Upland groundwater pumping and stream flow, San Jose Creek, Monterey County

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Abstract

To evaluate possible effects of groundwater pumping on streamflow in tributaries draining the Rancho San Carlos development near Carmel, Monterey County, California site, I compared pre- and post-development rainfall to stream runoff. Despite higher annual precipitation, unusually low summer flows occurred in San Jose Creek after 2000, when Rancho San Carlos groundwater pumping began. These results suggest that pumping groundwater has affected flow in streams, potentially affecting recharge to the Carmel River, and flows to steelhead trout and water supply for the Monterey Peninsula.

Introduction

The San Jose Creek drains 14 mi^2 (figure 1). It's headwaters are on a plateau which drains both San Jose Creek and tributaries of the Carmel River. This plateau contains a recent development project, Rancho San Carlos. Monterey County (figure 2) has a great interest in protecting water resources in this area because the Carmel River serves residents of Carmel and Monterey with drinking and commercial water. The Federal government is concerned with the protection of this area because these creeks are known habitat of the Federally-listed endangered species, Southern Steelhead Trout and Red-legged frogs.

History and Context:

In 1993, the Big Sur Land Trust acquired a large portion of the former Fish Ranch, including the lower portion of San Jose Creek. The Big Sur Land Trust transferred the land to the California Department of Parks and Recreation in November of 2003. The Santa Lucia Preserve comprises 24,200 acres. 2,500 of these are currently being developed into Ranchettes and large estates in the Rancho San Carlos development. (O'Farelli, 1997).

In November of 1996 ordinance No. 03857 (Measure M) was placed before the voters of Monterey County for the purpose of stopping the Rancho San Carlos development. The measure was defeated. In the same month the Ventana Chapter of the Sierra Club sued The Rancho San Carlos Development and the County Board of Directors for approving a development outside the scope of the County's General Plan. The suit specifically found fault with the EIR, hydrologic report, added hotel, golf course, and gas station. The suit was successful. Subsequently the development was restricted to its original Resource Conservation/40acre (RC/40) designation and required to omit the Board-approved hotel, and gas station. The court ordered a new EIR and an amended comprehensive hydrologic report [O'Farelli, 1997].

Site Location:

Rancho San Carlos is located in Monterey County, California, on an oak woodland just south of Carmel Valley. It straddles four watersheds on the 24,200 ac preserve. Three of these have creeks which are tributaries flowing to the Carmel river. Each runs completely dry during the late summer months. However San Jose Creek remains flowing year-round. San Jose Creek discharges at the state-owned Monastery Beach, just north of Point Lobos and south of Carmel.

Aquifer:

Part of the aquifer underlying Rancho San Carlos is located in the San Jose Creek watershed. This area is underlain by Monterey Shale, which dips an average of 15* to the north and strikes approximately due west. The aquifer is highly fractured due to the local faulting activity (Rosenberg, USGS, 1976). Groundwater capacity and transfer rates are not analyzed in this study.

Significance

The pumping of groundwater by new developments affects riparian habitat by decreasing stream base flow. This in turn is detrimental to Steelhead. Irrigation pumping and diversions are most intensive during the late summer when flows are already at a minimum and water is most scarce. Summer flows need to be sufficient to keep the water cool enough (25*C max) and oxygenated enough (3 parts/thousand) for the juvenile Steelhead (Gary Lasky, personal communication, April 24, 2004).

I compared rainfall to runoff for San Jose Creek after 1999 to determine if upland groundwater pumping has affected in-stream-flow during the late summer months.

Methods

Variables used:

Stream discharge data has been collected by the Monterey Peninsula Water Management District, MPWMD for WY 1999 to 2003. These flows are plotted for late summer months in figure 3. A permanent gaging station was installed in 1999 at the mouth of San Jose Creek (figure 1). This station comprises a Druck Pressure transducer, model No. 1830, which is rated to 5 PSI; and a Campbell CR510 data logger. Pressure readings have been

taken at 15 minute intervals for the past five years. Prior to 1999, some spot discharge measurements were taken using a price AA flow meter with corresponding channel cross sectional area. This data has not been obtained yet.

Observational data was collected in many of the affected watersheds by a series of hydrologic consultants. The primary consultants are Balance Hydrologics (Napolitano and Hect, 1990 - 1991). These field reports provide time and location of spot flow measurements and sedimentation state for Las Garzas Creek and many of San Jose Creek's tributaries.

Precipitation data were available from the Monterey County Flood Control tipping-bucket gages for water years 2000 and 2001, and the Rancho San Carlos development at the Golf Course Rain Bird SmartWeather Station for water years 2002 and 2003. The county gage nearest Rancho San Carlos is White Rock. This gage is located just to the south and west of San Jose Creek watershed. The bucket records measurements when significant precipitation events occur. It telemeters this data to the County Flood Control agency in real-time. Precipitation values at the Golf course in Rancho San Carlos were collected and reported by a golf course employee.

Comparisons made:

San Jose Creek discharge for the late summer, April through September, was plotted for WY 1999 to WY 2003 (Williams).

I averaged Rainfall data for water years 2000 and 2001 from the White Rock Gage. The tipping bucket gage collects a running total of precipitation. It therefore has multiple values recorded for each day. I limited each day's value to the highest measurement by using the Microsoft Excel function: Data>Filter>Advanced filter>Unique records only.

The White Rock gage has been operational since March of 1999. However, the only available complete water years of record are WY 2000 and WY 2001 (figure 4).

I determined total acre feet of precipitation for the San Jose creek watershed in WY 2002 and 2003 by multiplying monthly totals of Rancho San Carlos rainfall data (inches) for those years by the area, 8650 acres (14 mi^2), and dividing by 12 (figure 5)

I plotted each year's values against stream discharge by month. (Figure 6). I then plotted rainfall (acre-feet) against Runoff (acre-feet). These values were plotted in log-scale to clearly demonstrate the corollary relationship of rainfall to runoff (figure 7).

Results

In contrast to what is expected, there is an inverse relationship between precipitation (figure 4) and late summer discharge (figure 3) in the San Jose Creek watershed from WY 2000 to 2001. The rainfall averages for WY 2000 and 2001 indicate discharge should be greater in 2001 than in 2000. However, I found that discharge is lower in 2001 than 2000.

Precipitation in 2003 was greater than in 2002 and San Jose Creek had a correspondingly greater total runoff (figure 5). The percentage of rain water discharged from San Jose Creek is larger in the wetter year 2003 than in 2002.

Discussion

The data collected represents a possible connection to upland groundwater pumping and San Jose Creek stream flow in late summer.

San Jose Creek's base flow has declined since 1999. In WY 2002 there was a sharp decline in discharge and a correspondingly sharp increase to near-normal stream flow levels. This may be a product of in-stream diversions or some natural aberration. The decrease in stream discharge for late summer in WY 2002 may be a large contributing factor to the low discharge/precipitation relationship.

My analysis of average precipitation and discharge from San Jose Creek shows discharge has decreased in recent years despite increasing precipitation. This may be due to pumping by Rancho San Carlos or these other factors: evapotranspiration, aquifer recharge or a decrease in local precipitation.

Evapotranspiration could have increased thereby reducing stream discharge after Rancho San Carlos development. The aquifer could also be recharging from previous drought years or over pumping.

Future Studies

To better determine the effects of upland groundwater pumping on stream base flow in this watershed I recommend the development of an independently assessed water budget. This budget will incorporate both natural processes and human activities that may have affected base flow. It will aim to quantify water loss due to factors other than Rancho San Carlos's diversions. The following are some recommended components:

Precipitation input:

This value is the total input into the system—assuming no springs are present from other aquifers. By multiplying average precipitation with drainage area a rough value for the water year can be obtained.

The San Jose Creek watershed is approximately 8960 acres. An average of 2 ft of precipitation annually yields approximately 18000 acre feet precipitation. However, values should be determined based on appropriately distributed upland and lowland recorded values (CHS, Rancho San Carlos data source). These precipitation values would be especially valuable for years when well heights and stream flow are also available.

The Rancho San Carlos Development has maintained rain gages onsite since 1961. This information is reported to National Oceanic Administrative Agency, NOAA. Summaries of this data are available in the Comprehensive Hydrologic Report, CHS, as part of the Environmental Impact Report (Camp, Dresser, McKee, Inc, 1997).

Evapotranspiration

Evapotranspiration (ET) can account for a loss of 1/3 to ½ of total precipitation input (Dunne and Leopold). Water lost by evapotranspiration vaporizes from the soil or plants and is returned to the atmosphere before entering the stream. Because ET can affect the water budget so greatly it must be included in any future studies.

Rates of evaporation are difficult to determine, and can have large errors associated with them. Some figures of ET were calculated by Camp Dresser and McKee, hydrologic consultants for the Supplement No. 4 to the Comprehensive Hydrological Report for Rancho San Carlos.

Groundwater Pumping for Rancho San Carlos

The amount of water drawn from the aquifer is a focus of this research. An annual volume of pumped water may be calculated by obtaining and adding realistic pumping volumes, times, and durations.

Wells are located throughout the Santa Lucia Preserve and San Jose Creek. Land owners are required to give approximate pumping durations and other well heights to the County. This information should be included in the water budget.

Aquifer recharge and transmittance

Aquifer recharge rates affect the time it takes water to be transferred from precipitation to in-stream flow. A decrease in aquifer height will cause a decrease in hydraulic head and thus a decrease in amount of water transferred to the stream via subsurface flow. Well levels are an indicator of aquifer height. Groundwater fluctuations can be correlated with precipitation and stream discharge to ascertain aquifer conductance properties.

The aquifer's physical properties have been characterized by a few different consultants. These are outlined in the Comprehensive Hydrologic Study, CHS, for Rancho San Carlos (Camp Dresser and McKee inc, 1997).

Stream discharge:

Discharge is the end output of they hydrologic system. It is the net sum of all aforementioned factors. The Monterey Peninsula Water management District has been collecting discharge data in San Jose Creek since 1999. Some spot discharge measurements have been made since 1995. This data should be compared with well heights, precipitation to ascertain if Rancho San Carlos pumping has a direct impact on stream flow.

This data can be used to address how pumping may affect groundwater and correspondingly, stream levels. Some corollary questions that may be answered with the aforementioned data are:

What is the seasonal and annual variability in rainfall and how does it affect aquifer recharge? What effects do other land owner's well-pumping or in-stream diversions have on in-stream-flow?

Conclusions

Ground water pumping in the upper reaches of San Jose creek seems to affect stream base flow since pumping increased in 2000. A reduction in stream base flow during the late summer months can adversely affect Federally-listed Steelhead.

My analysis of average precipitation and discharge from San Jose Creek shows discharge has decreased in recent years despite increasing precipitation.

Substantiating this link would have major implications in a society that is concerned with the preservation of its natural heritage and resources.

References

Camp, Dresser and McKee Inc. Supplement No. 4 to the Comprehensive Hydrological Study. Santa Lucia Preserve Project. June 1997. (p109)

Dunne and Leopold, 1978. Water in environmental planning. W.H. Freeman and Company, New York.

Hecht, B. October 12, 2000. Minutes of Field Meeting, Las Garzas Creek Water Rights, Balance Hydrologics, Inc.

Knudsen, K. and Hecht, B. August 30, 1991. Report on Field Work conducted August 22 and 23, 1991 San Jose Creek, Williams Canyon, Van Winkleys Canyon, and unnamed tributary to San Jose Creek.

Monterey County General plan. Chapter V, Environmental Resource Management Element. http://www.co.monterey.ca.us/gpu/Reports/0104/

Napolitano, M. August 23, 1991. Restoration Reconnaissance of Lower Las Garzas Creek to Evaluate Dry Season Flow Persistence and the Relative Impact of Habitat Imparing Sedimentation. . Memo file 9054.7, Balance Hydrologics, Inc.

Napolitano, M. October 30, 1990. Field reconnaissance to characterize baseflow hydrology of lower Las Garzas Creek, Monterey County, California. Balance Hydrologics, Inc.

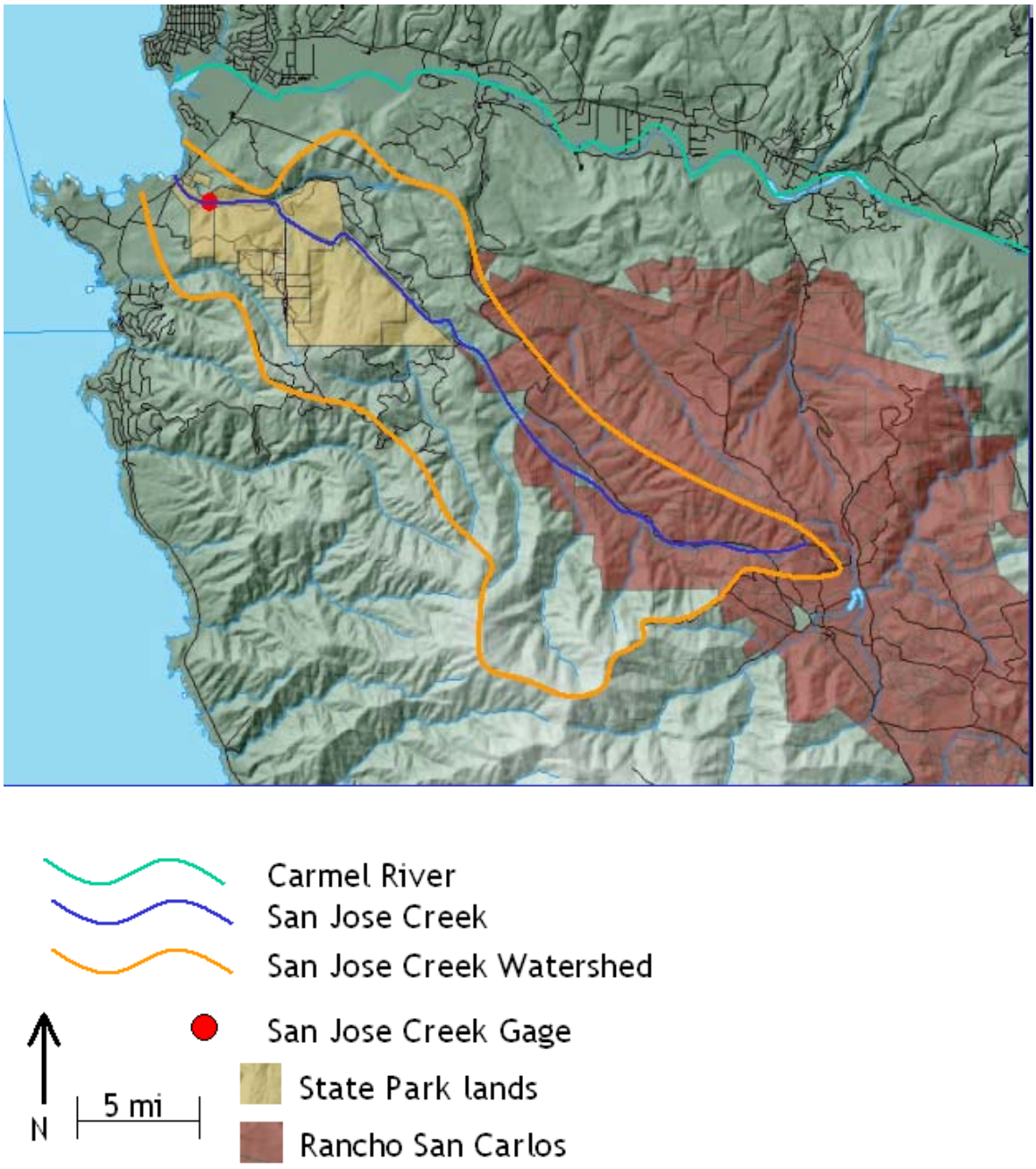
O'Farreli, Hon. Robert; Cassidy and Verges, county counsel. Statement of Decision. Court of California, County of Monterey. Ventana chapter of the Sierra Club v. County of Monterey, Board of Supervisors and Rancho San Carlos Partnership. March 04, 1997.

Smith, Curry, Jackson, Thistle, Marin. Steelhead Habitat Assessment and Restoration in Upper Williams Canyon Creek: Mitteldorf Redwood Preserve, Monterey County, California. 1997.
http://home.csumb.edu/s/smithdouglas/world/Doug/html/williams_canyon.html.

Williams, John G. Discharge measurements of San Jose Creek from Monterey Peninsula Water Management District 1999 to 2003. Unpublished.

Figure 1

San Jose Creek Watershed, Rancho San Carlos, Fish Ranch, and Stream Gage location



Monterey County, California

Figure 2

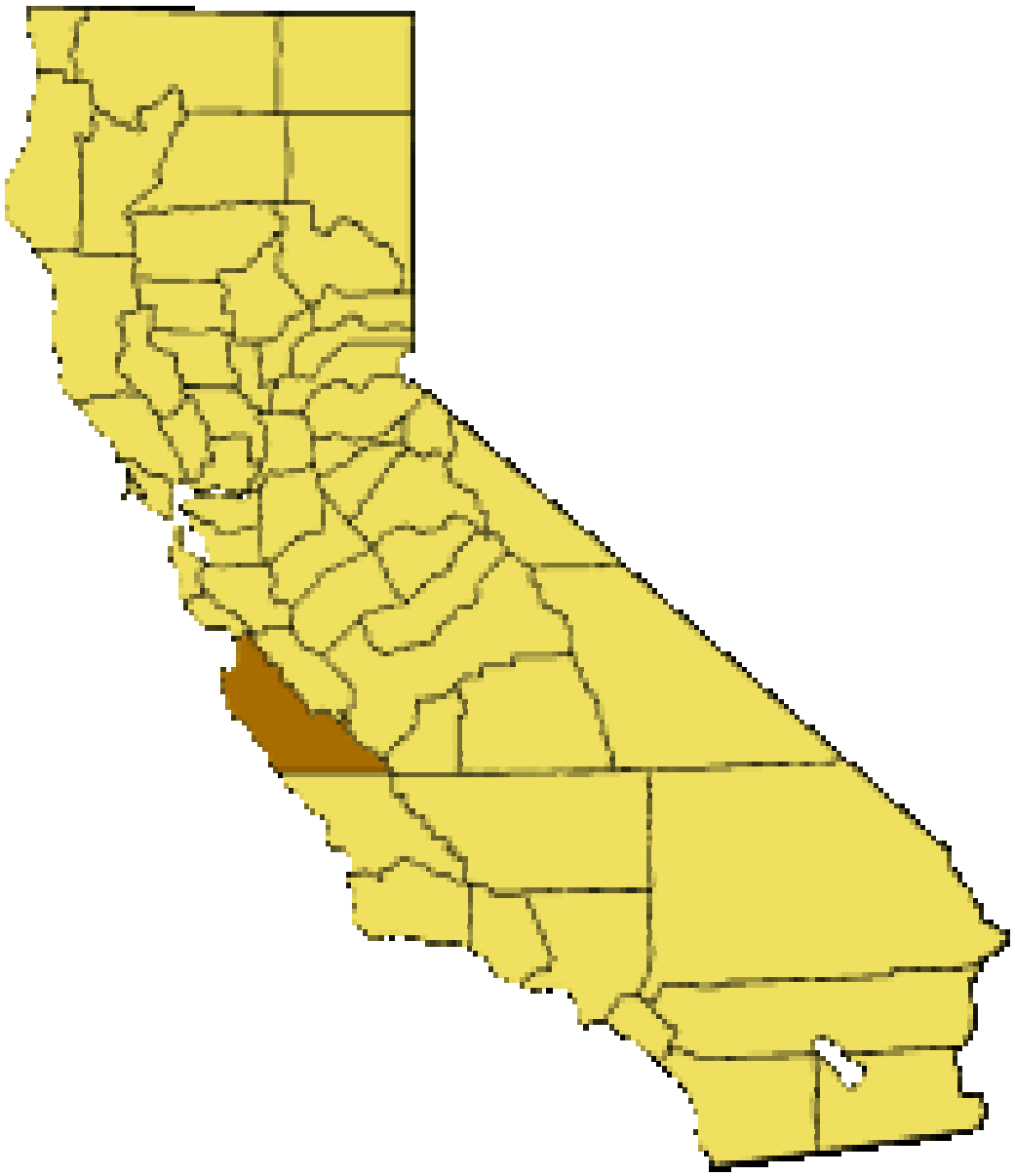


Figure 3

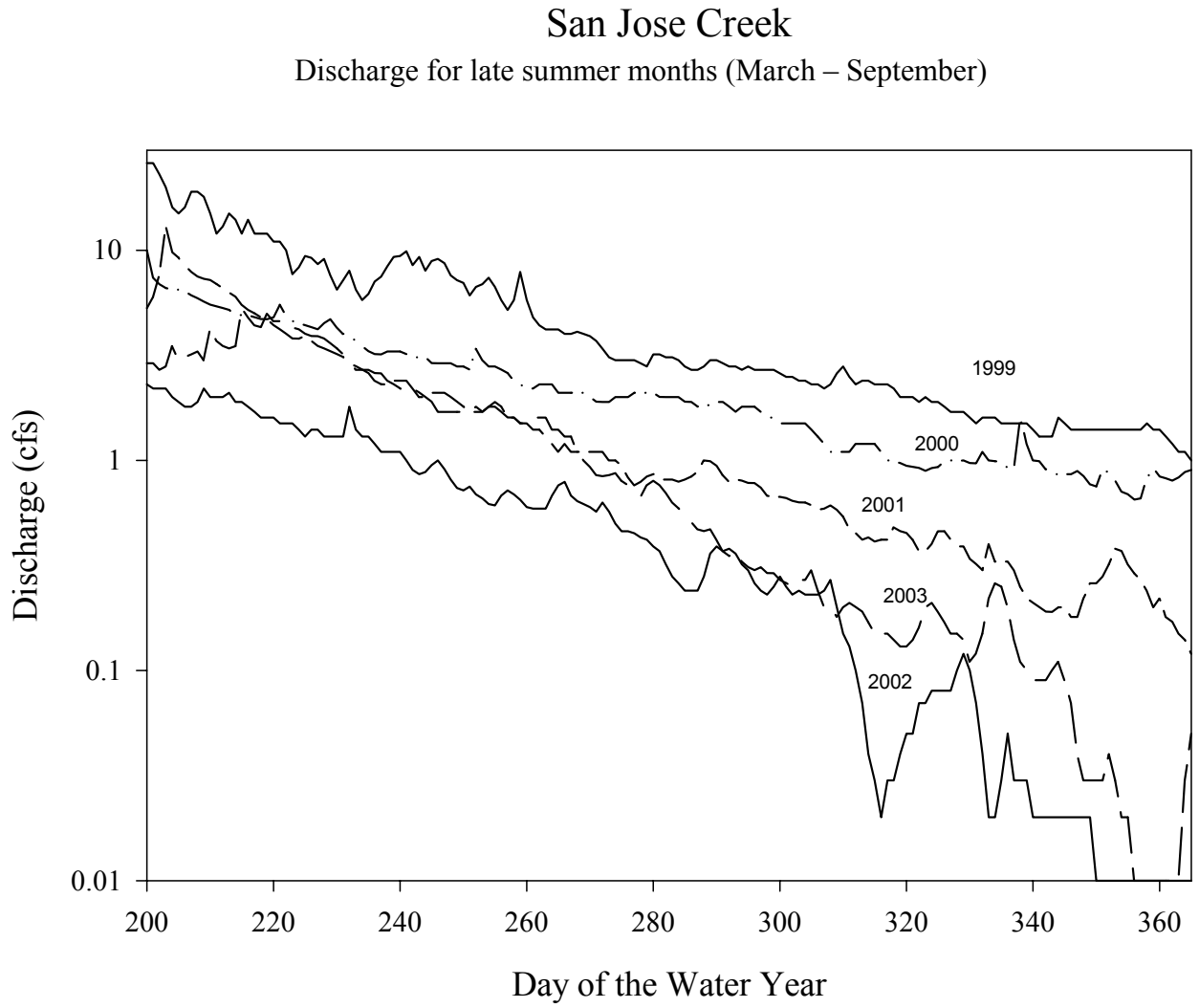

San Jose Creek
Discharge for late summer months (March – September)
Discharge (cfs)
10
1
0.1
0.01
1999
2000
2001
2003
2002
200
220
240
260
280
300
320
340
360
Day of the Water Year

Figure 4

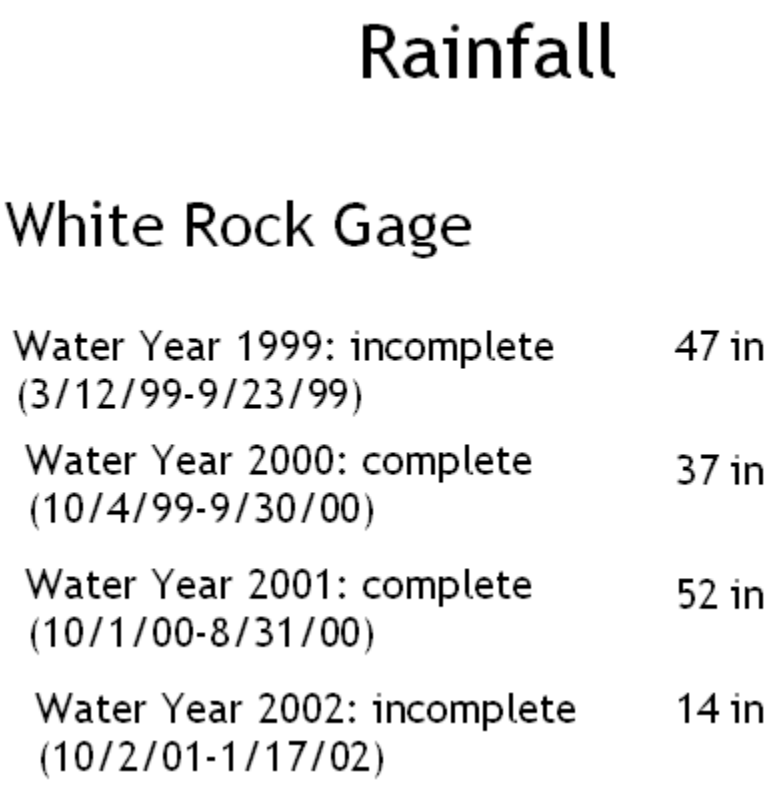
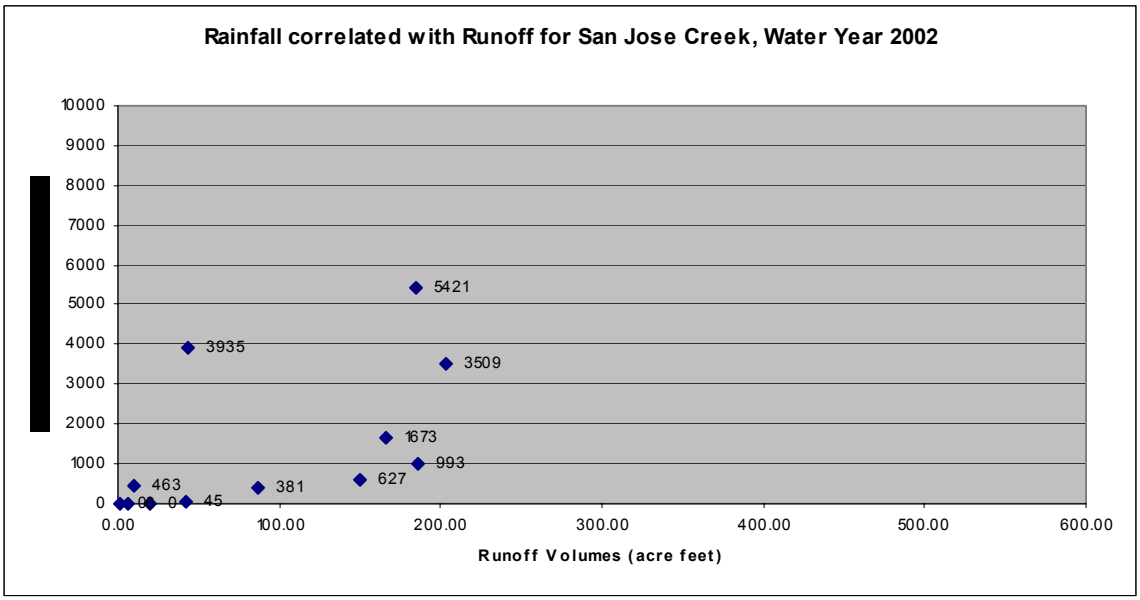

Rainfall
White Rock Gage
Water Year 1999: incomplete (3/12/99-9/23/99) 47 in
Water Year 2000: complete (10/4/99-9/30/00) 37 in
Water Year 2001: complete (10/1/00-8/31/00) 52 in
Water Year 2002: incomplete (10/2/01-1/17/02) 14 in

Figure 5

Precipitation and Stream Discharge measurements from Rancho San Carlos golf course rain gage and Lower San Jose Creek stream gage for Water Years 2002 and 2003.

	Precipitation		Runoff	Runoff/Rainfall x 100
WY 2002				
Month	Total (inches)	Total (acre feet)	Total (acre feet)	
October	0.62	463	10.21	2.21
November	5.27	3935	43.64	1.11
December	7.26	5421	184.66	3.41
January	1.33	993	185.46	18.68
February	2.24	1673	166.02	9.93
March	4.7	3509	203.70	5.80
April	0.84	627	149.55	23.84
May	0.51	381	86.40	22.69
June	0.06	45	41.63	92.93
July	0	0	19.89	
August	0	0	5.69	
September	0	0	0.99	
Sum	**22.83**	**17046**	**1097.86**	%6.44
WY 2003				
Month	Total (inches)	Total (acre feet)	Total (acre feet)	
October	0.01	7	0.22	2.92
November	6.96	5197	30.98	0.60
December	11.64	8691	534.45	6.15
January	2.1	1568	485.56	30.97
February	2.26	1687	149.95	8.89
March	1.88	1404	155.11	11.05
April	4.79	3577	174.35	4.87
May	1.07	799	214.61	26.86
June	0	0	89.00	
July	0	0	30.13	
August	0.01	7	11.03	147.70
September	0.02	15	3.21	21.52
Sum	**30.74**	**22953**	**1878.60**	%8.18

Figure 6


Rainfall correlated with Runoff for San Jose Creek, Water Year 2002
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
5421
3935
3509
1673
993
627
463
381
45
0.00
100.00
200.00
300.00
400.00
500.00
600.00
Runoff Volumes (acre feet)

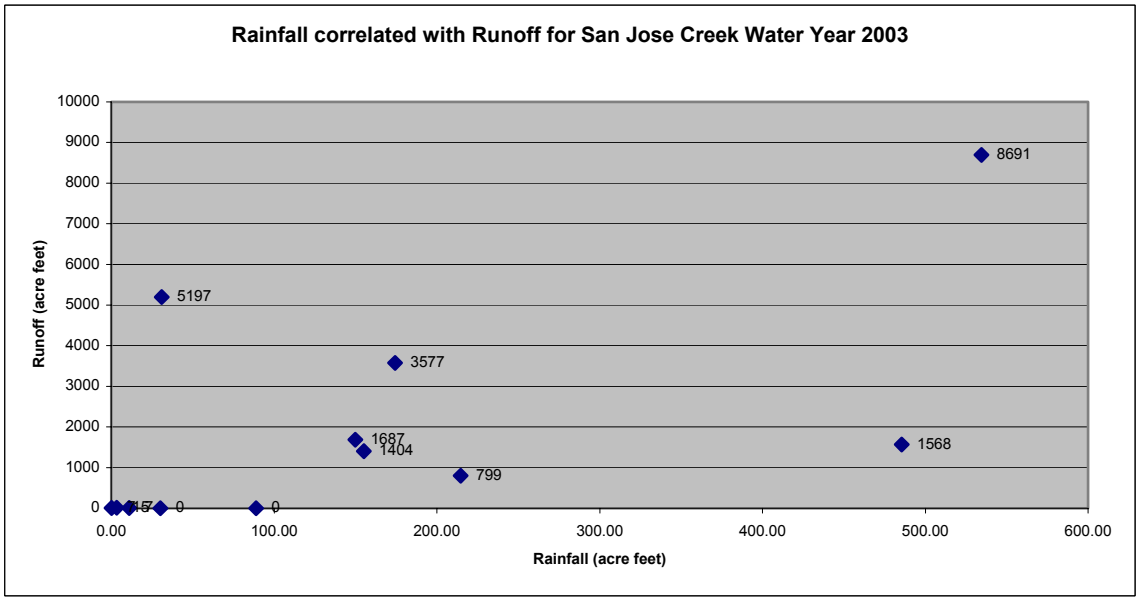
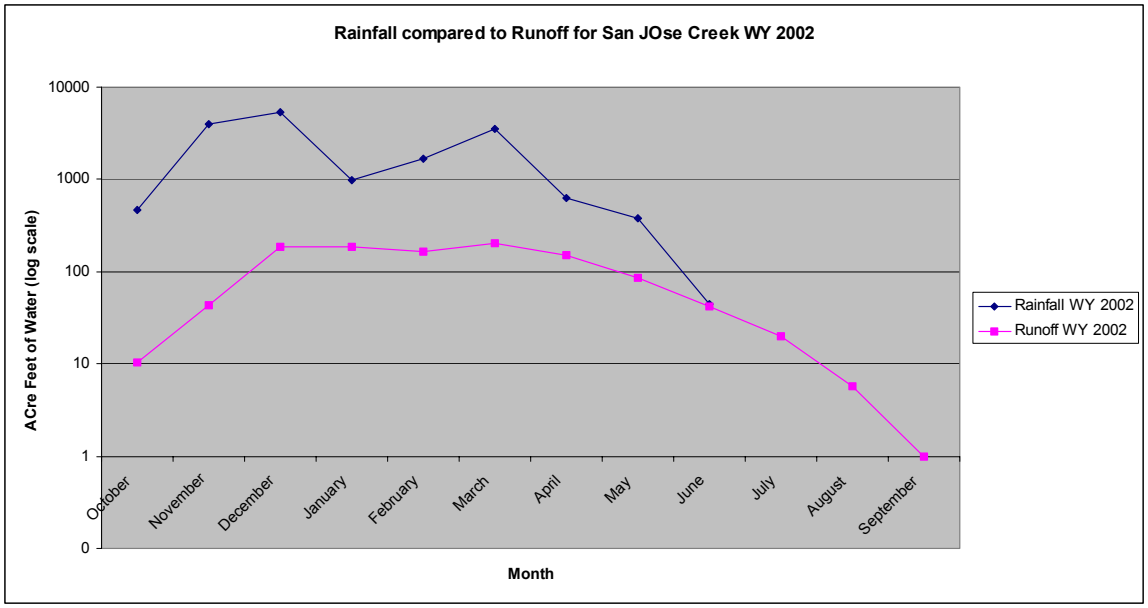
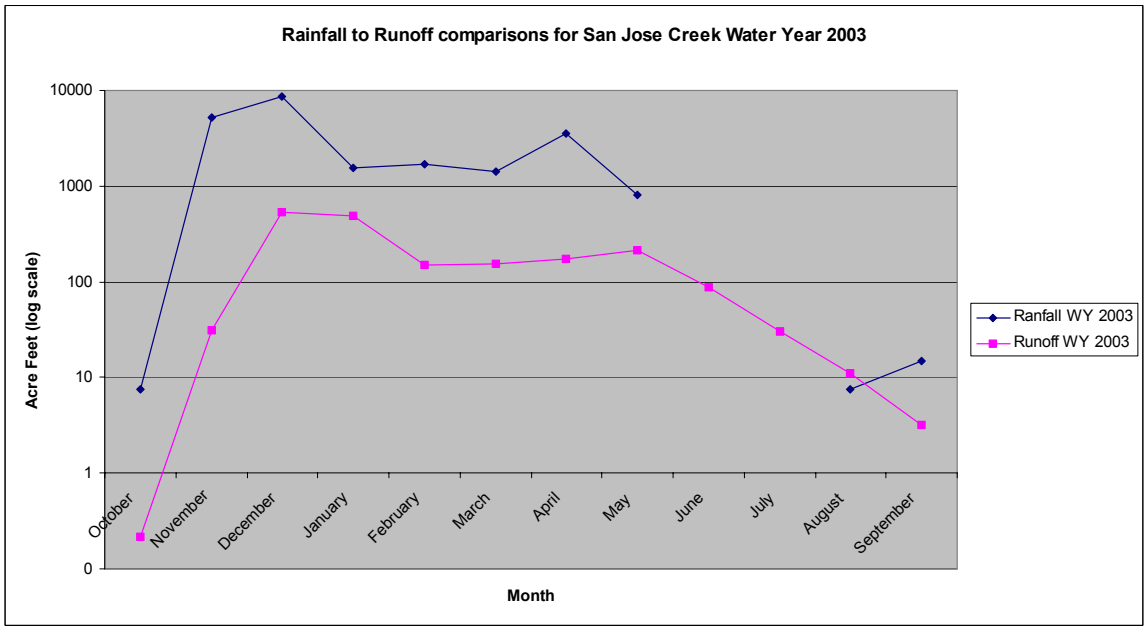

Rainfall correlated with Runoff for San Jose Creek Water Year 2003
Runoff (acre feet)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
8691
5197
3577
1687
1404
1568
799
0
0
0.00
100.00
200.00
300.00
400.00
500.00
600.00
Rainfall (acre feet)

Figure 7


Rainfall compared to Runoff for San JOse Creek WY 2002
ACre Feet of Water (log scale)
10000
1000
100
10
1
0
October
November
December
January
February
March
April
May
June
July
August
September
Month
Rainfall WY 2002
Runoff WY 2002


Rainfall to Runoff comparisons for San Jose Creek Water Year 2003
Acre Feet (log scale)
10000
1000
100
10
1
0
October
November
December
January
February
March
April
May
June
July
August
September
Month
Ranfall WY 2003
Runoff WY 2003

Site Photo, lower San Jose Creek