurately simulated during both dry and wet hydrologic conditions. The average annual groundwater pumping during this period was 5,800 acre-feet, ranging from 6,400 acre-feet during ED conditions to 5,100 acre-feet during VW conditions. The historical trend in groundwater pumping during the calibration period indicated that Camp Pendleton pumped more groundwater during dry periods and less during wet hydrologic conditions. Many factors that should be taken into account before planning for trends in water use include, but are not limited to: agricultural demand, troop population, municipal activity, and reclaimed water use. The 25-year Calibration Model simulated Camp Pendleton's median annual release of 1,480 acre-feet per year of treated wastewater at four different locations in the Lower Santa Margarita River Basin (Attachment C). The overall results of the Calibration run indicate that the 2006 Model simulates month-to-month wetting and drying, seasonal variability, and other hydrologic impacts to the aquifer that occur from multi-year drought and wet hydrologic conditions.

Figure 2 identifies the active model grid that was used to represent the aquifer in the Upper Ysidora, Chappo, and Lower Ysidora Subbasins. The physical description of the subbasins and aquifer, as well as the development of the groundwater model, is described in previous reports that document the initial development of the 2006 Model (Stetson, 2001, 2002, 2003). The 25-year calibration period was chosen due to the availability of data, including 24 target wells with more than 900 monthly water level measurements. Surface water data recorded at the Ysidora Gage located on Topomai Bridge were also used to compare groundwater model results to historical data. In addition to matching seasonal and year-to-year changes in hydrologic conditions, the 2006 Model was able to closely simulate historical measured month-to-month changes in streamflow and groundwater levels. Attachment C presents the results of the 25-year simulation period that were developed and tested to match historical datasets between 1980 and 2004.

Following the completion of the Calibration model run, the 2006 Model was used to simulate Baseline (no project) conditions that would be expected to occur over a future 50-year hydrologic period. Given no improvements to the existing diversion structures or water rights, Camp Pendleton could potentially produce up to 8,800 acre-feet per year of groundwater, if appropriate hydrologic conditions existed. Results from the Baseline indicated that Camp Pendleton's production would be limited to a 50-year annual average of 7,300 acre-feet, based on a median yield of 5,300 acre-feet during ED years and 8,800 acre-feet during VW conditions. Hydrological, environmental, and water quality constraints during the 50-year Baseline period prevented Camp Pendleton from fully exercising their prior rights of 8,800 acre-feet per year annually.

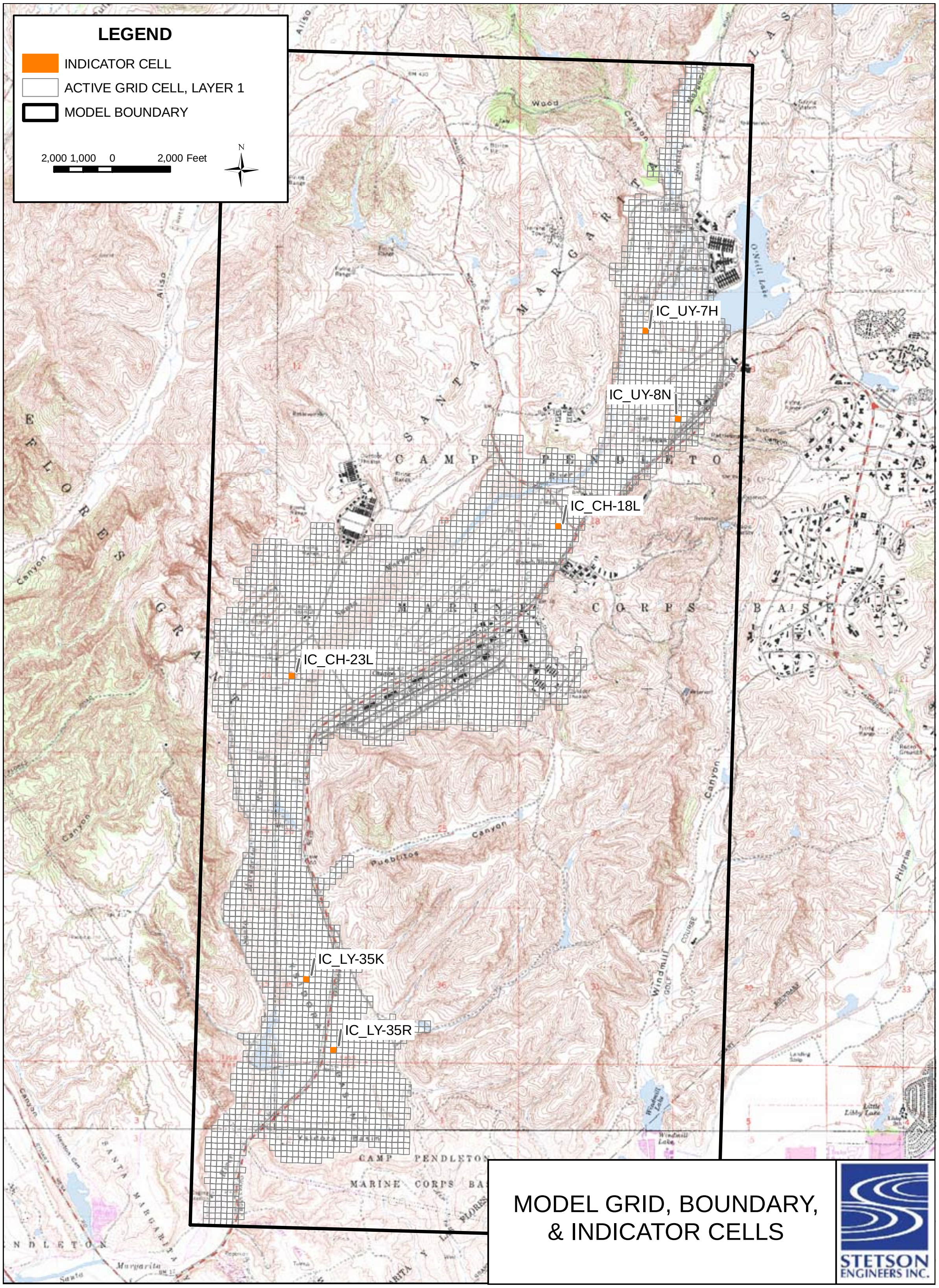

Figure 2. Model Grid, Boundary, and Indicator Cells.

Also shown on figure 2 are six Indicator Cells (IC) located within the active model boundary to depict water levels representative of baseline and future management scenario conditions. Two ICs were chosen for each subbasin, one to represent conditions within the riparian zone (IC_UY-7H, IC_CH-23L, and IC_LY-34K) and the other to represent water level conditions in the grassland areas that do not contain riparian vegetation (IC_UY-8N, IC_CH-18L, and IC_LY-35R). Attachment D presents groundwater level and model results of the 50-Year Baseline simulation period and compares these values to the 25-year Calibration. The figures provided in this attachment may be used to compare Baseline results to simulated historical water levels.

The reduced groundwater yield identified in the Baseline during ED and BN conditions is due to the application of the Dry-Year Management Scenario. The dry hydrologic conditions that historically occurred throughout the 1950s, 1960s, 1970s, and 1980s necessitated curtailment of water production from the aquifer in order to protect environmental resources. Lowered water levels during prolonged dry periods directly led to the need to mitigate drawdown before it occurred, resulting in the development of the 2006 Dry-Year Management Scenario. The result of the Dry-Year Management Scenario is an automatic reduction in groundwater pumping during ED and BN hydrologic conditions so that riparian resources and aquifer properties are protected and intrusion of seawater is prevented.

Due to the severity of the prolonged dry period that created the 7-year drought beginning in 1956, the Dry-Year Management Scenario directs groundwater pumping to be reduced (varying up to 4,000 acre-feet per year) during the first BN hydrologic year. If subsequent years continue to be BN, the Dry-Year Management Scenario requires additional reductions during the second and third consecutive BN years (varying up to 8,000 acre-feet per year and 9,000 acre-feet per year, respectively). If any year is determined to be ED, the annual groundwater pumping is reduced by up to 9,000 acre-feet per year. The annual reduction in dry year production was determined based on the optimization of groundwater pumping during the 7-year drought using a trial and error technique. The quantity of groundwater reduction for each condition is applied to a standard monthly pumping volume and is not additive to previous or subsequent reductions discussed herein. These rules were objectively applied to all BN and ED hydrologic conditions, whether or not a prolonged drought condition would occur. The volume of groundwater pumping curtailed for Dry-Year Management is shown on the well production tables contained in the attachments for each model run.

Similarly, in order to take advantage of wet conditions that exist during both AN and VW hydrologic years, a Wet-Year Algorithm was developed. The Wet-Year Algorithm allows for groundwater pumping to be increased during the second and third consecutive AN or VW hydrologic year. The Wet-Year Algorithm was optimized to take advantage of elevated streamflow without depleting the storage capacity of the groundwater aquifer that is necessary to meet the needs of the Santa Margarita River CUP. The increase in groundwater production during wet years was determined from an optimization of groundwater pumping based on historical hydrologic conditions. The total pumping was optimized so as not to cause negative impact during subsequent BN and ED years following consecutive wet years. The increased groundwater production for Wet-Year Management is shown on the well production tables contained in the attachments for each model run.

While additional groundwater wells were used by the Wet-Year Algorithm to maximize the yield of the Santa Margarita River CUP, direct diversion to surface storage or water treatment facilities was also considered. The total yield that results from the Wet-Year Algorithm is restricted by the need to replenish the storage in the Lower Santa Margarita River Basin's aquifers. Historical measured groundwater levels have shown that the Upper Ysidora Subbasin aquifer requires 1 year of AN or wetter hydrologic conditions to recover, while the Chappo Subbasin aquifer requires 2 years of AN or wetter hydrologic conditions to recover from prolonged dry conditions. Because of the need for each of these two Subbasins to recover in order for the CUP to optimize the water supply, the Wet-Year algorithm does not call on increased groundwater pumping until groundwater levels in the Upper Ysidora and Chappo Subbasins recover.

Table 2 summarizes the overall average annual water budget for the 50-Year Baseline, along with the median water budgets for each of the four hydrologic conditions. In the Baseline, Santa Margarita River streamflow represents 85% of the water budget inflow and 73% of the water budget outflow. Groundwater production is approximately 16% of the overall average water budget outflow. The 50-year average annual tributary inflow and precipitation recharge below the Camp Pendleton diversion is 2,300 acre-feet and 700 acre-feet, respectively. The budget shows that there is minimal change of groundwater in storage, indicating that the groundwater aquifer is hydrologically balanced during the 50-Year Baseline period.

Management Scenario Results

The Dry-Year Management Scenario and the Wet-Year Algorithm are incorporated into the Baseline and 12 management model scenarios. The groundwater production simulated in these model runs is summarized in table 3. The purpose of the management runs is to estimate the potential yield of the CUP that may result from changes in operations, types of diversion, environmental demands or requirements, and other factors that potentially impact the yield from the groundwater aquifer. The results of each of the model runs are

Table 2. Baseline Model Groundwater and Surface Water Budget (Acre-Feet Per Year)

	Average Annual		Median Yield ED	BN	AN	VW
Inflow:						
Santa Margarita River Inflow	38,000	85%	6,800	13,200	28,800	120,000
Subsurface Underflow	900	2%	900	900	900	900
Lake O'Neill Spill and Release	1,500	3%	700	1,300	2,100	2,300
Fallbrook Creek	1,200	3%	100	300	1,100	3,500
Minor Tributary Drainages	2,400	5%	1,500	1,400	2,500	4,700
Areal Precipitation	800	2%	400	300	500	1,500
	44,800	100%				
Outflow:						
Santa Margarita River Outflow	32,600	73%	1,900	6,900	20,300	117,400
Subsurface Underflow	100	0%	100	100	100	100
Groundwater Pumping	7,300	16%	5,300	7,300	8,800	8,800
Evapotranspiration	2,800	6%	2,100	2,800	3,000	3,100
Diversions to Lake O'Neill	2,000	4%	1,300	1,700	2,700	2,700
	44,800	99%				
Net Simulated Change of Groundwater in Storage:	0	0%	-400	-100	0	500

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding. The sum of median values does not reflect the change of groundwater in storage.

described in greater detail throughout the remainder of this document and in Attachments E through P. Attachment Q presents the surface water analysis and reservoir operations model (ROM) and is supported by TM 1.0 which statistically describes the surface water availability of the Santa Margarita River.

All simulated management scenarios (Runs 1 through 12) include similar assumptions regarding the CUP's diversion facilities that would be constructed in the Lower Santa Margarita River Basin. These facilities include a 200-cubic-foot-per-second (cfs) diversion structure, rehabilitation of seven recharge basins, improvements to diversion, control, and conveyance structures, as well as all additional groundwater wells required to meet the design capacity of these facilities. The size and capacity of all facilities are described in Reclamation's pre-feasibility study. Runs 6, 11, and 12 include a direct use diversion having a maximum capacity of 25 cfs located at the Fallbrook Public Utility District (FPUD) Sump in the Santa Margarita River, upstream of the Camp Pendleton boundary. Runs 8, 11, and 12 include a direct use diversion having a maximum capacity of 10 cfs, located within Camp Pendleton at the third recharge pond.

Table 3. Summary of Groundwater Production; Baseline and Management Runs 1 through 12 (Acre-Feet Per Year)

		Median Yield			
Run	Average	ED	BN	AN	VW
Baseline	7,300	5,300	7,300	8,800	8,800
Run 1	11,100	5,400	8,900	15,900	16,800
Run 2	11,700	5,400	8,900	15,900	16,700
Run 3	12,100	6,300	9,800	17,100	17,700
Run 4	9,300	5,000	8,000	12,800	13,800
Run 5	11,900	6,100	9,800	16,600	17,600
Run 6R[1]	10,400	5,100	8,800	14,300	16,200
Run 7	12,100	7,100	11,300	15,900	16,900
Run 8[1]	11,000	5,100	9,000	15,900	16,500
Run 9	11,700	5,700	9,900	16,700	17,600
Run 10[2]	11,100	5,400	8,900	15,900	16,800
Run 11[1]	11,000	5,100	9,000	15,900	16,500
Run 12[1]	12,100	6,200	11,400	16,200	17,800

[1] Groundwater production simulated for Runs 6R, 8, 11, and 12 is only part of the total basin yield. These management scenarios also incorporate yield from direct use diversions that is not summarized in this table. See "Conclusions" section for comparison of total basin yield for the 12 model runs.

[2] Values presented for Run 10 represent the average pumping of maintaining a variable bypass at the Diversion Point. Detail of specific bypass is presented in the text.

The groundwater modeling technical team met with Reclamation's environmental expert and their consultant North State Resources. Consensus was reached between the groundwater modeling and the environmental teams to limit groundwater pumping within the riparian corridor, but not to constrain the pumping below grasslands that do not rely on groundwater for survival. The environmental constraint applied to all runs except Run 3 (Mitigation) and Run 12 (Two Direct Use Diversions with Options) was not to draw down the groundwater levels in the riparian corridor lower than historical levels. Conversely, no environmental limitation, historical or otherwise, was placed on the drawdown of groundwater levels in areas where vegetation did not rely on groundwater levels. Common to all model runs, groundwater pumping was limited so as not to cause compaction or induce seawater intrusion. In order to prevent compaction to the aquifer, minimum groundwater levels were not allowed to drop below the top elevation of known clay sequences in both the Lower Ysidora and Chappo Subbasins. Similarly, in order to prevent seawater intrusion, groundwater levels were constrained to maintain minimum subflow out of the model boundary toward the Santa Margarita River estuary.

Results from the 12 management scenarios identify Run 3, 7, and 12 as having the greatest average groundwater yield of 12,100 acre-feet per year. The groundwater yields of these model runs suggests that drawing down the aquifer below the riparian root zone will result in a project that yields on average almost 4,800 acre-feet per year more than the Baseline. As illustrated in the water level graphs and groundwater budget provided in the attachments to this Technical Memorandum, there would likely be negative impact to riparian vegetation due to reductions in supporting groundwater levels. Results of each of the 12 management runs are detailed in the next several sections.

Run 1 – Project

Run 1 was initially chosen to simulate groundwater yield expected to occur based on construction of the preferred project. Groundwater pumping was restricted to the Upper Ysidora and Chappo Subbasins only. The results of these constraints indicate that the average annual groundwater yield during the simulation period is 11,100 acre-feet per year (as compared to 7,300 acre-feet per year in the Baseline), with median yields varying between 5,400 acre-feet per year and 16,800 acre-feet per year, depending on the hydrologic conditions. Explained in greater detail under Run 8, the preferred project was changed in the October 2006 Draft Decision Memorandum to include direct surface diversion facilities on Camp Pendleton.

The model results for Run 1 are included as Attachment E. Annual simulated groundwater well production is summarized in table E-1, ranging from 4,700 acre-feet per year in MY-10 to 17,400 acre-feet per year in MY-42. Nine additional wells, six in the Upper Ysidora Subbasin and three in the Chappo Subbasin, simulated pumping to maximize the basin yield. Four of these new wells simulated groundwater pumping occurring less than 10% of the months during the 50-year simulation period, but maximized well capacity and project pumping during AN and VW hydrologic conditions. Table E-2 summarizes the percentage of time that each well is in use. Two of the new wells replace existing production wells located in the Chappo Subbasin to reduce the effects of well interference. Figure 3 shows the location of these additional wells: UY-1 through UY-6 and CH-1 through CH-3. The wells were placed to minimize any impact to riparian habitat, contaminant migration, and well interference effects.

The aquifer in the Chappo Subbasin contains approximately twice the storage capacity as the aquifer in the Upper Ysidora Subbasin but provides an equivalent usable storage due to hydraulic conductivity, additional recharge from the percolation ponds, and other constraints. Historical water levels show that it takes two AN, or wetter, hydrologic years, following a series of dry hydrologic conditions, for the groundwater levels in the Chappo Subbasin aquifer to recover. The aquifer in the Upper Ysidora Subbasin only requires one AN, or wetter, year for groundwater levels to recover following a series of dry hydrologic years.

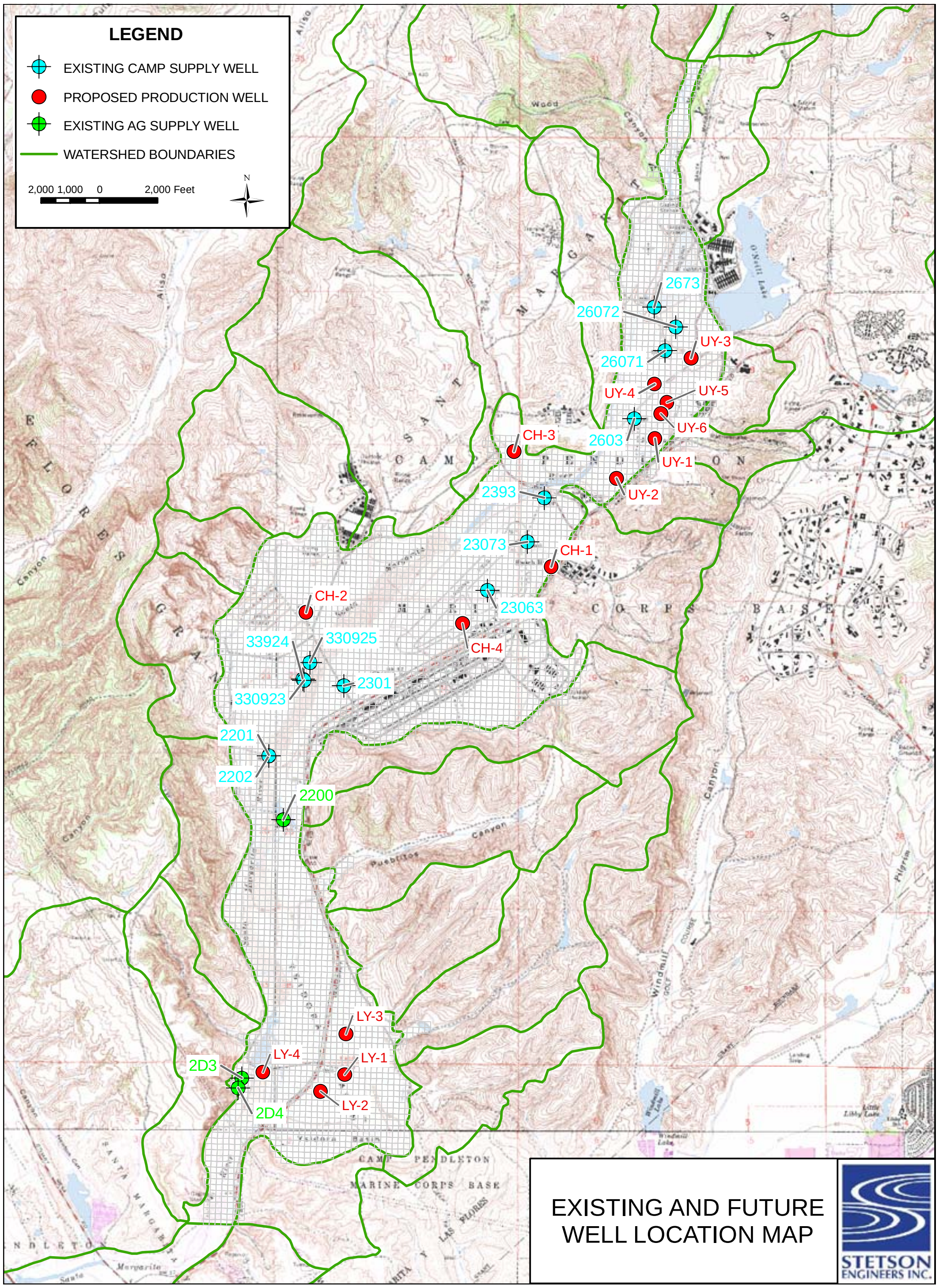

Figure 3. Existing and Future Well Location Map.

During AN hydrologic conditions, Run 1 simulates 55% of pumping occurring in the Upper Ysidora Subbasin and 45% occurring in the Chappo Subbasin to maximize the yield, given the size of the Subbasins. However, during dry hydrologic conditions, Run 1 simulates 80% of pumping occurring in the Upper Ysidora aquifer to maximize the higher transmissivity and rebounding quality of that subbasin during drier conditions.

Attachment E and figures E-1 through E-4 compare Run 1 simulated groundwater levels and streamflow to the Baseline. Simulated groundwater levels in the riparian corridor do not drop below measured historical groundwater levels in the Upper Ysidora and Chappo Subbasins. Simulated groundwater levels in the grassland area of each subbasin are allowed to drop lower because there are no phreatophytes that could be adversely affected by the lowered groundwater table. The lowest drawdown in groundwater levels in these grassland areas is approximately 22 and 35 feet below land surface in the Upper Ysidora and Chappo Subbasins, respectively. Run 1 groundwater levels in the Lower Ysidora Subbasin stay within the range of the Baseline groundwater levels, indicating salt water intrusion would not occur under this scenario. Simulated streamflow between subbasins and toward the estuary for Run 1 falls within the range as the Baseline, with a gaining stream reach in the Lower Ysidora Subbasin before the river reaches the estuary.

Table 4 summarizes the overall average annual and median groundwater water budgets for Run 1 during each of the four hydrologic conditions. In Run 1, Santa Margarita River streamflow is 85% of the water budget inflow and 65% of the water budget outflow. Groundwater Production is approximately 25% of the overall average water budget outflow in Run 1. The overall average change of groundwater in storage for Run 1 is zero acre-feet per year, indicating that the groundwater aquifer was balanced during the 50-year simulation period. The quantity of surface water and groundwater necessary to prevent seawater intrusion by creating a positive flow gradient to the ocean is dependent upon surface flow, underflow, subsurface flow in the aquifer, pumping, and upstream biological demands. Subsurface underflow, identified as Outflow in the groundwater and surface water budget, is an indicator of flow direction and does not necessarily represent the quantity of water necessary to prevent seawater intrusion.

Run 2 – 3-Basin

Run 2 included all the diversion facilities required in Run 1 but allowed for additional groundwater pumping in the Lower Ysidora Subbasin. The results of these constraints indicate that the average annual groundwater yield during the simulation period is 11,700 acre-feet per year, with median yields varying between 5,400 and 16,700 acre-feet per year, depending on the hydrologic conditions. Run 2 average annual groundwater yield over the 50-year simulation period is 600 acre-feet per year greater than in Run 1.

Table 4. Model Run 1 Groundwater and Surface Water Budget (Acre-Feet Per Year)

	Average Annual		Median Yield			
			ED	BN	AN	VW
Inflow:						
Santa Margarita River Inflow	38,000	85%	6,800	13,200	28,800	120,000
Subsurface Underflow	900	2%	1,000	900	900	800
Lake O'Neill Spill and Release	1,500	3%	700	1,300	2,100	2,300
Fallbrook Creek	1,200	3%	100	300	1,100	3,500
Minor Tributary Drainages	2,400	5%	1,500	1,400	2,500	4,700
Areal Precipitation	800	2%	400	300	500	1,500
	44,800	100%				
Outflow:						
Santa Margarita River Outflow	29,100	65%	1,000	3,200	15,700	109,900
Subsurface Underflow	100	0%	100	100	100	100
Groundwater Pumping	11,100	25%	5,400	8,900	15,900	16,800
Evapotranspiration	2,500	6%	1,600	2,200	2,500	2,800
Diversions to Lake O'Neill	2,000	4%	1,300	1,700	2,700	2,700
	44,800	101%				
Net Simulated Change of Groundwater in Storage:						
	0	0%	0	-100	-500	100

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding. The sum of median values does not reflect the change of groundwater in storage.

The model results for Run 2 are included as Attachment F. Table F-1 summarizes the annual simulated well production that ranges from 4,900 acre-feet per year in MY-10 to 18,500 acre-feet per year in MY-42. Eleven additional wells simulate pumping to maximize the basin yield from all three subbasins. Figure 3 shows the location for these wells: UY-1 through UY-6 in the Upper Ysidora Subbasin, CH-1 through CH-3 in the Chappo Subbasin, and LY-1 and LY-2 in the Lower Ysidora Subbasin. Four of these new wells operated less than 10% of the months during the 50-year period and were included in order to increase the available groundwater during AN hydrologic conditions. Table F-2 summarizes the operation time that each of the model's simulated wells is in use. Two of the new wells replace existing production wells located in the Chappo Subbasin to reduce the effects of well interference. The wells were placed to minimize any impact to riparian habitat, contaminant migration, or well interference effects. In addition, the Lower Ysidora Subbasin production wells were placed so as not to reverse the groundwater gradient close to the estuary and minimize the risk of salt water intrusion.

During AN hydrologic conditions, Run 2 simulates a groundwater production split of 53%, 43%, and 4% of the pumping occurring in the Upper Ysidora, Chappo, and Lower Ysidora Subbasins, respectively. This maximizes the yield given the usable surface and groundwater storage in each subbasin. However, during dry hydrologic conditions when overall pumping is reduced, Run 2 simulates a groundwater production split of 75%, 24%, and 1% in these basins to minimize the potential for salt water intrusion and to maximize the higher transmissivity and rebounding quality of the Upper Ysidora Subbasin during dryer conditions.

Attachment F and figures F-1 through F-4 compare Run 2 simulated groundwater levels and streamflow to the 50-Year Baseline. Simulated groundwater levels in the riparian corridor do not drop below measured historical groundwater levels in any of the three subbasins. Where there are multiple consecutive dry hydrologic years in the early simulated period, simulated groundwater levels approach historical levels recorded in the early 1960s, but do not drop below this level due to the Model's dry-year pumping management scenario. Simulated groundwater levels in the grassland area of each subbasin are allowed to drop lower because there are no phreatophytes in these locations to be adversely affected by the lowered groundwater table. The lowest drawdown in groundwater levels in these grassland areas is approximately 22 feet, 35 feet, and 13 feet below land surface in the Upper Ysidora, Chappo, and Lower Ysidora Subbasins, respectively. Run 2 groundwater levels in the Lower Ysidora Subbasin stay within the range of the Baseline groundwater levels, indicating salt water intrusion would not occur under this scenario. Simulated streamflow between subbasins and toward the estuary for Run 2 is lower than the Baseline due to no agricultural pumping from the Lower Ysidora Subbasin. Run 2 simulates greater streamflow than historically recorded values. This is partly due to well placement. Historically, agricultural wells have been placed closer to the river. In Run 2, some of the production wells have been placed closer to the grassland area. Run 2 still maintains a gaining stream reach in the Lower Ysidora Subbasin before the river reaches the estuary.

Table 5 summarizes the overall average annual and median groundwater budgets for Run 2 during each of the four hydrologic conditions. In Run 2, Santa Margarita River streamflow is 85% of the water budget inflow and 64% of the water budget outflow. Groundwater Production is approximately 26% of the overall average water budget outflow in Run 2. The overall average change of groundwater in storage for Run 2 is 100 acre-feet per year, which occurs in the Upper Ysidora Subbasin, not the Lower Ysidora Subbasin where salt water intrusion is a potential concern.

Run 3 – Mitigation

Run 3 was designed to simulate groundwater yield expected to occur if groundwater levels along the riparian corridor were allowed to drop below the root extinction depth. Table 2 provides a summary of all other limitations and constraints. The result of removing environmental constraints indicates that the

Table 5. Model Run 2 Groundwater and Surface Water Budget (Acre-Feet Per Year)

	Average Annual		Median Yield ED	BN	AN	VW
Inflow:						
Santa Margarita River Inflow	38,000	85%	6,800	13,200	28,800	120,000
Subsurface Underflow	900	2%	1,000	900	900	800
Lake O'Neill Spill and Release	1,500	3%	700	1,300	2,100	2,300
Fallbrook Creek	1,200	3%	100	300	1,100	3,500
Minor Tributary Drainages	2,400	5%	1,500	1,400	2,500	4,700
Areal Precipitation	800	2%	400	300	500	1,500
	44,800	100%				
Outflow:						
Santa Margarita River Outflow	28,800	64%	700	2,700	15,200	109,300
Subsurface Underflow	100	0%	0	0	100	100
Groundwater Pumping	11,700	26%	5,400	8,900	15,900	16,700
Evapotranspiration	2,300	5%	1,400	2,100	2,300	2,700
Diversions to Lake O'Neill	2,000	4%	1,300	1,700	2,700	2,700
	44,900	100%				
Net Simulated Change of Groundwater in Storage:						
	-100	0%	-100	-100	-200	200

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding. The sum of median values does not reflect the change of groundwater in storage.

average annual groundwater yield during the simulation period is 12,100 acre-feet per year, with median yields varying between 6,300 and 17,700 acre-feet per year, depending on the hydrologic conditions. Run 3 average annual groundwater yield over the 50-year simulation period is 1,000 acre-feet per year greater than Run 1.

The model results for Run 3 are included as Attachment G. Table G-1 summarizes the annual simulated well production, ranging from 5,400 acre-feet per year in MY-10 to 18,600 acre-feet per year in MY-42. Ten additional wells simulate pumping to maximize the basin yield from all three subbasins. Figure 3 illustrates the location for these wells: UY-1 through UY-6 in the Upper Ysidora Subbasin and CH-1 through CH-4 in the Chappo Subbasin. Three of these new wells simulated pumping occurring less than 10% of the months during the 50-year period and increased the capacity to capture the groundwater available during AN hydrologic conditions. Table G-2 summarizes the percentage of time that each well is in use. Two of the new wells replace existing production wells located in the Chappo Subbasin to reduce the effects of well interference. The wells were placed to avoid contaminant migration.

Run 3 simulates a groundwater production split of 55% and 45% in the Upper Ysidora and Chappo Subbasins, respectively, during wet hydrologic conditions.

This division maximizes the groundwater yield given the usable surface and groundwater storage in each subbasin. However, during drier hydrologic conditions when overall pumping is reduced, Run 3 simulates a groundwater production split of 76% and 24%. Attachment G and figures G-1 through G-4 compare Run 3 simulated groundwater levels and streamflow with the 50-Year Baseline. Given that Run 3 considers groundwater production with habitat mitigation, simulated groundwater levels in the riparian corridor are allowed to drop below measured historical groundwater levels. In the Upper Ysidora Subbasin, simulated groundwater levels dropped approximately 2 feet lower than historical low to 26 feet below land surface during consecutive dry years. In the Chappo Subbasin, simulated groundwater levels dropped approximately 3 feet lower than the historical low to 26 feet below land surface during this same period. The lowest simulated drawdown in groundwater levels in the grassland areas is approximately 24 feet, 35 feet, and 12 feet below land surface in the Upper Ysidora, Chappo, and Lower Ysidora Subbasins, respectively. Run 3 groundwater levels in the Lower Ysidora Subbasin stay within the range of the Baseline groundwater levels, indicating salt water intrusion would not occur under this scenario. Simulated streamflow between subbasins and toward the estuary for Run 3 fall within the same range as the Baseline, with a gaining stream reach in the Lower Ysidora Subbasin before the Santa Margarita River reaches the estuary.

Table 6 summarizes the overall average annual and median groundwater budgets of Run 3 for each of the four hydrologic conditions. The Santa Margarita River streamflow is 85% of the water budget inflow and 63% of the water budget outflow. Groundwater production is approximately 27% of the overall average water budget in Run 3, compared with 16% of the Baseline outflow. The overall average change of groundwater in storage for Run 3 is 100 acre-feet per year.

Run 4 – No CWRMA

Run 4 was intended to estimate the impact to groundwater yield of the Santa Margarita River CUP if CWRMA releases were not available. The impact of eliminating augmentation to the Santa Margarita River from CWRMA releases results in a reduction of the average annual groundwater yield by 1,800 acre-feet per year, when compared to Run 1. When compared to the Baseline, the average annual groundwater yield increases by 2,000 acre-feet per year. During the 50-year simulation period, Run 4 average annual yield is 9,300 acre-feet per year, with median yields varying between 5,000 and 13,800 acre-feet per year, depending on the hydrologic conditions.

The model results for Run 4 are included as Attachment H. Table H-1 summarizes the annual simulated well production, ranging from 3,800 acre-feet per year in MY-10 to 14,700 acre-feet per year in MY-42. Six additional wells

Table 6. Model Run 3 Groundwater and Surface Water Budget (Acre-Feet Per Year)

	Average Annual		Median Yield ED	BN	AN	VW
Inflow:						
Santa Margarita River Inflow	38,000	85%	6,800	13,200	28,800	120,000
Subsurface Underflow	900	2%	1,000	900	900	800
Lake O'Neill Spill and Release	1,500	3%	700	1,300	2,100	2,300
Fallbrook Creek	1,200	3%	100	300	1,100	3,500
Minor Tributary Drainages	2,400	5%	1,500	1,400	2,500	4,700
Areal Precipitation	800	2%	400	300	500	1,500
	44,800	100%				
Outflow:						
Santa Margarita River Outflow	28,400	63%	700	2,500	15,100	108,900
Subsurface Underflow	100	0%	100	100	100	100
Groundwater Pumping	12,100	27%	6,300	9,800	17,100	17,700
Evapotranspiration	2,300	5%	1,300	1,800	2,300	2,700
Diversions to Lake O'Neill	2,000	4%	1,300	1,700	2,700	2,700
	44,900	100%				
Net Simulated Change of Groundwater in Storage:	-100	0%	-200	-300	-100	400

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding. The sum of median values does not reflect the change of groundwater in storage.

simulate pumping to maximize the basin yield. Figure 3 shows the location for these wells: UY-1 through UY-4 in the Upper Ysidora Subbasin and CH-1 through CH-2 in the Chappo Subbasin. One of the six new wells simulated only pumped during 1 year of the 50-year period—this is due to the 80% utilization criteria. If a higher utilization rate was used for this 1 year, only five new wells would be required for the Run 4 scenario. Table H-2 summarizes the percentage of time that each well is in use. Two of the new wells replace existing production wells located in the Chappo Subbasin to reduce the effects of well interference or contaminant migration. The proposed wells were placed to minimize any impact to riparian habitat, contaminant migration, or well interference effects.

Run 4 simulates a groundwater production split of 55% and 45% in the Upper Ysidora and Chappo Subbasins, respectively, during wet hydrologic conditions and a groundwater production split of 70% and 30% during dry conditions. Attachment H and figures H-1 through H-4 compare Run 4 simulated groundwater levels and streamflow with the 50-Year Baseline. Run 4 considers the effect of reduced streamflow on the project and shows groundwater levels are lowered greater than 20 feet below land surface more frequently under these conditions compared with the Baseline and Run 1. Simulated groundwater levels in the riparian corridor do not drop below measured historical groundwater levels in the Upper Ysidora and Chappo Subbasins. Simulated groundwater levels in the grassland area of each subbasin are allowed to drop lower because there are no phreatophytes in these locations to be adversely affected by the lowered groundwater table. The lowest drawdown in groundwater levels in these grassland areas is approximately 22 feet and 32 feet below land surface in the Upper Ysidora and Chappo Subbasins, respectively. Run 4 groundwater levels in the Lower Ysidora Subbasin stay within the range of the Baseline groundwater levels, indicating salt water intrusion would not occur under this scenario.

Table 7 summarizes the overall average annual and median groundwater budgets of Run 4 for each of the four hydrologic conditions. Run 4 simulates 3,100 acre-feet per year average annual reduction in Santa Margarita River streamflow due to loss of CWRMA releases. Compared with Run 1, this reduction is mostly offset by curtailing pumping by 1,800 acre-feet per year and reduced streamflow out of the Lower Ysidora by 800 acre-feet per year. Other water demands that are affected by this scenario include reducing Lake O'Neill net diversions and releases, increasing subsurface underflow during dry years, and decreasing evapotranspiration. The overall average change of groundwater in storage for Run 4 is minimal. Simulated streamflow between subbasins and toward the estuary for Run 4 fall within the same range as the Baseline, with a gaining stream reach in the Lower Ysidora Subbasin before the Santa Margarita River reaches the estuary.

Run 5 – Title 22

Run 5 estimated the impact of releasing Title 22 water in the Lower Ysidora Subbasin. Similar to Run 2 (3-Basin), Run 5 allowed for additional groundwater pumping in all of Camp Pendleton's aquifers. The impact of adding Title 22 water to the Lower Ysidora Subbasin and increasing groundwater pumping resulted in an average annual groundwater yield during the simulation period of 11,900 acre-feet per year, with median yields varying between 6,100 acre-feet per year and 17,600 acre-feet per year, depending on the hydrologic conditions.

Run 5 model results are included as Attachment I. Table I-1 summarizes the annual simulated well production, ranging from 6,000 acre-feet per year in MY-5 to 18,600 acre-feet per year in MY-42. Twelve additional wells simulate pumping to maximize the basin yield from all three subbasins. Figure 3 illustrates the locations for these wells: UY-1 through UY-5 in the Upper Ysidora Subbasin, CH-1, CH-2, and CH-4 in the Chappo Subbasin, and LY-1 through LY-4 in the Lower Ysidora Subbasin. Five of these new wells simulated groundwater pumping occurring less than 10% of the months (table I-2) during the 50-year period and provide the increased capacity necessary to capture the groundwater available during wet hydrologic conditions. The new wells were placed to minimize any impact to riparian habitat or contaminant migration. The Lower

Table 7. Model Run 4 Groundwater and Surface Water Budget (Acre-Feet Per Year)

	Average Annual		Median Yield			
			ED	BN	AN	VW
Inflow:						
Santa Margarita River Inflow	34,900	85%	5,100	10,000	23,800	116,700
Subsurface Underflow	1,000	2%	1,100	1,000	900	900
Lake O'Neill Spill and Release	1,000	2%	200	700	1,300	2,300
Fallbrook Creek	1,200	3%	100	300	1,100	3,500
Minor Tributary Drainages	2,400	6%	1,500	1,400	2,500	4,700
Areal Precipitation	800	2%	400	300	500	1,500
	41,300	100%				
Outflow:						
Santa Margarita River Outflow	28,300	68%	700	2,600	14,500	109,200
Subsurface Underflow	100	0%	100	100	100	100
Groundwater Pumping	9,300	23%	5,000	8,000	12,800	13,800
Evapotranspiration	2,300	6%	1,400	2,100	2,500	2,900
Diversions to Lake O'Neill	1,300	3%	400	900	1,700	2,700
	41,300	100%				
Net Simulated Change of Groundwater in Storage:						
	-100	0%	-300	-700	300	700

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding. The sum of median values does not reflect the change of groundwater in storage.

Ysidora production wells were placed so as not to reverse the groundwater gradient close to the estuary and minimize the risk of salt water intrusion.

With the addition of Title 22 water in the Lower Ysidora Subbasin, Run 5 simulates a groundwater production split of 46%, 45%, and 9% of the pumping occurring in the Upper Ysidora, Chappo, and Lower Ysidora Subbasins, respectively, during wet hydrologic conditions and a split of 60%, 25%, and 15% during dry hydrologic conditions. There is an average annual increase of 800 acre-feet per year in groundwater production when compared with Run 1 and 4,600 acre-feet per year compared with the Baseline.

Simulated groundwater levels (Attachment I, figures I-1, 2, 3) and streamflow (figure I-4) for Run 5 are compared with the 50-Year Baseline. Simulated groundwater levels in the Lower Ysidora Subbasin riparian corridor (figure I-3) are closer to land surface in this scenario because of the shallow recharge of Title 22 water. This higher water table is also reflected in the increased evapotranspiration and streamflow toward the estuary for Run 5.

Table 8 summarizes the overall average annual and median groundwater budgets of Run 5 for each of the four hydrologic conditions. Four percent of the water budget inflow is attributable to Title 22 water recharged in the Lower Ysidora Subbasin. When compared with Run 1, the average annual 1,800-acre-feet-per-year increase from Title 22 water results in an increase of 900 acre-feet per year of streamflow out of the model, 800 acre-feet per year additional pumping, and 100 acre-feet per year from expanded evapotranspiration. The overall average change of groundwater in storage for Run 5 is minimal.

Table 8. Model Run 5 Groundwater and Surface Water Budget (Acre-Feet Per Year)

	Average Annual		Median Yield			
			ED	BN	AN	VW
Inflow:						
Santa Margarita River Inflow	38,000	82%	6,800	13,200	28,800	120,000
Subsurface Underflow	900	2%	900	900	900	800
Lake O'Neill Spill and Release	1,500	3%	700	1,300	2,100	2,300
Fallbrook Creek	1,200	3%	100	300	1,100	3,500
Title 22 Water	1,800	4%	1,800	1,800	1,800	1,800
Minor Tributary Drainages	2,400	5%	1,500	1,400	2,500	4,700
Areal Precipitation	800	2%	400	300	500	1,500
	46,600	101%				
Outflow:						
Santa Margarita River Outflow	30,000	64%	1,500	4,100	16,200	111,200
Subsurface Underflow	100	0%	100	100	100	100
Groundwater Pumping	11,900	26%	6,100	9,800	16,600	17,600
Evapotranspiration	2,600	6%	1,900	2,300	2,600	2,800
Diversions to Lake O'Neill	2,000	4%	1,300	1,700	2,700	2,700
	46,600	100%				
Net Simulated Change of Groundwater in Storage:						
	0	0%	100	0	-500	0

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding. The sum of median values does not reflect the change of groundwater in storage.

Run 6R – Alternative 2 FPUD Sump

The purpose of Run 6R was to simulate groundwater yield if a direct use diversion was constructed at the FPUD Sump. While all facilities on Camp Pendleton remained the same as those proposed in Run 1, a 25-cfs direct use diversion was emplaced in the Santa Margarita River upstream of Camp Pendleton. The average annual basin yield for Run 6R is 13,800 acre-feet per year with a 50-year median of 13,200 acre-feet per year. The results of Run 6R indicated that the average annual groundwater yield during the simulation period would be 10,400 acre-feet per year, with median yield varying between 5,100 acre-feet per year and 16,200 acre-feet per year, depending on hydrologic conditions. In addition to the groundwater yield, the amount of water diverted at the FPUD Sump for direct use averaged 3,400 acre-feet per year, with a median variation between zero and 8,700 acre-feet per year, depending on hydrologic conditions. Run 6R presents a revised update to Run 6 which was reported in the June 2006 Draft TM 2.0. Revised Run 6R accounts for the Lake O'Neill and the 4,000-acre-foot water rights licenses on Camp Pendleton to be met before direct use diversion at the FPUD sump could occur.

Model Run 6R results are included as Attachment J. Annual simulated groundwater well production is summarized in table J-1, ranging from 4,700 acre-feet per year in MY-5 to 17,200 acre-feet per year in MY-42. Nine additional wells (figure 3) simulate pumping to maximize the basin yield from the Upper Ysidora and Chappo Subbasins: UY-1 through UY-6 in the Upper Ysidora Subbasin and CH-1, CH-2, and CH-4 in the Chappo Subbasin. Five of these new wells simulated pumping occurring less than 10% of the months (table J-2) during the 50-year period. Assuming an upstream direct use diversion at the FPUD Sump, Run 6R simulates a groundwater production split of 55% and 45% of the pumping occurring in the Upper Ysidora and Chappo Subbasins, respectively, during AN hydrologic conditions and a split of 75% and 25% during drier hydrologic conditions. There is an average annual decrease of 700 acre-feet per year in groundwater production when compared with Run 1, Project, and an increase of 3,100 acre-feet per year compared with the Baseline.

Simulated groundwater levels (Attachment J, figures J-1, -2, -3) and streamflow (figure J-4) for Run 6R are compared with the Baseline. There is an increase in the frequency of low groundwater levels in consecutive dry years, while still remaining above the historical low in each subbasin. Figure J-4 shows the reduced higher streamflow events during Run 6R when compared with the Baseline between each subbasin and flow out of the Lower Ysidora Subbasin. Figure J-5 shows the time exceedance percent of the simulated FPUD Sump direct use diversions from the Santa Margarita River.

Table 9 summarizes the overall average annual and median water budgets of Run 6R for each of the four hydrologic conditions. The FPUD Sump direct use diversions represent approximately 8% of the overall water budget for Run 6R. When compared with Run 1, the 3,400-acre-feet-per-year decrease in streamflow into the model is offset by a 2,300-acre-feet-per-year decrease in streamflow out of the model toward the estuary, 700-acre-feet-per-year reduction in groundwater pumping, 300-acre-feet-per-year reduction in riparian evapotranspiration, and 100-acre-feet-per-year change of groundwater in storage.

Table 9. Model Run 6R Groundwater and Surface Water Budget (Acre-Feet Per Year)

	Average Annual		Median Yield ED	BN	AN	VW
Inflow:						
Santa Margarita River Inflow	34,600	84%	6,800	12,000	23,800	110,600
Subsurface Underflow	900	2%	1,000	900	900	900
Lake O'Neill Spill and Release	1,200	3%	700	1,200	1,400	1,400
Fallbrook Creek	1,200	3%	100	300	1,100	3,500
Minor Tributary Drainages	2,400	6%	1,500	1,400	2,500	4,700
Areal Precipitation	800	2%	400	300	500	1,500
	41,100	100%				
Outflow:						
Santa Margarita River Outflow	26,800	65%	900	2,300	14,900	100,200
Subsurface Underflow	100	0%	100	100	100	100
Groundwater Pumping	10,400	25%	5,100	8,800	14,300	16,100
Evapotranspiration	2,200	6%	1,500	1,700	2,000	2,600
Diversions to Lake O'Neill	1,700	4%	1,300	1,600	1,900	2,000
	41,200	100%				
Net Simulated Change of Groundwater in Storage:						
	-100	0%	-300	-700	300	700
FPUD Direct Use Diversion	3,400		0	1,900	4,000	8,700

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding. The sum of median values does not reflect the change of groundwater in storage.

Run 7 – Mitigate 7-Year Drought

Run 7 was developed in order to identify the impact to the basin yield due to implementing the Dry Year Management Scenario. This run has the same constraints as Run 1 except for the limits set to curtail the effects of a 7-year drought. As explained throughout TM 2.2, the Dry-Year Management Scenario reduces groundwater pumping in anticipation of existing or future prolonged drought conditions. Without foresight into the next year’s hydrologic condition, all model runs have been developed to anticipate worst case drought conditions similar to those that existed between 1956 and 1962. The Dry-Year Management Scenario in Model Run 7 was relaxed based on the ability to call upon an additional source of water to mitigate against drought conditions, resulting in an increase in annual and median groundwater extractions from the aquifer. Run 7 average annual yield is 12,100 acre-feet per year, with median yields varying between 7,100 and 16,900 acre-feet per year, depending on the hydrologic conditions (table 10). The average basin yield is 1,000 acre-feet per year greater than Run 1.

Table 10. Model Run 7 Groundwater and Surface Water Budget (Acre-Feet Per Year)

	Average Annual		Median Yield ED	BN	AN	VW
Inflow:						
Santa Margarita River Inflow	37,900	85%	6,800	12,900	28,800	120,000
Subsurface Underflow	900	2%	1,000	900	900	800
Lake O'Neill Spill and Release	1,500	3%	600	1,300	2,100	2,300
Fallbrook Creek	1,200	3%	100	300	1,100	3,500
Minor Tributary Drainages	2,400	5%	1,500	1,400	2,500	4,700
Areal Precipitation	800	2%	400	300	500	1,500
	44,700	100%				
Outflow:						
Santa Margarita River Outflow	28,400	63%	800	2,800	14,600	109,600
Subsurface Underflow	100	0%	100	100	100	100
Groundwater Pumping	12,100	27%	7,100	11,300	15,900	16,900
Evapotranspiration	2,300	5%	1,500	1,900	2,500	2,700
Diversions to Lake O'Neill	1,900	4%	800	1,700	2,700	2,700
	44,800	99%				
Net Simulated Change of Groundwater in Storage:						
	-100	0%	100	-800	500	600

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding. The sum of median values does not reflect the change of groundwater in storage.

Model Run 7 results are included as Attachment K. A total of 7,800 acre-feet of water (table K-1) is called upon during the 50-year simulation period to mitigate against negative impacts to the aquifer, of which 4,200 acre-feet could potentially come from CWRMA emergency releases. The Dry-Year Management Scenario in Run 7 was adjusted to allow for increased groundwater pumping during the beginning of a perceived dry period. Groundwater pumping during the first BN year was not reduced, as compared to 4,000 acre-feet in all other model runs. Similarly, Run 7 Dry Year Management Scenario reduced groundwater pumping by 3,000 acre-feet during the second consecutive BN years, as compared to 8,000 acre-feet per year in the other model runs. Finally, groundwater pumping was reduced by a maximum of 7,000 acre-feet per year, compared to 9,000 acre-feet per year in all other model runs. The result of adjusting the Dry Year Management Scenario not to anticipate the worst case 7-year drought resulted in additional yield from the aquifers on Camp Pendleton.

Run 8 – Proposed Action

The Draft Decision Memorandum prepared by Reclamation (October 2006) describes a proposed action that includes diversion for storage and direct use. Diversion of surface water for direct use will undergo treatment at the proposed advanced water treatment plant to meet the 425-milligram-per-liter (mg/L) total dissolved solid goal of treated water. Similar to Run 6R, the proposed action is intended to optimize diversions for direct use while supporting Camp Pendleton's existing pre-1914 Lake O'Neill water right and 4,000 acre-feet per year license. Contrary to Run 6R, the proposed action's direct use diversion is located in recharge pond #3 on Camp Pendleton with a reduced diversion capacity of 10 cfs. The impact to basin yield from the changes in the location and capacity of the diversion for direct use simulated in Run 8 may be directly compared to Run 6R.

Model Run 8 results are included as Attachment L. Annual simulated groundwater well production is summarized in table L-1, ranging from 4,500 acre-feet per year in MY-5 to 17,300 acre-feet per year in MY-42. The direct use diversion production is also summarized in table L-1, ranging from zero in multiple model years to 4,400 acre-feet per year in MY-29. Seven additional wells (figure 3) simulate pumping to maximize the basin yield from the Upper Ysidora and Chappo Subbasins: UY-1 through UY-6 in the Upper Ysidora Subbasin and CH-4 in the Chappo Subbasin which replaces well R23G4. Two of these new wells simulated pumping occurring 10% or less of the months (table L-2) during the 50-year period. Assuming a direct use diversion at recharge pond #3, Run 8 simulates a groundwater production split of 60% and 40% of the pumping occurring in the Upper Ysidora and Chappo Subbasins, respectively, during AN hydrologic conditions and a split of 69% and 31% during drier hydrologic conditions. There is an average annual decrease of 100 acre-feet per year in groundwater production when compared with Run 1 and an increase of 3,700 acre-feet per year compared to Baseline. However, if the groundwater production and direct use diversion are summed, there is an average annual increase of 1,100 acre-feet per year in total water production when compared with Run 1 and an increase of 4,900 acre-feet per year compared to the Baseline.

Simulated groundwater levels (Attachment L, figures L-1, 2, 3) and streamflow (figure L-4) for Run 8 are compared with Baseline. Although there is an increase in the frequency of low groundwater levels in consecutive dry years, levels still remain above the historical low in each subbasin. Figure L-4 shows the reduced higher streamflow events during Run 8 when compared with the Baseline between each subbasin and flow out of the Lower Ysidora Subbasin.

Table 11 summarizes the overall average annual and median groundwater budgets of Run 8 for each of the four hydrologic conditions. The direct use diversion represents approximately 3% of the overall water budget for Run 8. When compared with Run 1, the additional 1,100 acre-feet per year in basin yield is offset by a decrease of 1,100 acre-feet per year in streamflow out of the model toward the estuary, a reduction of 100 acre-feet per year in riparian evapotranspiration and an increase of 100 acre-feet per year of groundwater out of storage. The average direct use diversion (1,200 acre-feet per year) is less than the direct use diversion at the FPUD Sump in Run 6R (3,400 acre-feet per year).

Table 11. Model Run 8 Groundwater and Surface Water Budget (Acre-Feet Per Year)

	Average Annual		Median Yield ED	BN	AN	VW
Inflow:						
Santa Margarita River Inflow	38,000	85%	6,800	13,200	28,800	120,000
Subsurface Underflow	900	2%	1,000	900	900	800
Lake O'Neill Spill and Release	1,500	3%	900	1,300	2,100	2,300
Fallbrook Creek	1,200	3%	100	300	1,100	3,500
Minor Tributary Drainages	2,400	5%	1,500	1,400	2,500	4,700
Areal Precipitation	800	2%	400	300	500	1,500
	44,800	100%				
Outflow:						
Santa Margarita River Outflow	28,200	63%	900	2,800	16,100	105,500
Subsurface Underflow	100	0%	100	100	100	100
Groundwater Pumping	11,000	24%	5,100	9,000	15,900	16,500
Evapotranspiration	2,400	5%	1,500	2,000	2,400	2,800
Diversions to Lake O'Neill	2,000	4%	1,300	1,700	2,700	2,700
Direct Use Diversion	1,200	3%	0	200	1,500	3,400
	44,900	99%				
Net Simulated Change of Groundwater in Storage:						
	-100	0%	-200	0	-400	1,100

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding. The sum of median values does not reflect the change of groundwater in storage.

This decrease is due to the reduction in capacity from 25 cfs in Run 6R to 10 cfs in Run 8 and, to a lesser degree, the difference in water availability between the two diversion locations.

Run 9 – Maximize Chappo

Run 9 was developed to determine the maximum amount of groundwater pumping that could be developed from both the Chappo and Upper Ysidora groundwater subbasins without regards to migration of contaminants. While groundwater pumping has always optimized the Upper Ysidora Subbasin, all other model runs were constrained by the volatile organic compound (VOC) contaminant groundwater in the Chappo Subbasin. While the purpose of TM 2.2 is not to describe remediation of known contaminants in the aquifer, Run 9 assumes water treatment at the well-head, at the treatment plant, or through dilution could be used to treat known contaminants below their prescribed maximum contaminant level (MCL). Run 9 average annual yield is 11,700 acre-feet per year, with median yields varying between 5,700 and 17,700 acre-feet per year, depending on the hydrologic conditions. Compared to Run 1 which avoids migration of known contaminants in the lower Chappo Subbasin, Run 9 provides an additional average annual yield of 600 acre-feet.

Model Run 9 results are included as Attachment M. Annual simulated groundwater well production is summarized in table M-1, ranging from 5,000 acre-feet per year in MY-10 to 18,500 acre-feet per year in MY-42. Ten additional wells (figure 3) simulate pumping to maximize the basin yield from the Upper Ysidora and Chappo Subbasins: UY-1 through UY-6 in the Upper Ysidora Subbasin and CH-1 through CH-4 in the Chappo Subbasin. Four of these wells pump less than 10 percent of the time during the simulated 50 years. Table 12 summarizes the overall average annual and median groundwater budgets of Run 9 for each of the four hydrologic conditions.

Table 12. Model Run 9 Groundwater and Surface Water Budget (Acre-Feet Per Year)

	Average Annual		Median Yield			
			ED	BN	AN	VW
Inflow:						
Santa Margarita River Inflow	38,000	85%	6,800	13,200	28,800	120,000
Subsurface Underflow	900	2%	1,000	900	900	800
Lake O'Neill Spill and Release	1,500	3%	700	1,300	2,100	2,300
Fallbrook Creek	1,200	3%	100	300	1,100	3,500
Minor Tributary Drainages	2,400	5%	1,500	1,400	2,500	4,700
Areal Precipitation	800	2%	400	300	500	1,500
	44,800	100%				
Outflow:						
Santa Margarita River Outflow	28,800	65%	900	3,000	15,300	109,200
Subsurface Underflow	100	0%	100	100	100	100
Groundwater Pumping	11,700	26%	5,700	9,900	16,700	17,700
Evapotranspiration	2,300	5%	1,400	2,000	2,300	2,700
Diversions to Lake O'Neill	2,000	4%	1,300	1,700	2,700	2,700
	44,900	100%				
Net Simulated Change of Groundwater in Storage:						
	-100	0%	-200	-400	-400	600

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding. The sum of median values does not reflect the change of groundwater in storage.

Run 10 – Diversion Bypass

Run 10 was developed to test the sensitivity of allowing for different volumes of water to bypass the diversion structure at the head of O'Neill Ditch. Throughout Model Runs 1 to 9, a bypass of 3 cfs was maintained, when available, at the diversion structure to meet downstream riparian and environmental demands. The 3-cfs bypass was intended to match historical conditions and was originally estimated based on the amount of water that had likely flowed over, underneath, or through the existing diversion structure due to the diversion facility's design, construction, and age. Run 10 included four model runs that estimated basin yield based on allowing for a 1-cfs, 3-cfs, 6-cfs, and 9-cfs bypass at the diversion structure. A 0-cfs bypass model run was proposed but not performed due to numerical complications within the model that exist for optimizing diversions from the Santa Margarita River. A 1-cfs bypass was the smallest bypass that was consistent with model stability. Run 10 average annual yield is consistently 11,100 acre-feet per year for the 1-cfs, 3-cfs, 6-cfs, and 9-cfs bypass scenarios. Annual Median groundwater yield (table N-1) decreases from 11,100 to 10,900 acre-feet per year, while streamflow out of the model increases from 6,500 to 6,800 acre-feet per year. Attachment N presents the median annual water budgets for the four hydrologic conditions.

Model Run 10 confirms the Technical Team's conceptual model that the CUP relies on both the diversion to the recharge ponds and streambed infiltration to recharge the aquifer and meet riparian and environmental demands. Review of both the average annual and median annual water budgets, tables 13A and 13B respectively, show that the basin yield is not sensitive to changes in bypass flows within the 1-cfs to 9-cfs range. Conclusions drawn from the annual median groundwater budgets for the four hydrologic conditions (tables N-4 and N-5) support the conceptual model which suggests that the basin yield is more sensitive to changes in streamflow and bypass flows during ED conditions and less sensitive during VW conditions.

Run 11- Two Direct Use Diversions

The results of Model Runs 1 through 10 reflect the impact of changing only one operational parameter at a time to determine that parameter's influence on basin yield with respect to Run 1 (table ES-2). Runs 11 and 12 were developed to estimate the impact to basin yield based on the cumulative effect of executing multiple operational parameters within one run. Run 11 optimized direct use of surface water by considering two direct use diversions: one downstream from the second recharge pond (Run 8, Proposed Action), and one near the FPUD sump (Run 6R, Alt 2). Run 12 builds upon Run 11 and is discussed in detail in the following section. Run 11 average annual yield was 13,100 acre-feet per year, with median yields varying between 5,300 acre-feet per year during ED conditions and 21,500 acre-feet per year during VW conditions (table 14).

Consistent with Runs 1 through 10, the average basin yield may be compared to that of both Run 1 and the Baseline for comparison purposes, averaging an additional 2,000 and 5,800 acre-feet per year, respectively. For the purpose of presenting and understanding the results of Run 11, the basin yield is best compared to that of Run 8. The addition of the direct use diversion at the FPUD Sump reflected in Run 11 adds an additional average annual and median annual

Table 13A. Model Run 10 Average Groundwater and Surface Water Budget

	Average Annual (Acre-Feet Per Year)							
	1-cfs Bypass		3-cfs Bypass		6-cfs Bypass		9-cfs Bypass	
Inflow:								
Santa Margarita River Inflow	38,000	84%	38,000	85%	38,000	85%	38,000	85%
Subsurface Underflow	900	2%	900	2%	900	2%	900	2%
Lake O'Neill Spill and Release	1,800	4%	1,500	3%	1,500	3%	1,400	3%
Fallbrook Creek	1,200	3%	1,200	3%	1,200	3%	1,200	3%
Minor Tributary Drainages	2,400	5%	2,400	5%	2,400	5%	2,400	5%
Areal Precipitation	800	2%	800	2%	800	2%	800	2%
	45,100	100%	44,800	100%	44,800	100%	44,700	100%
Outflow:								
Santa Margarita River Outflow	29,100	65%	29,100	65%	29,300	66%	29,300	65%
Subsurface Underflow	100	0%	100	0%	100	0%	100	0%
Groundwater Pumping	11,100	25%	11,100	25%	11,100	25%	11,100	25%
Evapotranspiration	2,500	6%	2,500	6%	2,400	5%	2,400	5%
Diversions to Lake O'Neill	2,300	5%	2,000	4%	2,000	4%	1,900	4%
	45,100	101%	44,800	100%	44,900	100%	44,800	100 %
Net Simulated Change of Groundwater in Storage:	0	0%	0	0%	-100	0%	-100	0%

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding.

Table 13B. Model Run 10 Median Groundwater and Surface Water Budget

	Median Annual (Acre-Feet Per Year)			
	1-cfs Bypass	3-cfs Bypass	6-cfs Bypass	9-cfs Bypass
Inflow:				
Santa Margarita River Inflow	16,000	16,000	16,000	16,000
Subsurface Underflow	900	900	900	900
Lake O'Neill Spill and Release	2,000	1,500	1,300	1,200
Fallbrook Creek	600	600	600	600
Minor Tributary Drainages	2,100	2,100	2,100	2,100
Areal Precipitation	500	500	500	500
Outflow:				
Santa Margarita River Outflow	6,600	6,500	6,600	6,800
Subsurface Underflow	100	100	100	100
Groundwater Pumping	11,100	11,300	10,900	10,900
Evapotranspiration	2,500	2,500	2,400	2,400
Diversions to Lake O'Neill	2,600	2,200	1,800	1,800
Net Simulated Change of Groundwater in Storage:	-100	-100	-100	-100

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding. The sum of median values does not reflect the change of groundwater in storage.

Table 14. Model Run 11 Groundwater and Surface Water Budget (Acre-Feet Per Year)

	Average Annual		Median Yield ED	BN	AN	VW
Inflow:						
Santa Margarita River Inflow	37,100	85%	6,700	13,000	28,500	115,400
Subsurface Underflow	900	2%	1,000	900	900	800
Lake O'Neill Spill and Release	1,500	3%	900	1,300	2,100	2,300
Fallbrook Creek	1,200	3%	100	300	1,100	3,500
Minor Tributary Drainages	2,400	5%	1,500	1,400	2,500	4,700
Areal Precipitation	800	2%	400	300	500	1,500
	43,900	100%				
Outflow:						
Santa Margarita River Outflow	27,300	62%	900	2,500	15,900	101,000
Subsurface Underflow	100	0%	100	100	100	100
Groundwater Pumping	11,000	25%	5,100	9,000	15,900	16,500
Evapotranspiration	2,400	5%	1,500	2,000	2,400	2,800
Diversions to Lake O'Neill	2,000	5%	1,300	1,700	2,700	2,700
CPEN Direct Use Diversion	1,200	3%	0	200	1,500	3,400
	44,000	100%				
Net Simulated Change of Groundwater in Storage:	-100	0%	-200	0	-400	1,100
FPUD Direct Use Diversion	900		100	200	500	4,000
Basin Yield Summary	*13,100*		*5,300*	*10,600*	*18,100*	*21,500*

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding. The sum of median values does not reflect the change of groundwater in storage.

yield of 900 and 300 acre-feet per year, respectively, when compared to the results from Run 8. Described in greater detail below, the direct use diversion at the FPUD Sump provides an additional average annual yield of 900 acre-feet per year, but provides less than 300 acre-feet per year for half of the years during the 50-year simulation period.

The two direct use diversions included in Run 11 were operated only after Camp Pendleton’s existing pre-1914 Lake O’Neill and 4,000 acre-feet per year water rights licenses were satisfied. The first direct diversion, referred to as the “CPEN direct use diversion,” was located downstream from the second recharge pond and followed the same priority as that established for Run 8. The second direct diversion, referred to as the “FPUD direct use diversion,” was in the identical location as it was for Run 6R but was operated in a different manner. The FPUD direct use diversion was operated to capture the “excess” water that was flowing through the model to the estuary. The available water for the FPUD direct use diversion was based on Run 8’s Santa Margarita River flow out of the model;

whenever the flow out of the model exceeded 0.5 cfs in Run 8, the additional flow was diverted at the FPUD direct use diversion in Run 11. The water diverted under the FPUD direct use diversion was then deducted from the water available at Camp Pendleton's diversion point. The FPUD direct use diversion did not reduce the amount of water diverted to Camp Pendleton's recharge ponds, Lake O'Neill, or the CPEN direct use diversion. In addition to the two direct use diversions, the new groundwater wells established in Run 8 were used to extract all groundwater in Run 11.

The model results for Run11 are included in Attachment O. Annual simulated groundwater well production is summarized in table O-1 and ranged from 4,500 acre-feet per year in MY-5 to 17,300 acre-feet per year in MY-42. The CPEN direct use diversion ranged from zero acre-feet per year during 26% of the years (13 years out of 50 years) to a maximum 4,400 acre-feet per year in MY-29. The FPUD direct use diversion ranged from zero acre-feet per year during 10% of the years (5 years out of 50 years) to a maximum of 6,500 acre-feet per year in MY-42. Seven additional wells simulated pumping to maximize the groundwater production from the basin. The 50-year median yields of the CPEN direct use diversion and FPUD direct use diversion were 900 and 300 acre-feet per year, respectively.

Run 11's average and median annual groundwater yield were identical to that of Run 8, both of which reflect an increase above the Baseline of 3,700 and 2,700 acre-feet per year, respectively. Similarly, the average and median annual CPEN direct use diversion were also identical between Runs 8 and 11. However, when the FPUD direct use diversion is accounted for, the basin yield for Run 11 increases by an average of 900 acre-feet per year and a median of 300 acre-feet per year compared to Run 8. The total groundwater and direct use diversion average and median basin yield is 5,800 and 4,300 acre-feet per year greater than Baseline, respectively.

Simulated groundwater levels (Attachment O, figures O-1, 2, 3) and streamflow (figure O-4) for Run 11 are compared to the 50-Year Baseline. There was an increase in the frequency of low groundwater levels during consecutive dry years while remaining above the historical low in each subbasin. Figure O-4 shows significantly lower streamflow out of the Lower Ysidora Subbasin when compared to the Baseline, as expected since flow was diverted at the FPUD direct use diversion during 90% of the simulated years.

Table 14 summarizes the overall average annual and median groundwater and surface water budget for Run 11 during each of the four hydrologic conditions. The CPEN direct use diversion represents approximately 3% of the overall water budget for Run 11. The FPUD direct use diversion occurs outside the actual model, so was not calculated as a percentage of the model budget. When compared to Run 8, the additional 900 acre-feet per year extracted at the FPUD direct use diversion is offset by a decrease of 900 acre-feet per year of surface flow out of the model toward the Santa Margarita estuary. Similar to Run 8, two of the seven new additional groundwater wells simulated production during less than 10% of the 600 months that were simulated during the 50-year model period (table O-2).

Run 12 – Two Direct Use Diversions with Options

The purpose of Run12 was to estimate the impact to Run 11 basin yield due to combining additional operational parameters previously tested in Runs 1 through 10. Run 12 expanded from the two direct use diversions of Run 11 and added three additional operational parameters: the ability to call upon an additional source of water to mitigate against drought conditions (Run 7), the relaxation of VOC contamination constraints in the Chappo Subbasin (Run 9), and the ability to lower groundwater levels below the minimum measured historical water levels (Run 3). Table ES-2 provides a summary of all operational parameters included in Run 12 and the resulting change in basin yield compared to both the Baseline and Run 1 model simulations. The results of Run 12 show an average annual basin yield during the simulation period of 14,200 acre-feet per year, with median yields ranging from 6,300 acre-feet per year during ED conditions to 22,900 acre-feet per year during VW conditions. The average annual basin yield of Run 12 is 3,100 acre-feet per year greater than that of Run 1 and 6,900 acre-feet per year greater than the Baseline.

Results from Run 12 should not only be compared to those of the Baseline and Run 1 basin yield estimates, but also to the other model simulations that included a direct use diversion (Run 6R, Run 8, and Run 11). Table 15 shows a comparison of model results for the four runs that incorporated direct use diversions as operational parameters. Combining the two direct use diversions and the three additional operational parameters resulted in Run 12 average annual groundwater production being greater than any of the previous 11 model runs. Specifically, the average annual groundwater yield of Run 12 was 1,700 acre-feet greater than Run 6R and 1,100 acre-feet greater than Run 8 and Run 11. The impact of increasing the average annual groundwater yield not only results in the increase of total basin yield, but it is also reflected by additional reliability due to increasing the minimum groundwater production yield to 6,000 acre-feet per year.

The model results for Run 12 are included in Attachment P. The CPEN direct use diversion was zero acre-feet per year during the driest years, 100 acre-feet per year or more during 64% of the years, and 2,000 acre-feet per year or more during 20% of the years (table P-1). During these same conditions, the FPUD direct use diversion yielded no water 12% of the years, produced 100 acre-feet per year or more 74% of the years, and was greater than 2,000 acre-feet per year 12% of the

Table 15. Comparison of Average Basin Yield from Model Runs with Direct Use Diversion
(Acre-Feet Per Year)

Type of Diversion	Run 6R Alt 2	Run 8 Proposed Action	Run 11 Two Direct Use Diversions	Run 12 Two Direct Use Diversions with Options
Groundwater Production	10,400	11,000	11,000	12,100
CPEN Direct Use Diversion	–	1,200	1,200	1,200
FPUD Direct Use Diversion	13,400	–	[2]900	[2]900
Total Basin Yield	13,800	12,200	13,100	14,200

[1] FPUD direct use diversions in Run 6R are not constrained by surface water flow to the estuary.

[2] FPUD direct use diversions in Run 11 and Run 12 are constrained by surface water flow to the estuary.

years. The basin yield planning range determined for Run 12 varied from 6,300acre-feet per year during ED conditions to a 22,900 acre-feet per year for VW hydrologic conditions (table P-1).

In addition to emergency water provided by the CWRMA, a total of 4,200 acre-feet of additional water supply is called upon during the 50-year simulation period to mitigate against negative impacts to the aquifer. Groundwater production required ten additional wells pumping to maximize the basin yield from the Upper Ysidora and Chappo Subbasins: UY-1 through UY-6 in the Upper Ysidora Subbasin, and CH-1 through CH-4 in the Chappo Subbasin. Run12 simulated a groundwater production split between the Upper Ysidora and Chappo Subbasins of 54% to 46% during the AN hydrologic conditions; and a split of 66% to 34% during drier hydrologic conditions Similar to previous model runs, five of the ten new wells simulated groundwater pumping less than 10% of the months during the 50-year simulated period in order to capture excess water during VW hydrologic conditions.

Consistent with Model Run 3 operational parameters, Run 12 simulated groundwater levels in the riparian corridor dropped below measured historical groundwater levels (Attachment P). The simulated groundwater levels dropped approximately 2 feet below historical lows in both the Upper Ysidora and Chappo Subbasins. Run 12 groundwater levels in the Lower Ysidora Subbasin stay within the range of the Baseline groundwater levels, indicating salt water intrusion would not occur under this scenario. Run 12 simulated stream outflow from the model boundary is lower than Run 1 and Baseline quantities due to the direct use diversions and increased groundwater production.

Table 16 summarizes Run 12 groundwater and surface water budgets for median values during each of the four hydrologic conditions as well as overall average annual values. The Santa Margarita River streamflow is 85% of the water budget inflow and 60% of the water budget outflow. Groundwater production is approximately 27% of the overall average water budget in Run 12, compared with 16% of the Baseline outflow. The CPEN direct use diversion represents approximately 3% of the overall water budget for Run 12. The FPUD direct use diversion occurs outside the actual model so was not calculated as a percentage of the model budget.

Table 16. Model Run 12 Groundwater and Surface Water Budget (Acre-Feet Per Year)

	Average Annual		Median Yield ED	BN	AN	VW
Inflow:						
Santa Margarita River Inflow	37,200	85%	6,700	13,000	28,500	115,400
Subsurface Underflow	900	2%	1,000	900	900	800
Lake O'Neill Spill and Release	1,500	3%	900	1,300	2,100	2,300
Fallbrook Creek	1,200	3%	100	300	1,100	3,500
Minor Tributary Drainages	2,400	5%	1,500	1,400	2,500	4,700
Areal Precipitation	800	2%	400	300	500	1,500
	44,000	100%				
Outflow:						
Santa Margarita River Outflow	26,600	60%	500	2,100	15,000	100,100
Subsurface Underflow	100	0%	100	100	100	100
Groundwater Pumping	12,100	27%	6,200	11,400	16,200	17,900
Evapotranspiration	2,100	5%	1,300	1,700	2,200	2,600
Diversions to Lake O'Neill	2,000	5%	1,300	1,700	2,700	2,700
CPEN Direct Use Diversion	1,200	3%	0	200	1,500	3,400
	44,100	100%				
Net Simulated Change of Groundwater in Storage:	-100	0%	-400	-700	100	800
FPUD Direct Use Diversion	900	900		100	200	400
Basin Yield Summary	*13,100*	*14,200*		*6,300*	*12,900*	*18,500*

Note: Values are rounded to the nearest 100 acre-feet. Percentages may not add up to 100% due to rounding.
The sum of median values does not reflect the change of groundwater in storage.

Comparison to Previous Results

The 2001 Permit 15000 Study identified the Santa Margarita River CUP median groundwater yield to be 14,100 acre-feet per year, relying only on the natural flow of the Santa Margarita River and augmentation from CWRMA releases. The

2006 Model Run 2 hydrologic and environmental constraints were similar to the 2001 Permit 15000 Study alternative since it included groundwater pumping from all three subbasins. The primary difference between the two runs was 2006 Model's use of the 50-year simulation period that necessitated the need to update the Dry-Year Management Scenario. In order to compare the groundwater yields of the 2006 groundwater modeling effort to that of the 2001 Study, table 17 is provided to compare the results during identical simulation periods.

Table 17. Comparison of Groundwater Yield to Previous Report (Acre-Feet Per Year)

Run		Simulation Period	Average Pumping	Median Pumping
Permit 15000	(2001 Dry Management Only)	1980-1999	13,400	14,100
Permit 15000	(2001 Dry Management) (2006 Wet Algorithm)	1980-1999	16,500	17,000
Run 2	(2006 Dry Management) (2006 Wet Algorithm)	1980-1999	15,900	17,200
Run 1	(2006 Dry Management) (2006 Wet Algorithm)	1980-1999	15,000	16,200
Run 1	(2006 Dry Management) (2006 Wet Algorithm)	1952-2001	11,100	11,300

The Dry-Year Management Scenario developed in the 2001 Study recommended a 3,000-acre-foot-per-year cutback in the second consecutive BN year and a 6,000-acre-foot-per-year cutback in the third consecutive and subsequent dry years. The impact to the average and median yield of each run was much less when compared to the 2006 Dry-Year Management Scenario that requires groundwater pumping curtailment during the first BN or ED year. While the 2006 Dry-Year Management Run requires up to 9,000-acre-feet-per-year reductions in groundwater pumping, there were no additional reductions in groundwater pumping beyond the 6,000 acre-feet per year in the 2001 Permit 15000 Study. Finally, the 2001 Permit 15000 Study did not consider a Wet-Year Algorithm to take advantage of the large flows that occur during hydrologically wet periods.

Table 17 indicates that average groundwater pumping has been reduced from 13,400 acre-feet per year in 2001 to 11,100 acre-feet per year in 2006. Comparing results from identical simulation periods (1980 to 1999), the actual results indicate that average groundwater yield has actually increased from 13,400 acre-feet per year to 15,000 acre-feet per year. Closer review of the data indicates that the Permit 15000 Study would have produced an average yield of 16,500 acre-feet per year if the 2006 Wet-Year Algorithm had been developed to take advantage of wet hydrological periods. The 2001 Permit 15000 Study included pumping in all three basins, identical to the 2006 Run 2 which also included the 2006 Dry-Year Management and 2006 Wet-Year Algorithm. Hence, the impact of adding the most recent Dry-Year Management Scenario reduces the yield of the project from 16,500 acre-feet per year to 15,900 acre-feet per during the 1980 to 1999 simulation period. Finally, the impact of pumping only from the Upper Ysidora and Chappo Subbasins can be shown in the results of 15,000 acre-feet per year for Run 1.

The final results indicate that the previously reported groundwater yield has been reduced from 13,400 acre-feet per year in 2001 to 11,100 acre-feet per year in this Technical Memorandum due to: (1) a 50-year simulation period and (2) pumping from two groundwater basins only. The 50-year simulation period included the seven-year drought from 1956 to 1961 that necessitated the need for a more draconian Dry-Year Management Scenario. Finally, the impact of reducing groundwater pumping from all three subbasins to only the Upper Ysidora and Chappo Subbasins resulted in a further reduction in groundwater yield. Based on the comparison of identical simulation periods, the actual yield of the Santa Margarita River CUP has increased from the 2001 Study due to the development of the Wet-Year Algorithm and improvements to the model's reliability.

CUP Reliability on CWRMA Emergency Flows

Except for Run 4, the Baseline and management model runs presented in TM 2.2 rely on water supplied by natural inflow that is augmented by CWRMA releases. While natural inflow to the model is affected by climatic conditions, and to a lesser extent upper basin urbanization, CWRMA releases may be affected by legal water right issues between Camp Pendleton and Rancho California Water District. One provision of the CWRMA allows for banking of water for "Emergency Flows" and its subsequent release to the Santa Margarita River during drought conditions. Stipulated within this provision are both the total amount of water that may be released over a 12-month period and the total amount of water that may be banked at any one time. The conditions which trigger the release of Emergency Flows are based on Camp Pendleton's command declaring emergency drought conditions. For the purpose of modeling the Baseline and management runs, Stetson Engineers assumed that emergency drought conditions would be called upon after 3 years of BN conditions.

A sensitivity of the reliability of CWRMA emergency flows was performed in order to estimate the impact to basin yield if a more conservative approach to providing CWRMA emergency flows at the Gorge were to occur (table 18). Named Runs 1A and 8A, two management runs were performed to estimate the impact of reduced emergency flows to Runs 1 and 8, respectively. The Baseline and management runs reflect four drought emergencies occurring over a period of

Table 18. Impacts to Runs 1 and 8 Due to Changes in CWRMA Emergency Flows (Acre-Feet Per Year)

	Average Annual			
	Run 1	Run 1A	Run 8	Run 8A
Inflow:				
Santa Margarita River Inflow	38,000	37,800	38,000	37,900
Subsurface Underflow	900	900	900	900
Lake O'Neill Spill and Release	1,500	1,500	1,500	1,500
Fallbrook Creek	1,200	1,200	1,200	1,200
Minor Tributary Drainages	2,400	2,400	2,400	2,400
Areal Precipitation	800	800	800	800
	44,800	44,600	44,800	44,700
Outflow:				
Santa Margarita River Outflow	29,100	29,100	28,200	28,200
Subsurface Underflow	100	100	100	100
Groundwater Pumping	11,100	11,100	11,000	11,000
Evapotranspiration	2,500	2,400	2,400	2,400
Diversions to Lake O'Neill	2,000	1,900	2,000	1,900
Diversion for Direct Use	n/a	n/a	1,200	1,200
	-100	44,800	44,600	44,900

Note: Values are rounded to the nearest 100 acre-feet.

50 years. The more conservative approach to Emergency Flow releases estimates that Camp Pendleton will declare only two drought emergencies over the same 50-year period.

While there is no impact to average annual basin yield over a 50-year period from only declaring two drought emergencies, evapotranspiration and diversion to Lake O'Neill are somewhat reduced. The average annual budget clearly shows that both inflow and outflow is reduced approximately 200 acre-feet per year, resulting in a total reduction of almost 10,000 acre-feet over a 50-year period. Sensitivity analysis of Camp Pendleton's call on CWRMA Emergency Flows indicates that there is no impact to average annual basin yield over a 50-year period.

Conclusions

A collaborative effort between Reclamation and Stetson Engineers was used to refine the groundwater model initially developed by Camp Pendleton in 2001. The formation of the Santa Margarita River CUP Technical Team in October 2005 provided a systematic approach to peer review for the development of analyses that objectively defined surface and groundwater availability for the Santa Margarita River CUP. The technical review provided refinements to inflow and outflow components of the groundwater model that was used to define the total basin yield from the Santa Margarita River Basin. In addition to peer review, field work performed during 2005 provided a refinement to aquifer properties that physically describe the occurrence and movement of groundwater through the Santa Margarita River Basin.

Consensus was reached among the technical team during 5 separate meetings and 23 conference calls. Environmental constraints that provided direction for achieving meaningful results from the groundwater model were also agreed upon with Reclamation's NEPA expert and their consultant. Documented in technical memoranda and conference call notes (Attachment B), the results of the groundwater model were achieved through consensus.

The Santa Margarita River CUP optimized groundwater yield by maximizing recharge to the aquifers located on Camp Pendleton when surface water was available during the winter time. Maximum recharge volume is attained by drawing down the groundwater levels prior to the winter storms and subsequent streamflow events. Surface water diverted through the proposed project facilities are managed to replenish aquifer storage using groundwater recharge ponds and streambed infiltration, while maintaining environmental demands throughout the riparian corridor. The facilities that have been proposed for the Santa Margarita River CUP have been sized to a capacity of 200 cfs to take full advantage of the variability in the occurrence and quantity of streamflow. Increasing available storage capacity in the groundwater aquifers prior to winter storm events allows the proposed Santa Margarita River CUP to increase total sustainable basin yield when compared to historical and Baseline water management practices.

The 2006 Model was calibrated using historical water level and groundwater pumping data which occurred during a 25-year simulation period between 1980 and 2004. Results from the Calibration run indicated that the 2006 Model matched the hydrological and seasonal variability that historically occurred in Camp Pendleton's aquifers. Another aspect of simulating historical data during the 1980 to 2004 period was to verify the conceptual model that was originally developed in 2001 and further refined during this most recent effort.

The Baseline was developed to establish future groundwater level and pumping volumes if no project were to occur. The development of the Baseline during the 50-year simulation period highlighted the need to develop a Dry-Year Management Scenario and Wet-Year Algorithm. The Dry-Year Management Scenario was developed to curtail pumping during dry hydrologic years in order to protect groundwater levels in the aquifer from being drawn down below historical levels. Under the proposed Dry-Year Management Scenario, groundwater pumping was reduced 4,000 acre-feet per year during the first BN year; 8,000 acre-feet per year during the second BN year; and 9,000 acre-feet per year during either the third BN or first ED year. The result of the Dry-Year

Management Scenario is reflected in the water level graphs that show future simulations do not decline below historical minima.

The Dry-Year Management Scenario also addressed the impact to basin yield due to the historical 7-year drought or an even longer hypothetical drought period. The Dry-Year Management Scenario was optimized to take advantage of natural streamflow of the Santa Margarita River and augmentation from CWRMA releases. One aspect of CWRMA releases included the ability of Camp Pendleton to call on a 5,000-acre-foot groundwater bank during periods of drought emergency. Without the ability to call on the 5,000-acre-foot groundwater bank during the model simulation, the Dry-Year Management Scenario would have required additional reductions in groundwater withdrawal. While not simulated during the development of the Baseline and management runs, it is likely that the total basin yield would decrease if a drought lasting longer then 7 years was included in the planning process. The development of a Dry-Year Management Scenario to address a drought lasting longer than 7 years was not addressed since it fell outside the scope of work. Sensitivity analysis addressing the reliability of CWRMA Emergency releases, not the quantity in any 1 year, showed that by reducing the number of drought emergencies declared by Camp Pendleton had de minimus effect on average annual basin yield over a 50-year simulation period.

The Wet-Year Algorithm provided an increase in annual groundwater pumping during consecutively wet hydrologic years. Based on the proposed Wet-Year Algorithm, groundwater pumping was increased 2,000 acre-feet per year during the second consecutive AN year and 4,000 acre-feet per year during the second consecutive VW hydrologic year. The increase in groundwater pumping during wet hydrologic conditions was based on multiple simulations of the 2006 Model and close examination of the results. Conclusions reached from these wet-year optimization runs were that the aquifer in the Upper Ysidora Subbasin required at least 1 AN or greater hydrologic year to recover from a prolonged dry period, while the Chappo Subbasin required 2 consecutive AN or greater hydrologic years to recover from a similar dry period. These results provided for the development of the Wet-Year Algorithm that allows the Santa Margarita River CUP to take advantage of hydrologically wet years without jeopardizing the yield of the project during drier hydrologic conditions.

Results of Runs 1 through 12 are shown in the summary of average and median annual surface water and groundwater budgets (table 19A and 19B). Both the average and median groundwater pumping from each run are presented to identify the impact of different management scenarios. Review of the average annual water budget indicates that groundwater pumping and Santa Margarita River outflow vary greatly among the different runs. Run 12 simulated the greatest total

Table 19A. Average Annual Water Budgets; Baseline and Runs 1 to 12 (Acre-Feet Per Year)

	Baseline	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6R	Run 7	Run 8	Run 9	Run 10	Run 11	Run 12
Inflow:													
Santa Margarita River Inflow	38,000	38,000	38,000	38,000	34,900	38,000	34,600	37,900	38,000	38,000	38,000	37,100	37,200
Subsurface Underflow	900	900	900	900	1000	900	900	900	900	900	900	900	900
Lake O'Neill Spill & Release	1,500	1,500	1,500	1,500	1,000	1,500	1,200	1,500	1,500	1,500	1,400	1,500	1,500
Fallbrook Creek	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Title 22 Water						1,800							
Minor Tributary Drainages	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400
Areal Precipitation	800	800	800	800	800	800	800	800	800	800	800	800	800
	44,800	44,800	44,800	44,800	41,300	46,600	41,100	44,700	44,800	44,800	44,700	43,900	44,000
Outflow:													
Santa Margarita River Outflow	32,600	29,100	28,800	28,400	28,300	30,000	26,800	28,400	28,200	28,800	29,300	27,300	26,600
Subsurface Underflow	100	100	100	100	100	100	100	100	100	100	100	100	100
Groundwater Pumping	7,300	11,100	11,700	12,100	9,300	11,900	10,400	12,100	11,000	11,700	11,100	11,000	12,100
Evapotranspiration	2,800	2,500	2,300	2,300	2,300	2,600	2,200	2,300	2,400	2,300	2,400	2,400	2,100
Lake O'Neill Diversion	2,000	2,000	2,000	2,000	1,300	2,000	1,700	1,900	2,000	2,000	1,900	2,000	2,000
CPEN Direct Diversion									1,200			1,200	1,200
	44,800	44,800	44,900	44,900	41,300	46,600	41,200	44,800	44,900	44,900	44,800	44,000	44,100
Net Simulated Change of Groundwater in Storage:	0	0	-100	-100	0	0	-100	-100	-100	-100	-100	-100	-100
FPUD Direct Use Diversion							3,400					900	900
Basin Yield Summary	***7,300***	***11,100***	***11,700***	***12,100***	***9,300***	***11,900***	***13,800***	***12,100***	***12,200***	***11,700***	***11,100***	***13,100***	***14,200***

Notes: Run 10 Summary values represent 9-cfs bypass which includes up to a 3-cfs bypass until the Lake O'Neill and 4,000-acre-foot licenses are met, then up to a 9-cfs bypass thereafter.

Table 19B. Median Annual Water Budgets; Baseline and Runs 1 to 12 (Acre-Feet Per Year)

	Baseline	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6R	Run 7	Run 8	Run 9	Run 10	Run 11	Run 12
Inflow:													
Santa Margarita River Inflow	16,000	16,000	16,000	16,000	12,700	16,000	13,100	16,100	16,000	16,000	16,000	15,800	16,400
Subsurface Underflow	900	900	900	900	900	900	900	900	900	900	900	900	900
Lake O'Neill Spill & Release	1,500	1,500	1,500	1,500	800	1,500	1,200	1,500	1,500	1,500	1,200	1,500	1,500
Fallbrook Creek	600	600	600	600	600	600	600	600	600	600	600	600	600
Title 22 Water						1,800							
Minor Tributary Drainages	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
Areal Precipitation	500	500	500	500	500	500	500	500	500	500	500	500	500
Outflow:													
Santa Margarita River Outflow	8,500	6,500	6,000	5,500	3,800	7,600	5,400	4,800	6,200	6,100	6,800	6,000	4,800
Subsurface Underflow	100	100	100	100	100	100	100	100	100	100	100	100	100
Groundwater Pumping	8,300	11,300	11,700	12,100	9,300	12,300	10,400	12,200	11,000	11,300	10,900	11,000	12,200
Evapotranspiration	2,900	2,500	2,300	2,300	2,400	2,500	2,000	2,300	2,300	2,300	2,400	2,300	2,100
Lake O'Neill Diversion	2,200	2,200	2,200	2,200	1,300	2,200	1,700	2,100	2,100	2,200	1,800	2,100	2.100
CPEN Direct Diversion									900			900	900
Net Simulated Change of Groundwater in Storage:	100	-100	-100	-100	0	-100	200	300	100	-100	-100	100	200
FPUD Direct Use Diversion							2,800					300	300
Basin Yield Summary	***8,300***	***11,300***	***11,700***	***12,100***	***9,300***	***13,200***	***12,700***	***12,200***	***12,200***	***11,700***	***11,100***	***12,600***	***13,500***

Notes: Run 10 Summary values represent 9-cfs bypass which includes up to a 3-cfs bypass until the Lake O'Neill and 4,000-acre-foot licenses are met, then up to a 9-cfs bypass thereafter.
The sum of median values does not reflect the change of ground water in storage.

basin yield when diversion for both direct use and storage are accounted for in the operational parameters. Run 12's total diversion for direct use at both the Fallbrook Sump and on Camp Pendleton resulted in the least amount of Santa Margarita River outflow. Model Run 5 which includes the addition of Title 22 water has both increased groundwater pumping and increased Santa Margarita River outflow. Although numerical modeling tends to focus attention on total surface and groundwater production, changes in other components of the water budget provide insight to the physical reaction of the basin. When compared to Baseline conditions, all management runs simulated less streamflow out of the model boundary to the estuary and greater groundwater pumping from the aquifers.

Table 19B provides a summary of the median annual surface water and groundwater budget for the Baseline and 12 model runs. While many of the same conclusions may be reached as to the impact of each management scenario as that identified from average annual values, the median budget presents the value that is expected to occur 50% of the time during the simulation period. For example, the Baseline indicates that the median Santa Margarita River outflow to the estuary was simulated to be 8,500 acre-feet per year, but was reduced to 5,400 acre-feet per year during the same 50-year hydrologic period, under the proposed FPUD Sump diversion operations simulated in Run 6R. Similar comparisons regarding other surface water and groundwater components may be drawn from this table.

During January of VW hydrologic conditions, the maximum monthly instantaneous groundwater production rate was computed to be 37 cfs, 38 cfs, 39 cfs, 31 cfs, and 37 cfs for Runs 1 through 5, respectively (Attachment B – June 27 Memorandum). Run 6R maximum monthly instantaneous groundwater flow rate also occurred in January and was computed to be 30 cfs, not including the 25-cfs direct use diversion located at the FPUD Sump. Run 12 yielded the maximum instantaneous groundwater production rate of 40 cfs. The combined average annual groundwater production and direct use diversion for Run 12 was simulated to be 14,200 acre-feet per year with a maximum monthly total direct use diversion rate of 55 cfs occurring during January of consecutive VW hydrologic years.

Model Run 7 investigated the impact of the Dry-Year Management Scenario that was developed in order to mitigate adverse water level declines during drought conditions. Because all modeling decisions were based on developing a project that would protect against unknown future hydrologic conditions, the Dry-Year Management Scenario required draconian cut back measures during the first and second BN hydrologic years. Model Run 7 showed that average annual groundwater pumping could increase by 1,000 acre-feet per year, if an additional supply of water was available to mitigate against the worst case drought scenario which only occurs once out of every 81 years.

Figures 4A and 4B present the groundwater yield as a percent time exceedance for the Baseline and each of the 12 management runs. These figures and the supporting tables in the appendices, provided occurrence intervals that may be used by economists, planners, or engineers to determine the appropriate yield for the final design the Santa Margarita River CUP. Introduced in table ES-1, the minimum and maximum median annual yield provides a likely range that should be considered during the planning process. The minimum median annual value is based on the median groundwater pumping during ED conditions, while the maximum median value is derived from the median groundwater pumping during VW hydrologic conditions. Review of TM 1.0 and the attachments to TM 2.2 indicate that ED groundwater production, or a value greater, will be achieved 76% of the time while VW groundwater pumping, or some quantity greater, will occur 19% of the time.

Recommendations

Execution of the Calibration, Baseline, and 12 management model runs provided valuable information and results for completing the feasibility study and environmental impact statement/environmental impact report that will support the engineering and environmental analysis of the Santa Margarita River CUP. The results presented in TM 2.2 provide a comprehensive analysis of potential management scenarios that may be used to improve the design of the Santa Margarita River CUP. While additional model runs will always provide useful information, Stetson Engineers recommends that economic factors addressing the incremental capital and annual operating costs associated with each operational parameter should be developed and incorporated in the development of future model runs. Given the existing hydrologic and environmental constraints, the 12 management scenarios that were investigated during the course of this study provide excellent results for completing the other supporting studies during the development of the Santa Margarita River CUP.

Future decisions that require economic input include the need to investigate water development from the Lower Ysidora Subbasin, removal of environmental constraints, treatment of VOC contaminated groundwater, installation of low-utilized groundwater wells, development of an additional water supply for drought relief, and the inclusion of diversions for direct use. The capital and 50-year operation and maintenance costs for each operational parameter may be calculated based on the data presented in TM 2.2. Although total yield of each operational parameter is sometimes the limiting factor, decision makers should also incorporate each parameter’s dry-year reliability. The incremental value of water available during ED and BN hydrologic conditions is greater than the incremental value of the same quantity of water during AN and VW years. As an example, removing environmental constraints to groundwater pumping may provide a greater increase in basin yield during dry years then the installation of

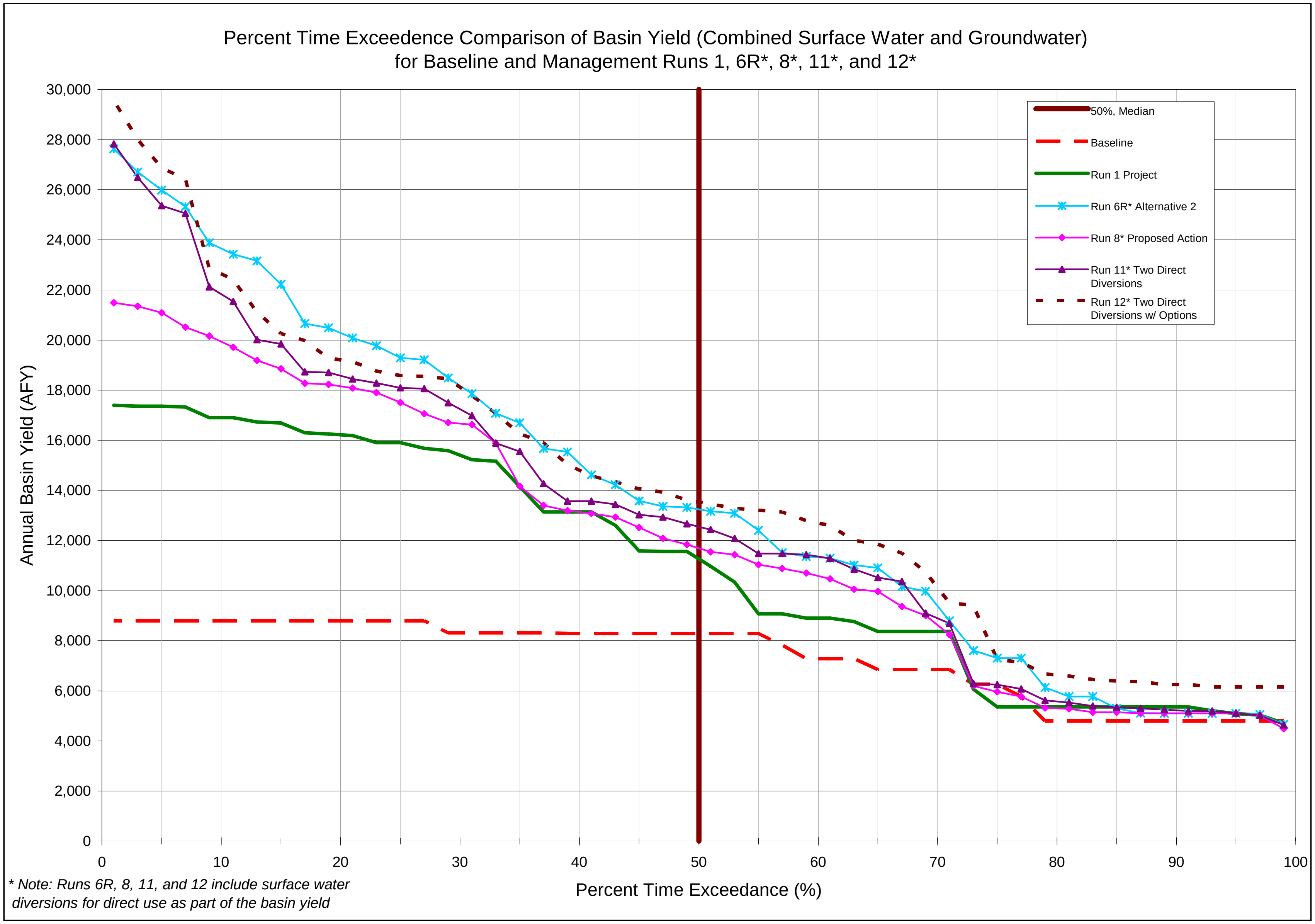

Figure 4A. Percent Time Exceedance Comparison of Basin Yield for Baseline and Management Runs 1, 6R, 8, 11, and 12.

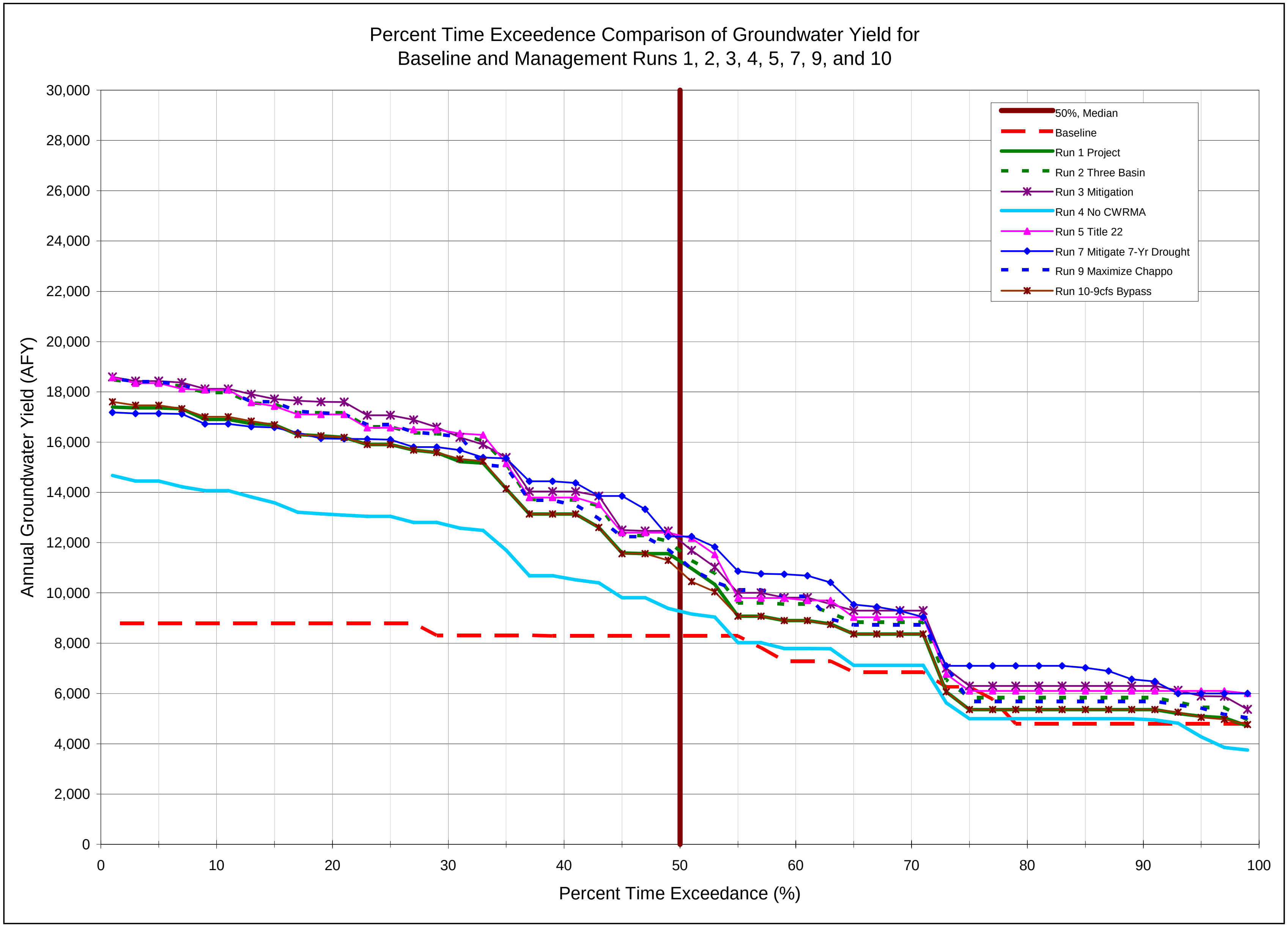

Figure 4B. Percent Time Exceedance Comparison of Basin Yield for Baseline and Management Runs 1, 2, 3, 4, 5, 7, 9, and 10.

low-utilized groundwater wells that provide water during VW conditions. Because there is an economic value to both an increase in production of groundwater during drought conditions and the sale of excess water, cost/benefit analyses using the statistical information in this report will supply the necessary information for drafting the optimal project.

Decisions for future model runs should also incorporate the cost of mitigation and environmental concerns, if any, in order to determine the total yield from the Santa Margarita River Basin. The 2006 Model provides monthly data that identifies each run's surface water outflow from the model boundary and changes in riparian water use, as compared to Baseline conditions. Surface water outflow from the model boundary is intended to simulate the Santa Margarita River as it flows to the estuary, while changes in riparian water use within the boundary are intended to simulate the overall condition of riparian vegetation. The environmental factors associated with each operational parameter, assumed to be included in the economic analysis, will provide the necessary data required by decisionmakers to identify future model runs.

Other recommendations listed in detail below include the need to develop an adaptive management methodology and identify diversions based on available water rights. Figure 5 depicts a flow chart for identifying the annual quantity of water that may be pumped given the various hydrologic conditions. The flowchart could be expanded to quantify triggers, thresholds, and action items that could be followed to optimize the yield from each basin without impact to the environment. During the development of the 12 management runs discussed throughout this technical memorandum, attempts were made to refine the adaptive management flow chart to include both climatological and water level data on both an annual and monthly time period. The attempts to complete a monthly flowchart for making management decisions to optimize groundwater production were found to require additional model runs that fell outside the scope of the work.

TM 2.2 only addressed the total surface water and groundwater yield from the Santa Margarita River Basin, not the incremental yield associated with a new Santa Margarita River CUP. Diversion quantities, types of storage, types of use, places of use, and other pertinent technical data required to legally support diversion of water should be addressed for all existing perfected and unperfected water rights held by the parties. A water rights analysis will provide the data necessary to determine if the proposed Santa Margarita River CUP may be operated under existing water rights or whether new water rights should be applied for from the State of California. Finally, a water rights analysis will direct decision makers to focus future modeling efforts so that they support existing water rights and address all legal issues identified in *United States* v. *Fallbrook PUD*.

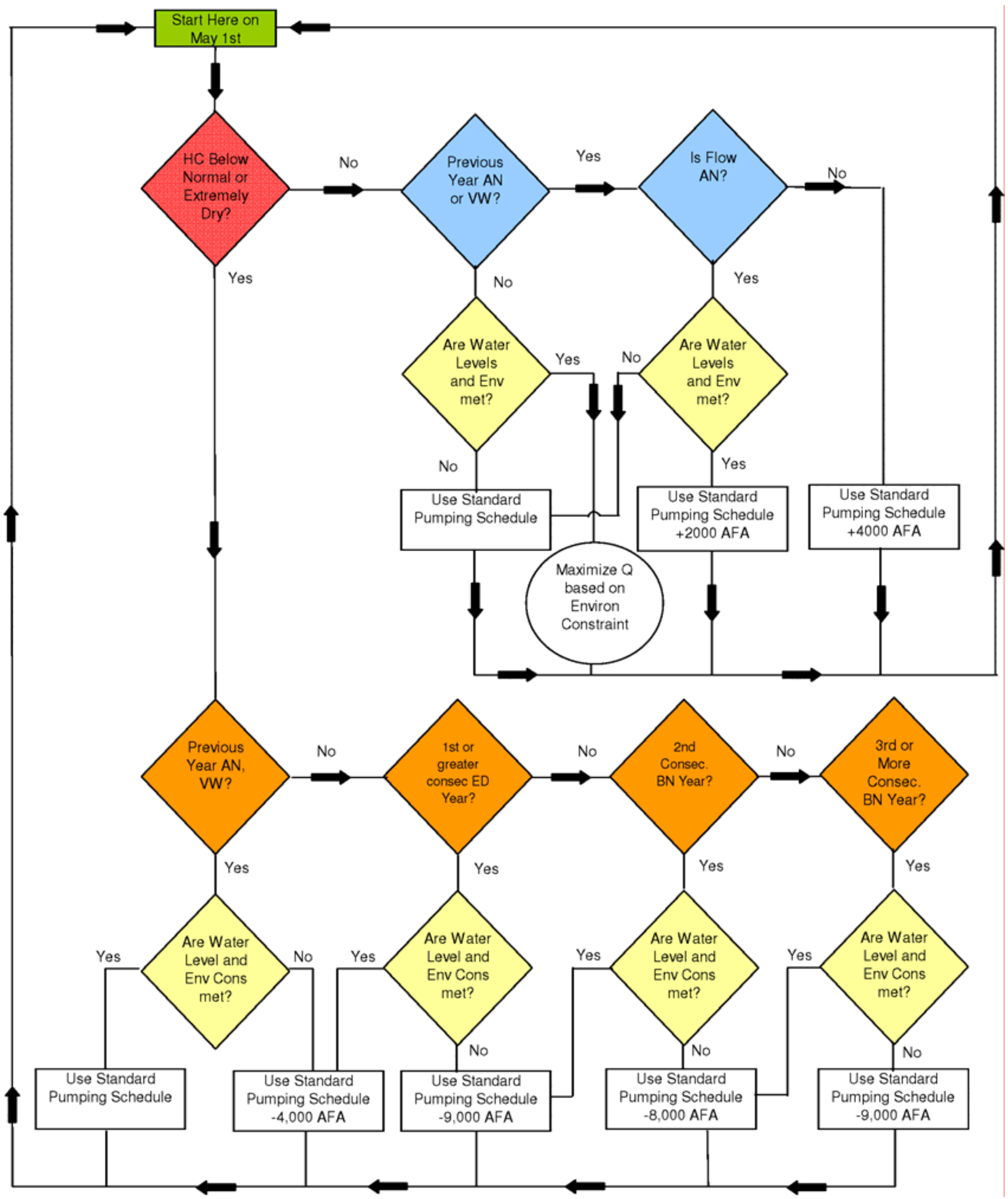

Figure 5. Adaptive Management Decision Tree for Optimizing Groundwater Pumping.

A summary of the recommendations is provided in the following list.

1. Initiate Economic Analysis: An economic analysis should be initiated to identify the capital and 50-year operation and maintenance cost of each operational parameter. Both quantity and reliability of available water during dry years and wet years should be addressed in the analysis. The Metropolitan Water District of Southern California and San Diego County Water Authority water costs during wet years and drought years, including possible dry-year reductions in quantity, would provide a benchmark for similar costs in the Camp Pendleton area. Environmental costs, if any, should also be included to identify the true value of each operational parameter. The results from this analysis may then be used to focus future modeling efforts to produce total basin yield results for a comprehensive project.

2. Identify Water Rights Used: Existing and/or future water rights that have been exercised to optimize the Santa Margarita River Basin yield should be clearly identified. This task will result in the assignment of groundwater and surface water diversions to the appropriate water right and whether or not new water rights are required to maximize the yield form the Santa Margarita River Basin. The method, type, and period of diversion, as well as other requirements of the State Water Resources Control Board, should be clearly identified and quantified for each management scenario.

3. Adaptive Management Plan: Stetson Engineers recommends that an Adaptive Management Plan (AMP) should be developed so that the yield of the Santa Margarita River CUP may be optimized while protecting environmental concerns. This task would include the development of a monthly flow chart that includes triggers, thresholds, and action items based on existing and new model runs.

4. Recommended Model Run: Perform a sensitivity analysis of the 200-cfs diversion structure to characterize the yield resulting from changes in the design capacity of project facilities. Results from Model Run 10 indicated that the total basin yield is not sensitive to changing diversion bypass between 1 cfs and 9 cfs.

Results of the 12 management scenarios indicated that the CUP would greatly benefit from adaptive management of both physical and environmental factors. For example, Run 7 indicates that development of an additional supply of water may be used to mitigate water level declines caused by a 7-year drought that would allow average annual groundwater yield to increase by 1,000 acre-feet per year. Run 10 demonstrated that basin yield was not sensitive to diversion bypass flows within the 1-cfs to 9-cfs range. Run 9 suggests that basin yield may increase by approximately 600 acre-feet per year if well head treatment, or other suitable means of remediation, is adopted in the 22/23 Area of the Chappo Subbasin.

The development of Runs 11 and 12 indicate that multiple operational parameters may be combined in order to increase the total yield from the Santa Margarita River Basin. Based on average annual values, the groundwater production could potentially increase by 4,800 acre-feet per year; and surface water direct use may increase by 2,100 acre-feet per year, when compared to baseline conditions. Run 12 total average annual basin yield was estimated to be 14,200 acre-feet per year, 6,900 acre-feet per year greater than Baseline conditions. Completion of economic, environmental, and water rights analyses will show that that the total average annual basin yield may either increase or decrease based on those studies' conclusions and recommendations.

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