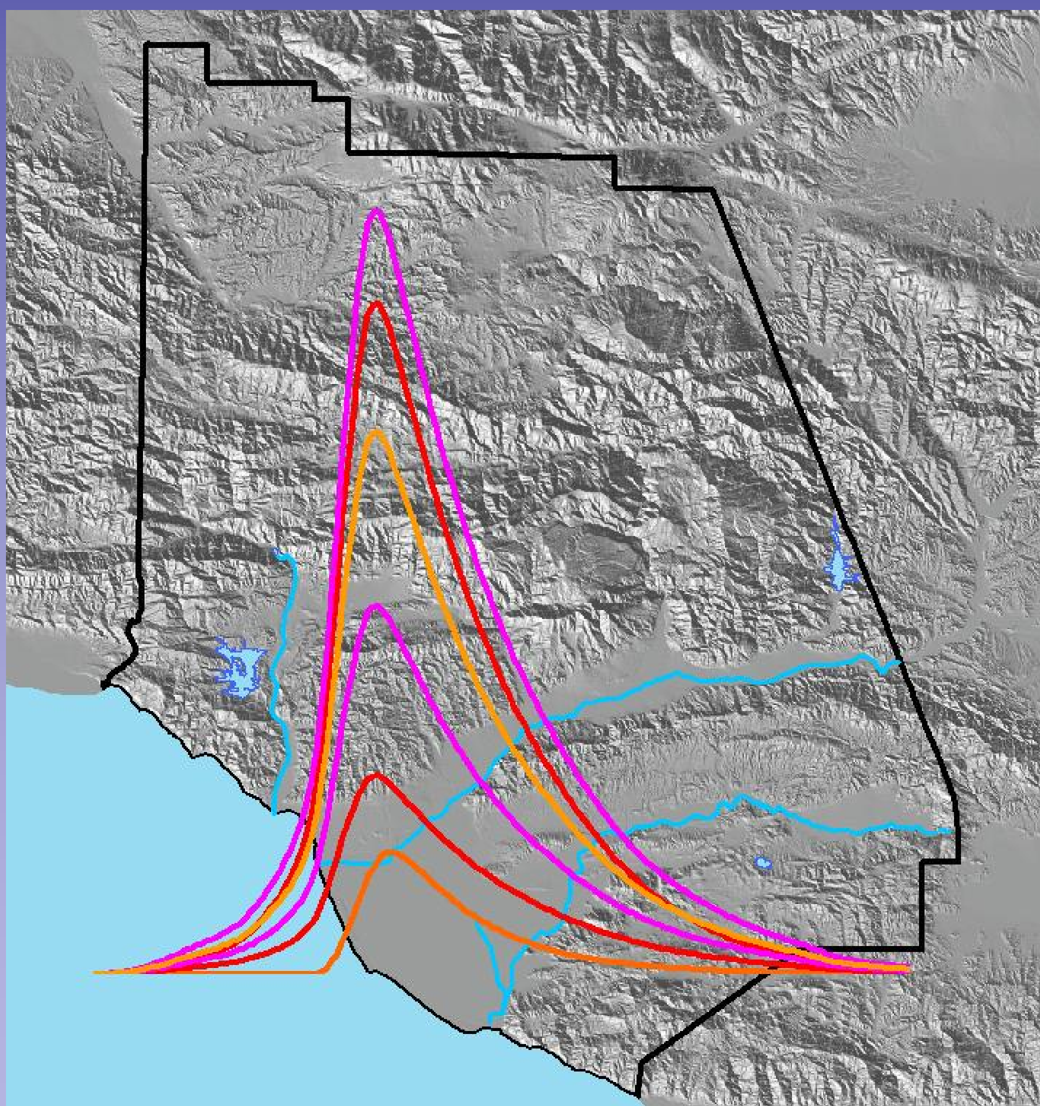
CALLEGUAS CREEK WATERSHED
HSPF MODEL CALIBRATION
DRAFT REPORT



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Hydrology Section
Watershed Resources and Technology Division
Ventura County Watershed Protection District

Ventura County

Watershed Protection District

Hydrology Section

Project 15042

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EXECUTIVE SUMMARY

This report documents the work done by the Hydrology Section of the Ventura County Watershed Protection District (District) in calibrating the Calleguas Creek Continuous HSPF Model (Aqua Terra 2005). The model has been used to evaluate historical runoff, TMDLs, and stream channel stability in the watershed. It is planned to be used for long term simulations of historical runoff, to evaluate the effects of detention in the watershed, and for design storm peaks.

The model was created by Aqua Terra in 2003 by extending a pilot study model for the City of Simi Valley to cover the entire watershed. The Pilot Study model simulated the runoff from the period 1977 through 2000. Because the hydrologic data from the rest of the watershed was not as robust, the extended model only simulated the period from 1987 through 2002. The model was then extended by Larry Walker and Associates (LWA) for their TMDL work for the Calleguas Watershed Management Plan to cover the period through calendar year 1994. Most recently, LWA added hydrologic data to extend the model through Water Year (WY) 2009.

LWA also changed the timestep of the model from 1-hr to 15-min so the small watershed runoff peaks from major storms could be adequately characterized. This led to a number of problems with the model that had to be repaired before it would run. One problem was daily total values for rainfall being present in the 15-min string causing the model to crash due to excessive runoff during that timestep. The stage-storage-discharge data used to control the channel routing in the model also had to be extended in some cases so that the model could route the 15-minute runoff correctly.

The calibration consisted of starting at the most upstream gage in the Arroyo Simi watershed and adjusting some of the parameters to better match total volumes, winter runoff, summer runoff, and individual storm peaks and hydrograph recession limbs. The results improved the match to the observed data for most of the gages except where improvements to the matches for an upstream gage worsened the matches at the downstream gages. It is expected that the calibration will improve the results when the model is used to obtain design storm peaks in the watershed.

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TABLE OF CONTENTS

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1. INTRODUCTION

This report documents the work done by the Hydrology Section of the Ventura County Watershed Protection District (District) in calibrating the Calleguas Creek Continuous HSPF Model (Aqua Terra 2005). The model has been used to evaluate historical runoff, TMDLs, and stream channel stability in the watershed. It is planned to be used for long term simulations of historical runoff, to evaluate the effects of detention in the watershed, and to provide design storm peaks for floodplain mapping.

The model was created by Aqua Terra in 2003 with by extending a pilot study model covering the City of Simi Valley to include the entire watershed as shown in Figure 1. The Pilot Study model simulated the runoff from the period 1977 through 2000. Because the hydrologic data from the rest of the watershed was not as robust, the extended model only simulated the period from 1987 through 2002. The model was then extended by Larry Walker and Associates (LWA) for their TMDL work for the Calleguas Watershed Management Plan to cover the period through calendar year 1994. Most recently, LWA was hired by the District to extend the model through Water Year 2009.

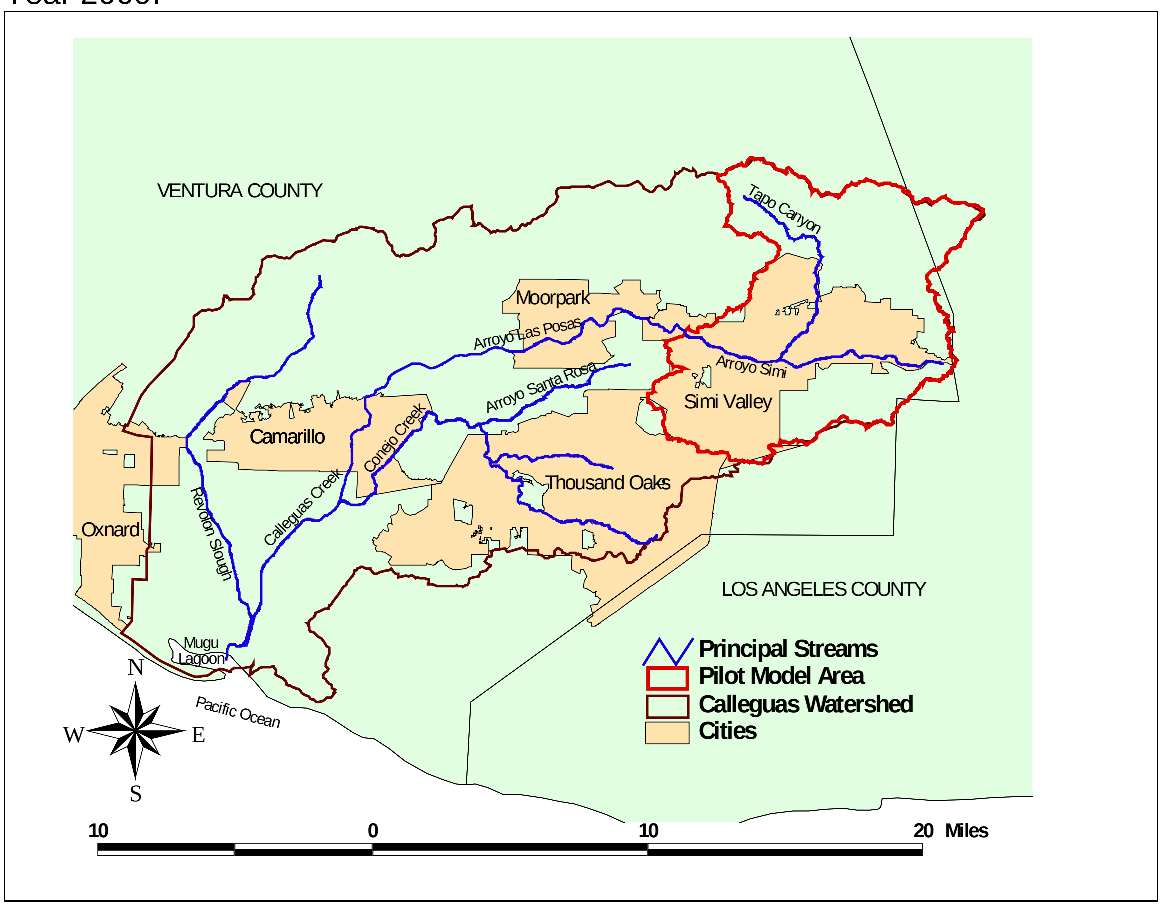

Figure 1 – Calleguas Creek Watershed Location, Municipalities, and Major Waterbodies (Aqua Terra, 2005)

The updated model as delivered by LWA showed a number of problems with the historic data sets. It also needed recalibrating for the new purpose of matching historic peaks and then providing design storm peaks and evaluating detention effects in the urban areas. It is this calibration effort that is described in this report.

2. BASELINE HSPF MODEL

The original Calleguas Creek HSPF Model (Aqua Terra, 2005) used an hourly timestep because its intended use for water quality simulations did not require matching instantaneous storm peaks but instead was primarily required to match total storm runoff volumes. However, in order to be used for additional studies to provide design storm peaks and evaluate detention effects, it is necessary to use a smaller timestep. This will provide better matches to historic peaks in the watershed, especially for small watersheds with small times of concentration.

Therefore, as LWA extended the model to run through Water Year 2009, they converted the model to provide results using a 15-min timestep. The 15-minute model had difficulty running because the input 15-min rain data sets in some cases did not have a full 15-min rain distribution. It is the practice of the District hydrographers to estimate the 15-min rain data from adjacent gages for periods where the data are missing. However, in some cases the estimate consists of a daily value inserted at 8:00 am which is the conventional end of the daily measurement period for District rain gages. In the hourly model, the daily rain estimate did not cause the model to crash. In the 15-min model, however, the model subareas subjected to this large rain value yielded runoff exceeding the limits of the stage-storage-discharge (Elev-Vol-Q) data used for channel routing and causing the model to crash.

The repairs to the model included searching the input rain data strings for these daily values and replacing them with rain data obtained from a nearby gage. The Elev-Vol-Q data were also extrapolated from the original data sets so that the channel routing could be done correctly with any increased flow observed in the 15-min model.

3. HSPF MODEL CALIBRATION

Because the HSPF model has a number of parameters controlling the amount of runoff as shown in Figure 2, it can be complicated to calibrate by hand. The HSPEXP program was developed by the USGS in 1996 to solve this problem. This program first looks at annual and daily flows and volumes and suggests parameters to alter the model to bring them into balance. It then looks at wet and dry season flows and individual storms to make sure that the volumes and flows and recession limbs are matched. If they are not, it suggests other parameters to alter to improve the match.

One problem with HSPEXP is that it does not provide guidance on the magnitude of the required change, so it is still necessary to use considerable engineering judgment in calibrating the model. A bigger problem is presented by the fact that the 1996 program is so old it would not run on the District's computers obtained in 2006.

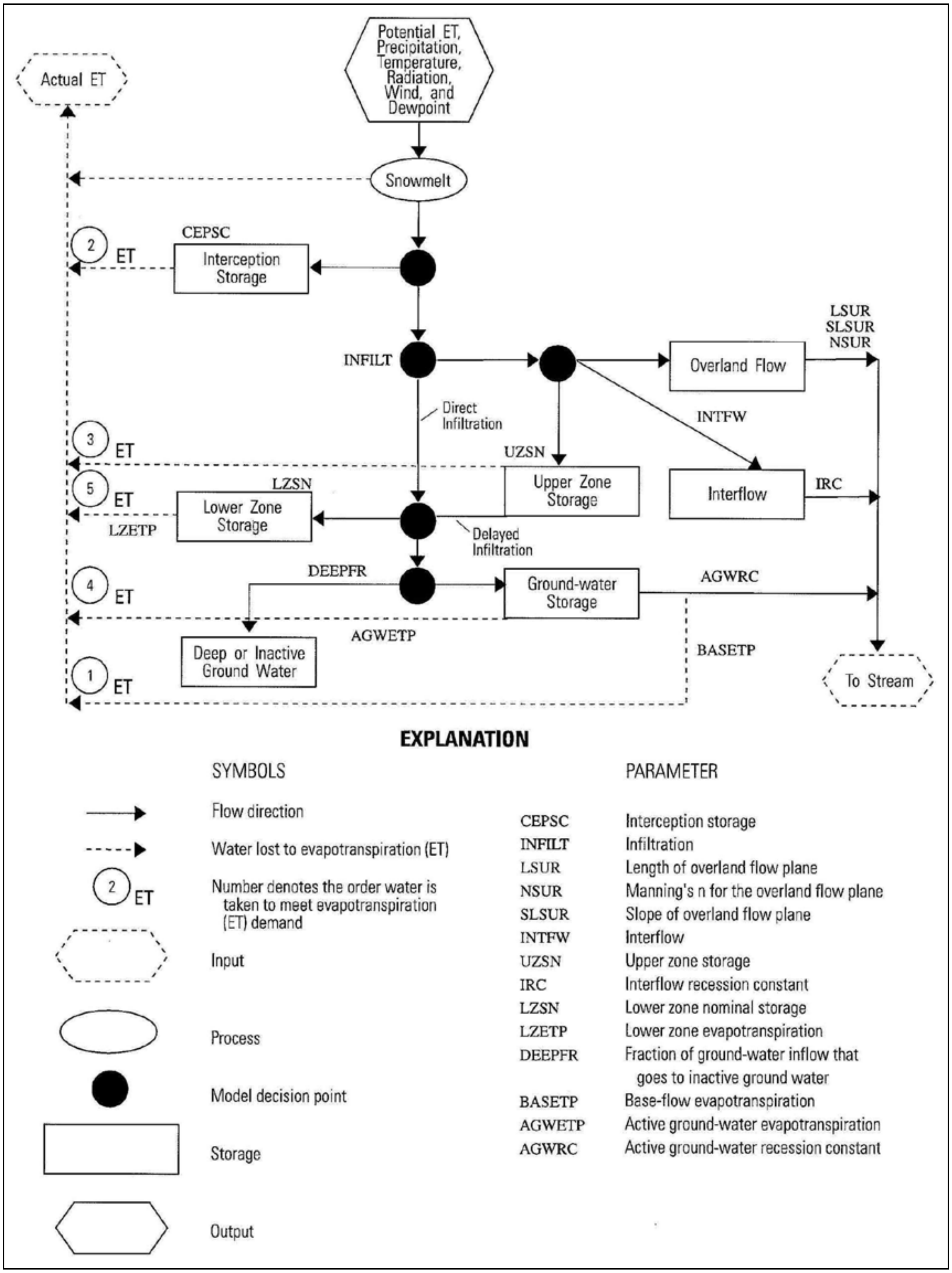

Figure 2 – HSPF Parameters and Conceptual Model of Flow

Another alternative to calibrating the model is to use the generic UCODE program. Based on web searches, it appears that this program was developed for primarily for calibrating groundwater models. However, it is a generic calibration code that can be adapted to calibrate almost any type of hydrologic model. It was previously used by

LWA on a small District project on the Bus Canyon Tributary to the Arroyo Simi. It is time-consuming to set up as you have to tell it where the input parameters are located in the input files, the allowable range for each parameter, and how to compare the input and output flow time series. However, once it is running it will automatically do simulations to test the sensitivity of the parameters that are allowed to vary and select a reasonable set of parameters that provide the best calibration. The District is planning on using UCODE to improve the calibration of the model in the future.

3.1. Current Model Calibration

Because HSPEXP would not run on the District's computers, and because UCODE was not set up to calibrate the full model, this calibration was done manually. The manual calibration was done by setting up spreadsheets to evaluate the following comparisons as used in the HSPEXP program:

1. Compare the sum of the daily runoff volumes over the simulation period from the observed and simulated data sets.
2. Compare the average of the top 10% of the daily runoff flows from the observed and simulated data sets.
3. Compare the average of the lowest 50% of the daily runoff flows from the observed and simulated data sets.
4. Evaluate the recession constants for the top 30% of the highest daily flows for the observed and simulated data sets.
5. Compare the runoff volumes for the main wet (Dec-Feb) season and dry (Jun-Aug) season between the observed and simulated data sets.
6. Compare the maximum annual peaks from the observed and simulated 15-min data.
7. Visually compare the storm hydrographs from major storms for the observed and simulated 15-min data sets.

The steps for the calibration included the following:

1. Start with the most upstream gage in the watershed.
2. Identify the reaches and HSPF perlnds and implnds connected to those reaches.
3. Evaluate the parameter sets assigned to the perlnds and impnds to see if previous calibrations have yielded results that are inconsistent with parameters assigned to adjacent subareas.
4. Adjust the volume of runoff by changing the amount of infiltrated water that is assigned to inactive groundwater (parameter DEEPFR) and lower zone storage (LZSN).
5. To better match storm peaks, change infiltration and perhaps the upper zone and interflow storage (UZSN and INTFC) to increase or retard how fast runoff occurs.
6. If the recession limb of the hydrograph is not well-matched, adjust the interflow and active groundwater recession exponents (IRC and AGWRC).

3.1.1 Groundwater Effects on Water Budget

In the original calibration of the HSPF model Aqua Terra found it necessary to simulate losing and gaining stream reaches in order to account for groundwater effects correctly. Therefore, in their model setup, the upstream reaches of the Arroyo Simi watershed were designed to pass 50% of the infiltrated groundwater down to the reach incorporating the Royal stream gage. This was also done for upstream reaches of the Beardsley gage in the Revolon subwatershed.

3.2. Calibration ResultsSummary

The long term gage locations evaluated in this calibration effort is shown in Figure 3. A summary of the baseline and calibration results using the metrics from HSPEXP discussed above for each long record gage location in the model is provided in Table 1. Table 2 shows the calibration results for two short record gages in the upper Arroyo Simi watershed.

At the most downstream gage, Calleguas CSUCI, the model underpredicts the gage volume by about 4%, or about 36,000 ac-ft. The wet season volume is underpredicted by about 5%, and the dry season volume is overpredicted by about 12%. The calibration improved the match to the volume over the baseline model performance as delivered by Aqua Terra. Similar results were obtained from the two major tributaries of the Calleguas, Conejo Creek and Revolon Slough. The Conejo calibration in particular was very good, matching the total and winter volumes to within 2.9% or less and almost exactly matching the summer volume. The Revolon calibration overpredicted the summer volume indicating the difficulting of setting the model parameters to accurately simulate groundwater baseflow conditions in the watersheds.

Short term gages in the Upper Arroyo Simi (Above White Oak and Stow, Table 2) overpredict the volumes from WY03 through WY09. However, at the downstream Royal gage, the long term volumes are significantly underpredicted by the model (about 31%). At the downstream Madera gage, however, the volumes are matched to within 1% for the total and winter volumes and to within 6% for the summer volumes. It was not possible to get better calibrations at the upstream gages without affecting the good results for the Madera gages or generating unreasonable parameter sets. It is possible that the rain gage distribution is not good enough to adequately characterize the rainfall in the upper watershed.

The gages downstream from Madera, Arroyo Las Posas at Hitch and Calleguas at Hwy 101, match the gage volumes to within about 5%. The summer volumes for the Hitch gage are also matched to within less than 5%, while there is almost no summer flow (0.05% of the total) at the Hwy101 gage to provide a meaningful comparison.

Table 1. Calibration Results Summary – Long Term Gages

	CALIBRATED				BASELINE			
	Observed	Simulated	% Diff.	Diff.	Observed	Simulated	% Diff.	Diff.
Royal WY88-05 #802								
Total Vol af	86,973	59,726	31.3%	27,247	86,973	60,557	30.4%	26,415
Winter Vol Dec-Feb af	67,394	47,904	28.9%	19,490	67,394	48,579	27.9%	18,815
Summer Vol Jun-Aug af	115	51	55.9%	64	115	47	59.2%	68
Days with Recession	524	622	NA	NA	525	645	NA	NA
Mean Recess. Top 30% cfs	0.509	0.269	47.2%	0.240	0.509	0.289	43.3%	0.2203
Mean Flow-Lower 50% cfs	0.00	0.00	0.0%	-	0.00	0.00	0.0%	-
Mean Flow-Top 10% cfs	66.22	45.53	31.2%	20.69	66.22	46.14	30.3%	20.08
Madera WY88-09 #803								
Total Vol af	268,074	270,409	-0.9%	(2,335)	268,074	251,055	6.3%	17,019
Winter Vol Dec-Feb af	153,539	154,726	-0.8%	(1,187)	153,539	139,838	8.9%	13,700
Summer Vol Jun-Aug af	23,349	24,628	-5.5%	(1,279)	23,349	24,747	-6.0%	(1,398)
Days with Recession	2,827	3,346	NA	NA	2,827	3,302	NA	NA
Mean Recess. Top 30% cfs	0.694	0.804	- 15.9%	(0.110)	0.694	0.804	-15.8%	(0.1096)
Mean Flow-Lower 50% cfs	4.91	4.32	12.1%	0.60	4.91	4.31	12.4%	0.6075
Mean Flow-Top 10% cfs	112.50	116.52	-3.6%	(4.02)	112.50	105.16	6.5%	7.35
Arroyo Las Posas-WY91-09 #841								
Total Vol af	487,298	507,543	-4.2%	(20,246)	487,298	498,691	-2.3%	(11,394)
Winter Vol Dec-Feb af	265,583	267,808	-0.8%	(2,225)	265,583	269,212	-1.4%	(3,628)
Summer Vol Jun-Aug af	49,985	52,382	-4.8%	(2,397)	49,985	50,790	-1.6%	(805)
Days with Recession	2,275	3,796	NA	NA	2,275	3,753	NA	NA
Mean Recess. Top 30% cfs	0.702	0.795	- 13.4%	(0.094)	0.702	0.788	-12.4%	(0.087)
Mean Flow-Lower 50% cfs	12.15	12.43	-2.3%	(0.28)	12.15	12.19	-0.4%	(0.05)
Mean Flow-Top 10% cfs	211.63	225.80	-6.7%	(14.17)	212.68	226.74	-6.6%	(14.06)
Calleguas Ck-Hwy 101 WY88-07 #806								
Total Vol af	286,400	275,048	4.0%	11,352	286,400	259,444	9.4%	26,956
Winter Vol Dec-Feb af	230,377	218,390	5.2%	11,987	230,377	209,078	9.2%	21,300
Summer Vol Jun-Aug af	141	33	76.7%	108	141	19	86.4%	122
Days with Recession	423	732	NA	NA	423	614	NA	NA
Mean Recess. Top 30% cfs	0.348	0.401	- 15.1%	(0.053)	0.348	0.332	4.6%	0.016
Mean Flow-Lower 50% cfs	0.00	0.00	0.0%	-	0.00	0.00	0.0%	-
Mean Flow-Top 10% cfs	195.65	187.78	4.0%	7.88	195.65	177.22	9.4%	18.44

Table 1. Continued.

	CALIBRATED				BASELINE			
	Observed	Simulated	% Diff.	Diff.	Observed	Simulated	% Diff.	Diff.
Conejo WY95-09 #800								
Total Vol af	395,643	386,083	2.4%	9,560	395,643	371,210	6.2%	24,433
Winter Vol Dec-Feb af	179,066	183,869	-2.7%	(4,803)	179,066	172,931	3.4%	6,135
Summer Vol Jun-Aug af	54,897	54,922	0.0%	(25)	54,897	54,408	0.9%	488
Days with Recession	1,906	2,972	NA	NA	1,906	2,957	NA	NA
Mean Recess. Top 30% cfs	0.743	0.778	-4.7%	(0.035)	0.743	0.780	-5.0%	(0.037)
Mean Flow-Lower 50% cfs	18.34	17.64	3.8%	0.70	18.34	17.52	4.5%	0.82
Mean Flow-Top 10% cfs	168.28	176.56	-4.9%	(8.29)	168.28	164.87	2.0%	3.41
Calleguas CSUCI WY88-09 #805								
Total Vol af	907,315	871,062	4.0%	36,253	907,315	785,360	13.4%	121,955
Winter Vol Dec-Feb af	550,481	523,363	4.9%	27,118	550,481	478,463	13.1%	72,018
Summer Vol Jun-Aug af	64,129	71,560	-11.6%	(7,431)	64,129	62,268	2.9%	1,861
Days with Recession	3,760	4,145	NA	NA	3,760	4,108	NA	NA
Mean Recess. Top 30% cfs	0.712	0.756	-6.2%	(0.044)	0.718	0.757	-5.4%	(0.039)
Mean Flow-Lower 50% cfs	13.26	14.09	-6.3%	(0.83)	13.26	13.44	-1.3%	(0.18)
Mean Flow-Top 10% cfs	392.51	379.60	3.3%	12.90	392.51	344.81	12.2%	47.69
Beardsley WY95-09 #780								
Total Vol af	50,348	46,324	8.0%	4,024	50,348	40,870	18.8%	9,478
Winter Vol Dec-Feb af	29,361	28,633	2.5%	728	29,361	26,540	9.6%	2,821
Summer Vol Jun-Aug af	4,245	2,780	34.5%	1,466	4,245	2,532	40.4%	1,714
Days with Recession	2,317	1,722			2,317	1,840		
Mean Recess. Top 30% cfs	0.745	0.826	-10.8%	(0.0803)	0.745	0.784	-5.1%	(0.0383)
Mean Flow-Lower 50% cfs	1.037	0.595	42.6%	0.4413	1.037	0.705	32.0%	0.3320
Mean Flow-Top 10% cfs	32.497	32.149	1.1%	0.35	32.497	28.649	11.8%	3.85
Revolon Slough WY88-09 #776								
Total Vol af	320,940	300,870	6.3%	20,071	320,940	328,400	-2.3%	(7,459)
Winter Vol Dec-Feb af	169,641	144,263	15.0%	25,379	169,641	156,036	8.0%	13,606
Summer Vol Jun-Aug af	30,396	40,203	-32.3%	(9,807)	30,396	46,401	-52.7%	(16,004)
Days with Recession	3,704	4,333	NA	NA	3,704	3,899	NA	NA
Mean Recess. Top 30% cfs	0.736	0.849	-15.4%	(0.113)	0.736	0.833	-13.2%	(0.097)
Mean Flow-Lower 50% cfs	6.38	5.63	11.8%	0.75	6.38	8.38	-31.2%	(1.99)
Mean Flow-Top 10% cfs	120.87	108.95	9.9%	11.92	120.87	109.00	9.8%	11.88

Table 2 - Calibration Results Summary – Short Term Gages

	Arroyo Simi Abv White Oak WY05-09 #831				Arroyo Simi – Stow WY03-09 #842			
	Calibrated	Observed	% Diff.	Diff.	Calibrated	Observed	% Diff.	Diff.
Total Vol af	2,555	1,360	46.8%	1,195	11,077	18,735	-69.1%	(7,657)
Winter Vol Dec-Feb af	2,302	1,327	42.4%	975	9,588	13,742	-43.3%	(4,154)
Summer Vol Jun-Aug af	-	-	0.0%	-	-	766	NA	(766)
Days with Recession	116	18	NA	NA	175	700	NA	NA
Mean Recess. Top 30% cfs	0.345	0.123	64.2%	0.222	0.363	0.567	-56.2%	(0.204)
Mean Flow-Lower 50% cfs	0.00	0.00	0.0%	-	0.00	0.38	NA	(0.38)
Mean Flow-Top 10% cfs	7.04	3.75	46.8%	3.29	8.45	12.89	-52.6%	(4.44)
	Santa Clara Drain WY96-07							
Total Vol af	7,509	17,772	-57.7%	-10,263				
Winter Vol Dec-Feb af	6,010	7,938	-24.3%	-1,929				
Summer Vol Jun-Aug af	8	2,739	-99.7%	-2,732				
Days with Recession	623	1,558						
Mean Recess. Top 30% cfs	0.636	0.769	17.3%	0.133				
Mean Flow-Lower 50% cfs	0.00	0.75	100.0%	0.75				
Mean Flow-Top 10% cfs	8.14	10.48	-22.3%	-2.34				

The model generally shows more days with daily average recession flow than the observed data except at the Beardsley gage. Likely this is due to 50% of the groundwater flow being passed downstream to the Revolon gage in the model, limiting the groundwater baseflow at the gage and minimizing the number of days with recession flow.

In terms of mean daily flows, the model matches the daily average flow for the lowest 50% of flows at each gage closely with a maximum difference of about 0.8 cfs at the Calleguas CSUCI gage (6.3%). For the top 10% of daily flows, the model flows are within 5% or less of the observed flows except for Royal (significantly underpredicted similar to flow volumes), Arroyo Las Posas (-6.7%) and Revolon (9.9%). The model annual peak flows generally are within 10-20% of the observed peaks for the biggest flow years contained in the simulation period (1995, 1998, and 2005). For smaller peak years, the percent differences vary widely. This is interpreted as being due to the type of storms that cause the peaks in these years- they are more limited in extent and so the rain observed at the rain gages is not as good an indicator of the average rainfall across the watershed as for the more widespread storms occurring in the wet years.

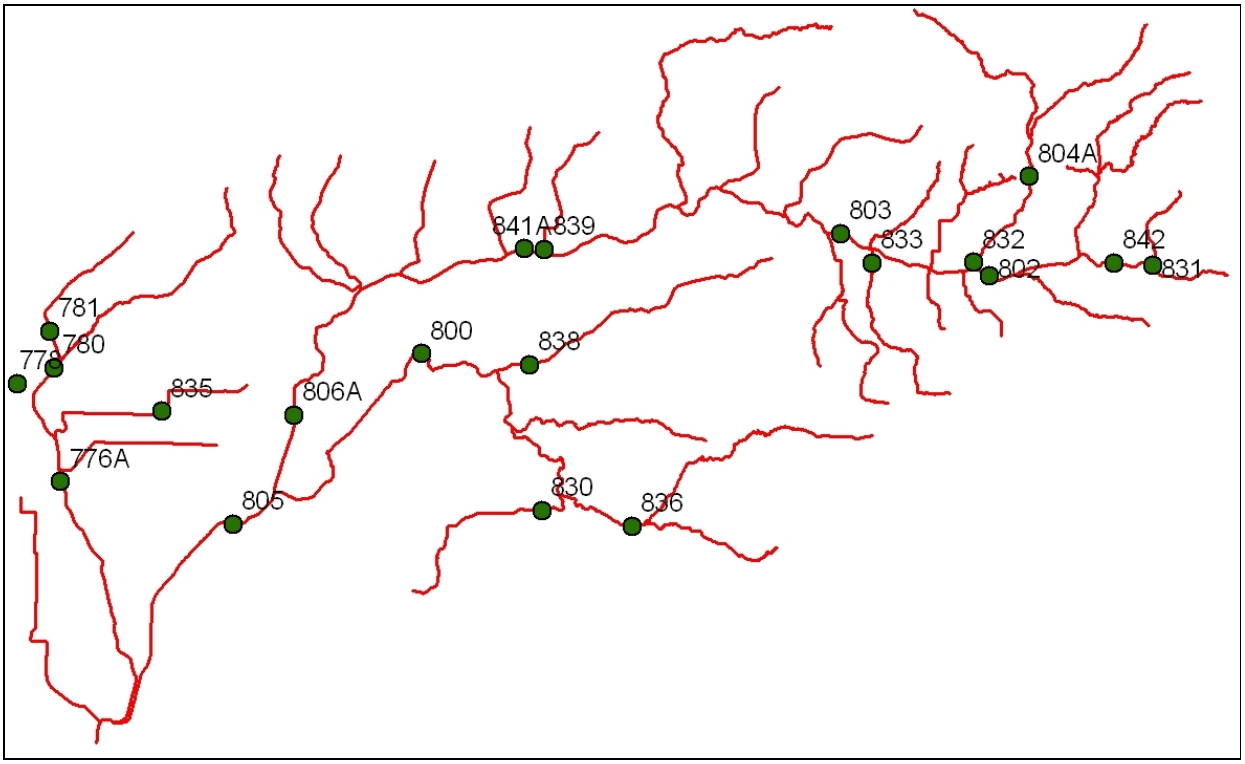

Figure 3 – Watershed Stream Gage Locations

A summary of the peak flow information obtained from the observed and simulated 15-min data from full record gages is shown in Table 3. The observed and simulated data are from 15 minute average data from each gage. Not all gage records have 15-min data for the entire simulation period as shown in the table.

Table 3. Annual Peak Flow Comparison- Full Record Gages

Water Year	Base-line cfs	Cali-brated cfs	Obser. cfs	Diff. cfs	% Diff	Base-line cfs	Cali-brated cfs	Obser. cfs	Diff. cfs	% Diff	Base-line cfs	Cali-brated cfs	Obser. cfs	Diff. cfs	% Diff
Gage	**Royal #802**					**Madera #803**					**Arroyo Las Posas Hitch #841**				
1988	-	-	-	-	-	863	842	1,980	1,138	57%	-	-	-	-	-
1989	-	-	-	-	-	424	471	751	280	37%	-	-	-	-	-
1990	-	-	-	-	-	333	445	1,150	705	61%	-	-	-	-	-
1991	-	-	-	-	-	1,180	1,310	1,600	290	18%	-	-	-	-	-
1992	-	-	-	-	-	4,420	5,900	8,060	2,160	27%	-	-	-	-	-
1993	-	-	-	-	-	3,450	3,810	3,240	(570)	-18%	-	-	-	-	-
1994	-	-	-	-	-	630	644	1,240	596	48%	-	-	-	-	-
1995	-	-	-	-	-	7,040	6,860	5,960	(900)	-15%	-	-	-	-	-
1996	-	-	-	-	-	862	1,290	1,460	170	12%	-	-	-	-	-
1997	-	-	-	-	-	872	800	1,570	770	49%	-	-	-	-	-
1998	-	-	-	-	-	6,470	7,970	6,440	(1,530)	-24%	-	-	-	-	-
1999	-	-	-	-	-	640	568	896	328	37%	-	-	-	-	-
2000	-	-	-	-	-	973	1,180	1,640	460	28%	-	-	-	-	-
2001	956	1,030	1,580	550	35%	2,060	2,410	2,780	370	13%	-	-	-	-	-
2002	393	408	-	(408)	NA	652	714	1,370	656	48%	-	-	-	-	-
2003	1,270	1,500	1,890	390	21%	2,500	3,940	2,390	(1,550)	-65%	-	-	-	-	-
2004	536	574	738	164	22%	1,090	1,260	1,710	450	26%	-	-	-	-	-
2005	2,230	2,720	3,860	1,140	30%	4,060	6,060	4,110	(1,950)	-47%	13,000	13,400	11,600	(1,800)	-16%
2006	278	345	951	606	64%	555	721	1,750	1,029	59%	1,010	1,240	2,080	840	40%
2007	275	270	426	156	37%	500	503	877	374	43%	550	535	623	88	14%
2008	1,070	1,200	1,340	140	10%	1,830	2,390	1,940	(450)	-23%	2,290	2,510	3,220	710	22%
2009	547	510	637	127	20%	998	921	1,540	619	40%	1,140	943	1,420	477	34%
Sum				2,865					3,445					315	

Table 3 Continued.

Water Year	Base-line cfs	Cali-brated cfs	Obser. cfs	Diff. cfs	% Diff	Base-line cfs	Cali-brated cfs	Obser. cfs	Diff. cfs	% Diff	Base-line cfs	Cali-brated cfs	Obser. cfs	Diff. cfs	% Diff
Gage	**Calleguas Creek at Hwy 101 #806**					**Calleguas CSUCI #805**					**Conejo #800**				
1988	-	1030	1,980	950	48%	-	-	-	-	-	-	-	-	-	-
1989	-	535	499	(36)	-7%	-	-	-	-	-	-	-	-	-	-
1990	-	539	747	208	28%	-	-	-	-	-	-	-	-	-	-
1991	-	1840	3,440	1,600	47%	3,410	3,920	4,540	620	14%	1,790	1,990	3,490	1,500	43%
1992	-	8950	12,560	3,610	29%	14,200	13,300	14,600	1,300	9%	5,950	6,240	9,620	3,380	35%
1993	-	3200	4,340	1,140	26%	4,750	4,960	7,330	2,370	32%	2,580	2,690	3,830	1,140	30%
1994	-	947	2,110	1,163	55%	1,510	1,520	-	(1,520)	NA	802	798	-	(798)	NA
1995	-	11300	9,120	(2,180)	-24%	18,500	17,400	14,600	(2,800)	-19%	10,300	10,400	5,370	(5,030)	-94%
1996	-	1460	2,180	720	33%	2,030	2,240	-	(2,240)	NA	830	822	-	(822)	NA
1997	-	1140	3,030	1,890	62%	2,160	2,380	-	(2,380)	NA	1,210	1,240	-	(1,240)	NA
1998	13,000	11,400	14,300	2,900	20%	19,800	18,700	20,700	2,000	10%	10,200	10,200	9,490	(710)	-7%
1999	635	586	-	(586)	NA	1,190	1,100	-	(1,100)	NA	701	699	-	(699)	NA
2000	1,860	1,860	-	(1,860)	NA	2,810	2,860	-	(2,860)	NA	1,590	1,650	-	(1,650)	NA
2001	4,930	4,590	7,020	2,430	35%	10,100	9,840	10,700	860	8%	5,020	4,760	4,580	(180)	-4%
2002	902	861	-	(861)	NA	1,450	1,360	-	(1,360)	NA	733	722	-	(722)	NA
2003	2,310	3,100	7,740	4,640	60%	7,410	8,140	9,230	1,090	12%	5,500	5,430	4,810	(620)	-13%
2004	2,440	2,800	7,490	4,690	63%	4,040	4,640	8,500	3,860	45%	1,740	2,110	1,880	(230)	-12%
2005	15,800	16,700	17,900	1,200	7%	17,500	18,200	19,600	1,400	7%	6,700	6,710	5,490	(1,220)	-22%
2006	924	1,270	2,350	1,080	46%	1,930	2,220	4,940	2,720	55%	1,240	1,240	2,440	1,200	49%
2007	188	164	282	118	42%	339	375	702	327	47%	333	329	655	326	50%
2008	2,230	2,420	3,540	1,120	32%	3,730	4,020	5,620	1,600	28%	1,760	1,910	2,430	520	21%
2009	1,030	933	1,480	547	37%	1,600	1,570	2,770	1,200	43%	847	887	1,400	513	37%
Sum				24,483					5,087					(5,342)	

Table 3 Continued.

Water Year	Base-line cfs	Cali-brated cfs	Obser. cfs	Diff. cfs	% Diff	Base-line cfs	Cali-brated cfs	Obser. cfs	Diff. cfs	% Diff
Gage	**Beardsley #780**					**Revolon #776**				
1988	-	-	-	-		-	-	-	-	
1989	-	-	-	-		-	-	-	-	
1990	-	-	-	-		-	-	-	-	
1991	-	-	-	-		1,370	641	2,840	2,199	77%
1992	-	-	-	-		8,680	6,340	7,120	780	11%
1993	-	-	-	-		2,760	1,710	4,490	2,780	62%
1994	-	-	-	-		975	836	-	(836)	NA
1995	7,210	4,900	2,450	(2,450)	-100%	9,500	7,660	7,450	(210)	-3%
1996	88	54	-	(54)	NA	924	414	-	(414)	NA
1997	417	190	-	(190)	NA	2,710	1,220	-	(1,220)	NA
1998	9,680	7,500	5,070	(2,430)	-48%	13,600	9,980	12,000	2,020	17%
1999	30	29	-	(29)	NA	695	638	-	(638)	NA
2000	182	65	-	(65)	NA	2,920	964	6	(958)	NA
2001	2,520	1,380	1,160	(220)	-19%	6,060	3,960	3,140	(820)	-26%
2002	64	64	-	(64)	NA	749	696	-	(696)	NA
2003	911	390	1,910	1,520	80%	6,000	3,160	5,150	1,990	39%
2004	189	82	955	873	91%	1,690	1,010	3,130	2,120	68%
2005	4,560	3,380	3,080	(300)	-10%	8,340	7,010	6,430	(580)	-9%
2006	76	55	1,380	1,326	96%	2,100	971	2,840	1,869	66%
2007	23	24	471	447	95%	450	424	940	516	55%
2008	594	190	1,160	970	84%	2,920	1,240	2,230	990	44%
2009	138	70	1,210	1,140	94%	3,130	1,220	1,950	730	37%
Sum				475					9,622	

Table 4. Annual Peak Flow Comparison- Event Only Gages

Water Year	Cali-brated cfs	Observ. cfs	Diff.	% Diff.	Cali-brated cfs	Observ. cfs	Diff.	% Diff.	Cali-brated cfs	Observ. cfs	Diff.	% Diff.	Cali-brated cfs	Observ. cfs	Diff.	% Diff.
Gage	**Arroyo Simi abv White Oak #831**				**Arroyo Simi – Stow #842**				**Tapo Canyon #832**				**Tapo Cyn –Upper #804**			
1988	125	205	80	39%	-	-	-	-	144	1,080	936	87%	-	-	-	-
1989	92	-	(92)	NA	-	-	-	-	99	237	138	58%	-	-	-	-
1990	49	-	(49)	NA	-	-	-	-	102	565	463	82%	-	-	-	-
1991	129	140	11	8%	-	-	-	-	270	928	658	71%	-	-	-	-
1992	546	1,200	654	55%	-	-	-	-	1,200	4,130	2,930	71%	-	-	-	-
1993	385	219	(166)	-76%	-	-	-	-	697	1,460	763	52%	-	-	-	-
1994	67	115	48	42%	-	-	-	-	100	520	420	81%	-	-	-	-
1995	469	442	(27)	-6%	-	-	-	-	898	1,750	852	49%	-	-	-	-
1996	86	-	(86)	NA	-	-	-	-	314	253	(61)	-24%	-	-	-	-
1997	86	-	(86)	NA	-	-	-	-	117	565	448	79%	-	-	-	-
1998	587	1,190	603	51%	-	-	-	-	2,210	2,110	(100)	-5%	-	-	-	-
1999	72	-	(72)	NA	-	-	-	-	90	380	290	76%	-	-	-	-
2000	82	135	53	39%	-	-	-	-	244	663	419	63%	-	-	-	-
2001	137	187	50	27%	-	-	-	-	381	638	257	40%	-	-	-	-
2002	101	115	14	12%	-	-	-	-	178	678	500	74%	-	-	-	-
2003	316	227	(89)	-39%	1,130	775	(355)	-46%	2,180	638	(1,542)	-242%	-	-	-	-
2004	94	133	39	29%	329	413	84	20%	142	750	608	81%	-	-	-	-
2005	528	350	(178)	-51%	1,410	1,570	160	10%	1,990	2,040	50	2%	1,800	841	(959)	-114%
2006	117	170	53	31%	255	526	271	52%	130	483	353	73%	1	171	170	99%
2007	61	77	16	20%	149	344	195	57%	98	571	473	83%	0	81	81	100%
2008	239	192	(47)	-24%	885	749	(136)	-18%	433	418	(15)	-4%	5	220	215	98%
2009	88	300	212	71%	295	540	245	45%	92	273	181	66%	-	-	-	-
Sum			70				464				9,021				(493)	

Table 4 (Continued)

Water Year	Cali-brated cfs	Observ. cfs	Diff.	% Diff.	Cali-brated cfs	Observ. cfs	Diff.	% Diff.	Cali-brated cfs	Observ. cfs	Diff.	% Diff.	Cali-brated cfs	Observ. cfs	Diff.	% Diff.
Gage	**Bus Canyon #833**				**Gabbert-Walnut Cyn #839**				**Santa Clara Drn #781**				**Nyeland Drn #778**			
1988	94	151	57	38%	108	250	142	57%	-	-	-	-	80	426	347	81%
1989	39	89	50	56%	84	161	77	48%	-	-	-	-	39	189	150	79%
1990	33	210	177	84%	66	182	116	64%	-	-	-	-	40	285	245	86%
1991	202	286	84	29%	161	502	341	68%	-	-	-	-	107	923	816	88%
1992	506	1,200	694	58%	1,350	668	(682)	-102%	-	-	-	-	907	2,550	1,643	64%
1993	478	395	(83)	-21%	423	606	183	30%	-	-	-	-	572	933	361	39%
1994	66	428	362	85%	192	250	58	23%	-	-	-	-	66	531	465	88%
1995	803	558	(245)	-44%	1,350	1,310	(40)	-3%	-	-	-	-	1,610	1,430	(180)	-13%
1996	76	163	87	53%	111	227	116	51%	9.5	479	470	98%	56	464	408	88%
1997	61	210	149	71%	108	350	242	69%	11.4	372	361	97%	55	460	405	88%
1998	817	846	29	3%	3,420	1,820	(1,600)	-88%	2,870	1,424	(1,446)	-102%	2,720	1,040	(1,680)	-162%
1999	43	138	95	69%	100	100	-	0%	4.6	92	87	95%	33	423	390	92%
2000	133	250	117	47%	130	130	-	0%	11.9	520	508	98%	100	605	505	84%
2001	421	305	(116)	-38%	482	312	(170)	-54%	934	584	(350)	-60%	607	674	67	10%
2002	55	237	182	77%	168	234	66	28%	9	-	(9)	NA	102	481	379	79%
2003	366	337	(29)	-9%	196	668	472	71%	88	637	549	86%	122	850	728	86%
2004	63	147	84	57%	380	440	60	14%	13	396	383	97%	94	719	625	87%
2005	601	618	17	3%	1,770	1,550	(220)	-14%	1,780	987	(793)	-80%	1,290	799	(491)	-61%
2006	99	341	243	71%	197	143	(54)	-38%	9	550	541	98%	70	625	555	89%
2007	22	176	154	88%	234	115	(119)	-103%	3	368	365	99%	48	313	265	85%
2008	116	221	105	48%	227	291	64	22%	206	567	361	64%	174	457	283	62%
2009	36	203	167	82%	88	104	16	15%	11	445	434	98%	72	536	464	87%
Sum			2,379				(933)				1,462				6,750	

Table 4 (Continued)

Water Year	Cali-brated cfs	Observ. cfs	Diff.	% Diff.	Cali-brated cfs	Observ. cfs	Diff.	% Diff.	Cali-brated cfs	Observ. cfs	Diff.	% Diff.	Cali-brated cfs	Observ. cfs	Diff.	% Diff.
Gage	**Camarillo Hills Drn #835**				**Santa Rosa Creek #838**				**Arroyo Conejo #836**				**South Branch Arroyo Conejo #830**			
1988	276	-	(276)	NA	92	-	(92)	NA	572	674	102	15%	406	580	174	30%
1989	293	643	350	54%	51	-	(51)	NA	311	438	127	29%	285	460	175	38%
1990	132	487	355	73%	31	-	(31)	NA	210	300	90	30%	297	580	283	49%
1991	302	590	288	49%	309	248	(61)	-25%	914	476	(438)	-92%	557	960	403	42%
1992	2,140	1,620	(520)	-32%	1,370	966	(404)	-42%	3,110	3,500	390	11%	1,780	2,200	420	19%
1993	725	698	(27)	-4%	579	648	69	11%	2,130	1,940	(190)	-10%	1,080	1,040	(40)	-4%
1994	414	1,130	716	63%	87	-	(87)	NA	339	592	253	43%	294	403	109	27%
1995	1,490	1,470	(20)	-1%	1,560	926	(634)	-68%	3,060	3,080	20	1%	3,460	2,480	(980)	-40%
1996	195	538	343	64%	74	179	105	58%	325	332	7	2%	267	724	457	63%
1997	579	643	64	10%	83	509	426	84%	509	937	428	46%	400	760	360	47%
1998	3,360	3,580	220	6%	1,780	2,400	620	26%	3,490	2,740	(750)	-27%	4,140	4,240	100	2%
1999	312	842	530	63%	56	225	169	75%	307	367	60	16%	317	580	263	45%
2000	460	965	505	52%	220	803	583	73%	538	951	413	43%	665	880	215	24%
2001	1,170	698	(472)	-68%	614	1,520	906	60%	2,180	1,730	(450)	-26%	1,530	2,560	1,030	40%
2002	344	1,330	986	74%	67	577	510	88%	390	552	162	29%	358	652	294	45%
2003	1,570	1,130	(440)	-39%	171	2,050	1,879	92%	2,660	2,330	(330)	-14%	1,550	1,340	(210)	-16%
2004	534	527	(7)	-1%	79	881	802	91%	1,210	928	(282)	-30%	374	1,000	626	63%
2005	2,180	1,470	(710)	-48%	1,210	2,990	1,780	60%	3,080	1,620	(1,460)	-90%	3,150	2,510	(640)	-25%
2006	525	813	288	35%	81	1,100	1,019	93%	518	1,090	572	52%	416	915	499	55%
2007	211	638	427	67%	28	56	28	50%	143	330	187	57%	260	354	94	27%
2008	543	558	15	3%	110	932	822	88%	1,030	666	(364)	-55%	455	1,090	635	58%
2009	581	977	396	41%	48	221	173	78%	276	453	177	39%	442	616	174	28%
Sum			3,011				8,531				(1,276)				4,441	30%

4. INDIVIDUAL STREAM GAGE CALIBRATION

This section presents discussions of the calibration efforts done for each full record gage. The discussion starts at the most upstream long term gage in the Arroyo Simi watershed. The baseline and calibrated plots for some of the major storms for each gage are presented in Appendix A.

4.1. Royal Gage 802, Upper Arroyo Simi

Watershed Area sq mi	32.6
Main Land Uses	Open space, low density residential
HSPF Reaches	1,2,3,4,11,21,22,23,24,25,31
Perlnd- Implnd Series	11,21,31,41,51,61,71,81,121
Daily Flow Data Period	WY88-05
15-min Flow Data Period	WY01-09
Main Calib. Parameters	LZSN, INTFW

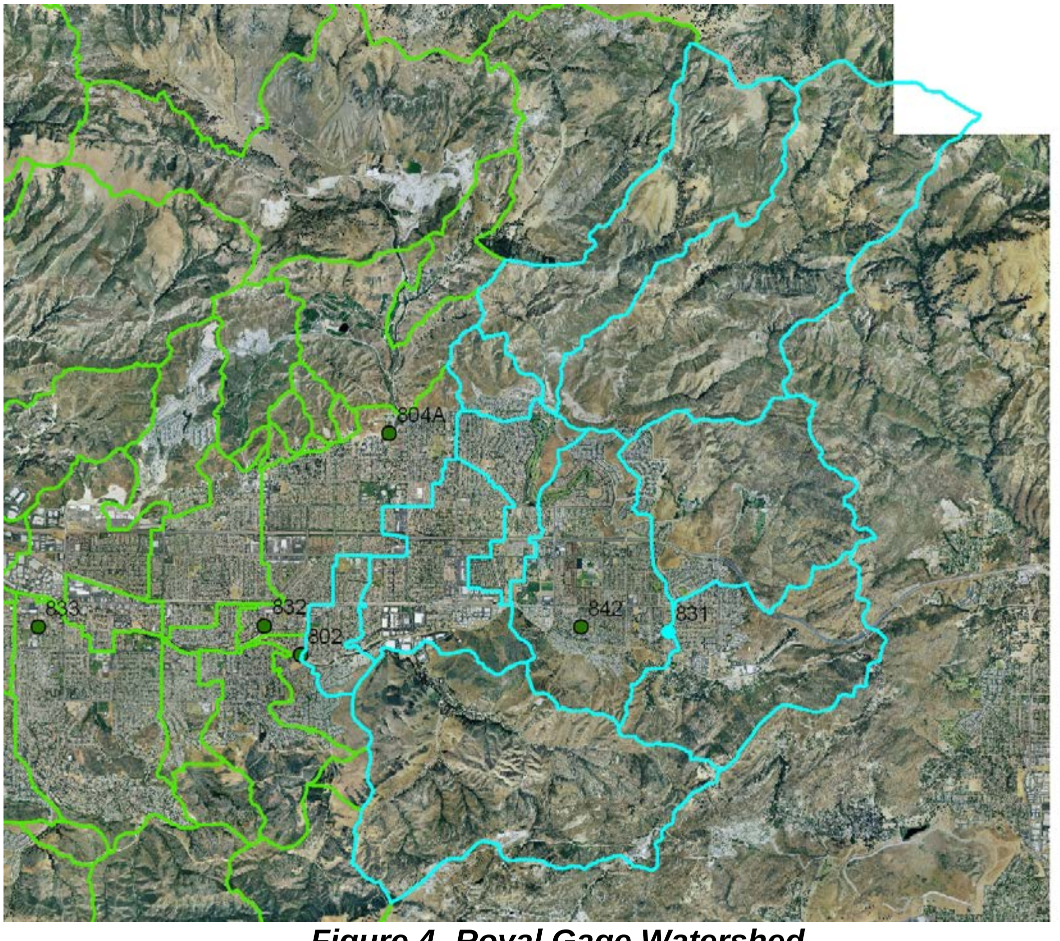

Figure 4- Royal Gage Watershed

Royal was a recording gage used to provide daily flow data and storm peaks from WY69 through WY05. Because many non-storm days showed no flow, it was converted to an event hydrograph gage at the end of WY05 and now provides 5-min hydrograph data whenever the storm flow is above the level of the gage sensor. From WY01 to WY05 the entire flow record was provided at 5-min intervals.

The baseline model using the 2002 calibration parameters showed that simulated volumes were less than observed volumes and that mean peaks were less than observed mean peaks. This calibration reduced LZSN and INTFW for some of the perlnds in order to increase the peaks and match the hydrograph recession behavior. This did not improve the match to the volume data or the average daily flows, but improved the match to the highest historical 15-min observed peak of 3,860 cfs in WY05 and other high flow years. It was not possible to improve the matches at Royal without causing the model to overestimate the flow volumes and peaks at the Madera gage used next in the calibration, especially given the fact that the model overestimates flow volumes at the upstream White Oak gage.

4.2. Madera Gage 803, Arroyo Simi

Watershed Area sq mi	71
Main Land Uses	Open space, low density residential
Addtn'l HSPF Reaches	904,5,6,7,8,41-46,51,52,952,61-63,65,71,72,81,82,91,92
Addtn'l PerInd- Implnd Series	91,101,111,121,131,141,151,161,181
Daily Flow Data Period	WY88-09
15-min Flow Data Period	WY88-09
Main Calibration Parameters	INTFW

Madera is a recording gage used to provide daily flow data and storm peaks from WY34 through WY09. As a full record gage, it provides 5-min flow data from WY69 to WY09.

The baseline model using the 2002 calibration parameters showed that simulated volumes were less than observed volumes and that mean peaks were less than observed mean peaks. This calibration reduced INTFW for some of the perlnds in order to increase the peaks and match the hydrograph recession behavior. The calibrated model improved the simulated to observed volume difference from 6.3% to 2.6%. The mean daily flow for the top 10% of historical flows increased from 105.2 to 110.9 cfs compared to the observed mean of 112.5 cfs.

The calibrated model shows annual peaks during the wet years of 1995, 1998, and 2005 that overpredict the observed peaks by as much as 2,000 cfs. However, it underpredicts the historical peak of 8,060 cfs in 1992 by about 2,100 cfs. These results were interpreted as showing that the rain gage network is not dense enough to characterize the rainfall occurring across the watershed during the historical storms.

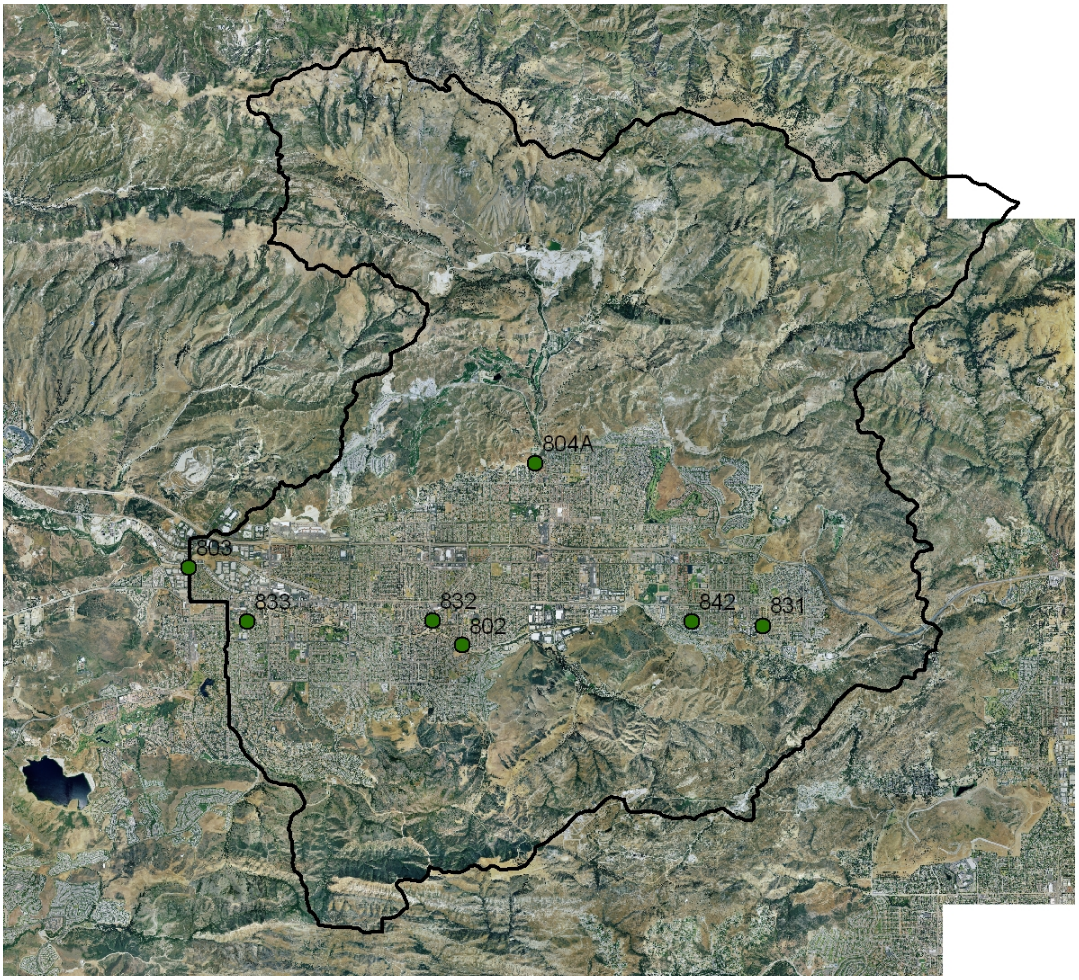

Figure 5 Madera Gage Watershed

4.3 Arroyo Las Posas at Hitch Gage 841, Calleguas Watershed

Watershed Area sq mi	129
Main Land Uses	Open space, low density residential
Addtn'l HSPF Reaches	101-109,190-193,201-205,212,220-224
Addtn'l PerInd- ImpInd Series	171,201,211,221, 271
Daily Flow Data Period	WY91-09
15-min Flow Data Period	WY05-09
Main Calibration Parameters	LSZN, DEEPFR, INTFW

Arroyo Las Posas (ALP) is a recording gage used to provide daily flow data and storm peaks from WY91 through WY09. As a full record gage, it provides 5-min flow data from WY05 to WY09.

The baseline model using the 2002 calibration parameters showed that simulated volumes and the top 10% of daily flow were more than observed data by about 2.3 and 6.6% respectively. However, a review of the downstream gages (Calleguas at Hwy 101 and Calleguas at CSUCI showed those gages to underpredict the observed volumes by 9.4 and 13.4% in the baseline model, respectively. Therefore, the ALP after calibration resulted in even more volume and higher peaks in order to provide a better match to the downstream gages. The calibrated model overpredicts the largest peak of record for this gage location, WY05, by about 1,800 cfs or 16%.

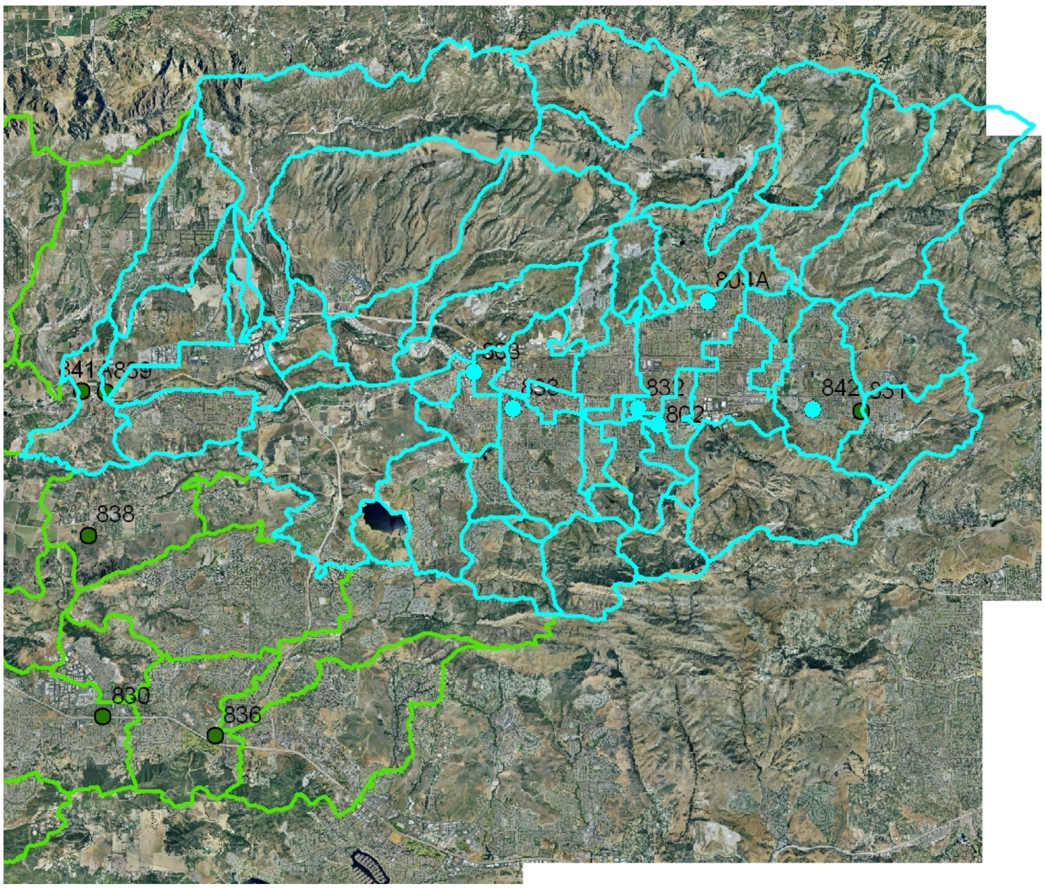

Figure 6- Arroyo Las Posas Gage Watershed

4.4 Calleguas Ck at Hwy 101 Gage 806

Watershed Area sq mi	187
Main Land Uses	Open space, low density residential, agriculture
Addtn'l HSPF Reaches	206,207,224-227,230,231,233,240,241,243, 301, 302,311
Addtn'l Perlnd- Implnd Series	251,261,271
Daily Flow Data Period	WY88-07
15-min Flow Data Period	WY98-09
Main Calibration Parameters	LZSN, DEEPFR, BASETP, INTFW, IRC

Calleguas at Hwy 101was a recording gage used to provide daily flow data and storm peaks from WY88 through WY97. From WY98 through WY07, it provided 5-min flow data. Due to the high infiltration rates in the area, many non-storm periods showed no flow. Because of this, it was converted to an event hydrograph gage beginning in WY07 to provide 5-min data whenever flow is above the gage sensor.

The baseline model using the 2002 calibration parameters showed that simulated volumes and mean daily flows were less than observed volumes and flows by about 9.5%. The calibrated model improved the match to these data to within about 4%. The simulated mean daily flow for the top 10% of historical flows increased from 177.2 to 187.8 cfs after calibration compared to the observed mean of 195.7 cfs. The calibrated model underpredicts the largest historical 15-min annual peaks for WY98 and WY05 for this gage by about 2,900 and 1,200 cfs, respectively. The 1995 peak is overpredicted by about 2,200 cfs.

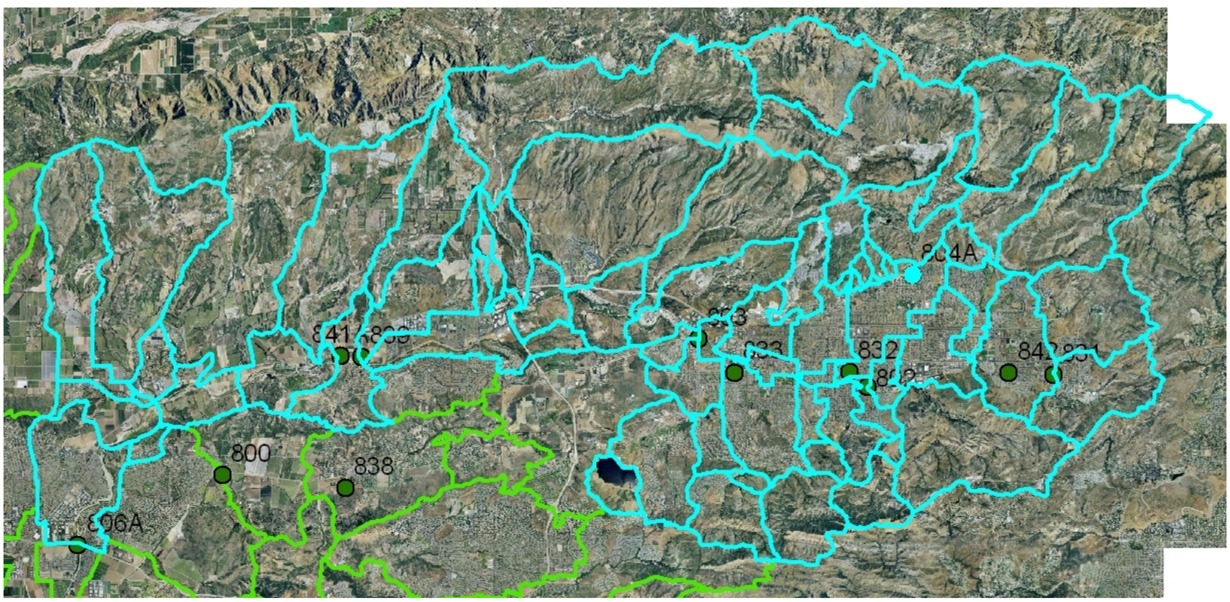

Figure 7 Calleguas Ck at Hwy 101 Watershed

4.5 Conejo Ck nr Hwy 101 Gage 800

Watershed Area sq mi	64
Main Land Uses	Open space, low density residential
Addtn'l HSPF Reaches	401-405,411,421,423,431,441-443,
Addtn'l Perlnd- Implnd Series	231,241
Daily Flow Data Period	WY91-09
15-min Flow Data Period	WY95-09*
Main Calibration Parameters	INFILT, DEEPFR, INTFW
*Note: 15-min data prior to WY95 shows anomalies, not used in calibration	

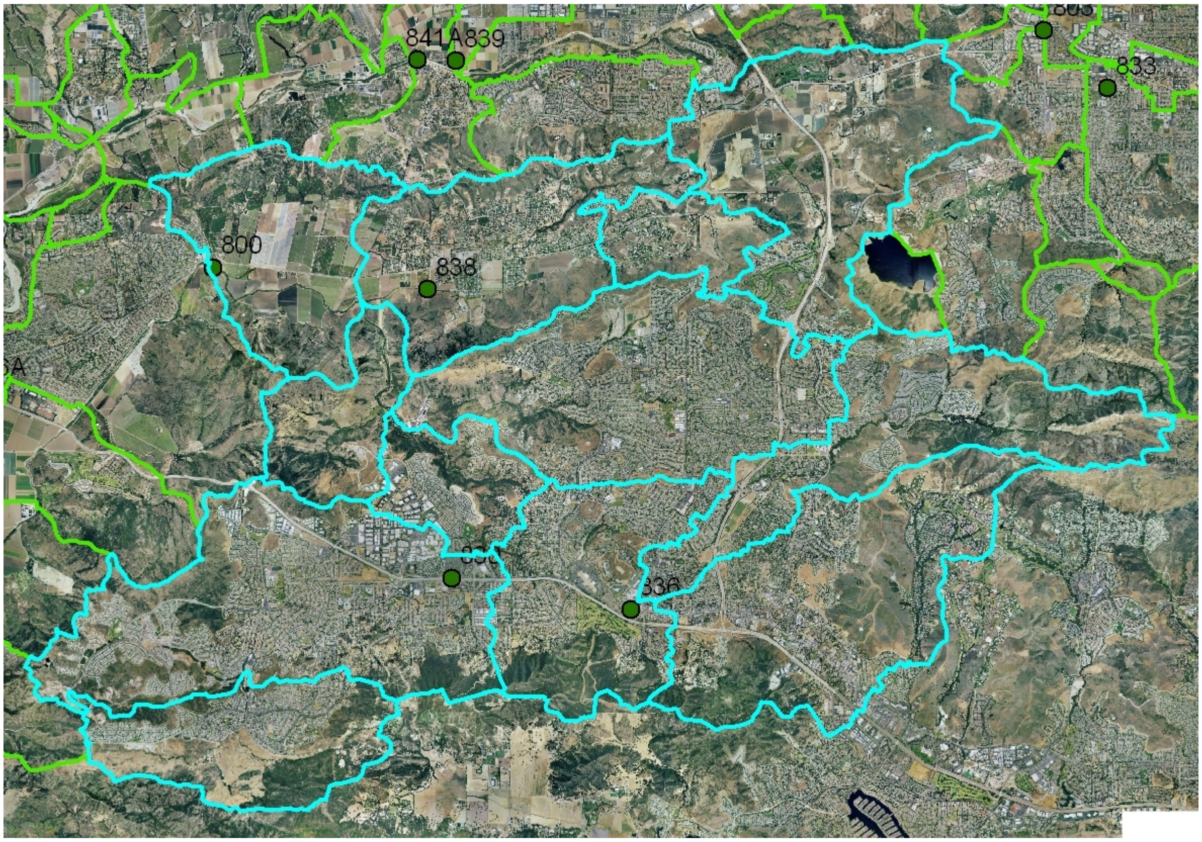

Figure 8 Conejo Ck nr Hwy 101 Watershed

Conejo Creek near Hwy 101 is a recording gage used to provide 5-min flow data and storm peaks from WY91 through WY09. Some of the data from WY92 during a big storm shows the effects of the stilling well silting in and so the data were not used for calibration until WY95.

The baseline model using the 2002 calibration parameters showed that simulated volumes and mean daily flows were less than observed volumes and flows by about 6.2 and 2.0%, respectively. The calibrated model increased the flow volumes and mean peaks so that they were within 2.3 and 4.9% of the observed data, respectively. The increases at this location helped to match the data at the downstream Calleguas Ck at CSUCI gage. The calibrated model annual peaks matched the peaks in WY98 and WY05 relatively well. As noted before, some of the 15-min data for this gage for the period before 1995 appears to need adjustment prior to using it in calibration efforts so not too much effort was put into addressing any discrepancies for these years.

4.6 Calleguas Ck at CSUCI Gage 805

Watershed Area sq mi	248
Main Land Uses	Open space, low density residential, agriculture
Addtn'l HSPF Reaches	302,303,406-408
Addtn'l Perlnd- Implnd Series	251,751
Daily Flow Data Period	WY88-09
15-min Flow Data Period	WY91-09*
Main Calibration Parameters	DEEPFR, INTFW, BASETP

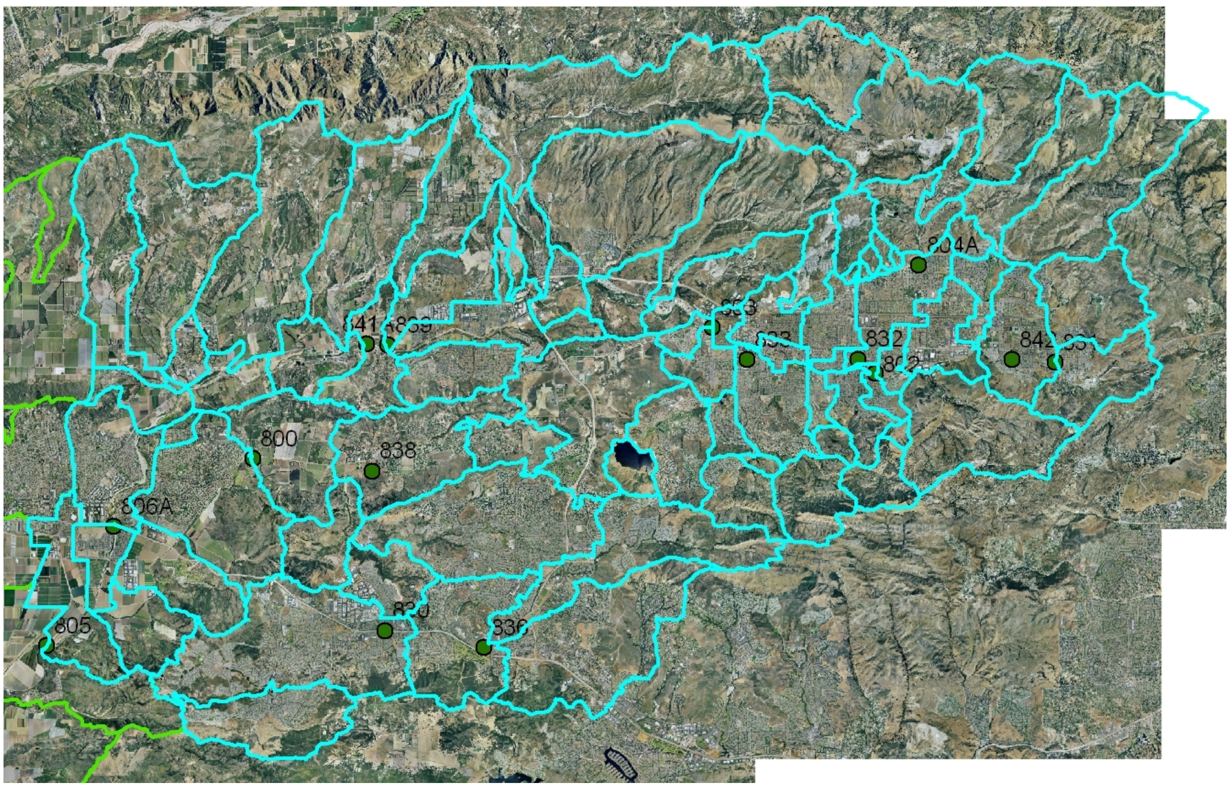

Figure 9. Calleguas Creek at CSUCI Watershed

Calleguas Creek near CSUCI is a recording gage used to provide 5-min flow data and storm peaks from WY91 through WY09 and daily flow data from WY88 to WY09.

The baseline model using the 2002 calibration parameters showed that simulated volumes and mean daily flows were less than observed volumes and flows by about 13.4 and 12.2%, respectively. The calibrated model increased the flow volumes and mean peaks so that they were closer to the observed data but still underpredicted the observed data by about 4 and 3.3% respectively. The mean daily flow for the top 10% of historical flows increased from 344.8 to 379.6 cfs compared to the observed mean of 392.5 cfs. The calibrated model matched the annual peaks in WY92, WY98, and WY05 relatively well (lower by 7 to 10%), and provided a peak that was about 2,800 cfs greater than the observed peak in WY95.

4.7 Beardsley Wash Gage 780

Watershed Area sq mi	24.9
Main Land Uses	Open space, agriculture
Addtn'l HSPF Reaches	499-503, 510-514
Addtn'l Perlnd- Implnd Series	281,291
Daily Flow Data Period	WY95-09
15-min Flow Data Period	WY95-09*
Main Calibration Parameters	DEEPFR, INTFW, INFILT, LZSN

Beardsley Wash is a recording gage used to provide 5-min flow data and storm peaks from WY95 through WY09. The baseline model using the 2002 calibration parameters showed that simulated volumes and mean daily flows were less than observed volumes and flows by about 19 and 12 %, respectively. The calibrated model increased the flow volumes and mean peaks so that they were less than the observed data by about 9.9 and 2.9% respectively. The mean daily flow for the top 10% of historical flows increased from 28.7 to 31.6 cfs compared to the observed mean of 32.5 cfs. The calibrated model provided annual peaks in WY95 and WY98 that were about 2,000 cfs higher than the observed peaks, while the model peak in WY05 matched the observed peak within 300 cfs.

There are some complexities associated with calibrating this portion of the model as approximately 50% of the active groundwater outflow upstream of the gage is assumed to remain in the subsurface and is routing to the reach downstream of the gage. This is done to match the storm recession hydrograph limbs as these recede very quickly back to 0 cfs and do not show sustained baseflow conditions. The difficulties in using the HSPF model to match the observed flow may be partially due to a lack of enough recording rain gages providing 5-min data during the simulation period in this portion of the Calleguas Creek watershed.

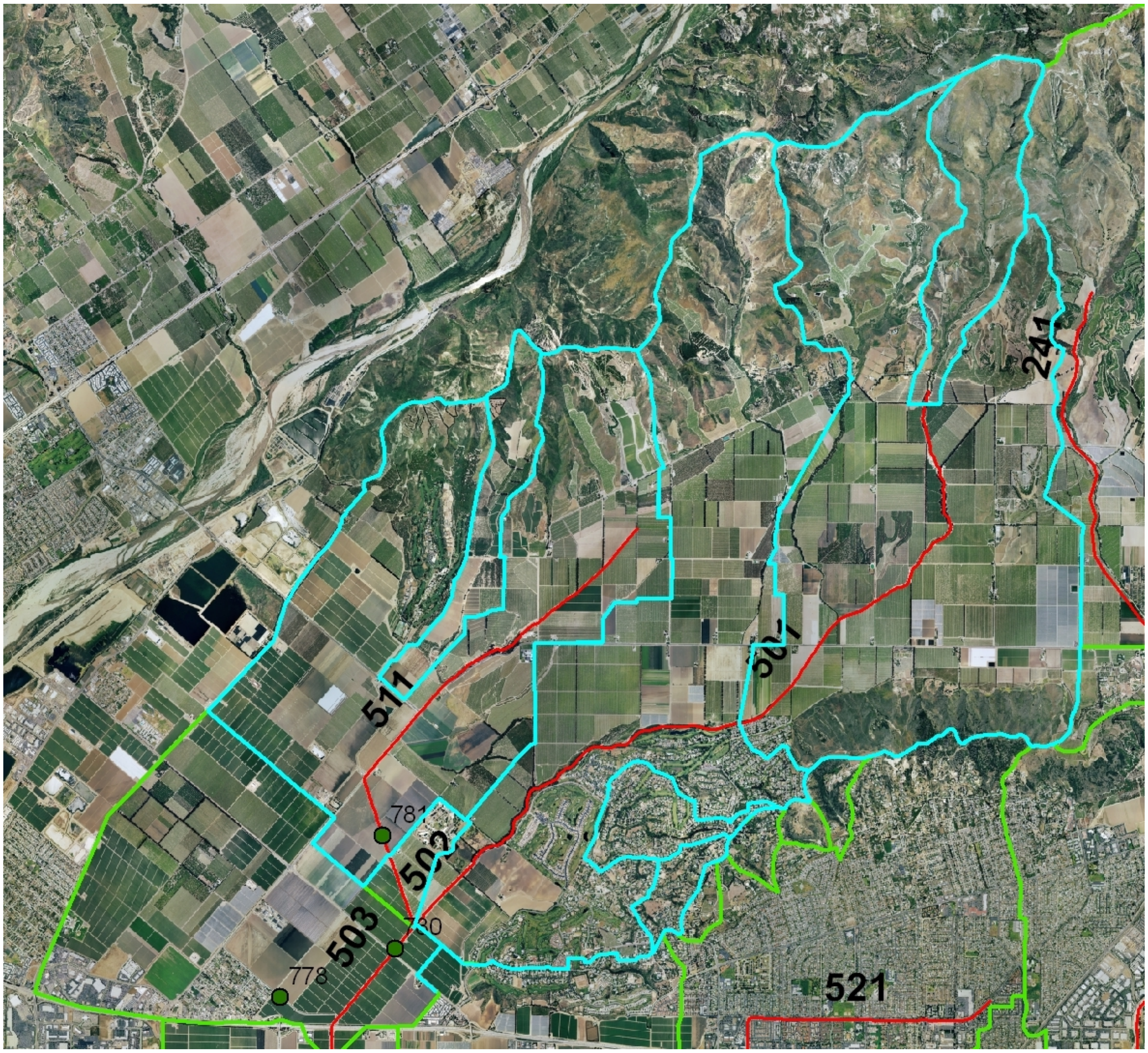

Figure 10. Beardsley Wash Watershed

4.8 Revolon Slough Gage 776

Watershed Area sq mi	46
Main Land Uses	Open space, agriculture, low density residential
Addtn'l HSPF Reaches	504, 505, 521-526,531
Addtn'l Perlnd- Implnd Series	291 (overlaps with Beardsley gage
Daily Flow Data Period	WY88-09
15-min Flow Data Period	WY91-09*
Main Calibration Parameters	DEEPFR, INTFW, INFILT, LZSN

Revolon Slough is a recording gage used to provide 5-min flow data and storm peaks from WY91 through WY09. From WY88 to WY90, the gage provided daily flow data and annual peaks. The baseline model using the 2002 calibration parameters showed that the simulated volumes overestimated the observed volumes by about 2% and underestimated the top 10% of mean daily flows by about 10%. The calibrated model decreased the flow volumes and matched the lowest 50% of mean daily flows better. The calibrated model provided annual peaks in WY92, WY95 and WY05 that matched the observed peaks, and provided a peak in WY98 that was about 2,000 cfs less than the observed peak of 12,000 cfs.

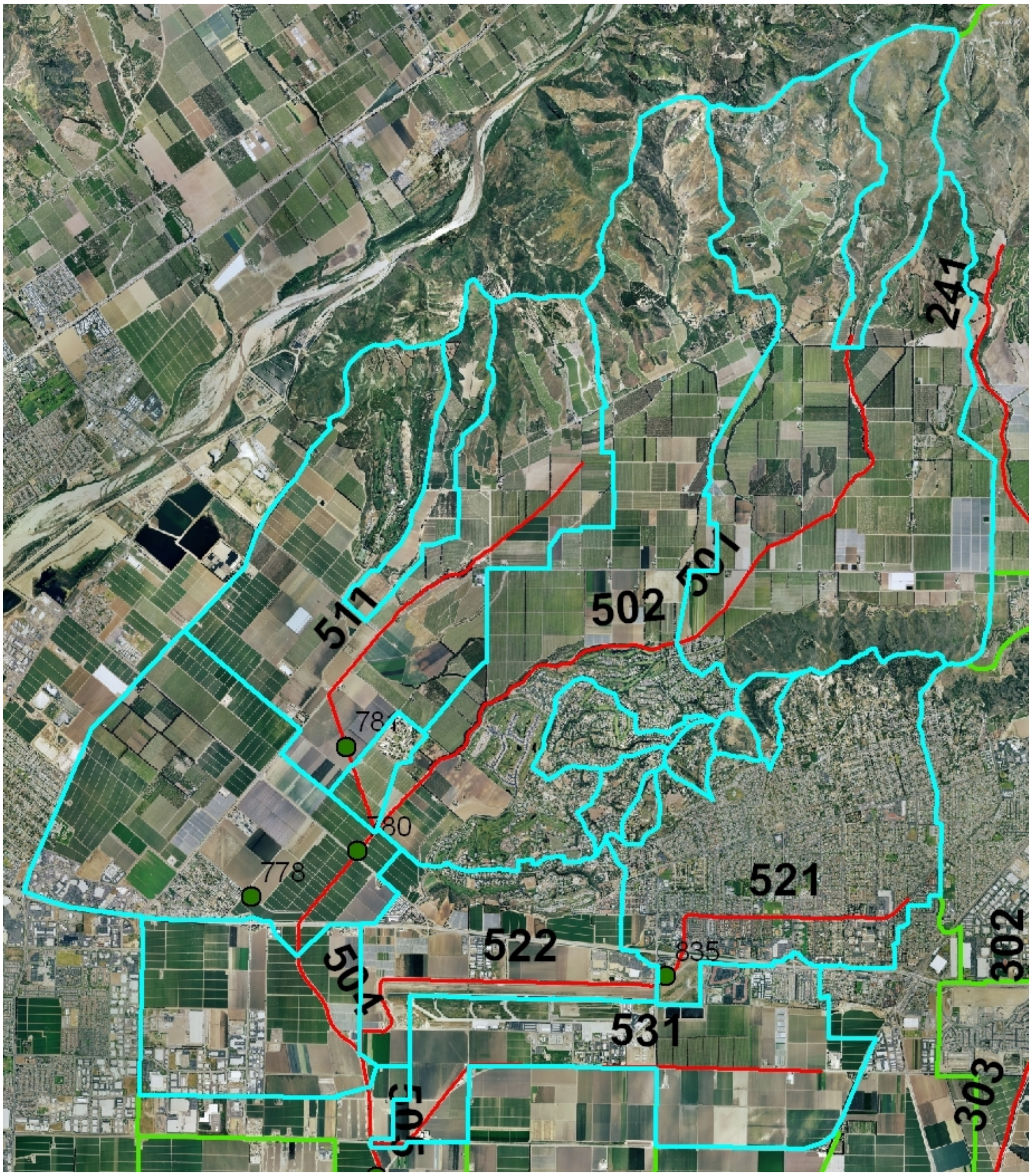

Figure 11. Revolon Slough Watershed

5. SHORT TERM GAGE RESULTS

5.1. Arroyo Simi above White Oak 831

Watershed Area sq mi	3.2
Main Land Uses	Open space, low density residential
HSPF Reach	1
Perlnd- Implnd Series	11,21
5-min Flow Data Period	WY05-09
Peak Flow Data Period	WY88-09*
Main Calibration Parameters	LZSN, INTFW

Arroyo Simi – White Oak is a recording gage used to provide 5-min flow data and storm peaks from WY05 through WY09. From WY71 to WY04, the gage provided storm event peak data. The calibrated model showed peaks and volumes higher than the observed flow volumes and peaks. The overestimates were necessary to better match the flow volumes and peaks at the downstream Royal gage.

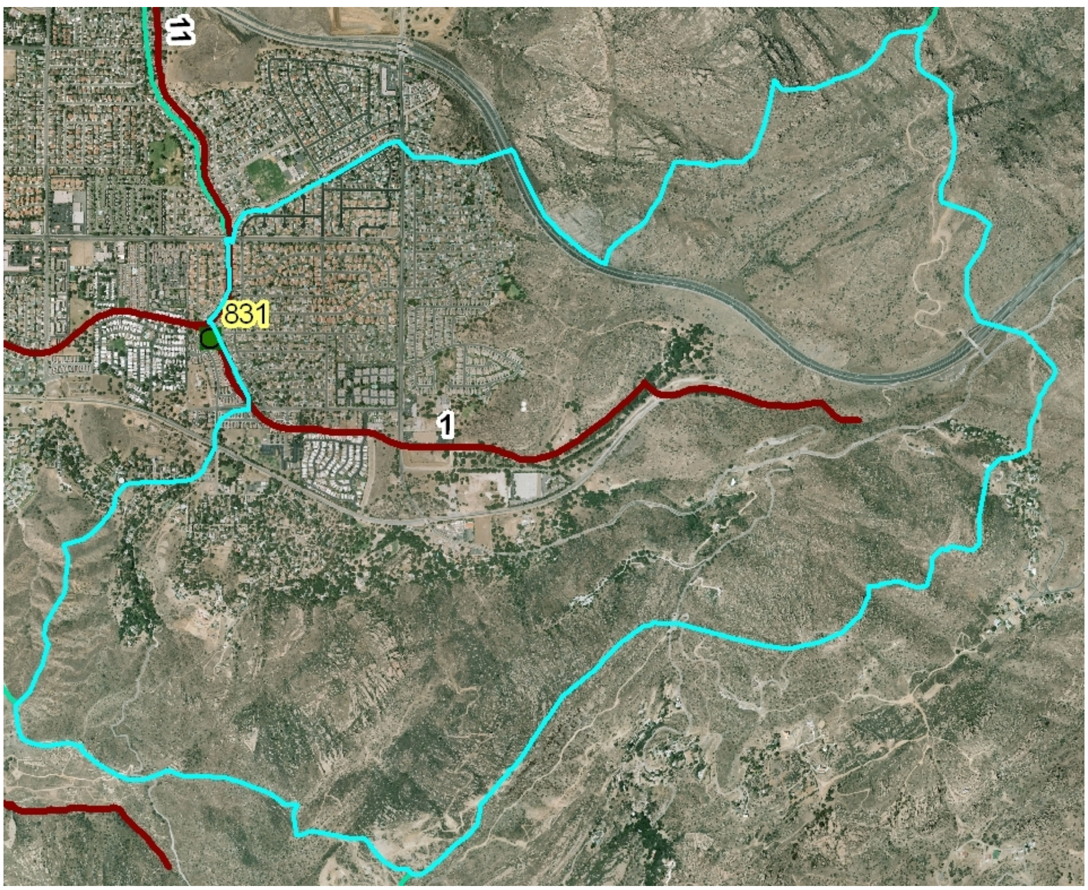

Figure 12. Arroyo Simi – White Oak Watershed

5.2 Upper Arroyo Simi- Stow Gage 842

Watershed Area sq mi	8.2
Main Land Uses	Open space, low density residential
HSPF Reach	1,11,12,2
Perlnd- Implnd Series	11,21,51,71,81,121
5-minFlow Data Period	WY03-09
Peak Flow Data Period	WY03-09*
Main Calibration Parameters	LZSN, INTFW

Arroyo Simi – Stow is a recording gage used to provide 5-min flow data and storm peaks from WY03 through WY09. The calibrated model provided volumes and peaks that were lower than observed flow volumes and peaks. The underestimates were necessary to better match the flow volumes and peaks at the downstream Madera gage.

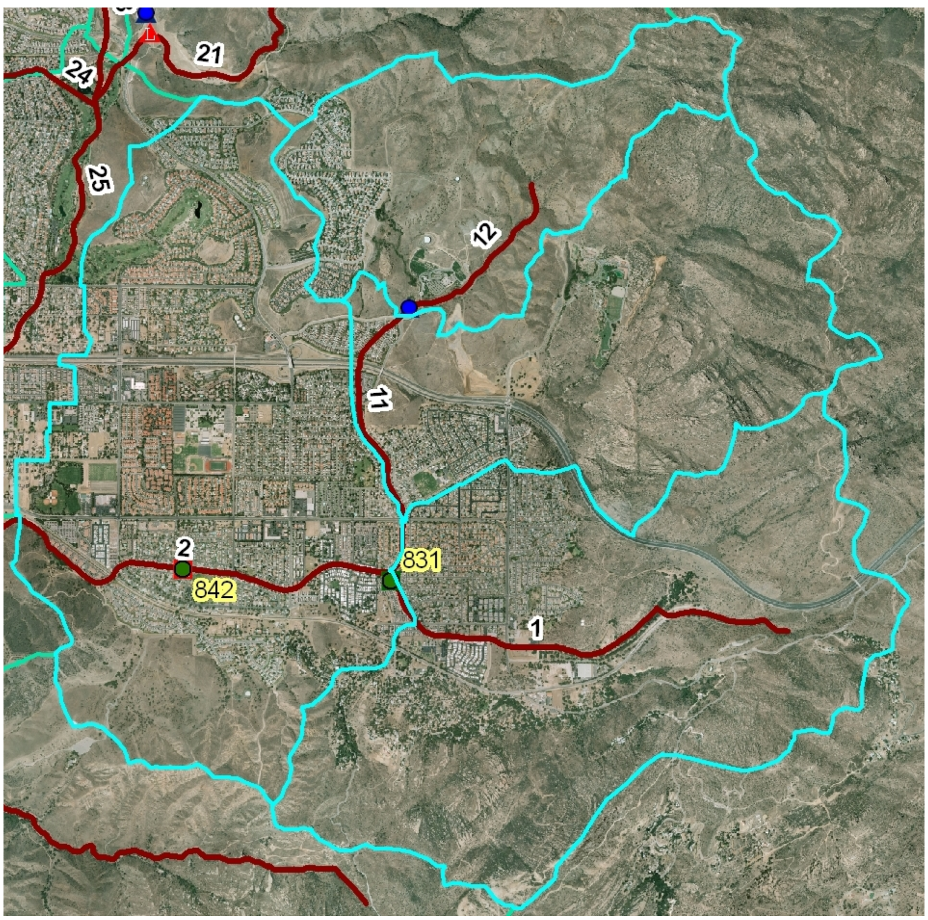

Figure 13. Arroyo Simi – Stow Watershed

5.3 Tapo Canyon 804 and 832

Watershed Area sq mi	17.2 and 20.2
Main Land Uses	804- Open space, 832- low density residential
HSPF Reach	1,11,12,2
Perlnd- Implnd Series	91,101,111,121,141
5-minFlow Data Period	WY05-09
Peak Flow Data Period	WY88-09 (832); WY05-08 (804)
Main Calibration Parameters	LZSN, INTFW

The Tapo Canyon gage 832 located in the downstream developed area of the watershed provided peak flow data for the entire model period. Gage 804 was installed at the beginning of Water Year 2005 at the developed/undeveloped boundary and provides 5-min data from the undeveloped area during storm events. This gage is used primarily as a storm monitoring location and so less time is spent on the record ensuring that the flows are as accurate as possible compared to the full record locations.

In general the developed area gage underpredicted the historical peaks except for two of the top four recorded peaks. When the model was calibrated to improve the performance for lower flow peak years, the model then over predicted the peaks during the high flow peak years. Therefore, the current calibration for gage 832 was accepted as the best estimate to provide a reasonable design storm peak. The 804 gage for the undeveloped area has a very short record. In the one flow year with a relatively high peak, the model over predicted the observed peak. As 804 and 832 are event gages, there is not enough data for an assessment of annual volumes to compare to the model results.

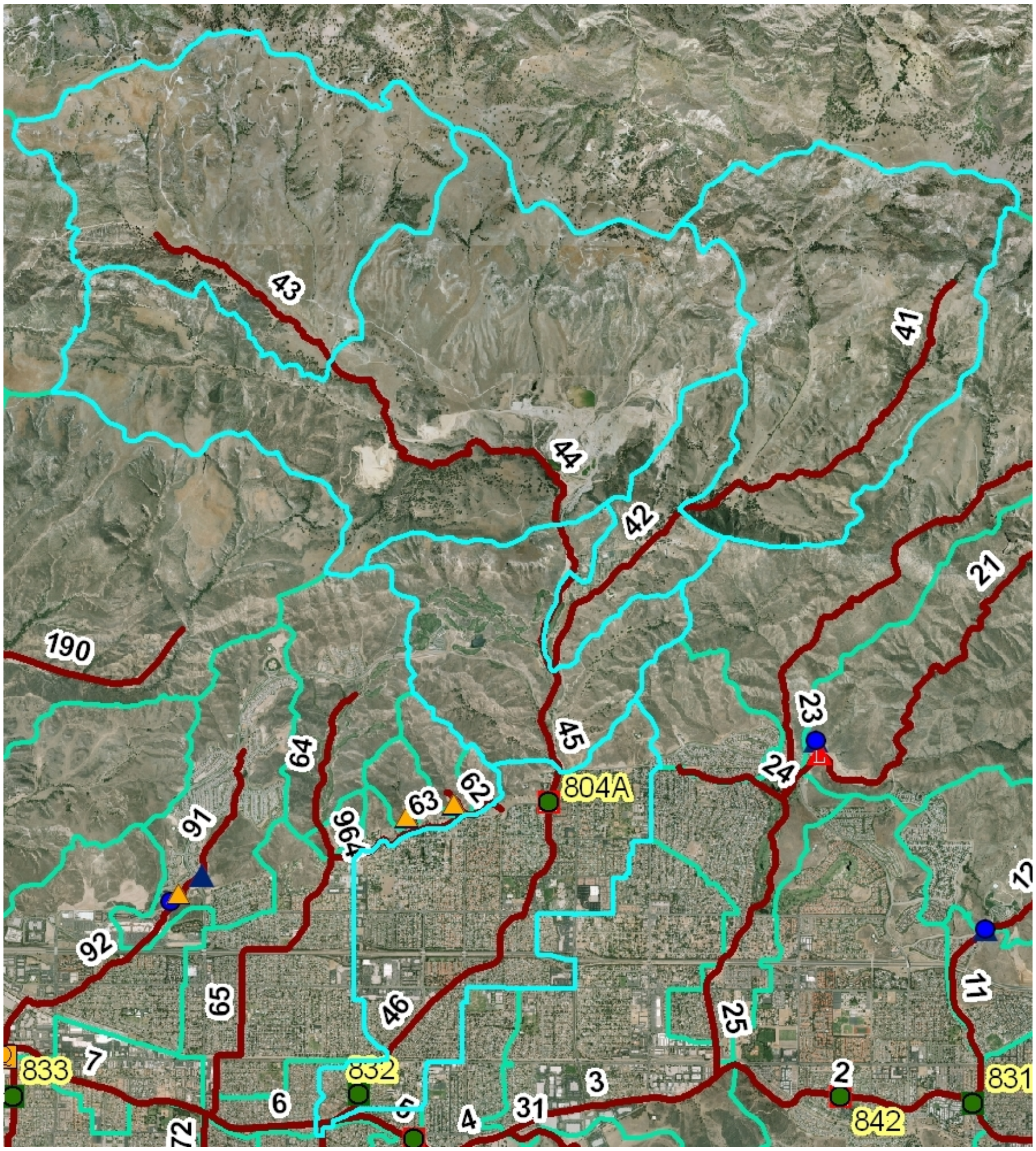

Figure 14. Tapo Cyn Watershed

5.4 Bus Canyon Gage 833

Watershed Area sq mi	4.9
Main Land Uses	Open space,and low density residential
HSPF Reach	81,82
Perlnd- Implnd Series	141, 151, 161, 181
5-minFlow Data Period	WY05-09
Peak Flow Data Period	WY88-09
Main Calibration Parameters	LZSN, INTFW

The Bus Canyon gage 833 located in the downstream developed area of the watershed provided peak flow data for the entire model period. The record was processed beginning in WY05 to provide 5-min data during storm events.

For the top four flow years, the model provided annual peaks that matched the observed data from WY98 and WY05. The model underestimated the historical peak in WY92 and overestimated the peak in WY95. This variability in matching the historic peaks is attributed to the lack of a rain gage in the watershed to adequately characterize the rainfall in the watershed.

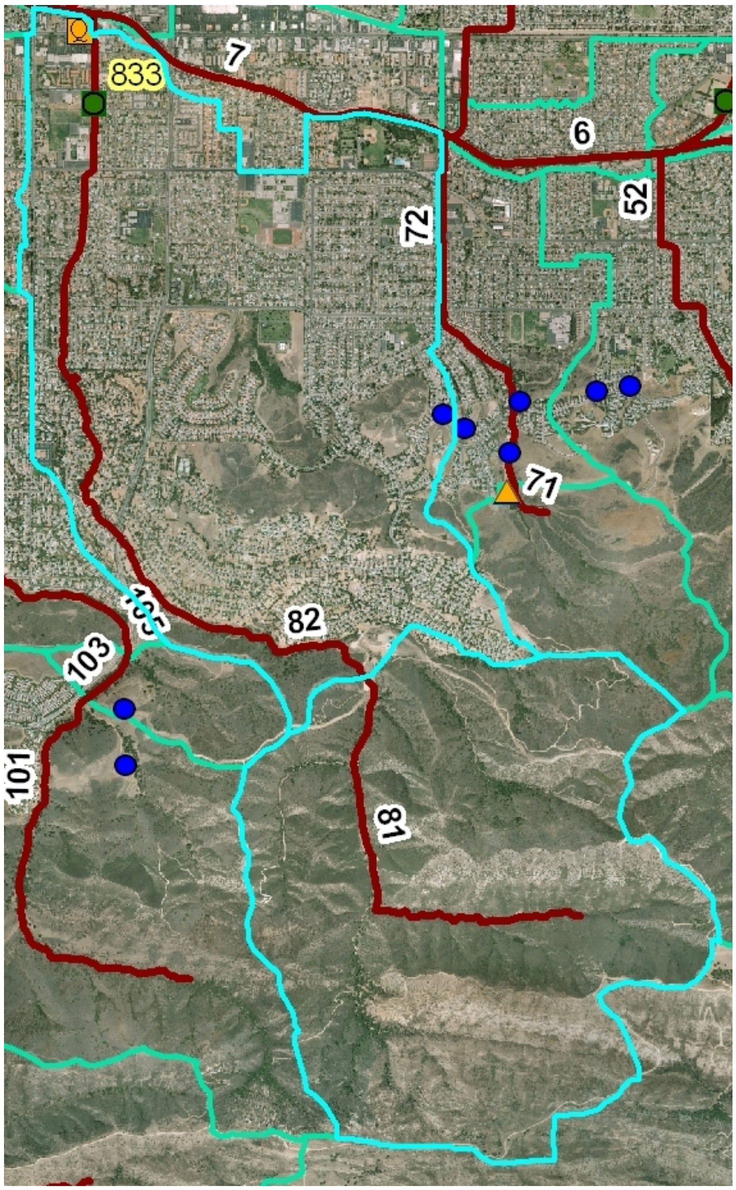

Figure 15. Bus Cyn Watershed

5.5 Gabbert-Walnut Cyn Gage 839

Watershed Area sq mi	6.8
Main Land Uses	Open space,and low density residential
HSPF Reaches	221,222(basin),223
Perlnd- Implnd Series	201,211
5-minFlow Data Period	WY05-09
Peak Flow Data Period	WY88-09
Main Calibration Parameters	LZSN, INTFW

The Gabbert-Walnut gage 839 located downstream of Moorpark provided peak flow data for the entire model period. After Water Year 2005 the record was processed to provide 5-min data during storm events. The Gabbert portion of the watershed has a debris basin that controls runoff from the 3.8 sq mi Gabbert subarea that attenuates peak from smaller storms. Depending on how much sediment has accumulated in the basin, the degree of attenuation can vary. The Walnut portion of the watershed has one regional basin and several smaller homeowner peak flow mitigation basins that are not included in the HSPF model. The Master Plan for this tributary has several additional basins to mitigate deficient conditions that would lead to flooding if the design storm was to occur in this watershed.

For the top four flow years, the model provided annual peaks that matched the observed data from WY95 and WY05. The model overestimated the historical peaks in WY92 and WY98.

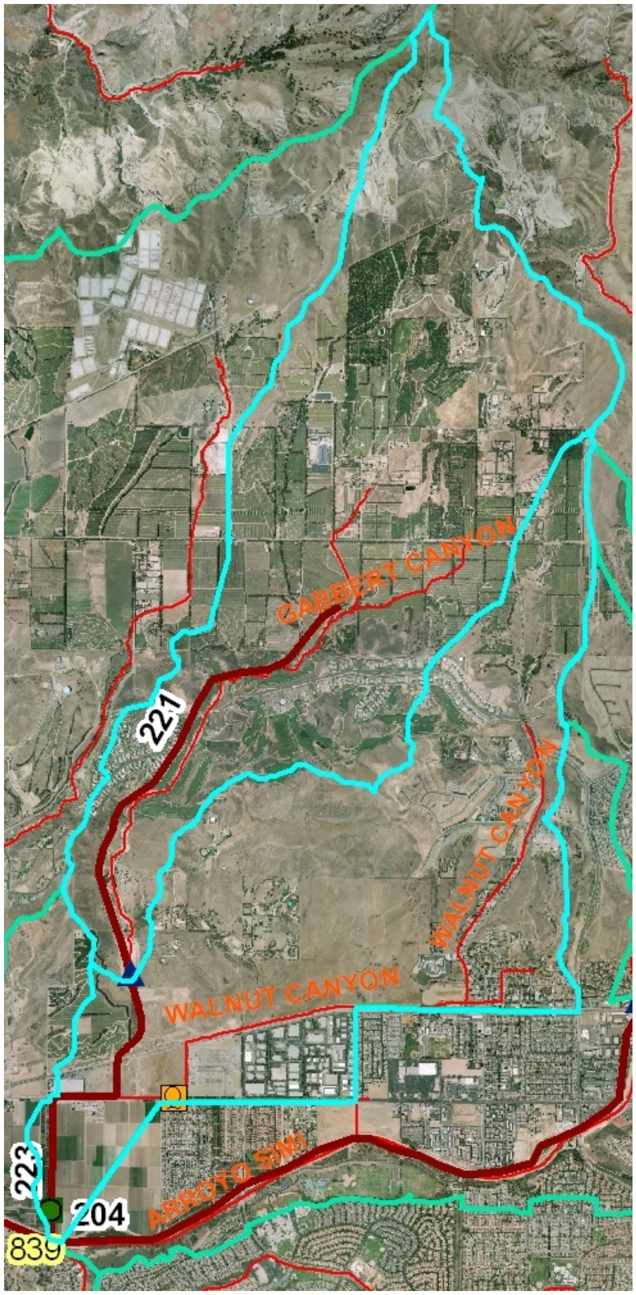

Figure 16. Gabbert Walnut Watershed

5.6 Santa Clara Drain 781

Watershed Area sq mi	7.7
Main Land Uses	Agriculture, Open space
HSPF Reach	510, 511
PerInd- ImpInd Series	391
5-minFlow Data Period	WY01-09
Peak Flow Data Period	WY95-09
Main Calibration Parameters	LZSN, INTFW

The Santa Clara Drain gage 781 located in the Revolon Slough Watershed provided peak flow data from WY96-09, with daily average data available from WY96-WY07. The record was processed for 5 min data starting in WY01. After WY07, only storm hydrographs were processed. This subarea has a debris basin that controls runoff from the 1.1 sq mi Ferro Ditch subarea that attenuates peaks from smaller storms. Depending on how much sediment has accumulated in the basin, the degree of attenuation can vary.

Although the flow volumes and peaks at the Beardsley gage just downstream are matched well by the model, the volumes at gage 781 are underestimated while the available top historic peaks in WY98 and WY05 are overestimated. The top historic peaks for gage 778 (including WY92 and WY95) for the adjacent Nye watershed are over and underestimated by the model using the same model parameters applied to the Santa Clara Drain watershed. It appears that the available rain gages may not characterize the rainfall for the Santa Clara and Nyeland Drain watersheds so that the model can match the peaks and volumes.

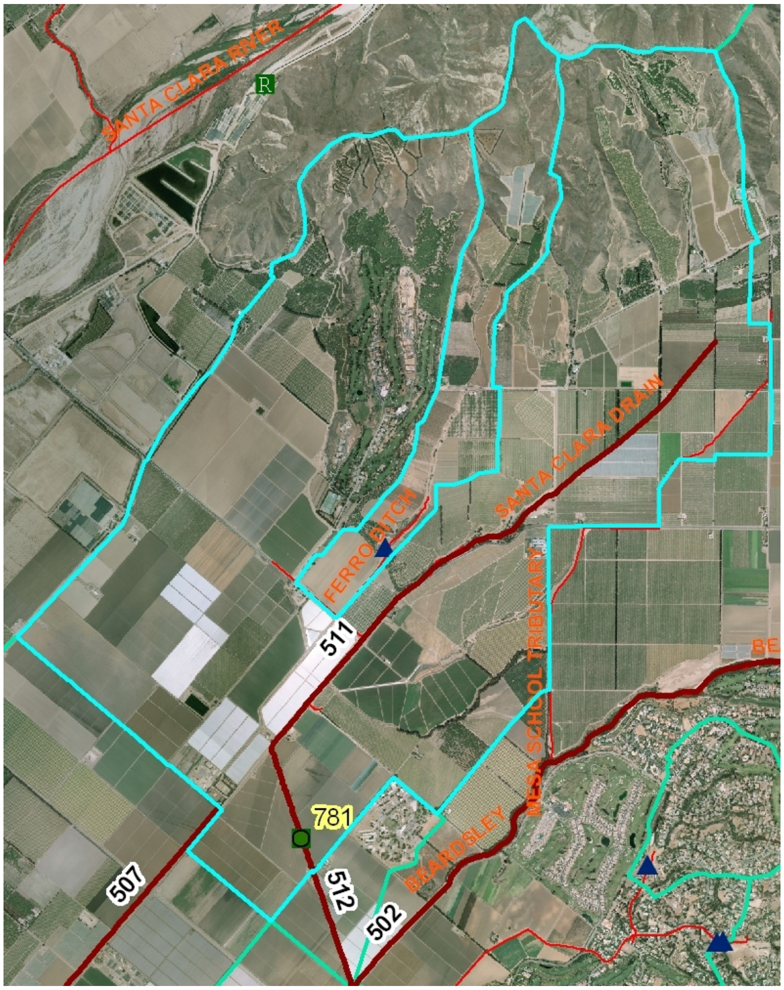

Figure 17. Santa Clara Drain Watershed

5.7 Nyeland Drain Gage 778

Watershed Area sq mi	3.6
Main Land Uses	Agriculture and low density residential
HSPF Reach	507
PerInd- ImpInd Series	391
5-minFlow Data Period	WY05-09 (event hydrographs)
Peak Flow Data Period	WY88-09
Main Calibration Parameters	LZSN, INTFW

The Nyeland Drain gage 778 provided peak flow data for the entire model period. For the top four historic storms, the model over and underestimates the peaks. In drier years, the model generally underestimates the annual peaks. As discussed for the Santa Clara Drain, it appears that the rain gages assigned to this subarea in the model do not represent the actual rain falling on the catchment and so the model cannot match the observed data.

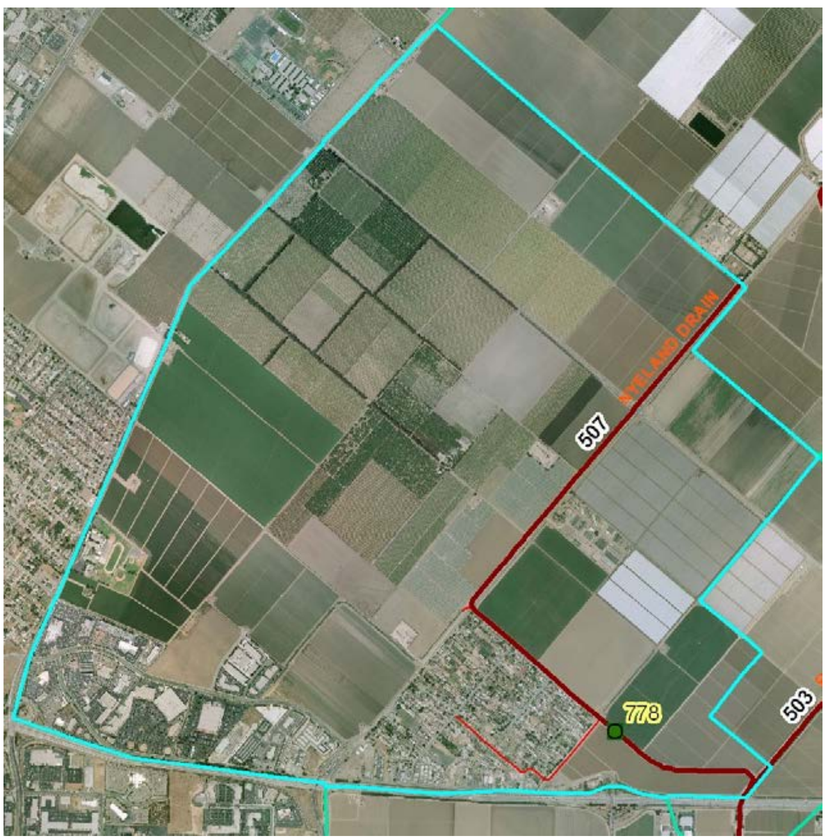

Figure 18. Nyeland Drain Watershed

5.8 Camarillo Hills Drain Gage 835

Watershed Area sq mi	5.3
Main Land Uses	Low Density Residential, Agriculture, Commercial
HSPF Reach	521,523-526 (Debris Basins)
PerInd- ImpInd Series	291
5-minFlow Data Period	WY05-09 (Event Hydrographs)
Peak Flow Data Period	WY88-09
Main Calibration Parameters	LZSN, INTFW

The Camarillo Hills Drain gage 835 provided peak flow data for the entire model period. There are four small debris basins that attenuate the peak flows to a limited extent depending on the magnitude of the storm and how much debris has accumulated in the basins. For the top four historic storms, the model matches the peaks from WY95 and 98, and overestimates the peaks from WY92 and 05. In drier years, the model generally underestimates the annual peaks.

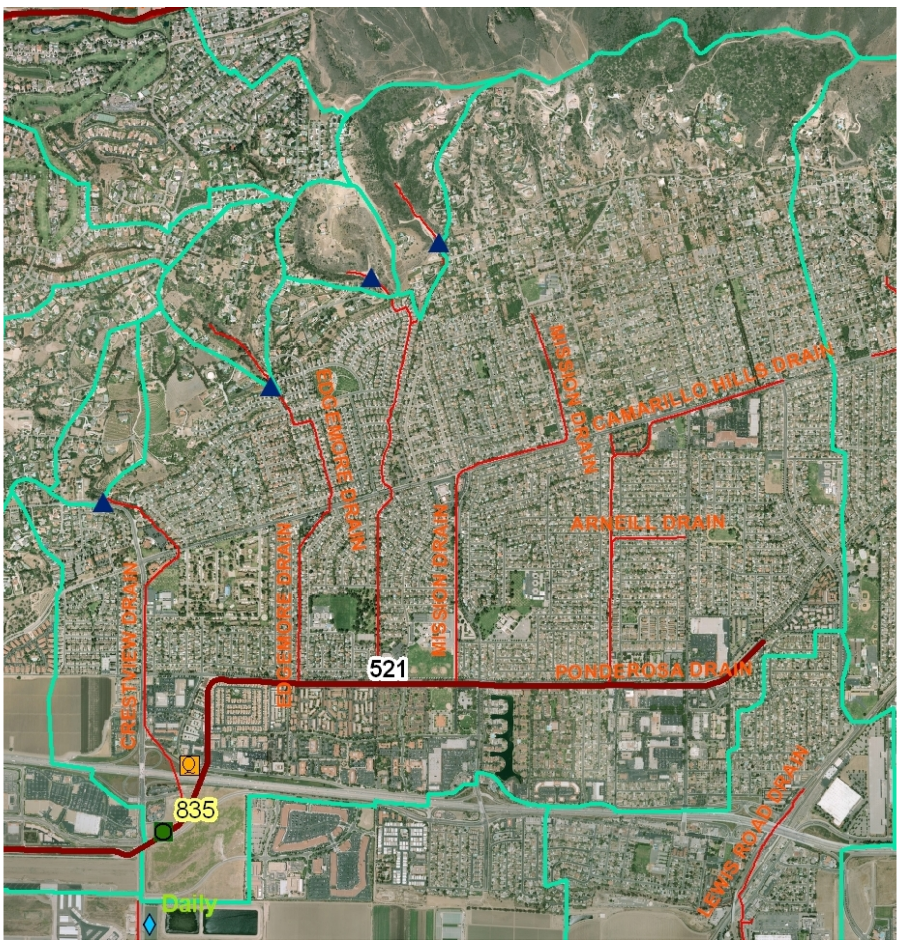

Figure 19. Camarillo Hills Drain Watershed

5.9 Santa Rosa Creek Gage 838

Watershed Area sq mi	13.7

Main Land Uses	Open space, low density residential
HSPF Reach	441, 442, 443
PerInd- ImpInd Series	191,321
5-minFlow Data Period	WY05-09 (event hydrographs)
Peak Flow Data Period	WY88-09
Main Calibration Parameters	LZSN, INTFW

The Santa Rosa gage 838 provided peak flow data for the entire model period. There is one debris basin that attenuates the peak flows to a limited extent depending on the magnitude of the storm and how much debris has accumulated in the basin. There are some culverts and drainage facilities in the upper watershed (subarea 441) that provide detention to attenuate peaks. The observed data show that the flow at the gages has exceeded 1,000 cfs in 1998, 2001, 2003, 2005, and 2006. For these storms, the model underestimates the flows from the watershed. In drier years, the model generally underestimates the annual peaks. The results indicate that the rain gages assigned to these subareas in the model do not adequately characterize the average rain across the catchment.

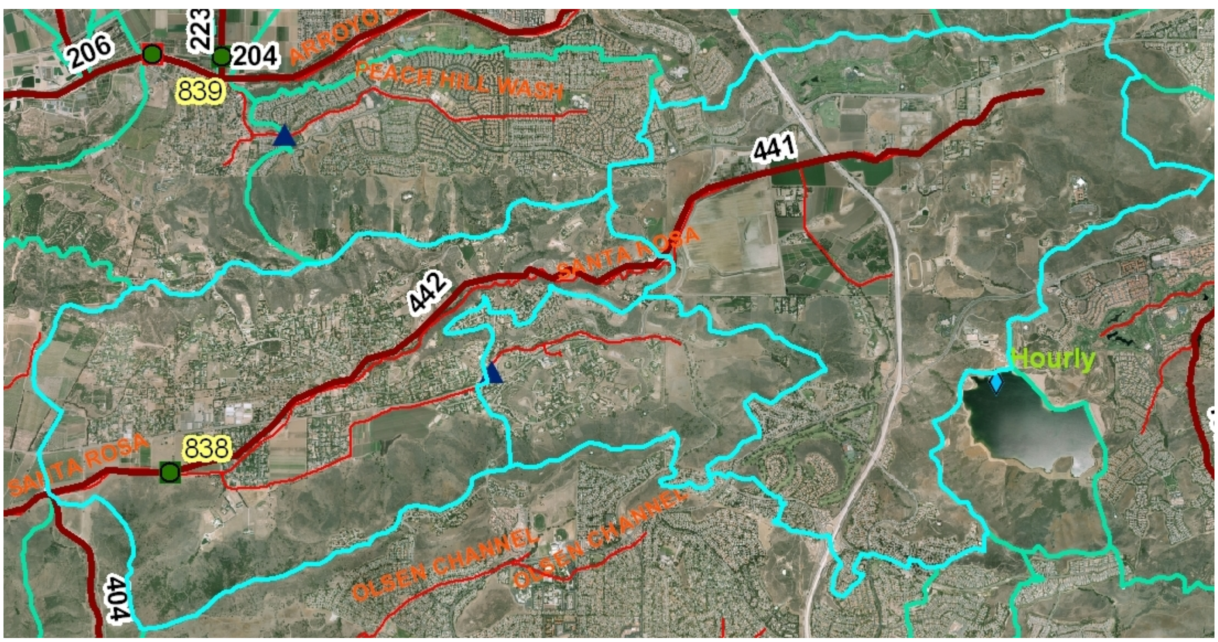

Figure 20. Santa Rosa Creek Watershed

5.10 South Branch Arroyo Conejo 830

Watershed Area sq mi	12.5
Main Land Uses	Open space, low density residential

HSPF Reach	421m 422(basin), 423
PerInd- ImpInd Series	241
5-minFlow Data Period	WY05-09
Peak Flow Data Period	WY88-09 (832)
Main Calibration Parameters	LZSN, INTFW

The South Branch Arroyo Conejo (SBAC) gage 830 provided peak flow data for the entire model period. There are five detention basins in series in the upper watershed along the Conejo Mtn Creek tributary, and two other detention basins along the SBAC that are represented in the Modified Rational Method model of the area. The only basin that was included in the HSPF model was the South Branch Arroyo bypass basin (Reach 422 in model) that diverts a portion of the flow into a basin. Although a number of basins that attenuate peak flows are not in the HSPF model, the peak flow data show that the flow exceeded 2,000 cfs in 1992, 1995, 1998, 2001, and 2005. The model matches the 1998 historic peak of 4,240 cfs within 100 cfs, underestimated the peaks in 1992 and 2001 by up to 1,000 cfs, and overestimated the peaks in 1995 and 2005 by as much as 1,000 cfs. In drier years, the model generally underestimates the annual peaks. The variable results for the calibration indicate that detention basins constructed in the watershed in the beginning in the late 1990's should be included in the HSPF model.

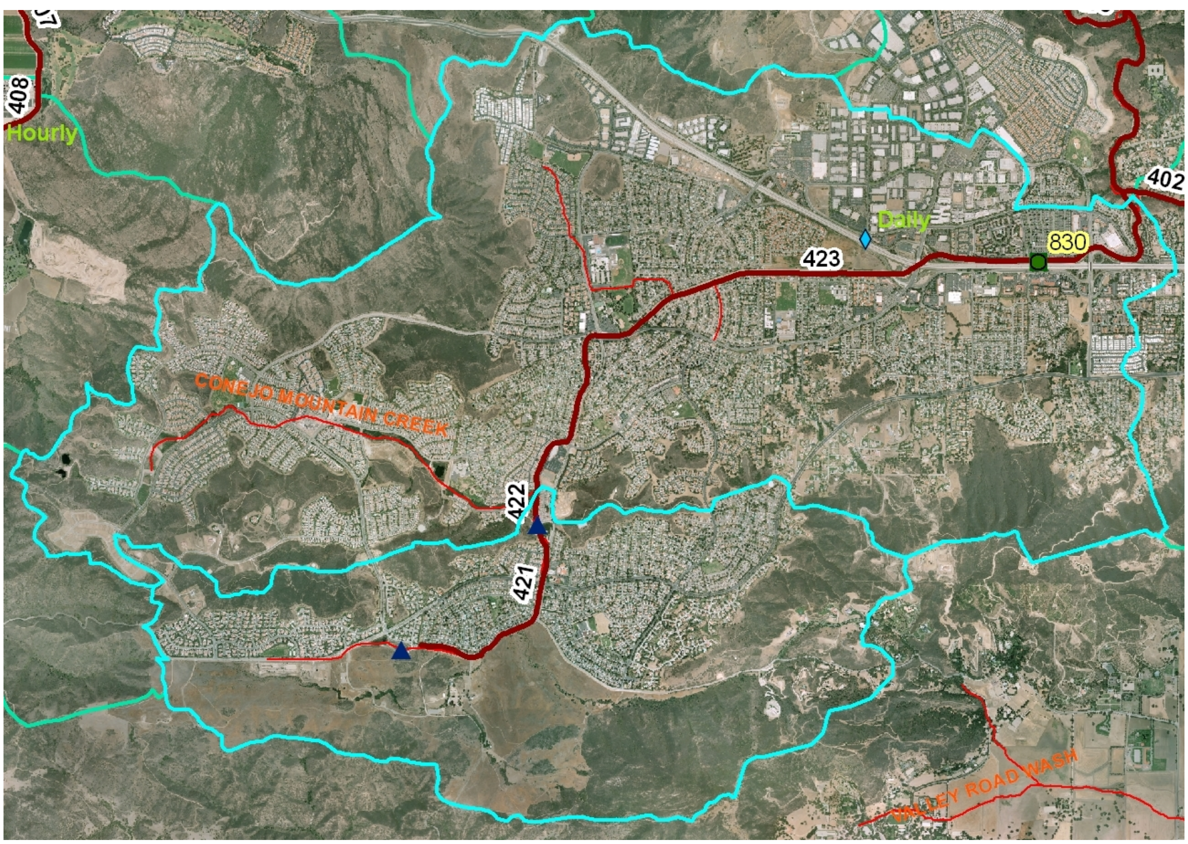

Figure 21. South Branch Arroyo Conejo Watershed

5.11 Arroyo Conejo Gage 836

Watershed Area sq mi	14.2
Main Land Uses	Open space, low density residential, commercial
HSPF Reach	401, 410, 411
PerInd- ImpInd Series	231
5-minFlow Data Period	WY05-09
Peak Flow Data Period	WY88-09 (832)
Main Calibration Parameters	LZSN, INTFW

The Arroyo Conejo gage 836 provided peak flow data for the entire model period. One major detention basin was completed in 2004 on the Lang Creek Tributary that controls 3.6 sq mi of the watershed. Although peaks prior to 2004 were not attenuated by the basin, the percent of area controlled by the basin is relatively small and so the calibration was done with the basin in the model. The peak flow data show that the model or observed flow exceeded 2,000 cfs in 1992, 1993, 1995, 1998, 2001, 2003, and 2005. The model matched the 1992 historic peak of 3,500 cfs within 400 cfs and the 1995 peak of 3,080 cfs within 20 cfs. The model overestimated the peaks in the other wet years by up to several hundred cfs, except that the 2005 peak of 1,620 cfs was overestimated by 1,460 cfs. In drier years, the model generally underestimates the annual peaks.

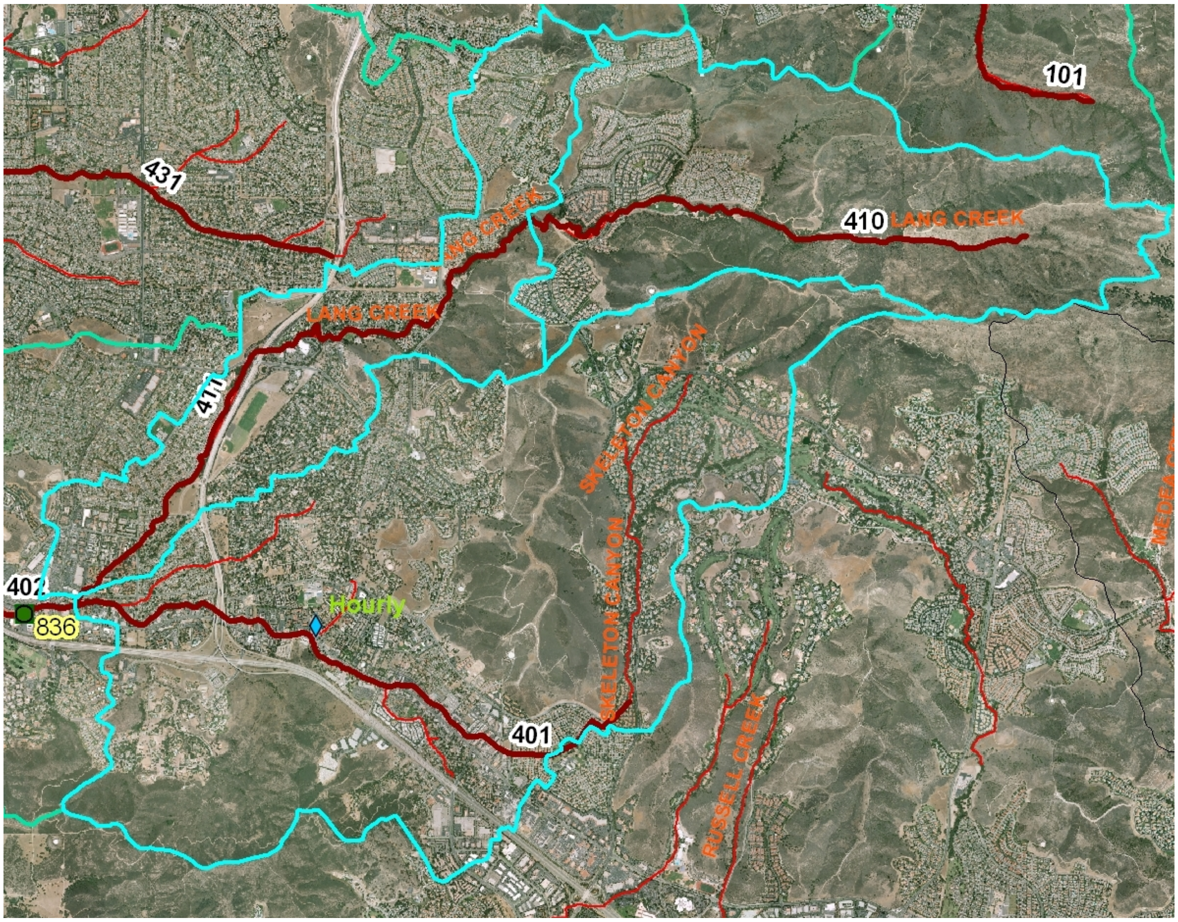

Figure 22. Arroyo Conejo Watershed

6. REFERENCES

Aqua Terra Consultants, 2005. Hydrologic Modeling of the Calleguas Creek Watershed with the U.S. EPA Hydrologic Simulation Program – FORTRAN (HSPF)- Final Report. March 2005.

7. APPENDIX A – BASELINE AND CALIBRATION PLOTS

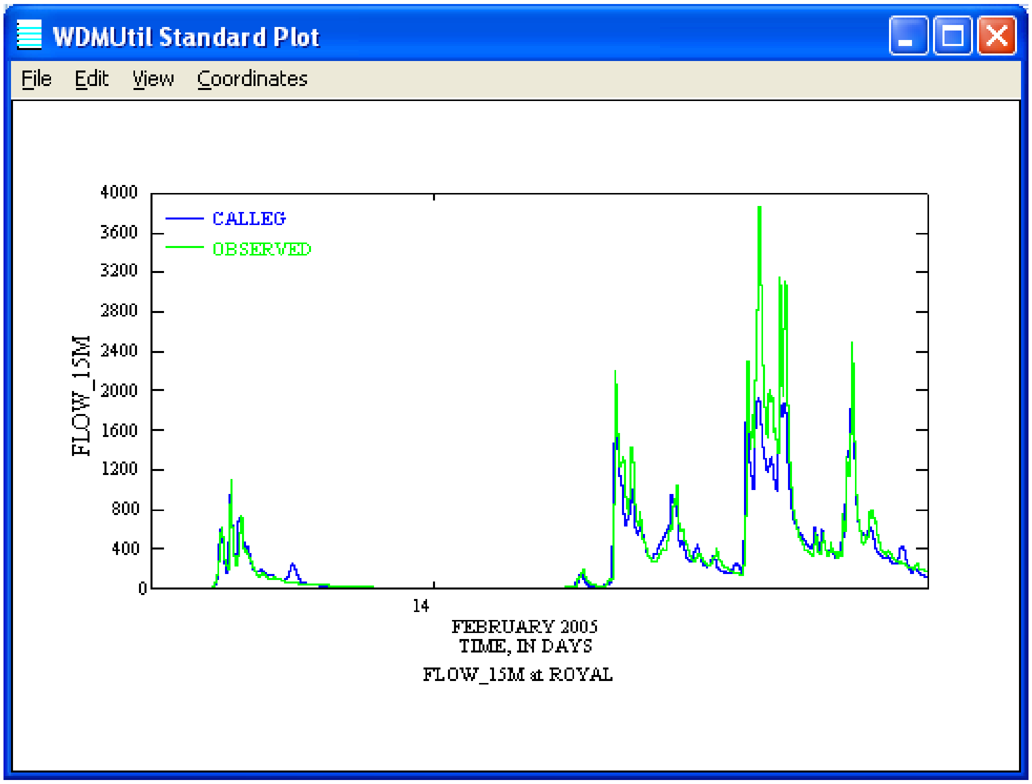

Figure A-1a. Royal Baseline Plot Feb 2005

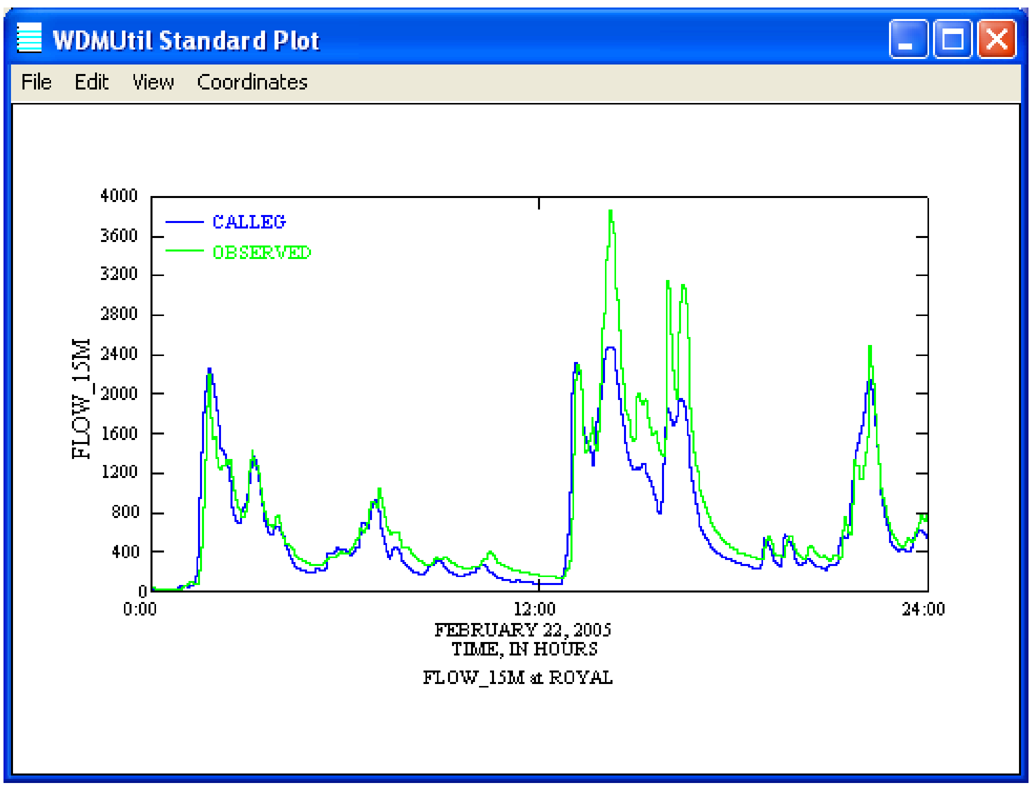

Figure A-1b. Royal Calibrated Plot Feb 2005

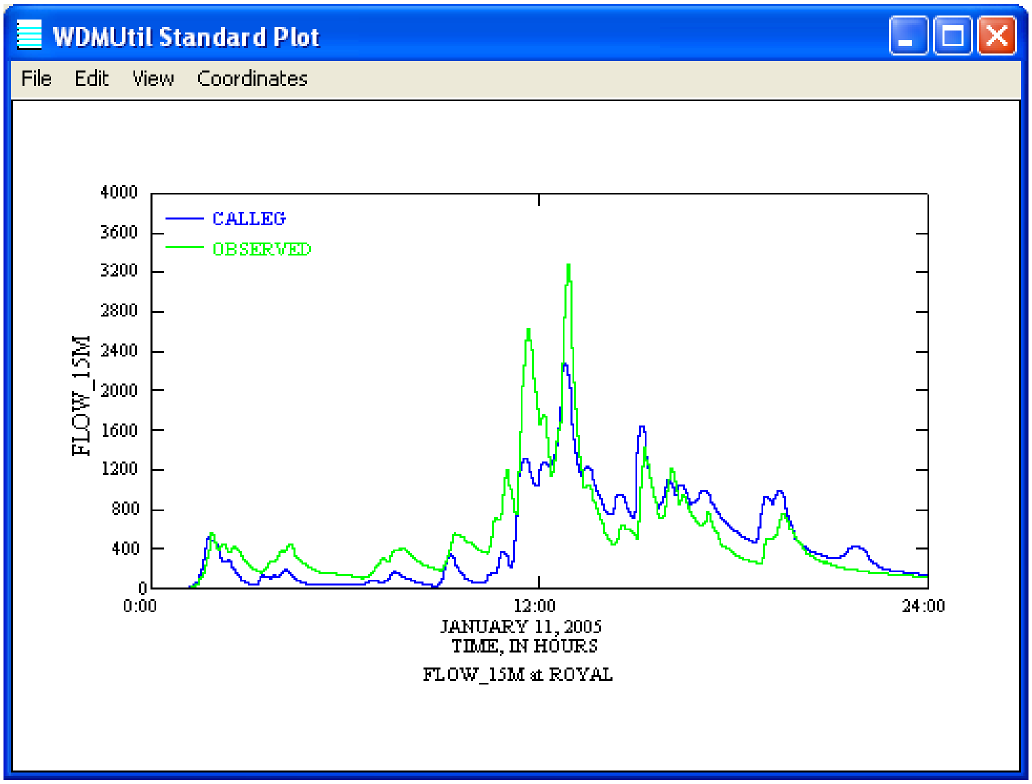

Figure A-2a. Royal Baseline Plot Jan 2005

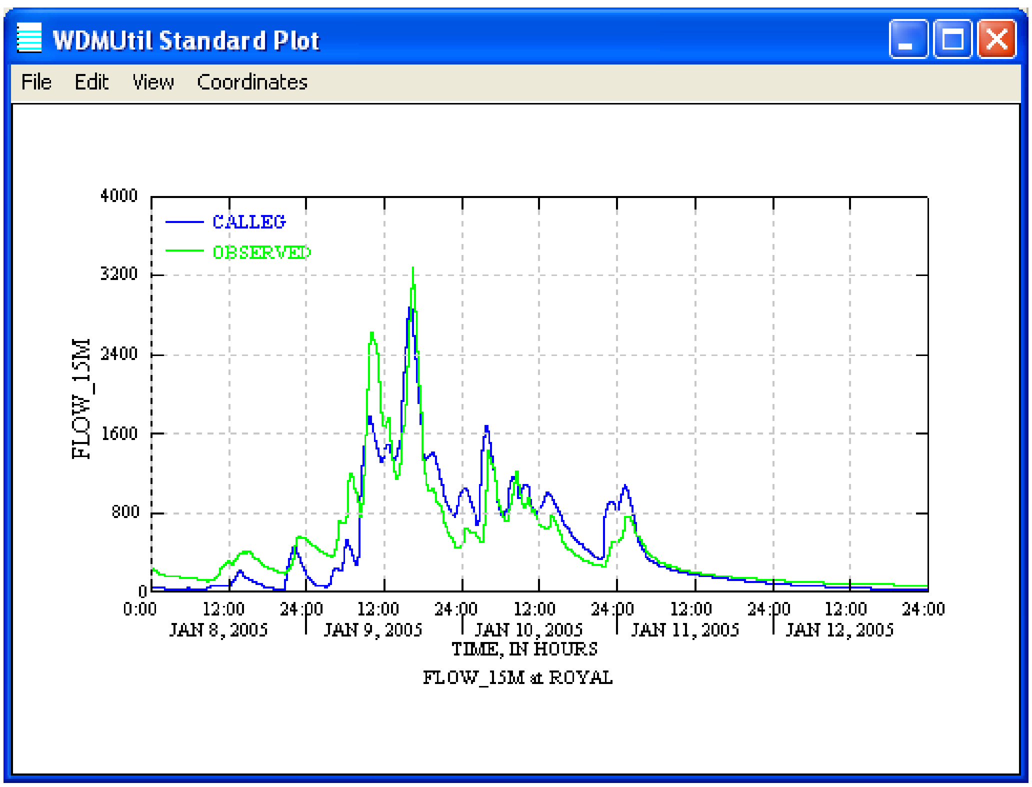

Figure A-2b. Royal Calibrated Plot Jan 2005

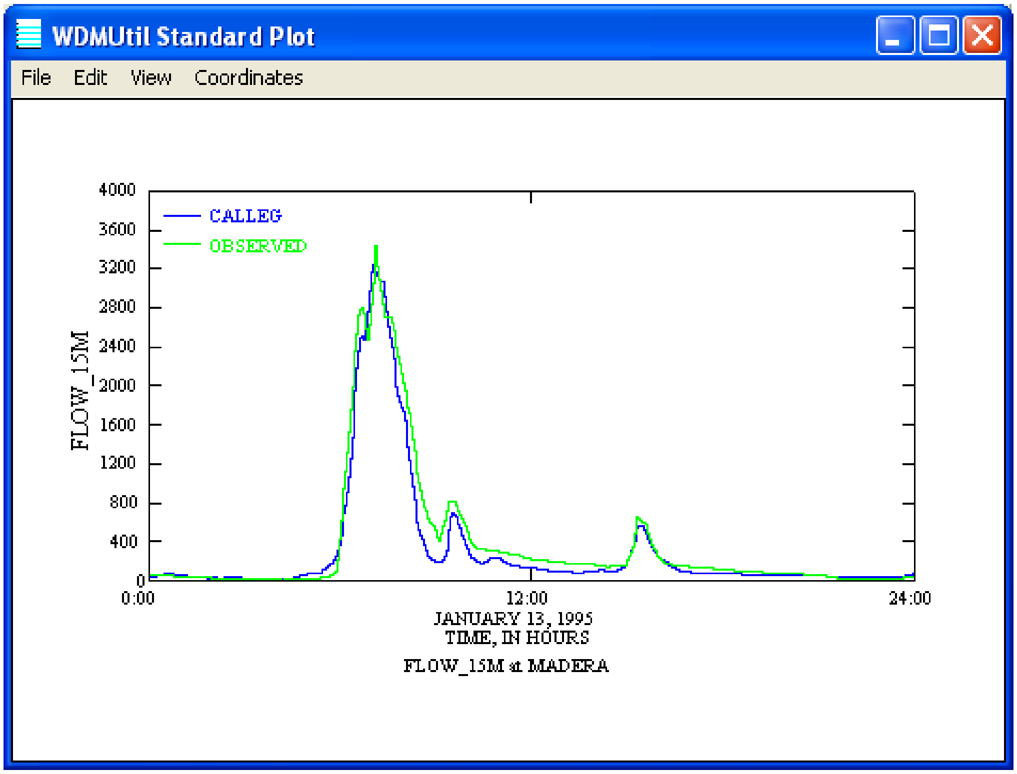

Figure A-3a. Madera Baseline Plot Jan 1995

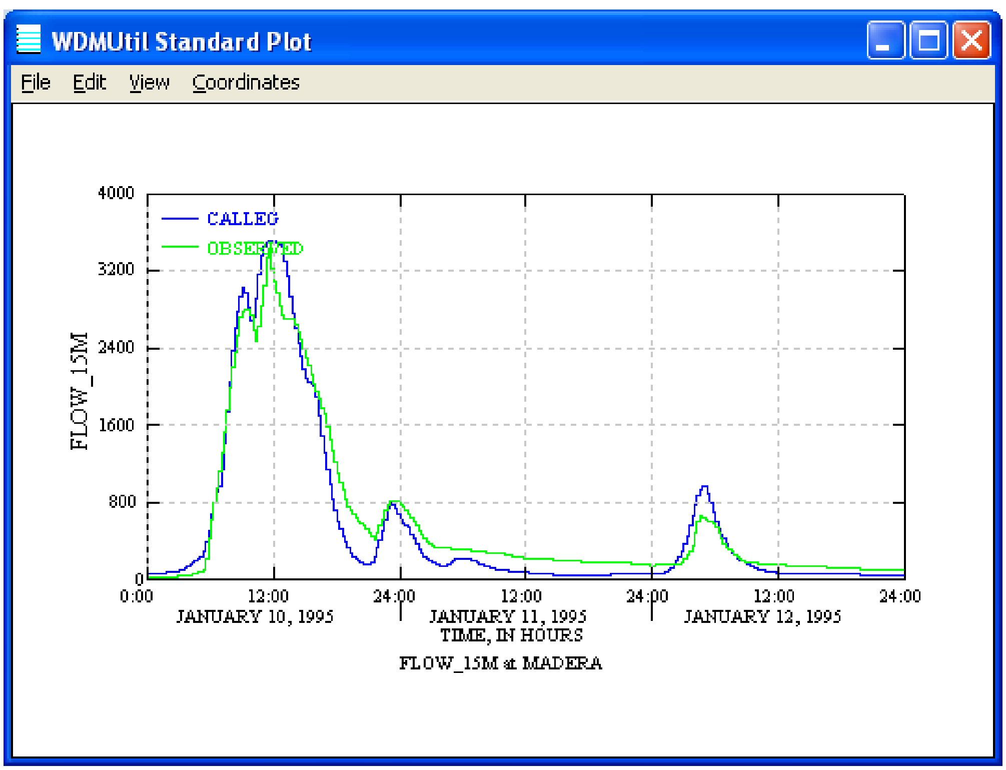

Figure A-3b. Madera Calibrated Plot Jan 1995

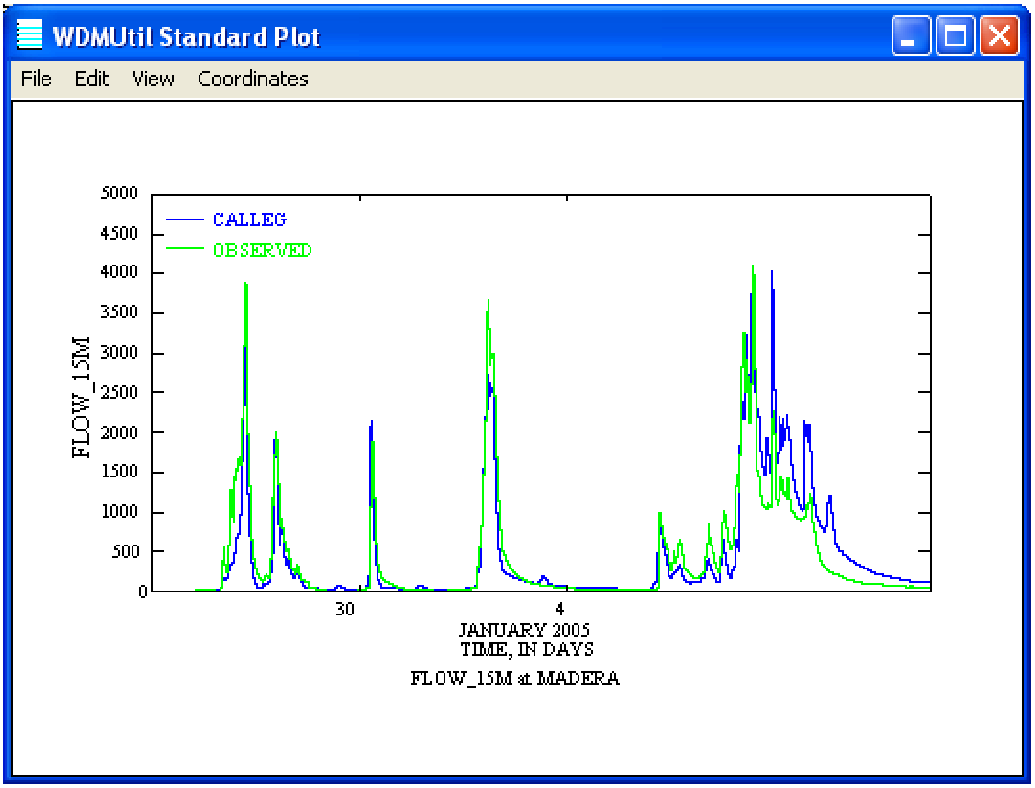

Figure A-4a. Madera Baseline Plot Jan 2005

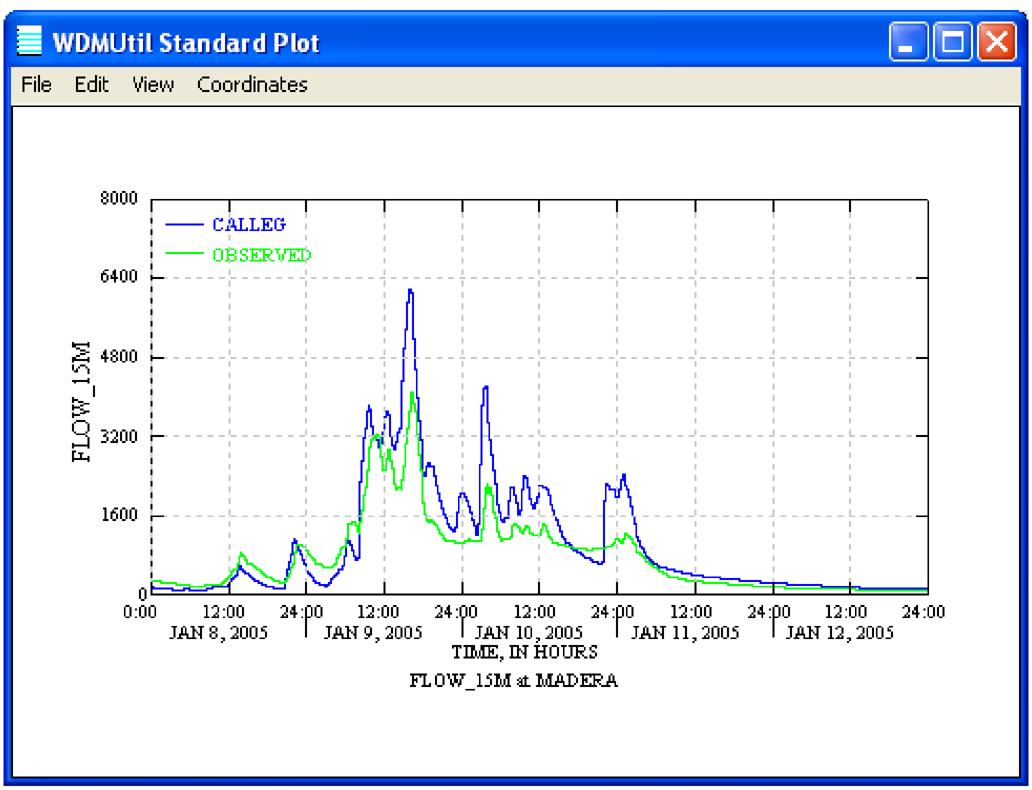

Figure A-4b. Madera Calibrated Plot Jan 2005

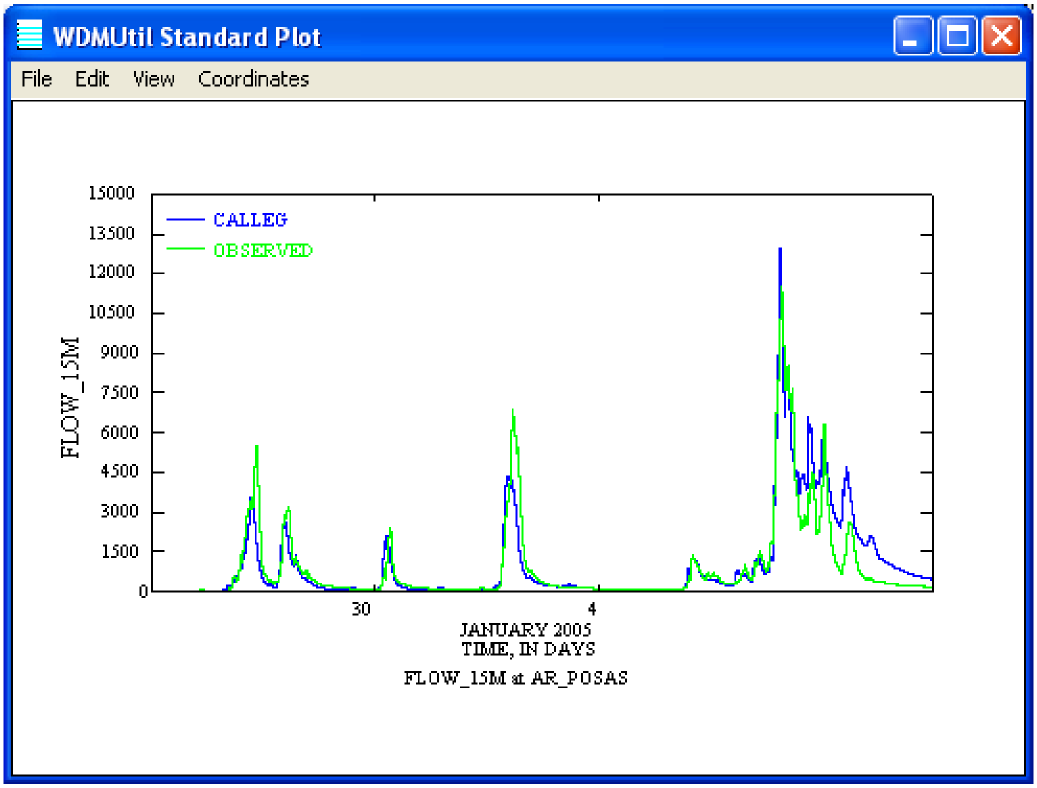

Figure A-5a. Arroyo Las Posas Baseline Plot Jan 2005

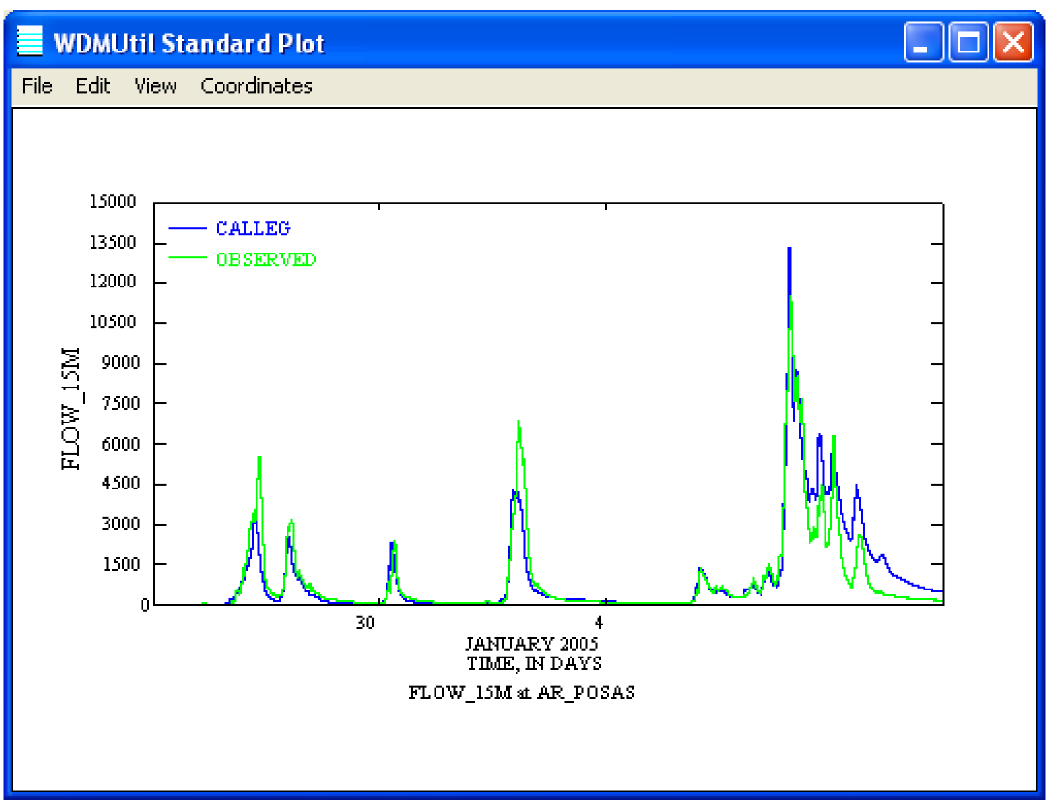

Figure A-5b. Arroyo Las Posas Calibrated Plot Jan 2005

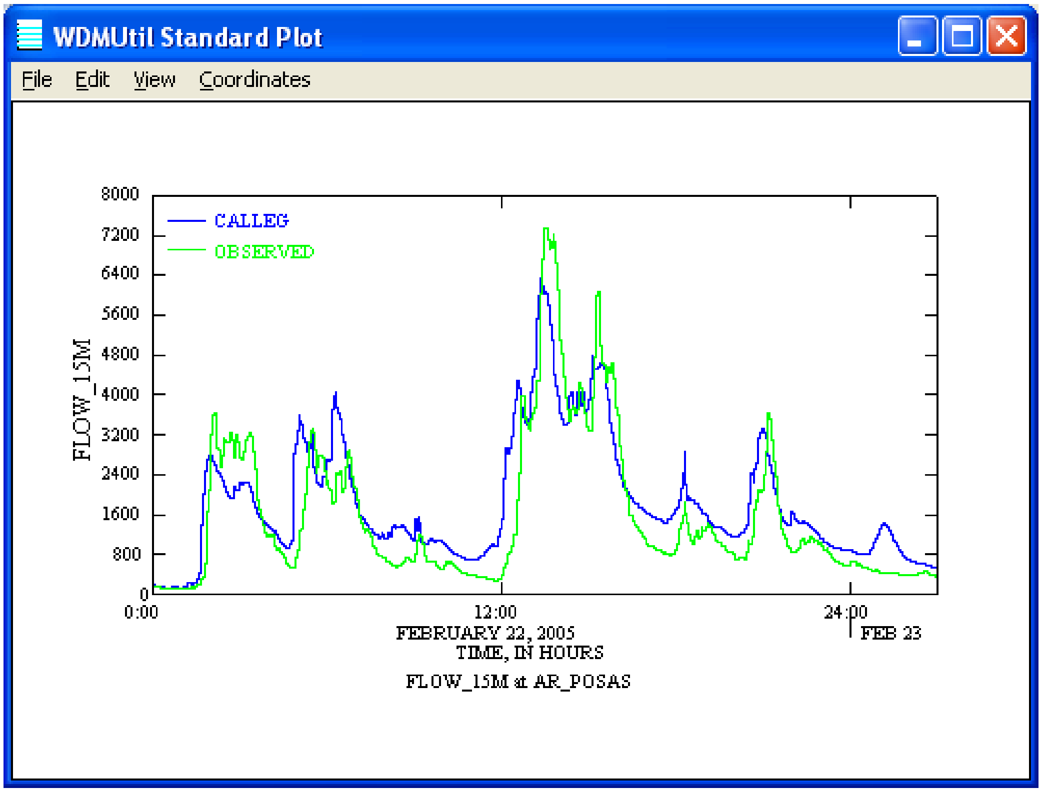

Figure A-6a. Arroyo Las Posas Baseline Plot Feb 2005

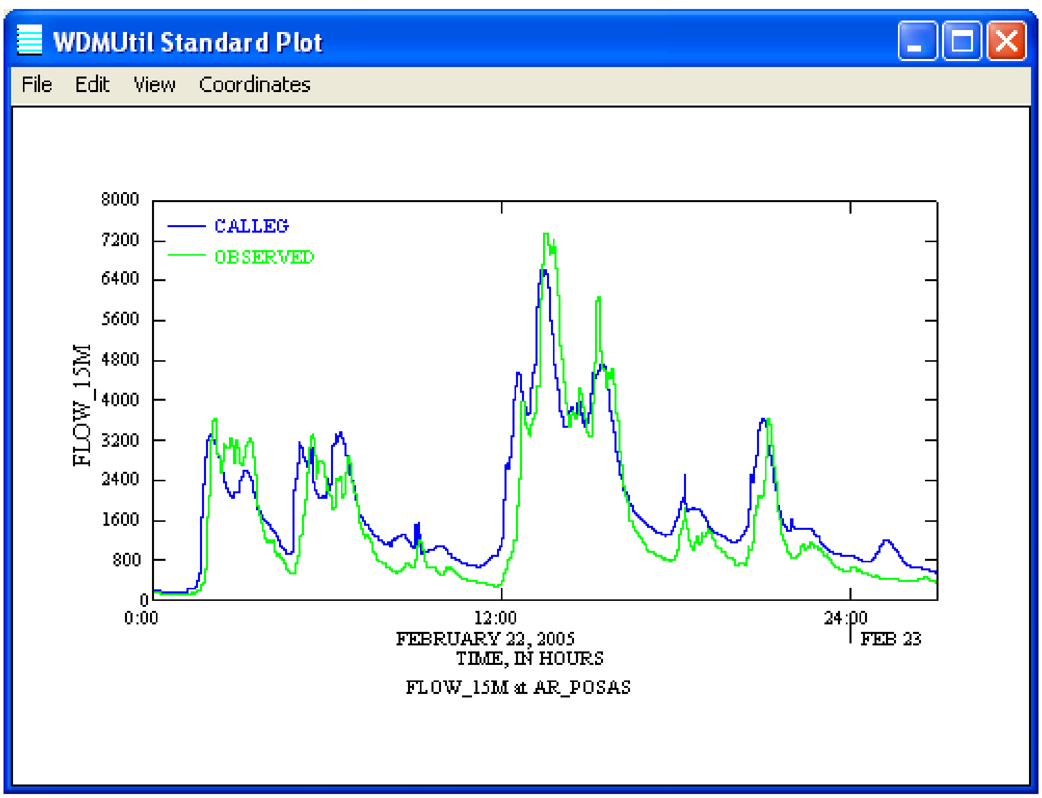

Figure A-6b. Arroyo Las Posas Calibrated Plot Feb 2005

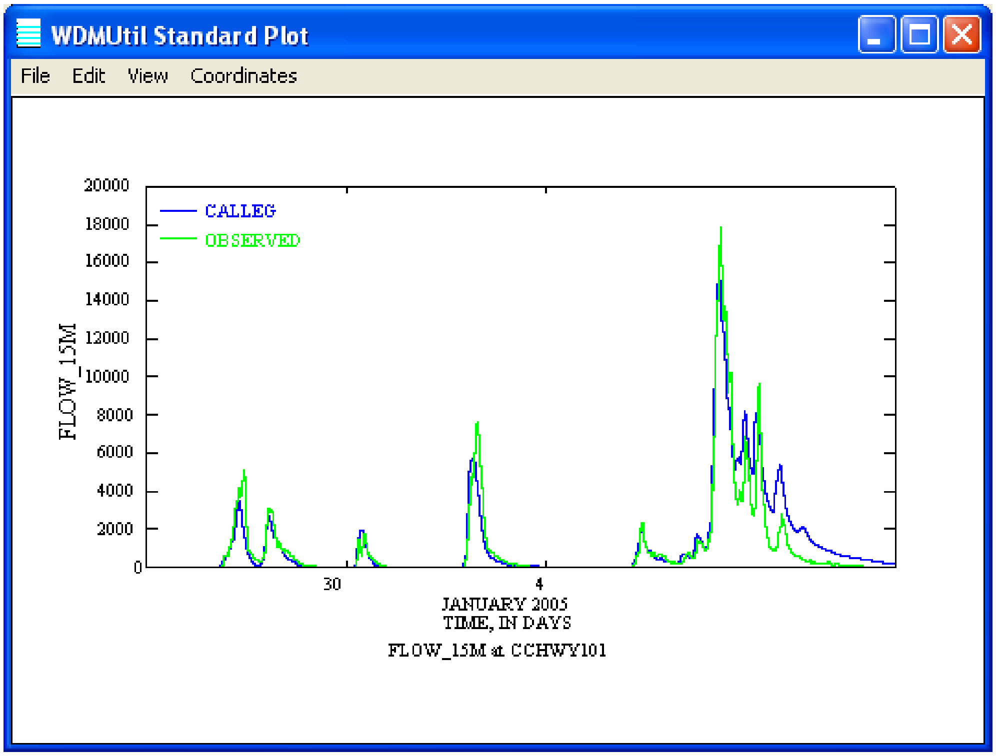

Figure A-7a. Calleguas Ck at Hwy 101 Baseline Plot Jan 2005

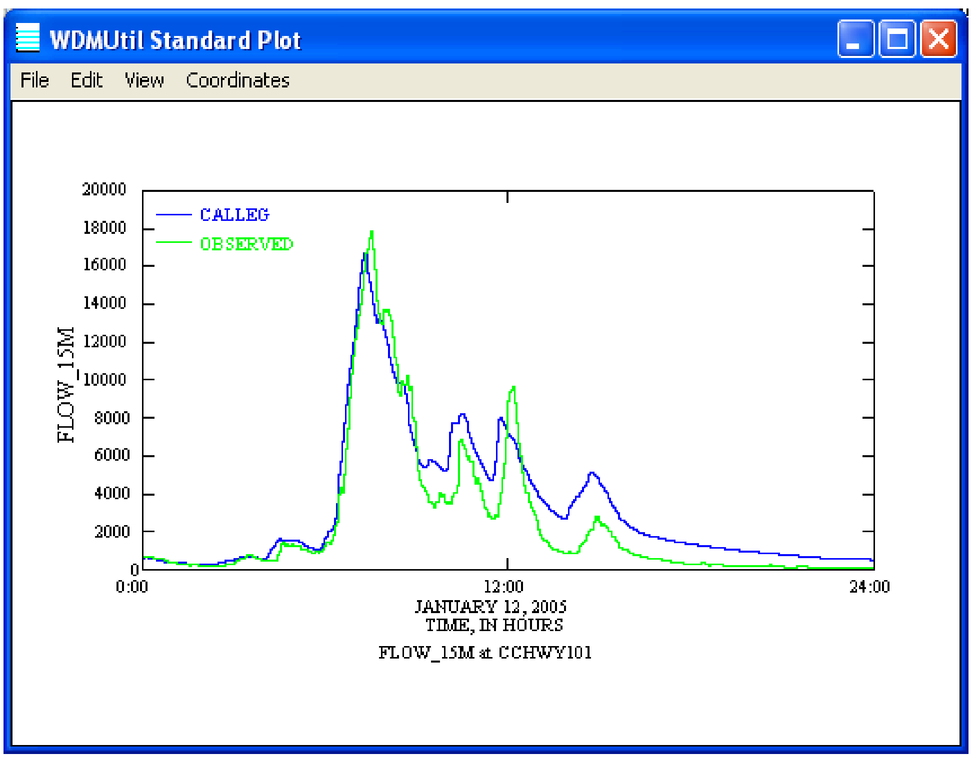

Figure A-7b. Calleguas Ck at Hwy 101 Calibrated Plot Jan 2005

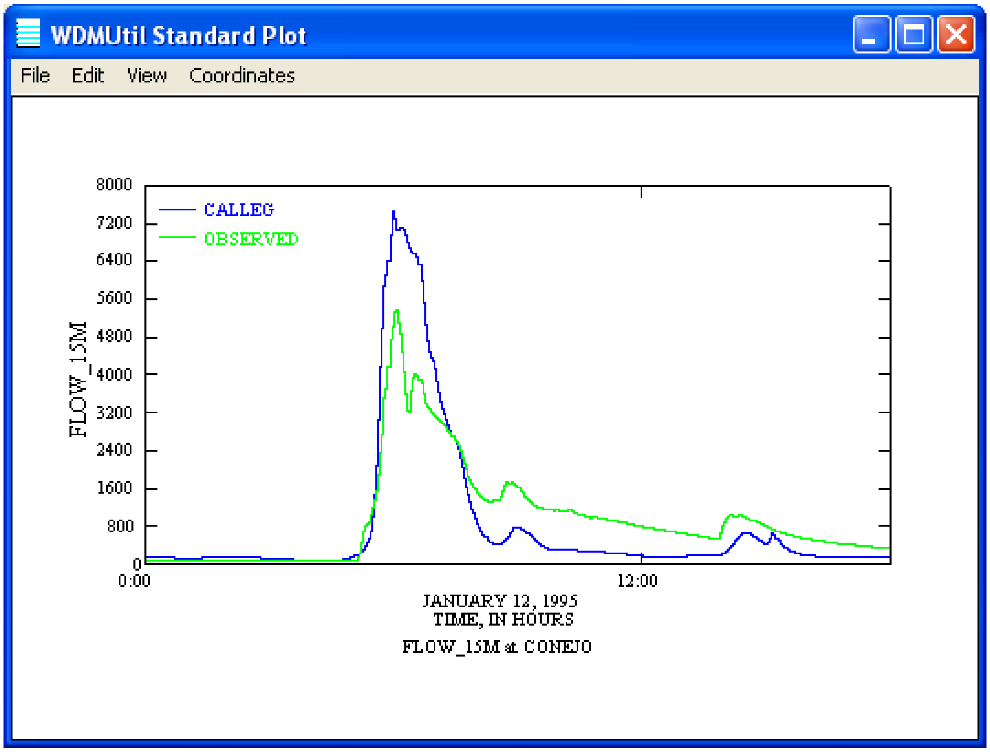

Figure A-8a. Conejo Ck nr Hwy 101 Baseline Plot Jan 1995

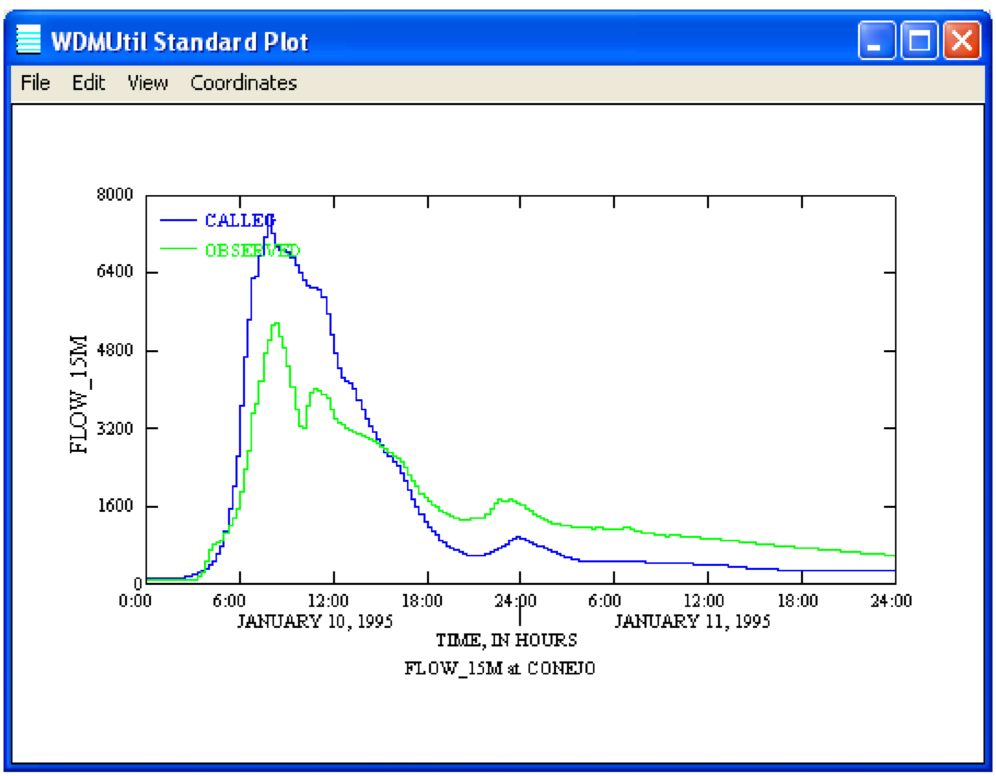

Figure A-8b. Conejo Ck nr Hwy 101 Calibrated Plot Jan 1995

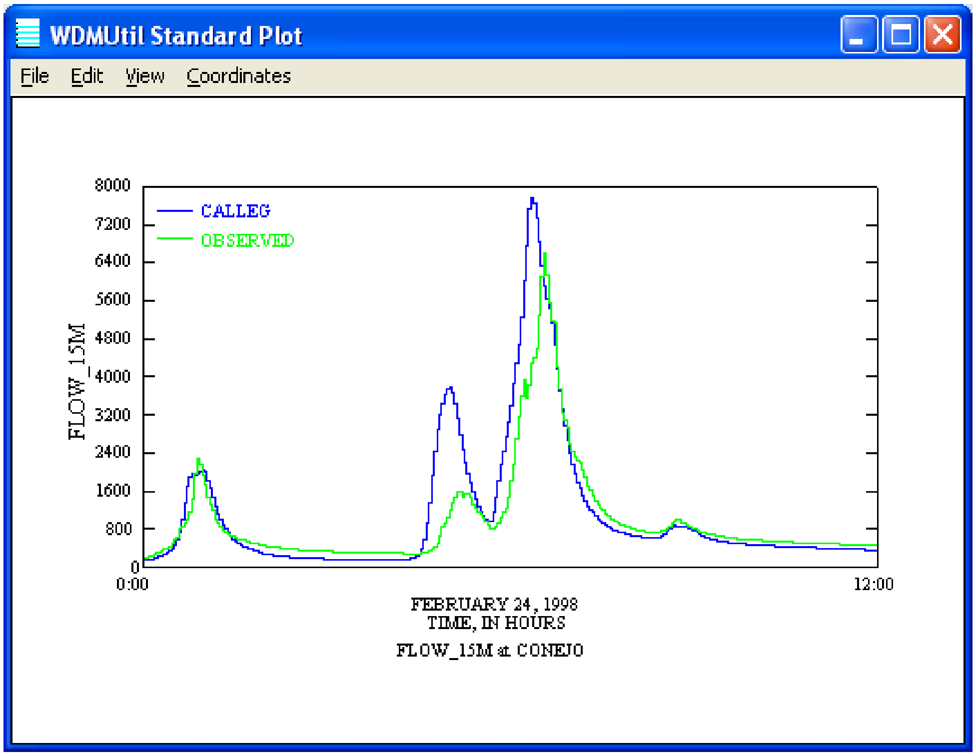

Figure A-9a Conejo Ck nr Hwy 101Baseline Plot Feb 1998

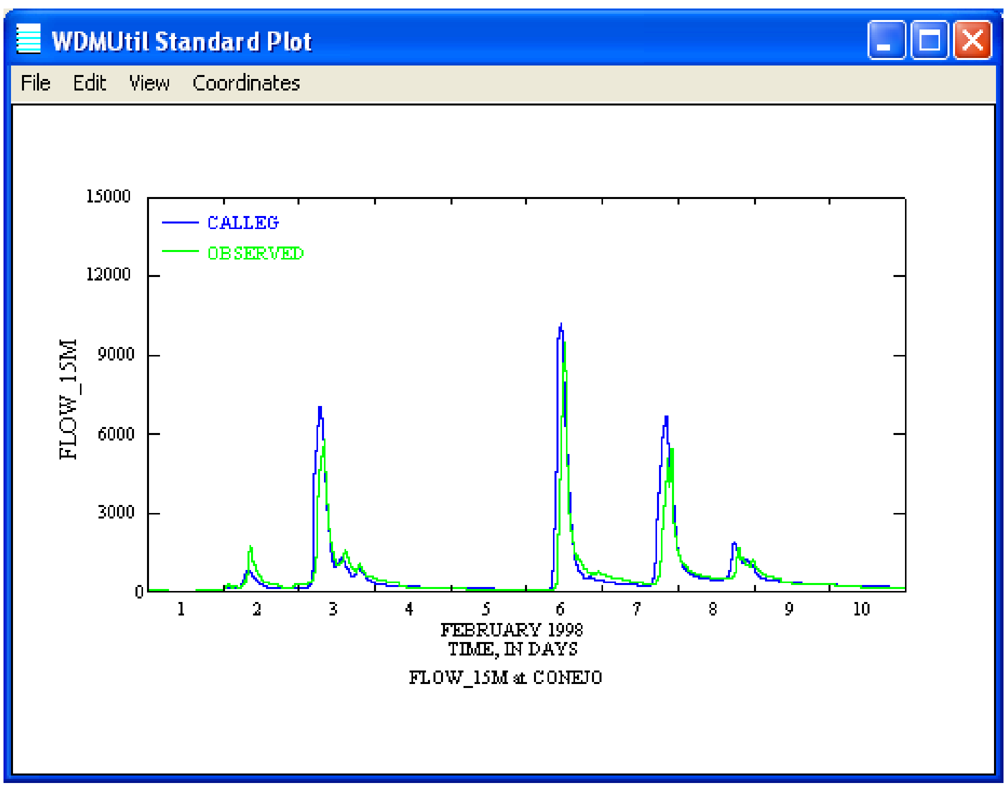

Figure A-9b. Conejo Ck nr Hwy 101Calibrated Plot Feb 1998

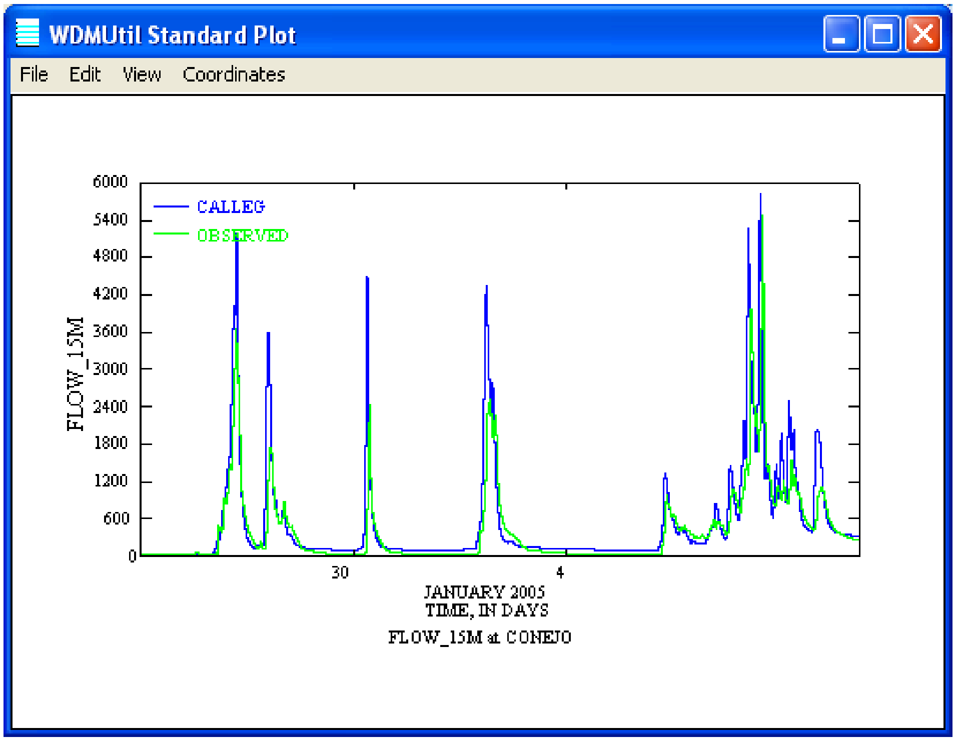

Figure A-10a. Conejo Ck nr Hwy 101 Baseline Plot Jan 2005

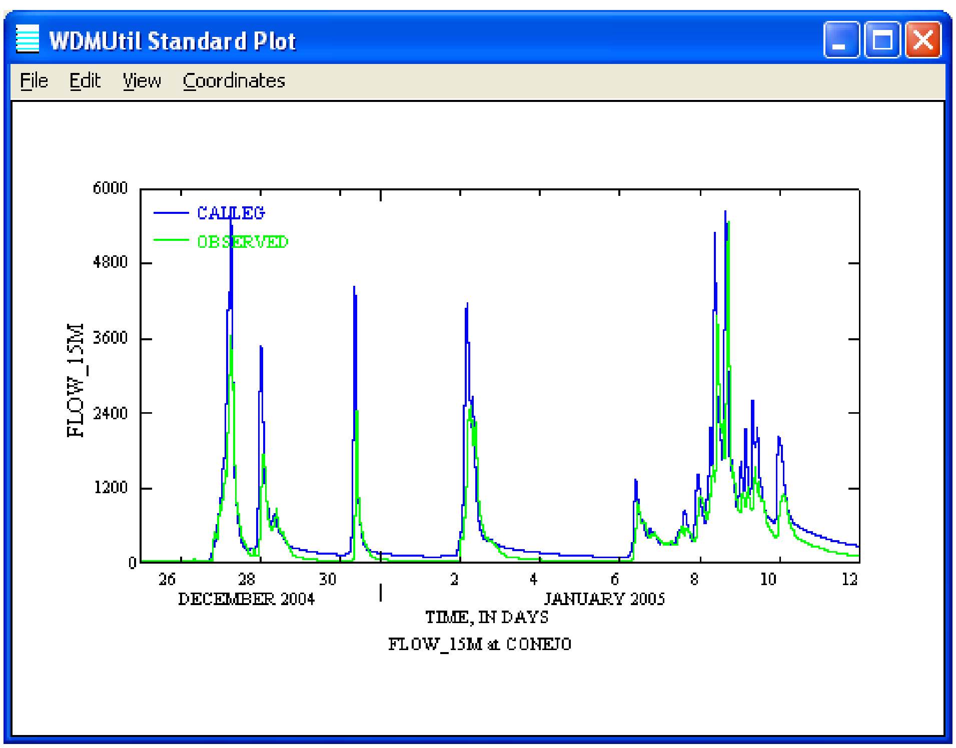

Figure A-10b. Conejo Ck nr Hwy 101 Calibrated Plot Jan 2005

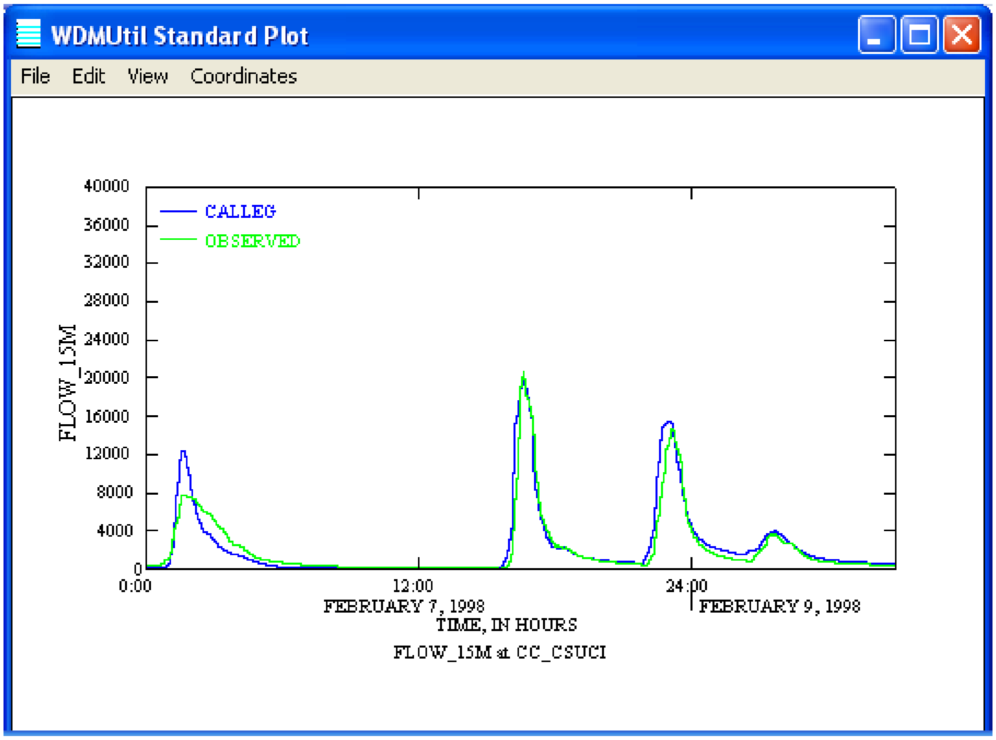

Figure A-11a. Calleguas Ck at CSUCI Baseline Plot Jan 1998

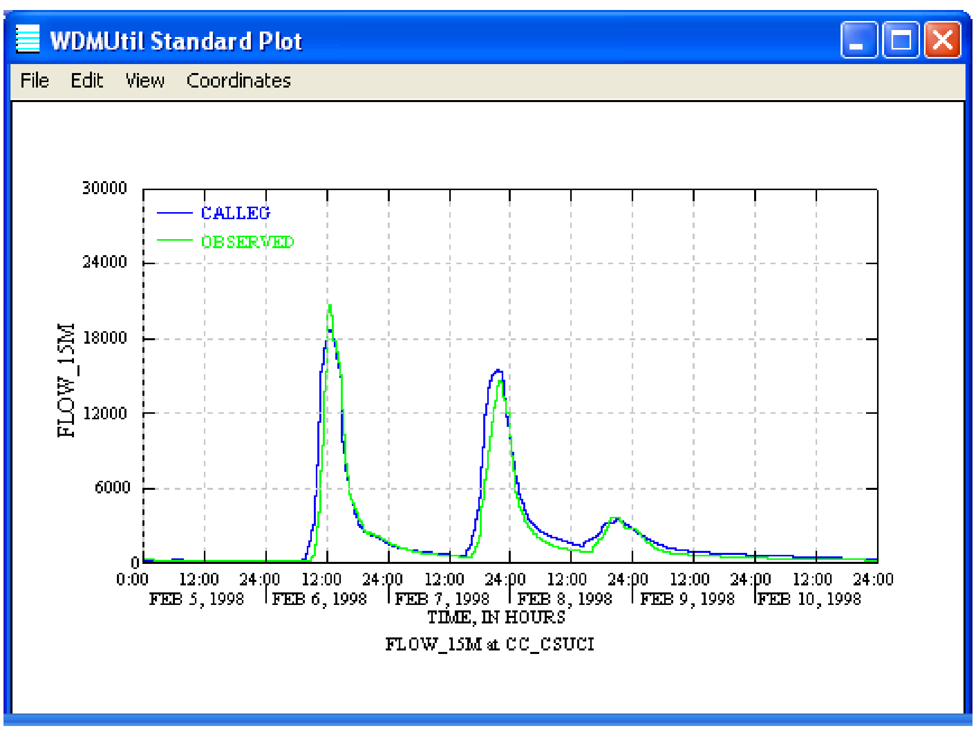

Figure A-11b. Calleguas Ck at CSUCI Calibrated Plot Jan 1998

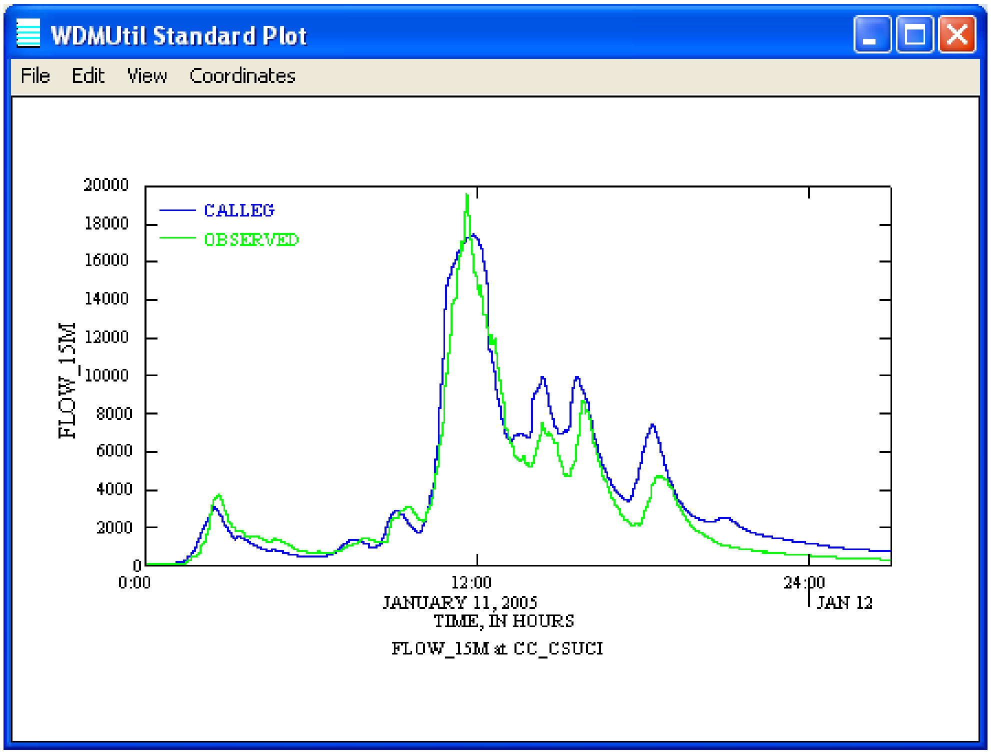

Figure A-12a. Calleguas Ck at CSUCI Baseline Plot

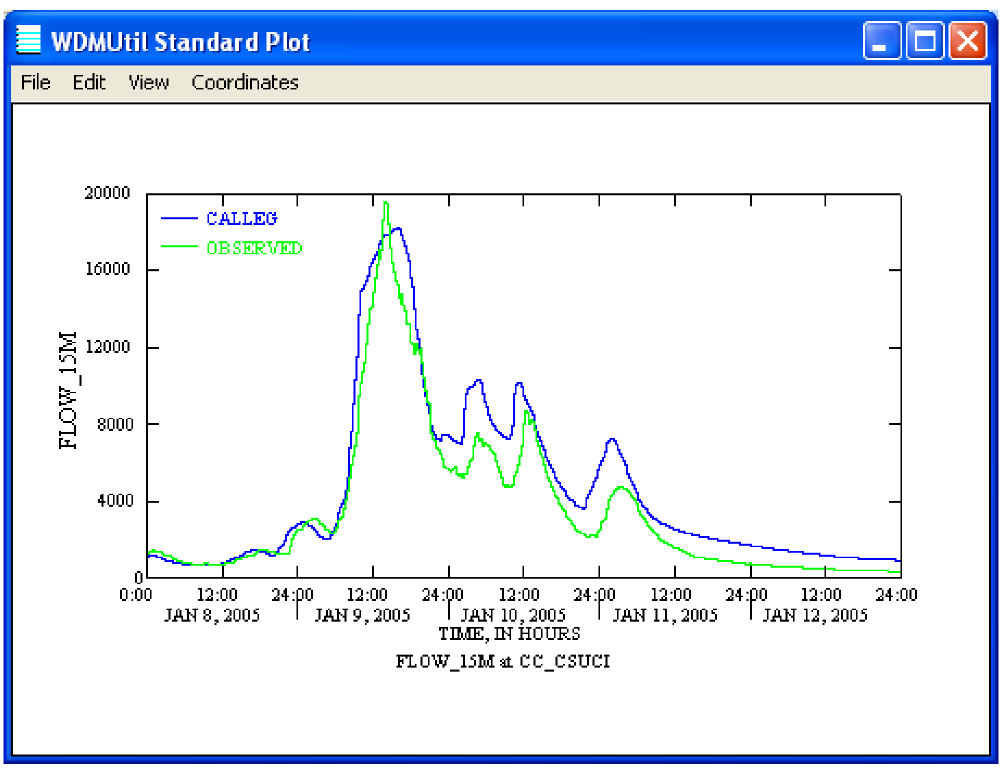

Figure A-12b. Calleguas Ck at CSUCI Calibrated Plot Jan 2005

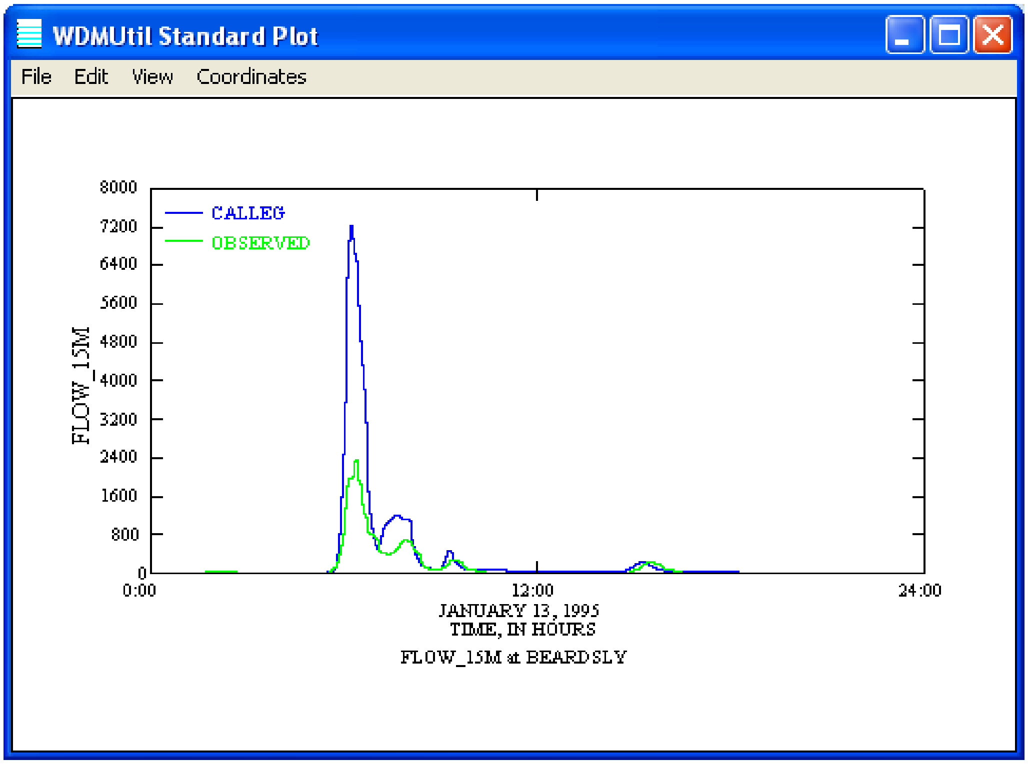

Figure A-13a. Beardsley Baseline Plot Jan 1995

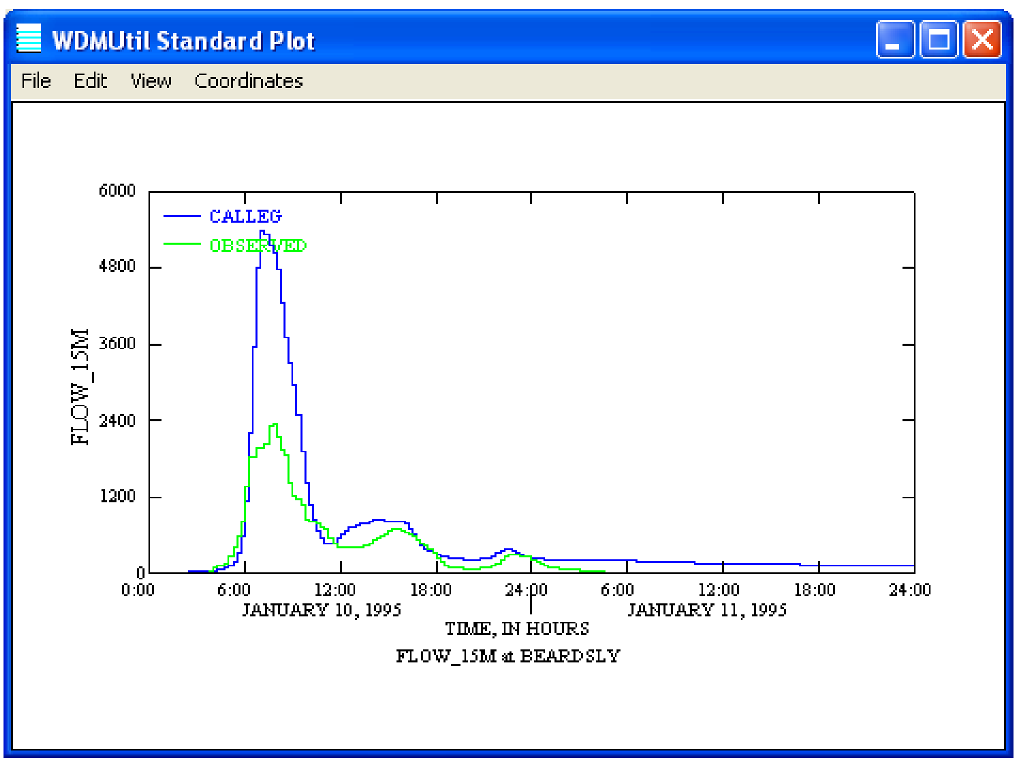

Figure A-13b. Beardsley Calibrated Plot Jan 1995

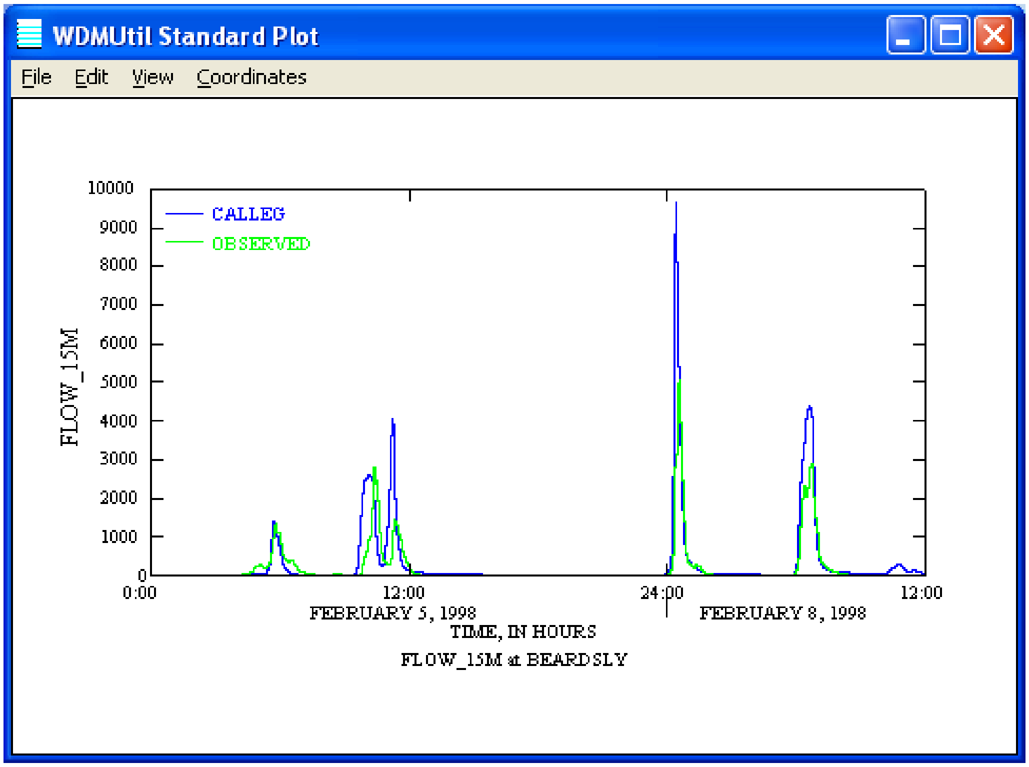

Figure A-14a. Beardsley Baseline Plot Feb 1998

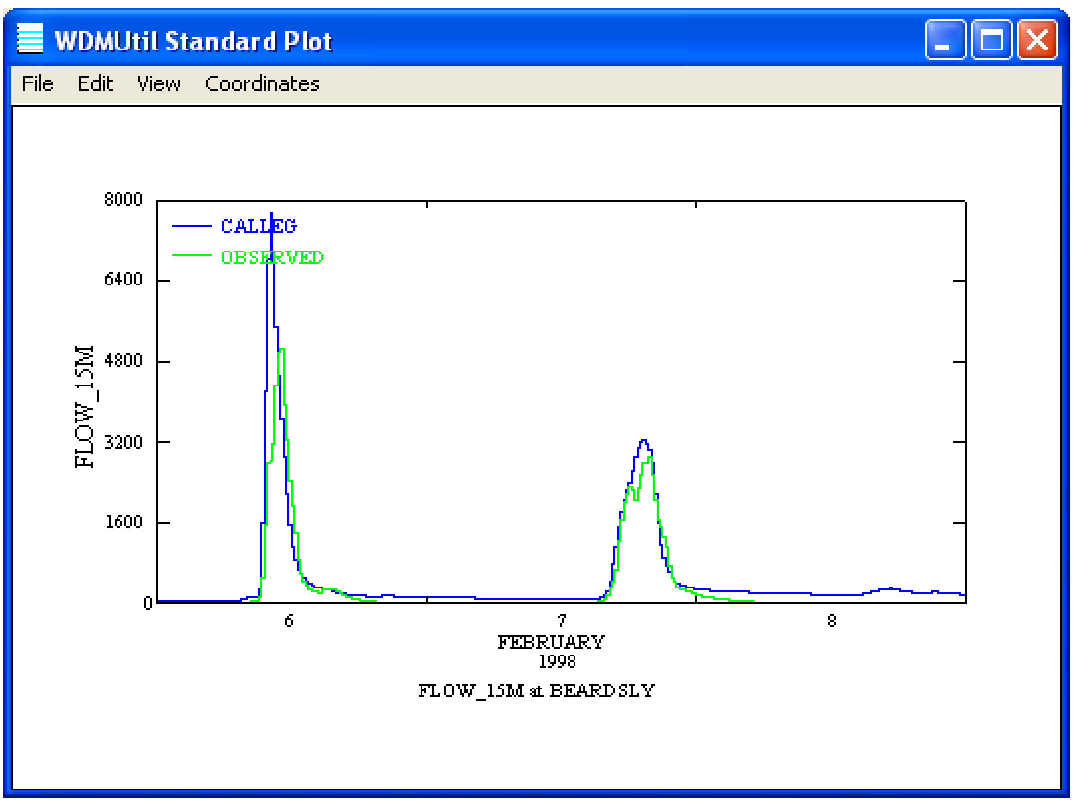

Figure A-14b Beardsley Calibrated Plot Feb 1998

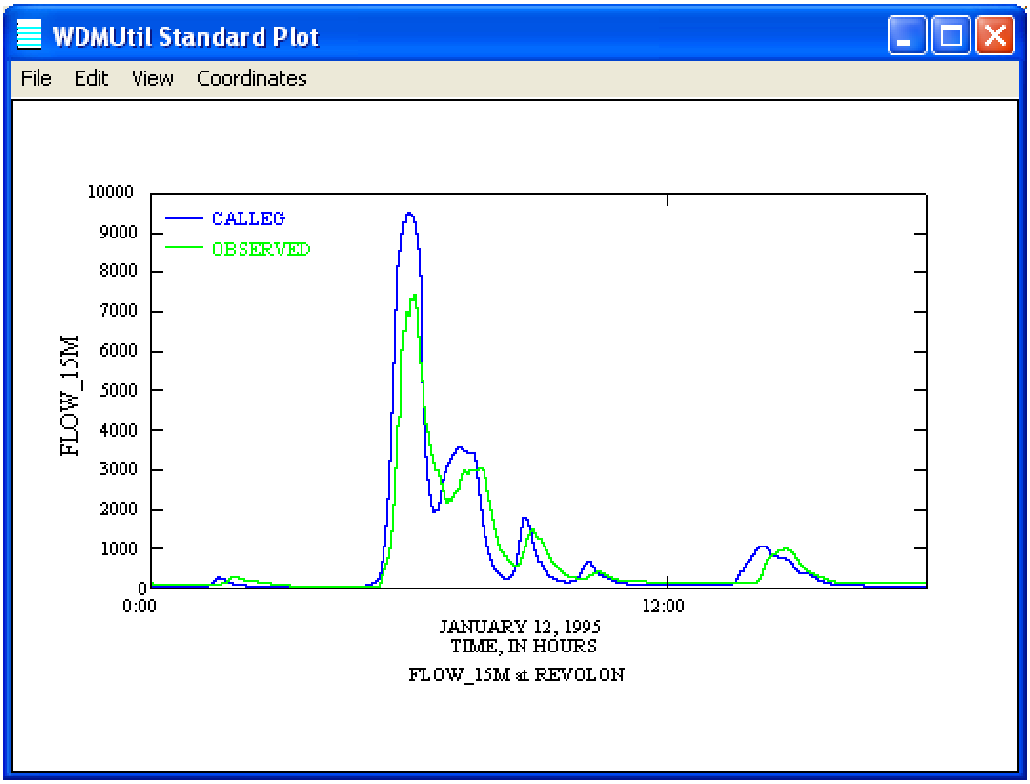

Figure A-15a. Revolon Baseline Plot Jan 1995

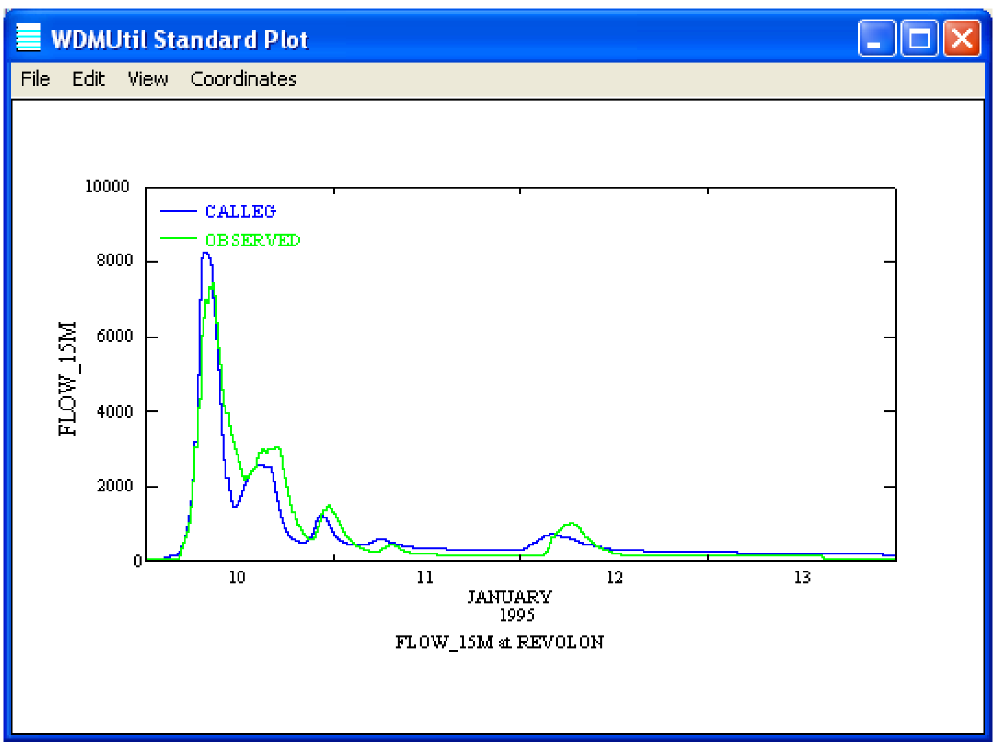

Figure A-15b. Revolon Calibrated Plot Jan 1995

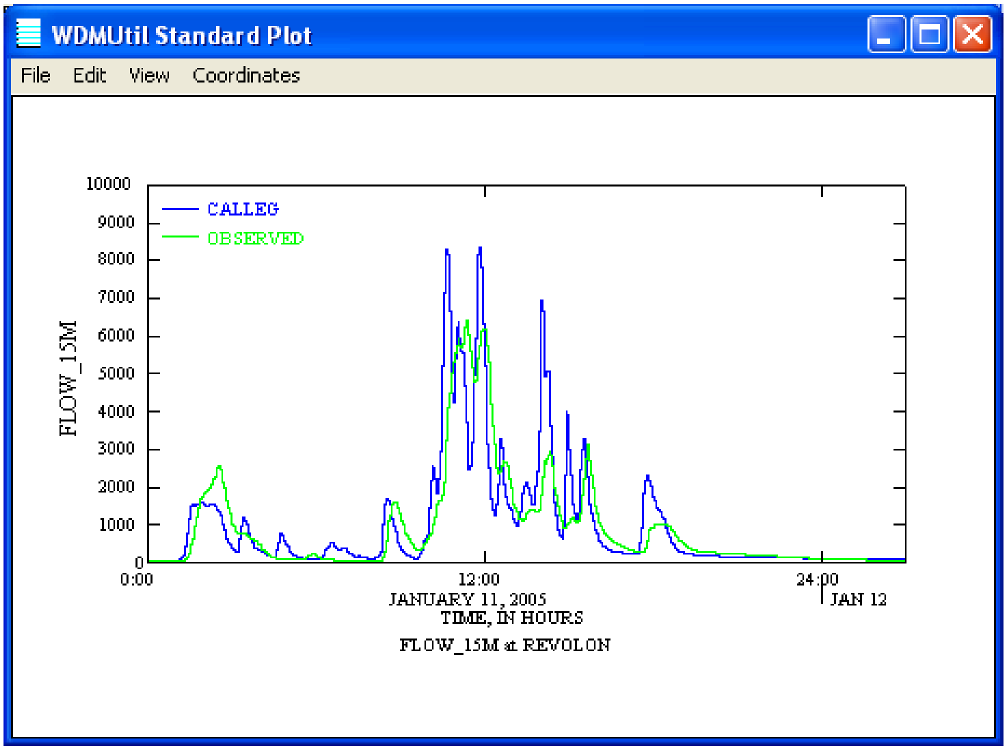

Figure A-16a. Revolon Baseline Plot Jan 2005

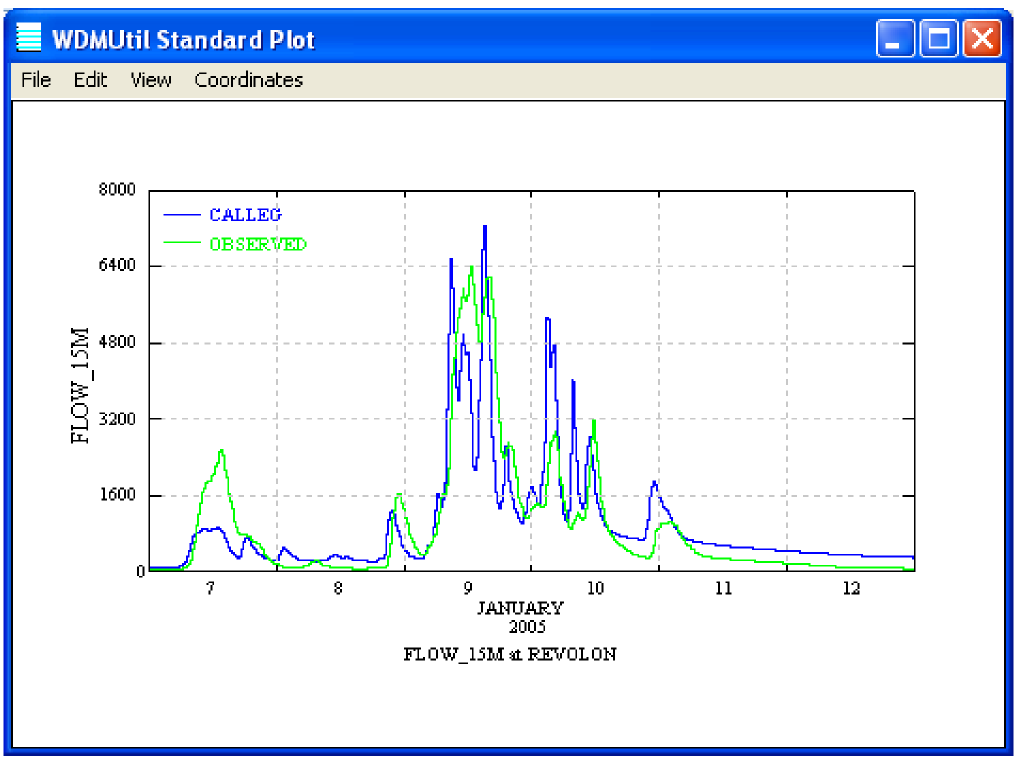

Figure A-16b. Revolon Calibrated Plot Jan 2005

8. APPENDIX B – EVENT STREAM GAGE CALIBRATION PLOTS

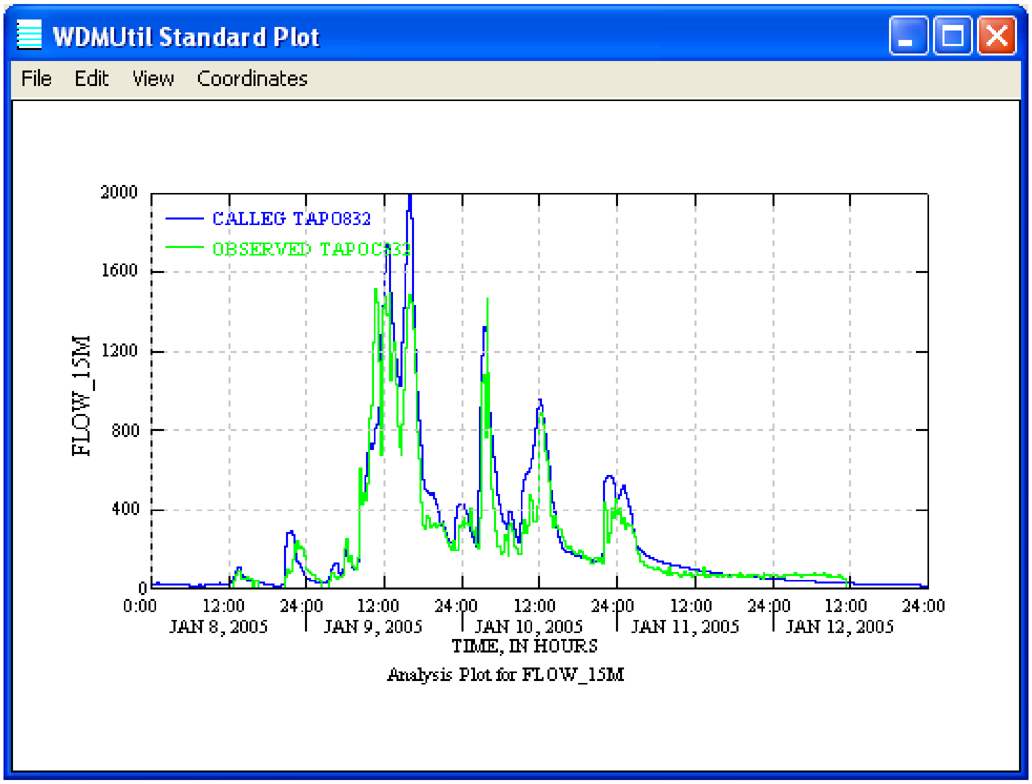

Figure B-1. Tapo Cyn 832 Calibrated Plot Jan 2005

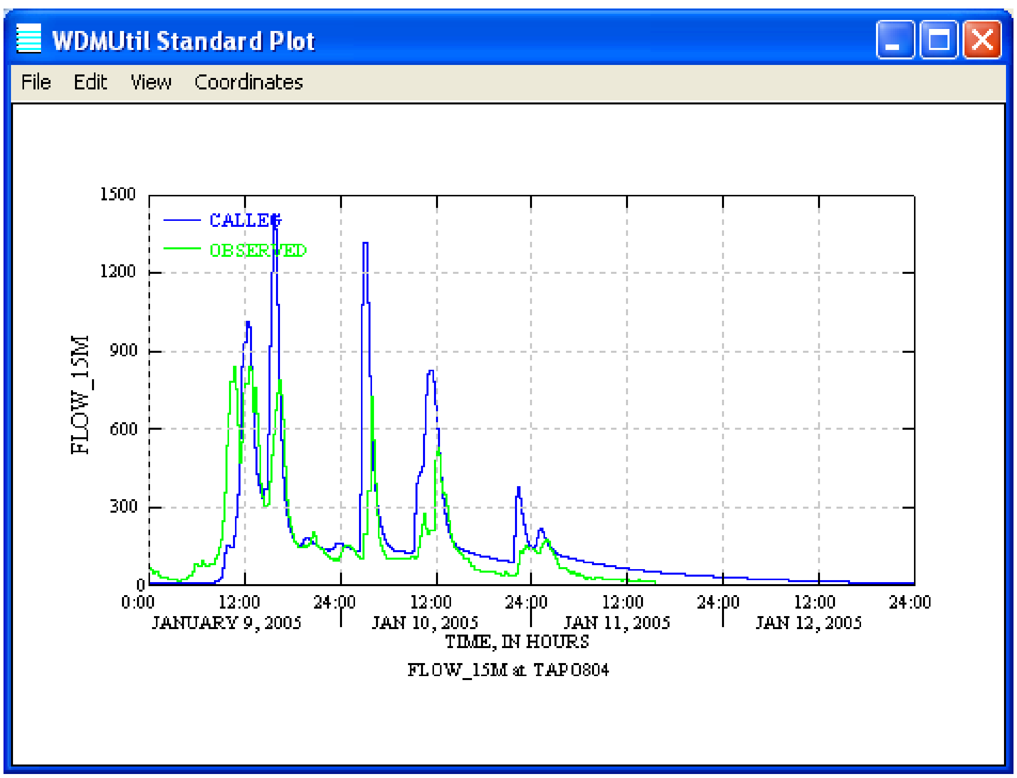

Figure B-2. Tapo Cyn Undeveloped 804 Calibrated Plot Jan 2005

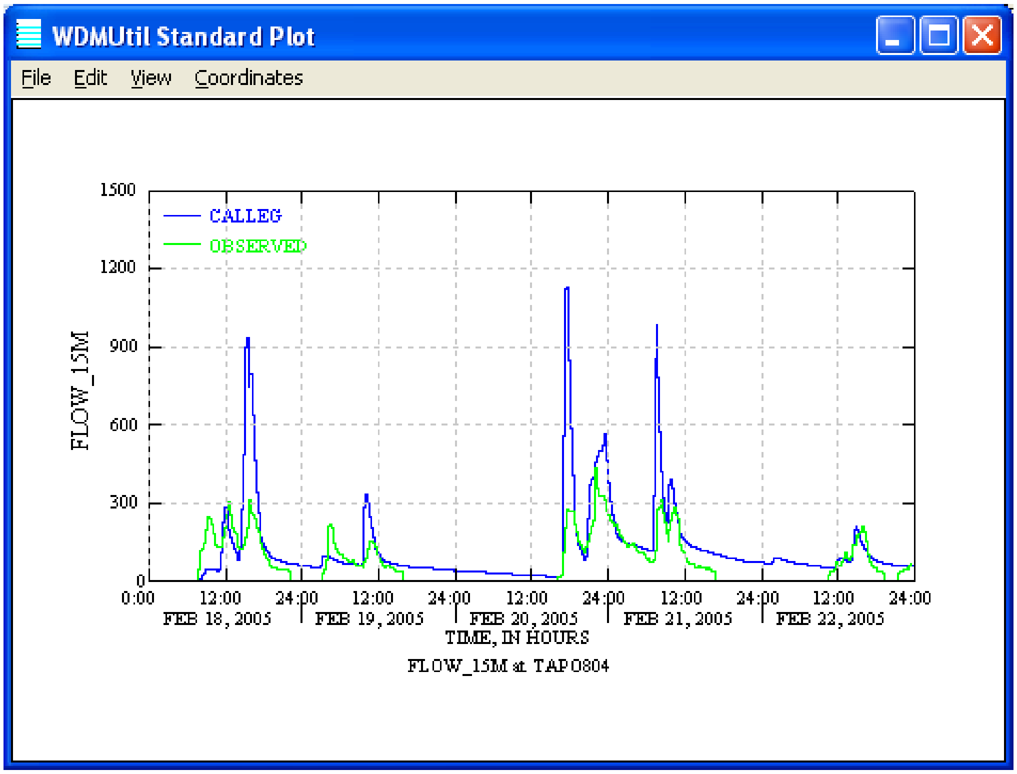

Figure B-3. Tapo Cyn 804 Calibrated Plot Feb 2005

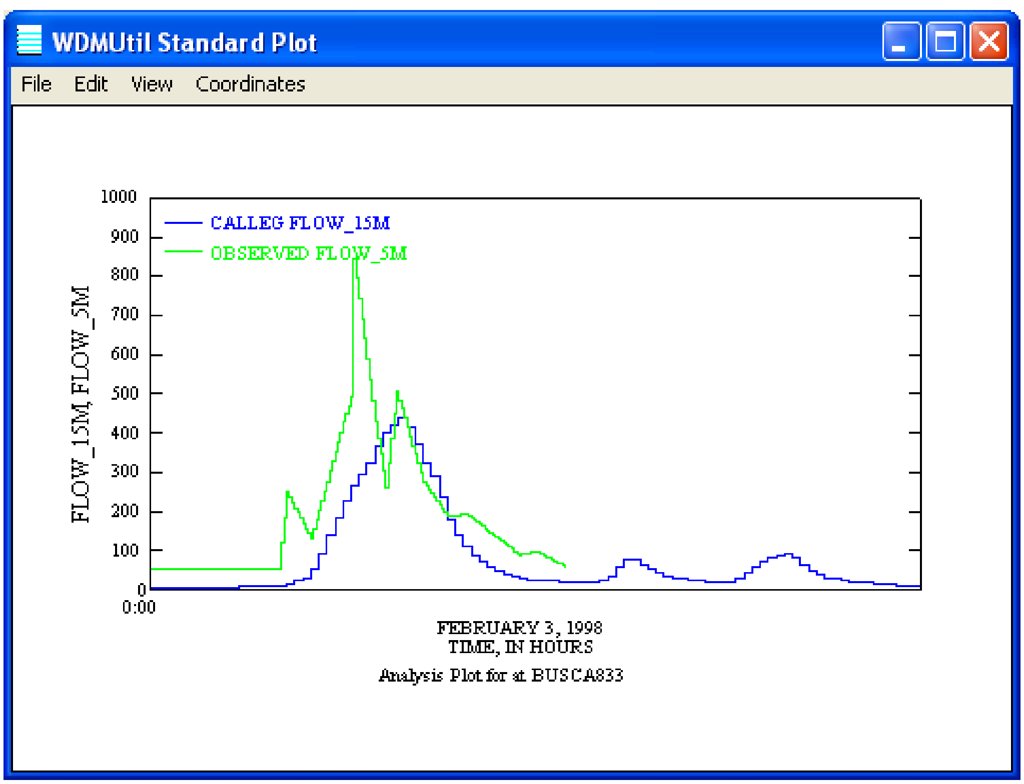

Figure B-4. Bus Cyn 833 Calibrated Plot Feb 1998

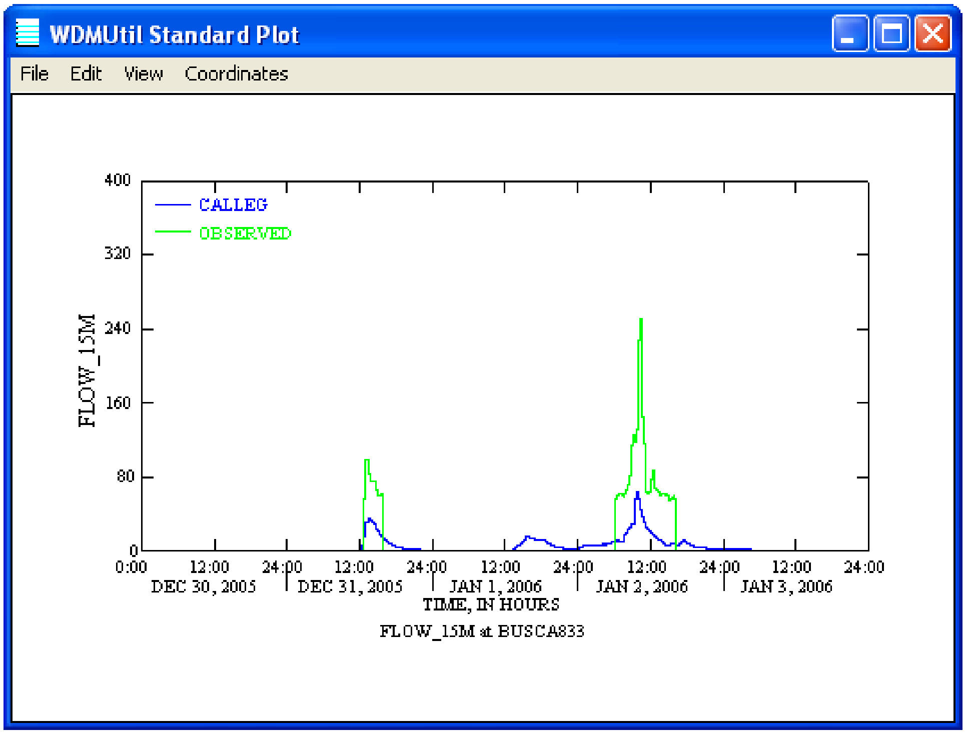

Figure B-5. Bus Cyn 833 Calibrated Plot Jan 2006

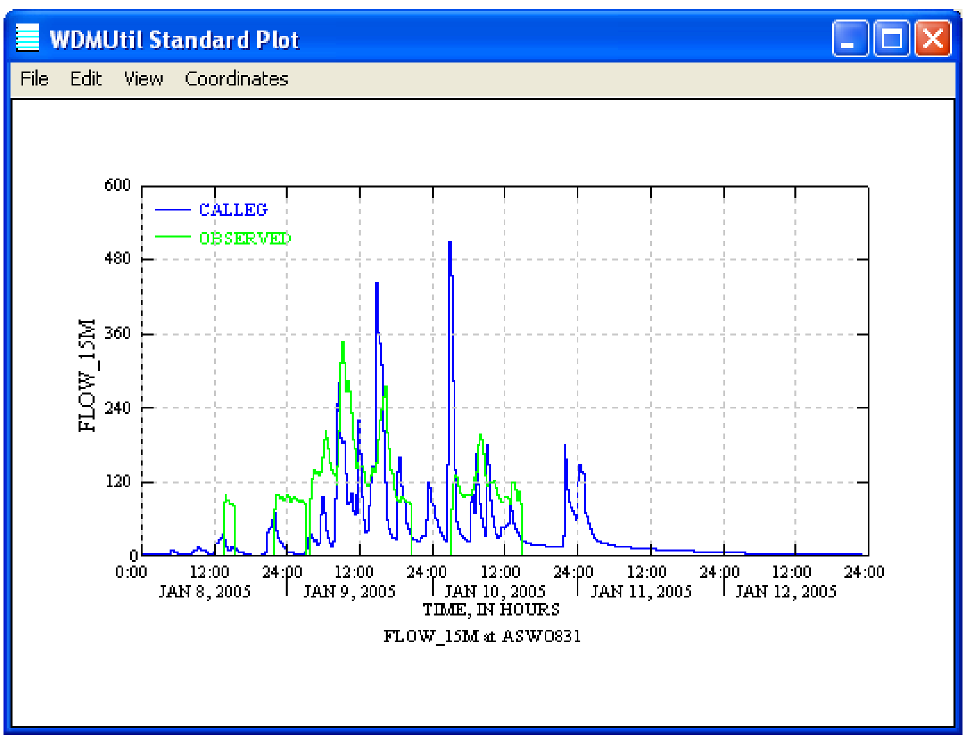

Figure B-6. Arroyo Simi Above White Oak 831 Calibrated Plot Jan 2005

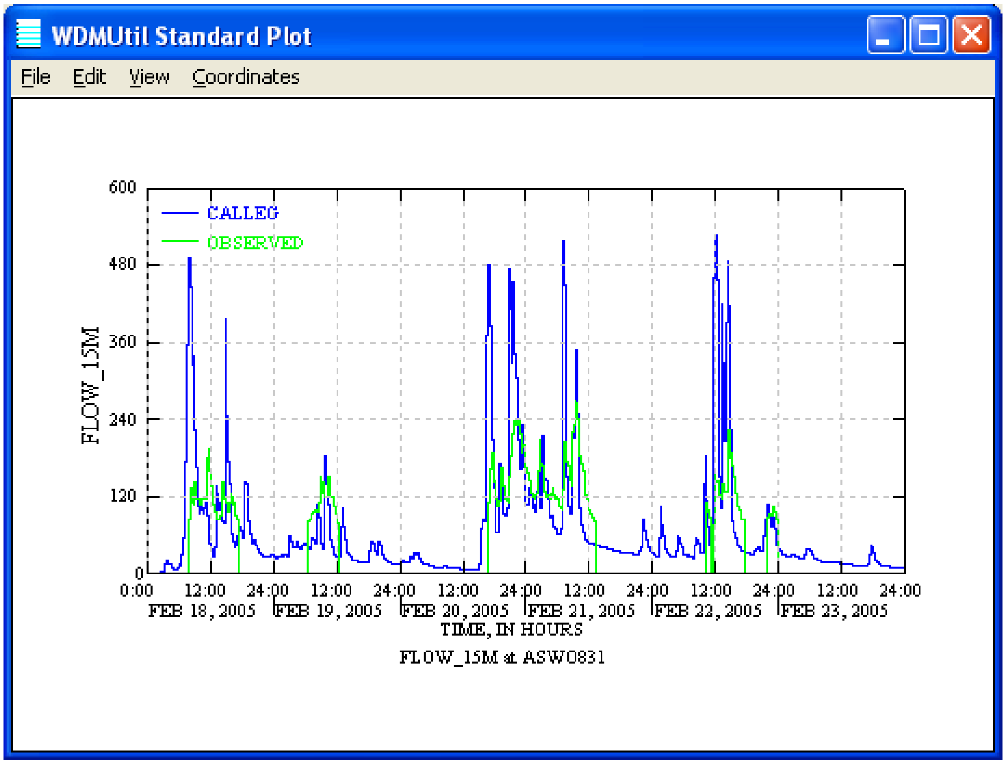

Figure B-7. Arroyo Simi Above White Oak 831 Calibrated Plot Feb 2005

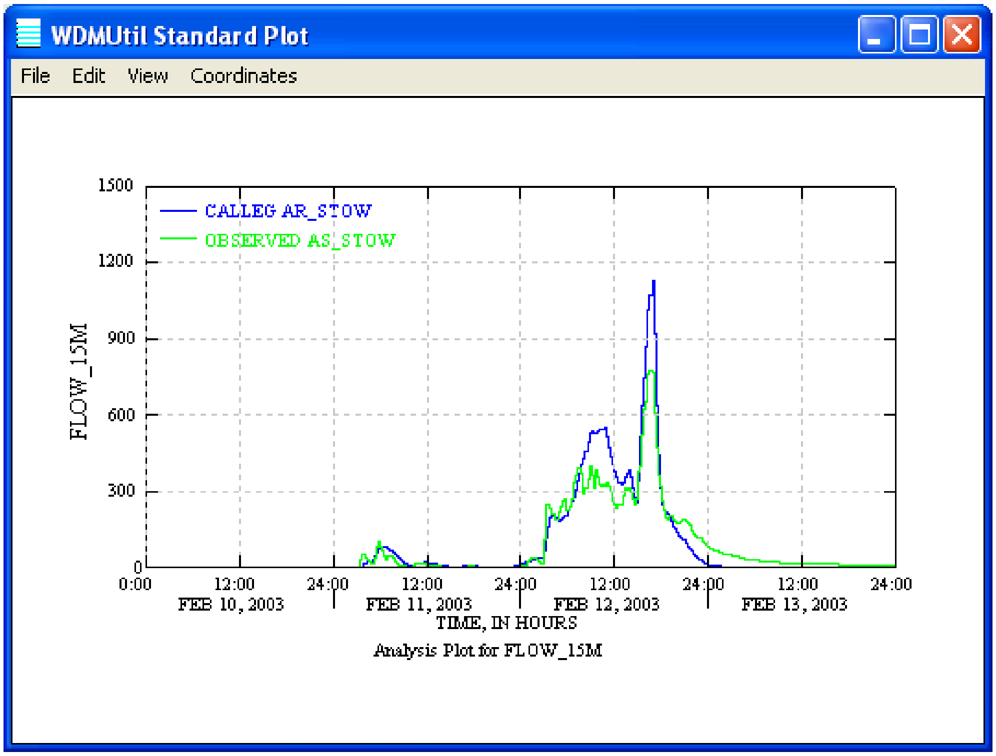

Figure B-8. Arroyo Simi Stow 842 Calibrated Plot Feb 2003

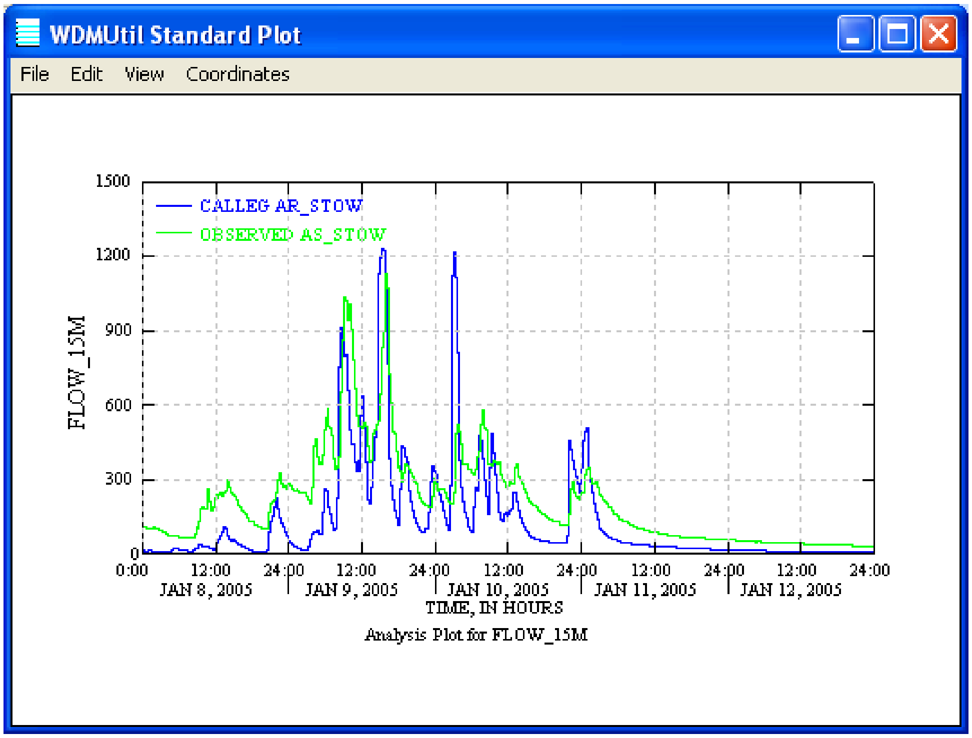

Figure B-9. Arroyo Simi Stow 842 Calibrated Plot Jan 2005

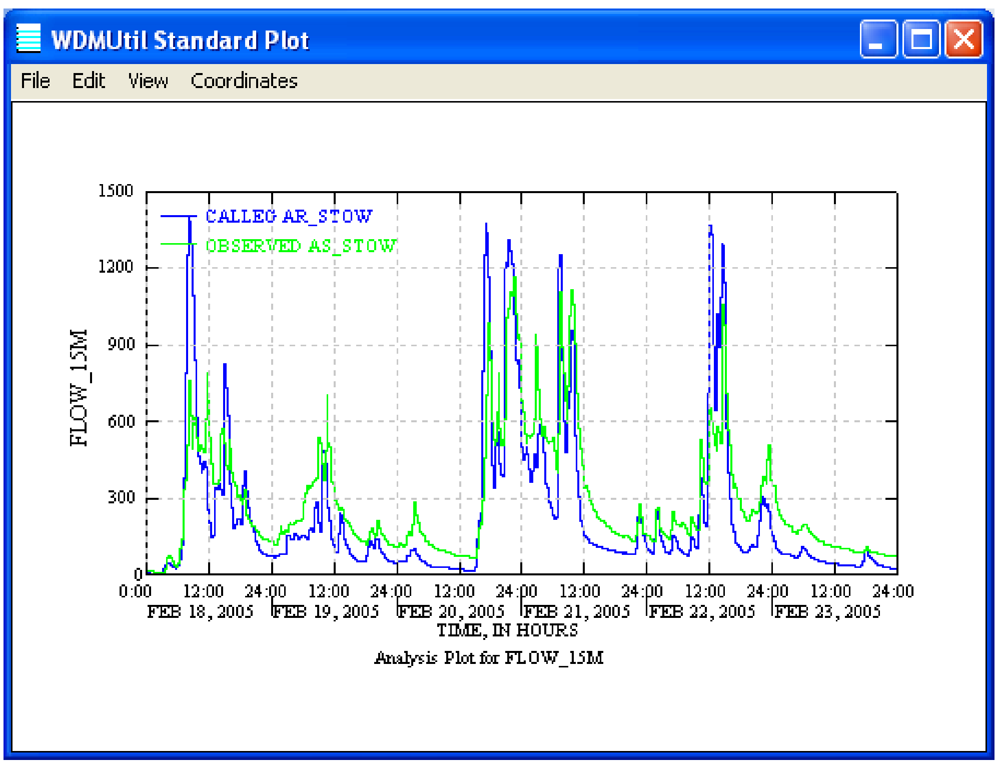

Figure B-10. Arroyo Simi Stow 842 Calibrated Plot Feb 2005

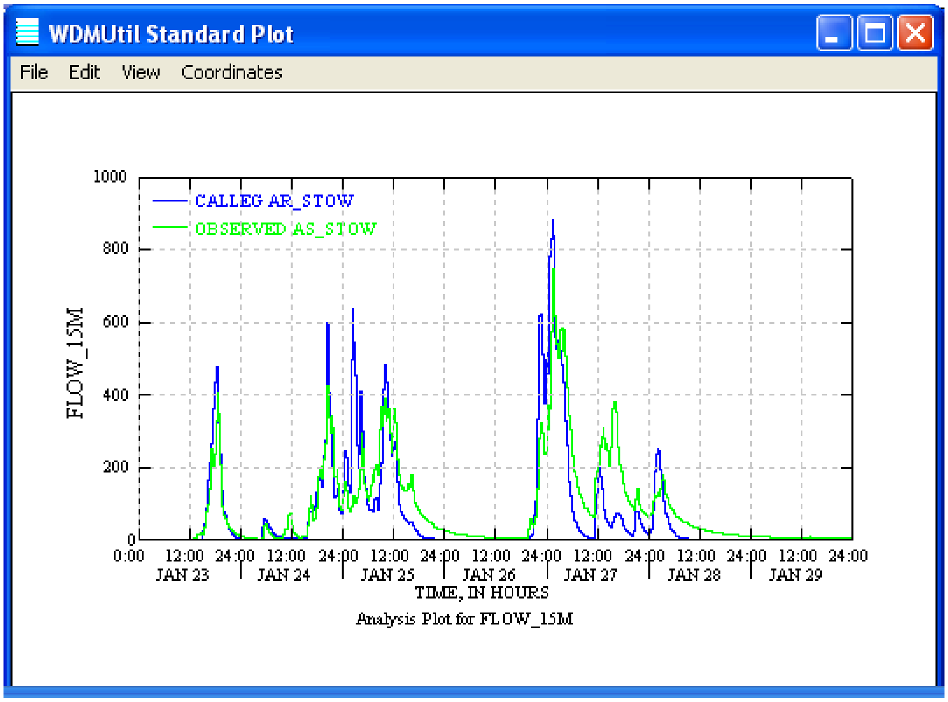

Figure B-11. Arroyo Simi Stow 842 Calibrated Plot Jan 2008

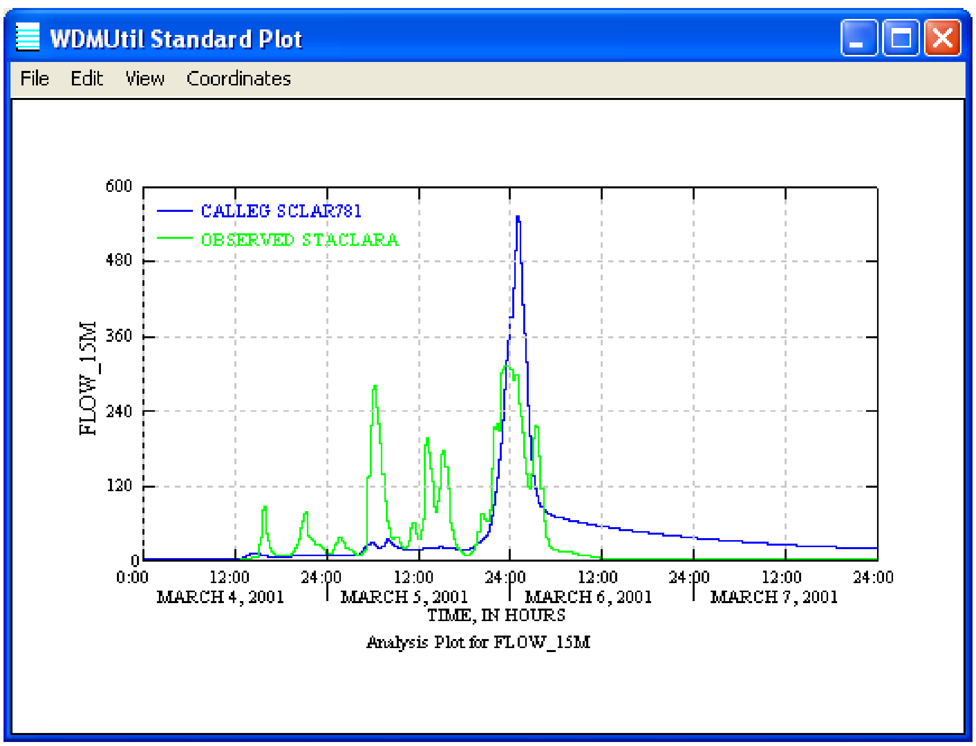

Figure B-12. Santa Clara Drain 781 Calibrated Plot Mar 2001

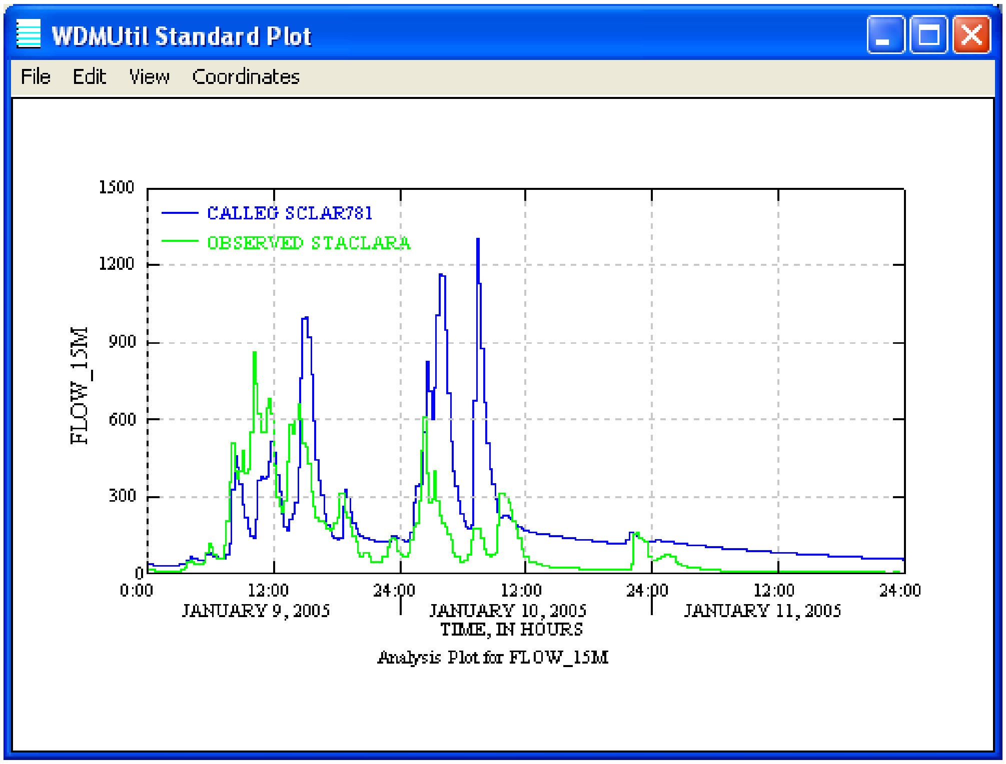

Figure B-13. Santa Clara Drain 781 Calibrated Plot Jan 2005

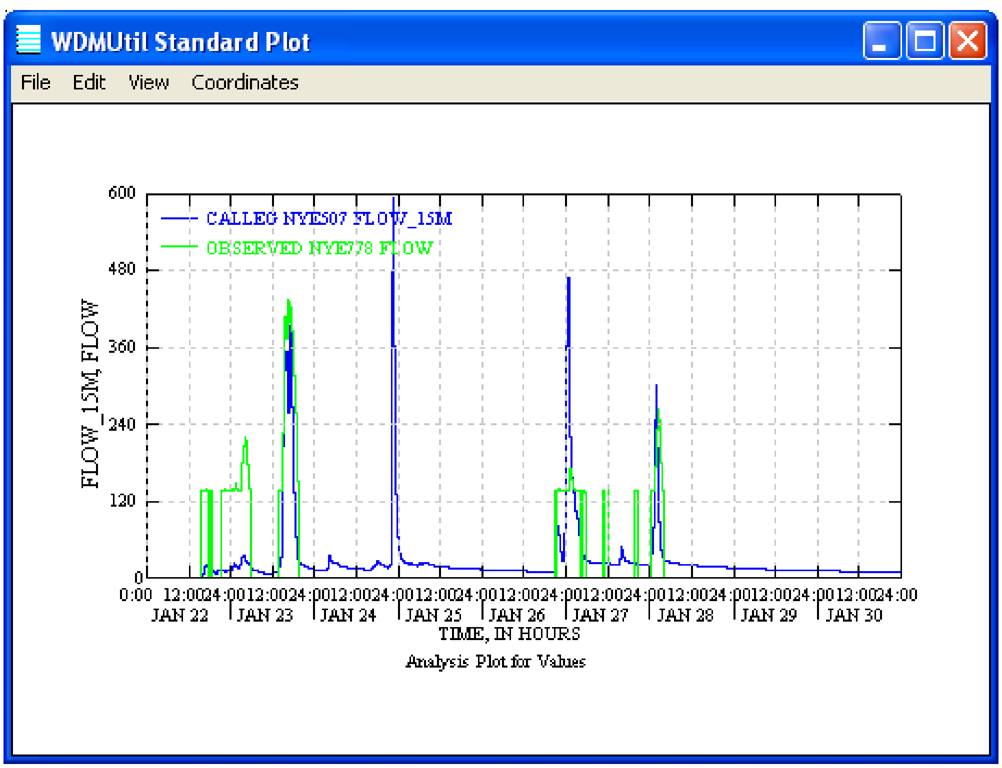

Figure B-14. Nyeland Drain 778 Calibrated Plot Jan 2006

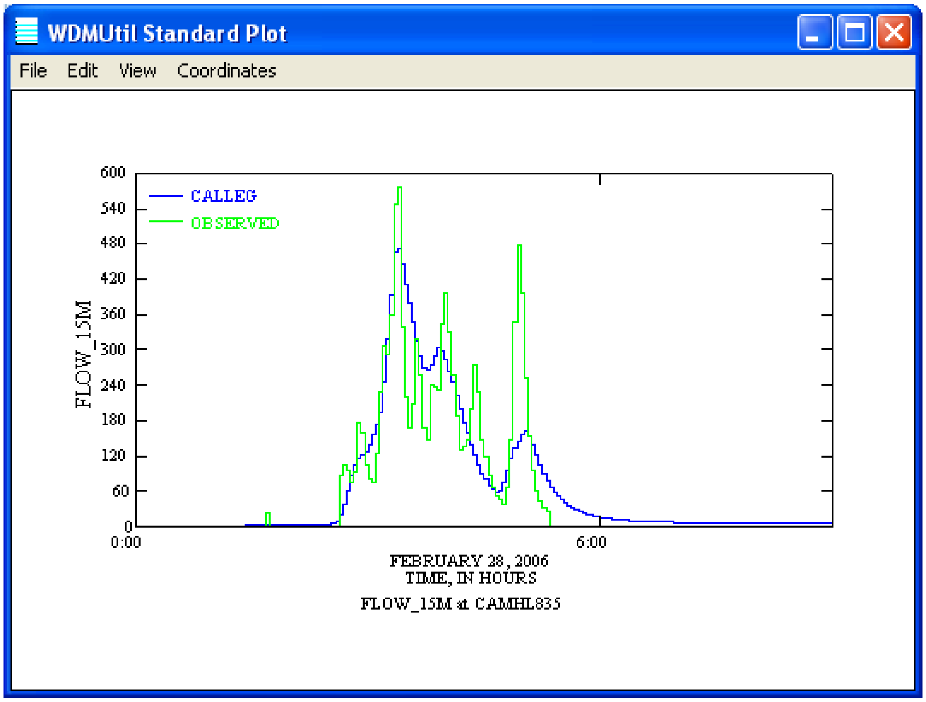

Figure B-15. Camarillo Hills Drn 835 Calibrated Plot Feb 2006

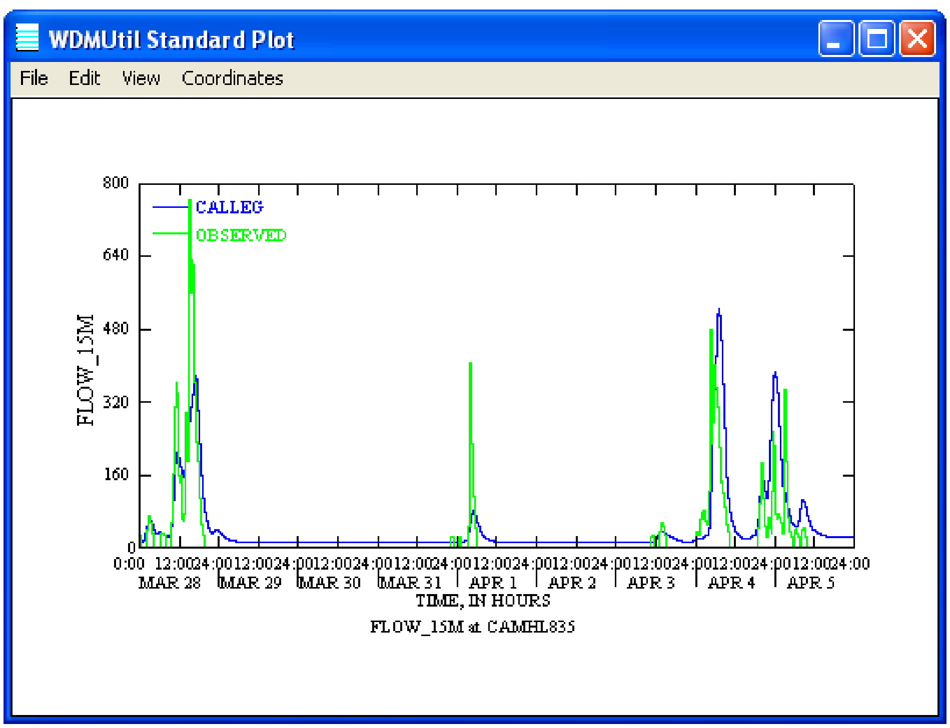

Figure B-16. Camarillo Hills Drn 835 Calibrated Plot Mar 2006

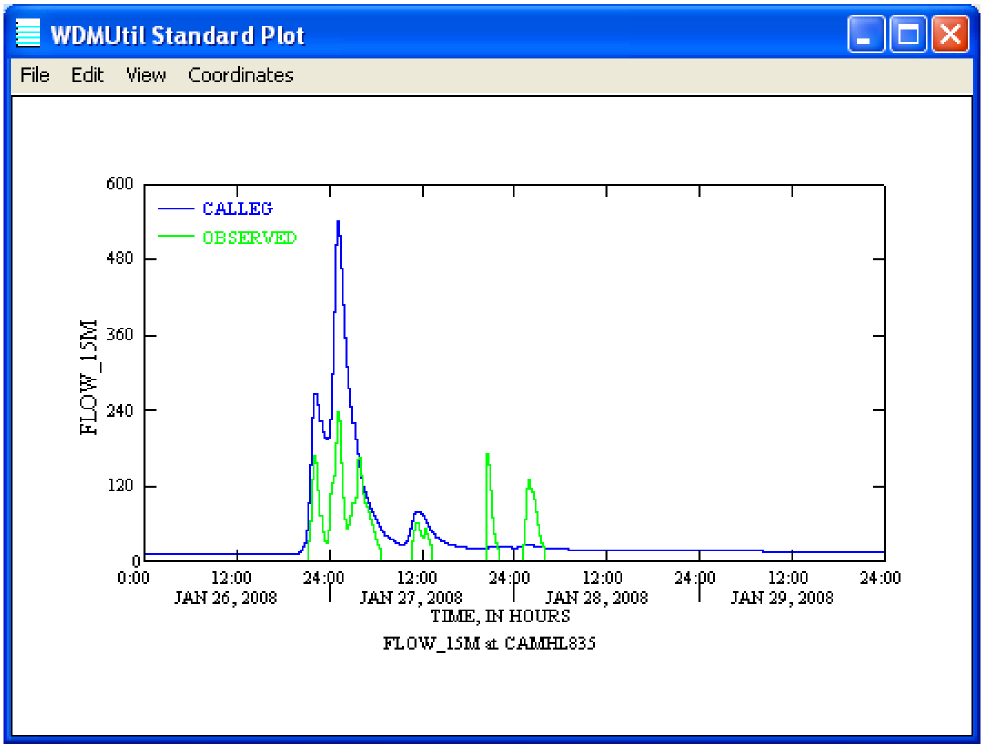

Figure B-17. Camarillo Hills Drn 835 Calibrated Plot Jan 2008

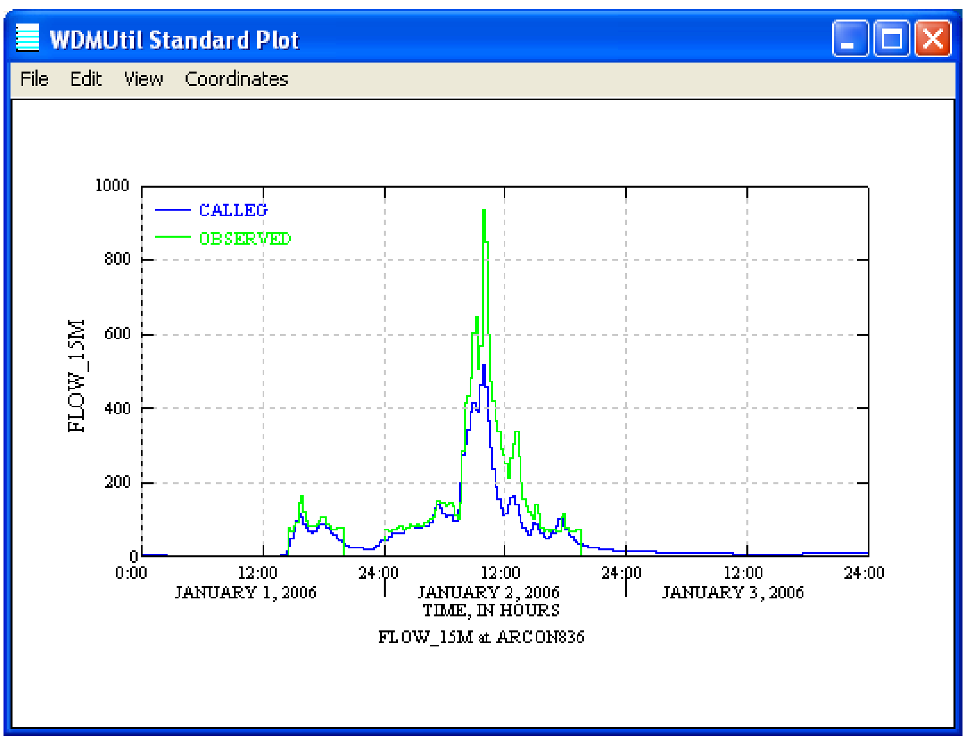

Figure B-18. Arroyo Conejo 836 Calibrated Plot Jan 2006

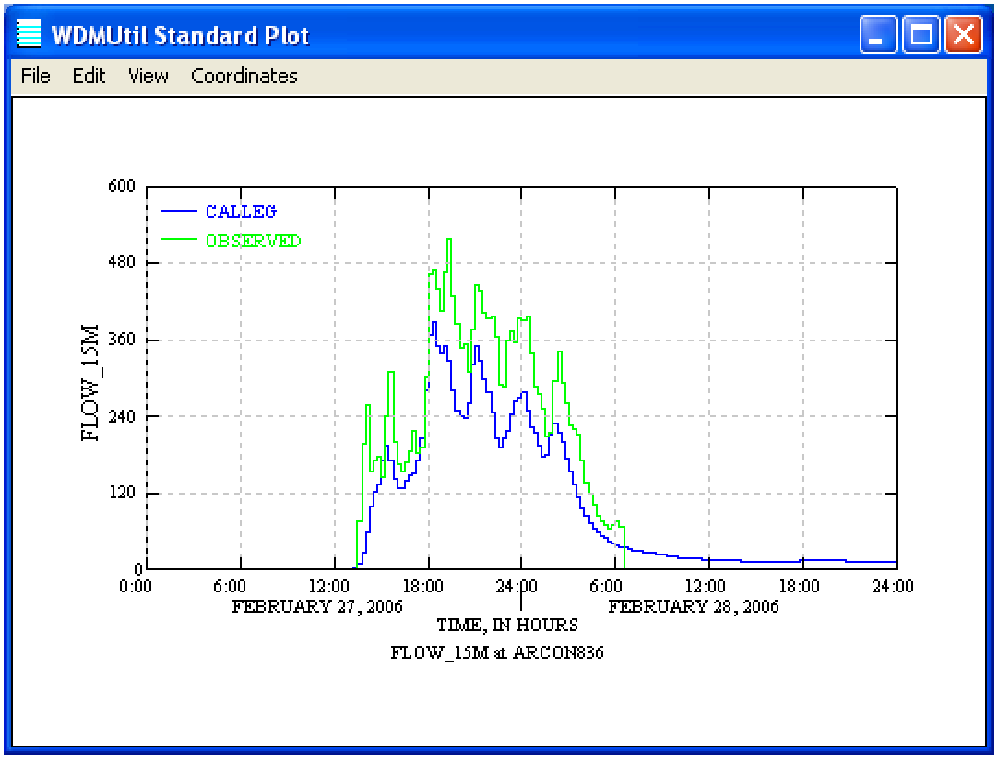

Figure B-19. Arroyo Conejo 836 Calibrated Plot Feb 2006

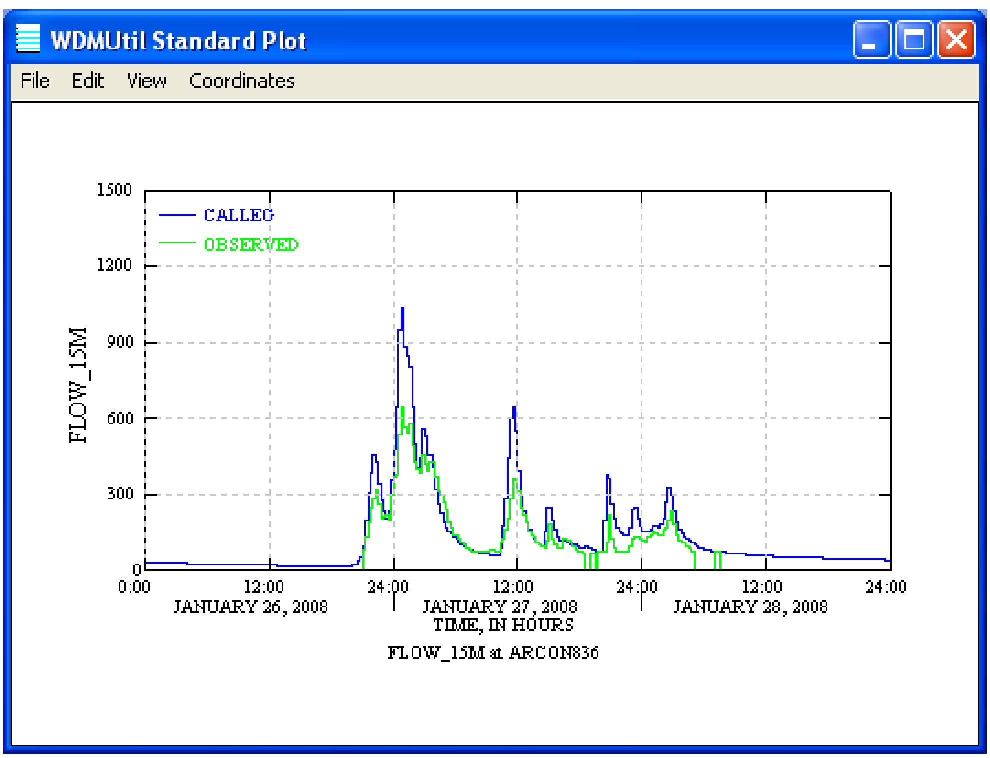

Figure B-20. Arroyo Conejo 836 Calibrated Plot Jan 2008

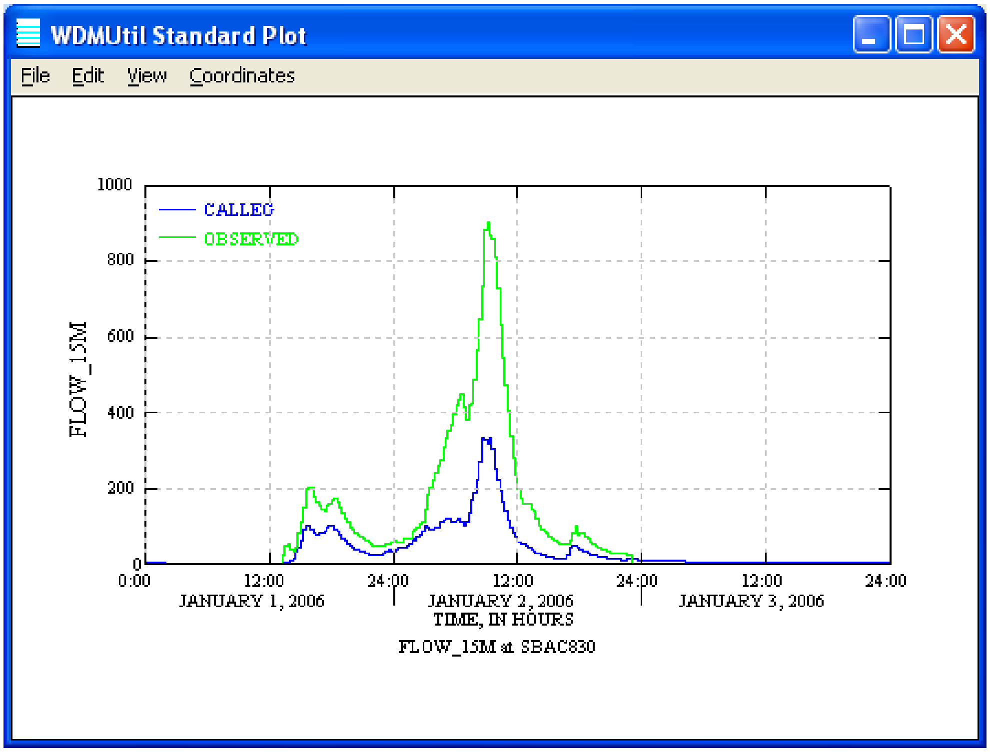

Figure B-21. So. Brnch Arr. Conejo Calibrated Plot Jan 2006

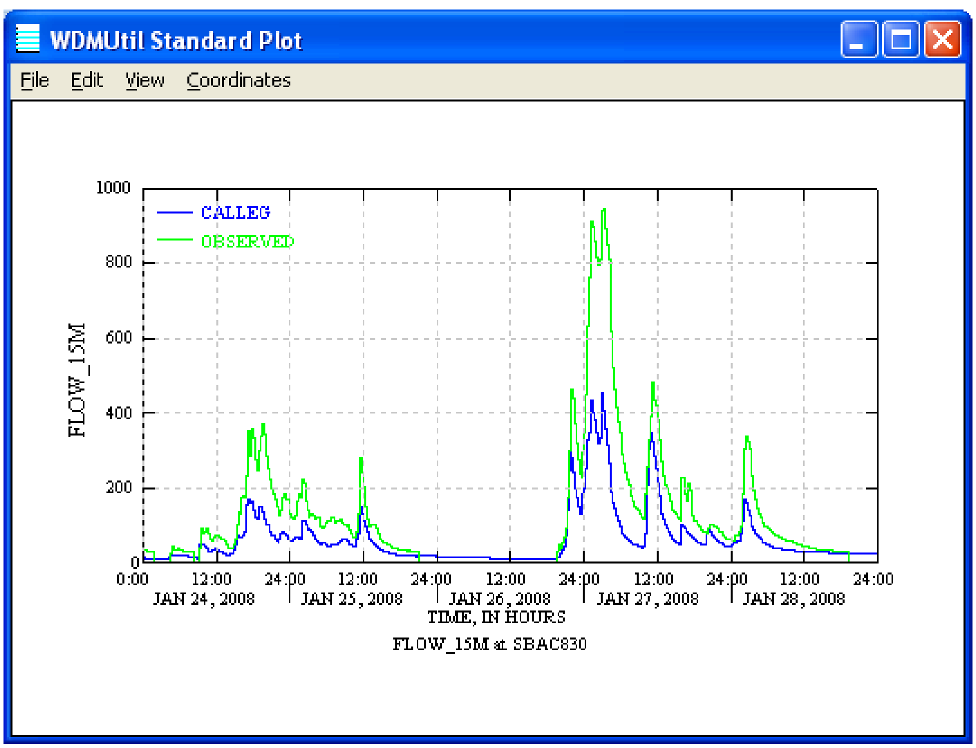

Figure B-22. So. Brnch Arr. Conejo Calibrated Plot Jan 2008

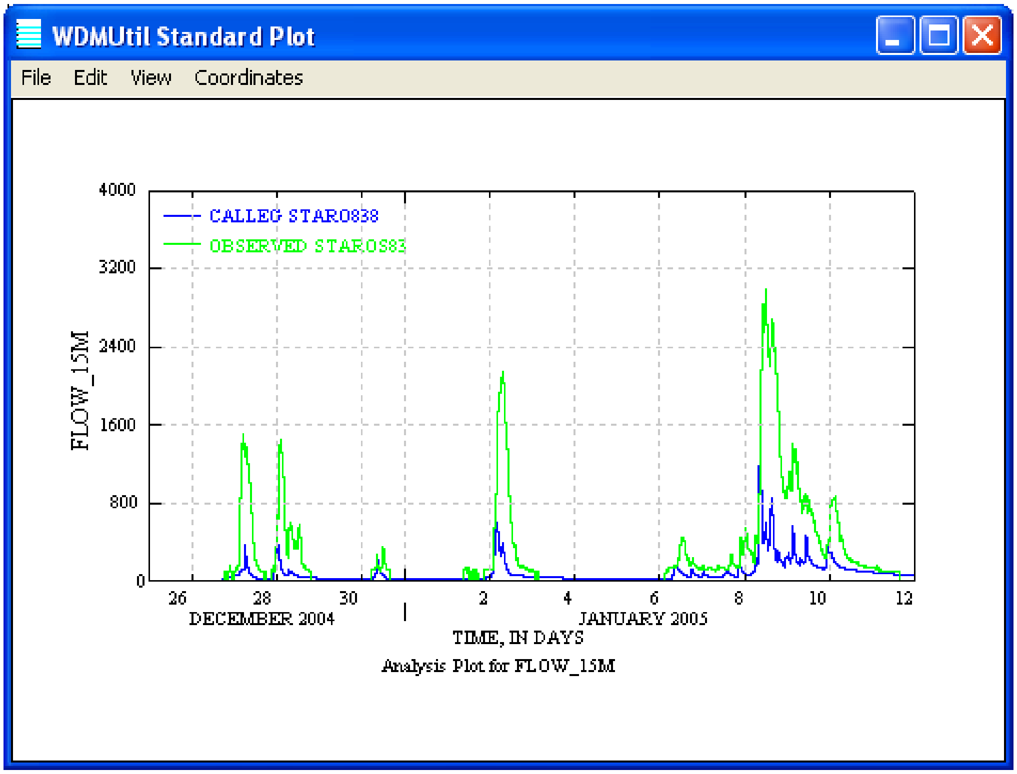

Figure B-23. Santa Rosa Ck Calibrated Plot Jan 2005

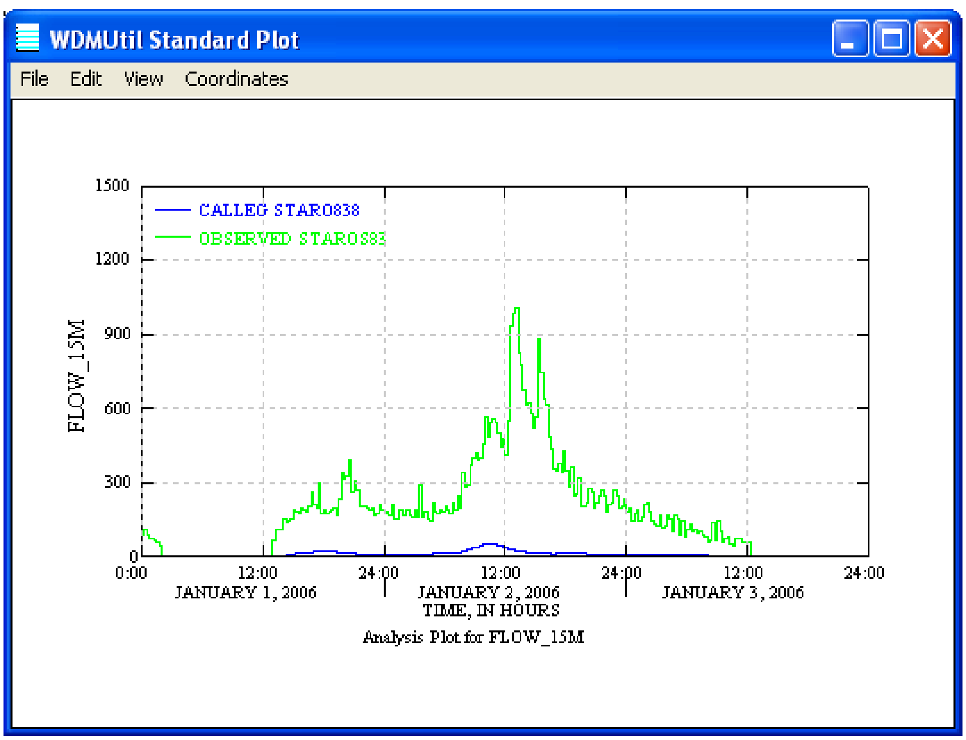

Figure B-24. Santa Rosa Ck Calibrated Plot Jan 2006

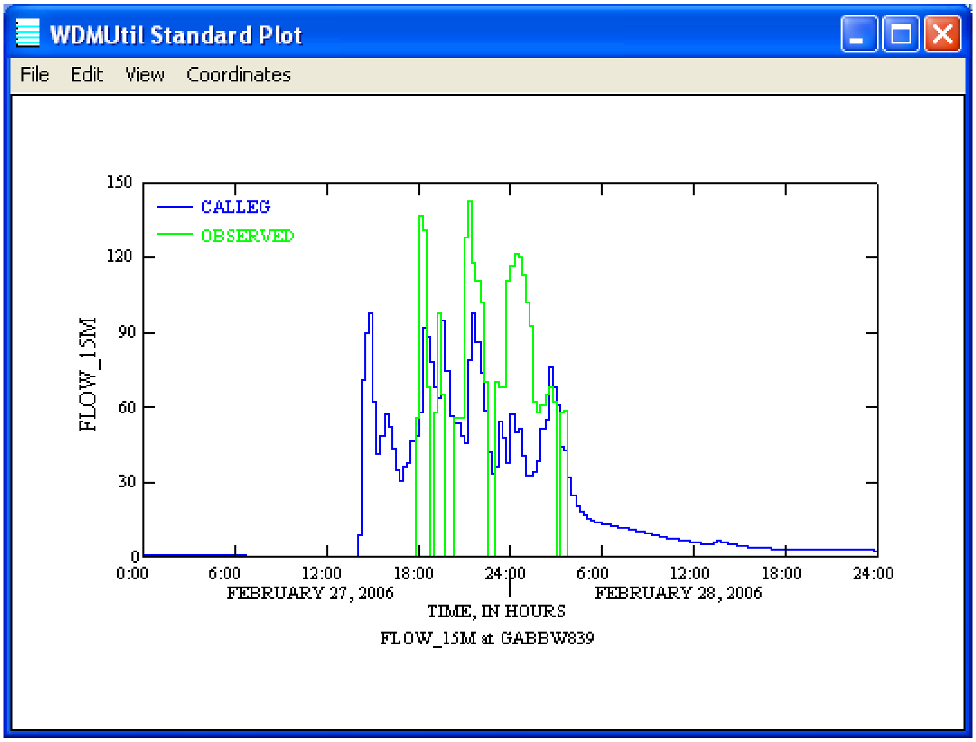

Figure B-25. Gabbert-Walnut 839 Calibrated Plot Feb 2006

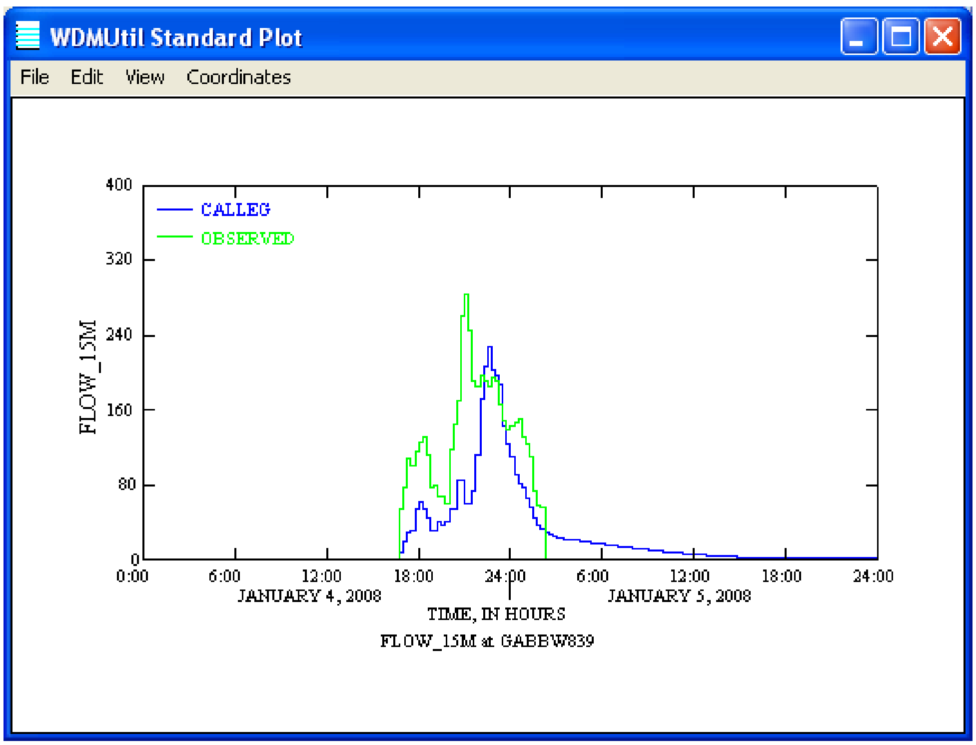

Figure B-26. Gabbert-Walnut 839 Calibrated Plot Jan 2005