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A Decade of Changes in the Wildcat Creek Flood Control Channel, North Richmond

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Landscape Architecture and Environmental Planning 222: Hydrology for Planners

Professor Matt Kondolf

Abstract: The lower Wildcat Creek flood control and riparian restoration project was one of the first of its kind and is commonly cited in literature on river restoration. The project was initially constructed in 1989 but was reworked in 2000. The project consists of small low flow channel which meanders through a riparian corridor which is adjacent to a larger flood plain. Contra Costa County conducted yearly cross-sectional surveys of the channel until the year 2005 when they abruptly stopped. These surveys were instrumental in determining morphological changes to the channel due to deposition of sediment and scouring of the channel. Survey data was crucial in determining whether sediment removal was necessary to keep the project functioning. I went out to the project site in early May 2008 to survey six cross-sections of the channel. These cross-sections were compared to cross-sections from previous years, at the same locations, and it was determined that channel morphology is continuing to change. Sediment has been building up on the flood control plain and scouring has occurred in the low flow channel. In order to better understand what maintenance must be done to keep the project working to its full potential the practice of annually surveying the channel must continue.

Introduction

Wildcat Creek Watershed is located in the northeastern region of the San Francisco Bay Area (Figure 1). Wildcat Creek is a fifth-order channel that measures 13.5 miles long from its headwaters in Tilden Park to its outlet in San Pablo Bay and had a drainage area or 8.8 mi^2 (Wang & Kondolf, 2008).The headwaters flows through a steep canyon reach underlain by tertiary volcanic basalts. As the creek crosses the Hayward fault there is a break in slope and enters a region characterized by tertiary mudstone which is easily erodible. This section of the creek is its alluvial fan and natural floodplain.

Development began on the floodplain of Wildcat Creek, which is unincorporated land belonging to Contra Costa County, in the 1940's(Wang & Kondolf, 2008). At this time it was common for the creek to flood its banks during wet winter months. In the 1950's, to mitigate the risks involved with flooding of the creek, Contra Costa County, with the help of the U.S. Army Corp. of Engineers, began planning a flood control project. Many projects were proposed and drawn up over the next few decades but none of them ever came to fruition due to lack of funding, public disapproval, or increasing environmental regulations. With increased development came an increased need for flood control. Local community groups joined forces with Contra Costa County and came up with a suitable flood control and riparian restoration project in 1985. The project gained approval and construction began in 1986 with the removal of the original trapezoidal channel and was completed in 1989. The Wildcat Creek flood control and riparian restoration project was one of the first of its kind and included a shallow low-flow channel and floodplain, riparian vegetation, a downstream marsh, and an upstream sediment retention basin (Wang & Kondolf, 2008). The low-flow channel was placed in the floodplain so as not to disturb the riparian vegetation. However, an externality of this decision was that the floodplain soon became inundated with invasive cattails due to the channels exposure to solar radiation (Wang & Kondolf, 2008). Even though the cattails were removed on a yearly basis they still lead to build up of sediment in the channel and caused unforeseen migration of the low flow channel. In 1996 multiple storm events caused Wildcat Creek to escape its channel and flood the surrounding neighborhood. This led the design team, now formally recognized as a watershed council, to recognize that the flood control channel was not sustainable and needed to be revamped (Wang & Kondolf, 2008). It was determined that a deeper, wider and more natural low flow channel need to be created, and it needed to run through the riparian vegetation. The new and improved Wildcat Creek flood control and riparian restoration project was completed and initial monitoring indicated that the channel was functioning well and holding up to winter storms. However, in 1998, while conducting annual cattail removal, the county lowered the floodplain below the elevation of the active channel (Riley, 2003). This change again led to the lateral migration of low flows and caused instability and flooding. This again led to a redesign of the channel. The new design used local gauge records more applicable to tidally influenced streams to create a flow duration curve and account for channel sediment transport over time from surveyed cross-sections and profiles (Wang & Kondolf, 2008).

The new channel was constructed in 2000 and consisted of lowering the low flow channel and pushing the soil to the outside bends of the meanders on the floodplain side. This was the last major modification to the flood control project. Since the year 2000 routine maintenance has occurred in the form of removal of sediment from the detention basin and channel along with removal of vegetation. (Table 1)

Proper maintenance of the project requires accurate monitoring in the form annual cross-sectional surveys. These surveys were being carried out up until the year 2005 and then abruptly stopped. But project maintenance was carried out as recently as September 2006 based solely on observations. This paper sets out to pick up where the monitoring of project left off. The goal is to determine if and how the morphology of the channel is changing. This information is crucial to understanding whether or not the project is self sustaining or whether it still requires help in the form of dredging.

Methods

In order to asses how the flood control channel has changed ten different cross-sections were surveyed annual from the years prior to construction all the way through 2005. To continue to monitoring process I decided to go and resurvey six of the ten cross sections across the channel. The cross sections were located at 96+26, 95+55, 93+00, 88+00, 83+00 and 66+00 feet upstream from San Pablo Bay. The survey pins are located on the right bank of the creek, while looking upstream, but to make sure that the cross sections were taken at the right angle azimuths were taken, with the help of a Brunton Compass, off of aerial photographs which had previous cross sections overlaid on top of them(Figure 3). My colleague Scott Stromberg and I surveyed the first three cross sections on May 2^{nd} 2008 and second three on May 3^{rd}. We used standard surveying equipment including a level and tripod, tape measurer, stadia rod, and hip waders. Surveying was done starting at the surveying pin and going all the way across the channel until the opposite flood plain was reached. Measurements were taken at every point where there was a break in slope and at regular intervals through the creek.

Upon returning from the field the data was synthesized and put into a Microsoft Excel spread sheets. Data from the surveys conducted from 2000-2005 (obtained from PHD student Hsiao-Wen Wang) was also put into these spread sheets. The cross-sections were graphed, overlaid, and lined up so that all seven years of data for one cross-section were seen on one plot.(figures 4-9) This way it was possible to see the morphological changes over time. From the data sets the thalweg for the low flow channel and the flood plain for 88+00, 83+00 and 66+00, or just the channel in general for 96+26, 95+55 and 93+00, were graphed over time.(figures 10-15) Furthermore a gauge records from the USGS gauge on Wildcat Creek at Vail Road were used to construct a flood frequency curve for the creek.(figure 16)

Finally, a graph of annual peak flow was created for Wildcat Creek from 1965-2006.(figure 19) This was done by first inputting data from the USGS gauge which ran up until 1997.(figure 17) Then to extrapolate for the next ten years the peak flows for Wildcat Creek were plotted against the peak flows for near by San Ramon Creek creating a double mass curve.(figure 18) A linear regression was done on the scatter plot to come up with an equation which related the peak flows of Wildcat Creek to those of San Ramon Creek year to year. Using this equation and the gauge data from San Ramon Creek from 1998-2006 the approximate peak flows on Wildcat Creek, for those years, were calculated. Putting all this data together an annual peak flow graph was constructed for Wildcat Creek.

Results

Of the six cross sections the changes over time of the top three, above Giaramita Avenue (96+26, 95+55 and 93+00) are noticeably similar and the bottom three, below Giaramita Avenue (88+00, 83+00 and 66+00) are quite similar to each other as well. For this reason they will be discussed as groups.

The three cross-sections above Giaramita Avenue can be characterized as wide smoothly shaped trapezoidal channels. There are large amounts of vegetation attached to the bed of the channel at cross sections 96+26 and 95+55. Looking at the 96+26 cross-section from 2000 to 2001, when the flood control channel was reworked, the bed of the channel was raised slightly while retaining the same overall shape. From 2001-2002 the channel cut into its bed creating a narrower channel whose thalweg was almost 2 feet deeper than it had been the previous year. The following year the channel did not change significantly. From 2003-2004 the depth of the channel dropped 1.5 ft and the channel widened on the order of 50 feet. From 2004-2005 there were no significant changes to the channel. From 2005-2008 the channel has migrated through erosion of its southern bank and accumulation of sediment on its northern bank.(Figures 4 & 10)

Moving down stream to the 95+00 cross-section similarities can be seen during the year of the project in that the bed of the channel was raised while maintaining the same general profile. The key changes from post construction to 2008 can be characterized as erosion of the bed and south bank. From 2001 to 2002 there was significant lowering and narrowing of the channel. From 2002 to 2003 the channel aggraded slightly but then degraded back down to its 2002 level by 2004. From 2004 to 2005 the channel eroded its south bank and this processes continued further up until 2008 at which time the channel had eroded away its bank downgraded over 1 foot from its 2005 level.(figures 5 & 11)

As with the first two cross-sections the level of the 93+00 cross-section was raised slightly during the year of construction. From 2001 to 2005 the level and dimensions of the channel remained static. However from 2005 to 2008 the channel degraded almost two and a half feet while the banks remained static.(figure 6 & 12)

The channel below Giaramita Avenue can be characterized as consisting of two channels; one of which is a wide floodplain and the other is the deep, narrow low flow channel that meanders through the riparian corridor on the south side of the profile. The same morphological changes have occurred at all three of the lower cross-sections over the years. From 2000 to 2001, during which time the project was reworked, the thalweg of the low flow channel was lowered from two to three and a third feet. During the same year the level of the floodplain was raised 1.3 ft at the 66+00 profile but staid relatively the same at the 83+00 and 88+00 cross-sections. Since the project was created the level of the floodplains at all three cross-sections have slowly but steadily aggraded with thalwegs raising an average of 0.89 ft for the three cross-sections. The thalwegs for the low flow channel migrated slightly but hovered around the same elevation up until 2005. However, from 2005-2008 the low flow channel has entrenched.(figures 7,8,9,13,14 & 15)

Using the flood frequency curve (figure 16) and the graph of annual peak flows on Wildcat Creek (figure 19) it is possible to determine the return intervals and the magnitudes of the flows during the time of monitoring. The two largest flows occurred in 2003 and 2006. The 2003 peak flow had a discharge of 1685 cubic feet per second (cfs) and a return interval of 20 year. The 2006 peak flow had a return interval of 35 years and a discharge of 1994 cfs.

Discussion

It has been shown that all of the cross-sectional profiles changed from the time of construction through 2005, when annual surveying stopped, and continued to change through 2008, when I conducted my survey. These processes involved in changing the channel morphology can be characterized as either natural processes i.e. large flows, or unnatural processes, such as dredging of the channel. The three cross-sections above Giaramita Avenue all experienced similar changes in their morphology and this leads one to believe that the same processes are occurring through this entire reach. The 96+26 and 95+00 cross-sections experienced the most significant change between the 2003 and 2004 surveys and between the 2005 and 2008 surveys (figures 4,5,10 & 11) The times of these changes coincide with the two large flows which occurred on December 16, 2002 and December 31, 2005(figure 19). These large flows can explain the erosion of the bed and the south bank. Another process which would have contributed to these changes is the dredging of the channel in September 2006.(table 1) The only significant changes to the 93+00 cross-sectional profile occurred between 2005 and 2008(figures 6 & 12). This erosion of the channel bed can be explained by the 35 year flow that occurred in the 2006 water year. The reason that the walls of the channel were not altered in the way that the higher cross-sections were is that they are reinforced with rip rap since the channel passes under the Giaramita Avenue Bridge just downstream from this cross-section.

As with the upper cross-sectional profiles the lower profiles morphological changes can be linked to a specific disturbance to the channel. The lowering of the low flow channel between the 2000 and 2001 surveys is due to the reworking of the channel which was carried out with a specific goal in mind to lower this channel. Over the years sediment began to build up on the floodplain through sediment, this can be attributed to large peak annual flows, which carry not only a lot of water but also carry a lot of sediment. As these large flows run through the flood control channel the sediment settling out of the water column because the creek slows due to the low grade floodplain The entrenching of the low flow channel into its bed between 2005 and

2008 can again be attributed to the 35 year flood even of 2006 along with the dredging of the channel.

Conclusions

The lower Wildcat Creek flood control project was one of the first of its kind and has been very instrumental in influencing future projects(Wang & Kondolf, 2008). Monitoring of the channel is an important way of tracking changes in the channels morphology. To do this properly the channel must be surveyed on a regular basis meaning at least once a year. Contra Costa County must pick up their practice of annual surveying the channel. Conducting these surveys is not difficult. Two undergraduate students were able to perform these six cross sections in less than one hour each. By comparing the annual surveys it is possible to track the vertical and horizontal migration of the channel. By comparing this information with data on annual peak flow and dredging records within the channel it is possible to determine the causes of the morphological changes to the channels. These processes must be understood in order to conduct proper maintenance of the project.

References Cited

Riley, A.L. 2003. Wildcat Creek Restoration Project: a Case Study in Adaptive Management. In Faber, P.M. (ed.) California Riparian Systems: Processes and Floodplain Management, Ecology, and Restoration. 2001 Riparian Habitat and Floodplains Conference Proceedings, Riparian Habitat Joint Venture, Sacramento, California

Wang, Hsiao-Wen and Matt Kondolf. 2008 Lessons Learned from the Lower Wildcat Creek Floodf Control Project in California, work in progress.

Tables

Basin silt removal information

Removal Date	CY rem.	Cost
September 2006	9,667	$ 168,000
October 2003	10,208	$ 150,472
July 2002	4,921	$ 57,672
October 2001	5,392	$ 68,218
October 1998	10,000	$ 94,343
October 1997	14,396	$ 79,251
October 1996	7,602	$ 51,689
October 1995	6,657	$ 46,022
August 1995*	2,700	$ 20,900
Totals:	71,543	$ 736,567

*Sediment removed as part of Corps project. Estimated at 4'd(140'w)(131'L)/27 = 2,700 cy
Assumed $7.00/CY contract cost

Basin Annual Silt Deposit

2006-1995 is 11 years	71,543 /11 =	6,504	CY per year

Channel silt removal - September 2006

Rich. Pkwy and Giaramita	7,759	CY	$ 178,000

Channel silt removal - October 1997

Stations	CY rem.	Cost
Sta 66 - 80	6,404	$ 47,415
Sta 81 - 95	10,285	$ 68,659
Totals:	16,689	$116,074

Channel Annual Silt Deposit

2006-1995 is 11 years	24,448 /11 =	2,223	CY per year

Wildcat Creek Basin and Channel Totals

Per Year	CY rem.	Cost
8,726	95,991	$ 1,030,641

Channel and Basin Silt Removal Annual Cost

2006-1995 is 11 years	$ 1,030,641 /11 =	$93,695	per year

Table 1: Dredging records of Wildcat Creek Flood control Project.

Figures

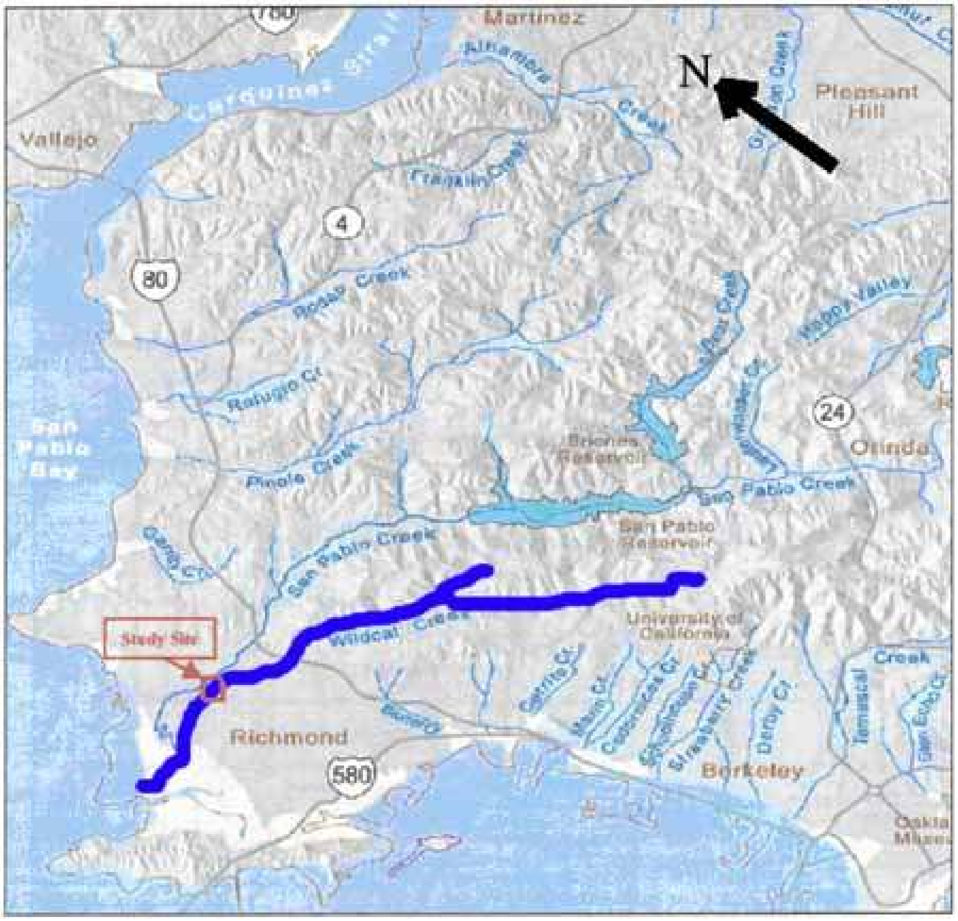

Figure 1: Area Map

Figure 2: Location Map

Figure 3: Location Map with Cross-sections

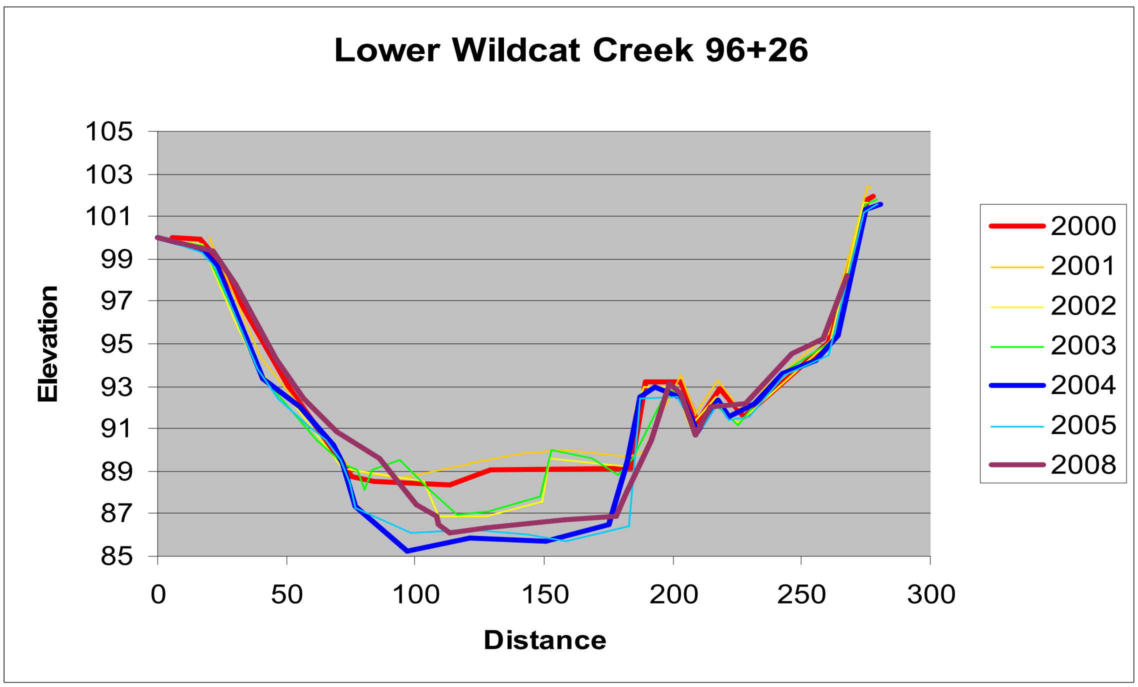

Figure 4: Cross section 9626 feet above San Pablo Bay. Looking upstream with distance zero on the right bank of the channel.

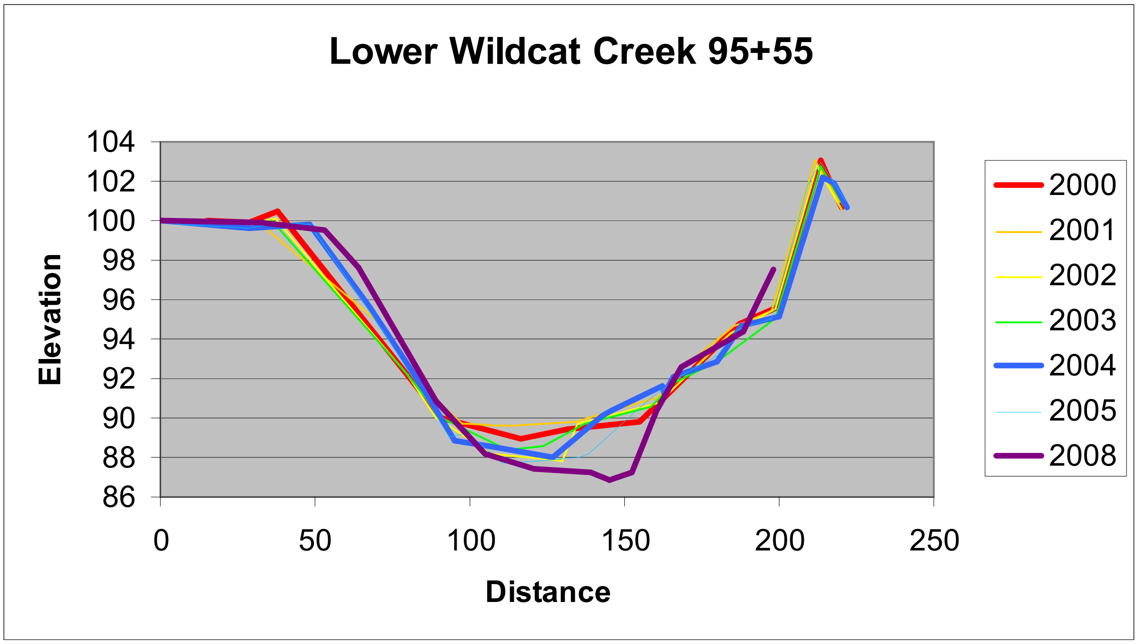

Figure 5: Cross section 9555 feet above San Pablo Bay. Looking upstream with distance zero on the right bank of the channel.

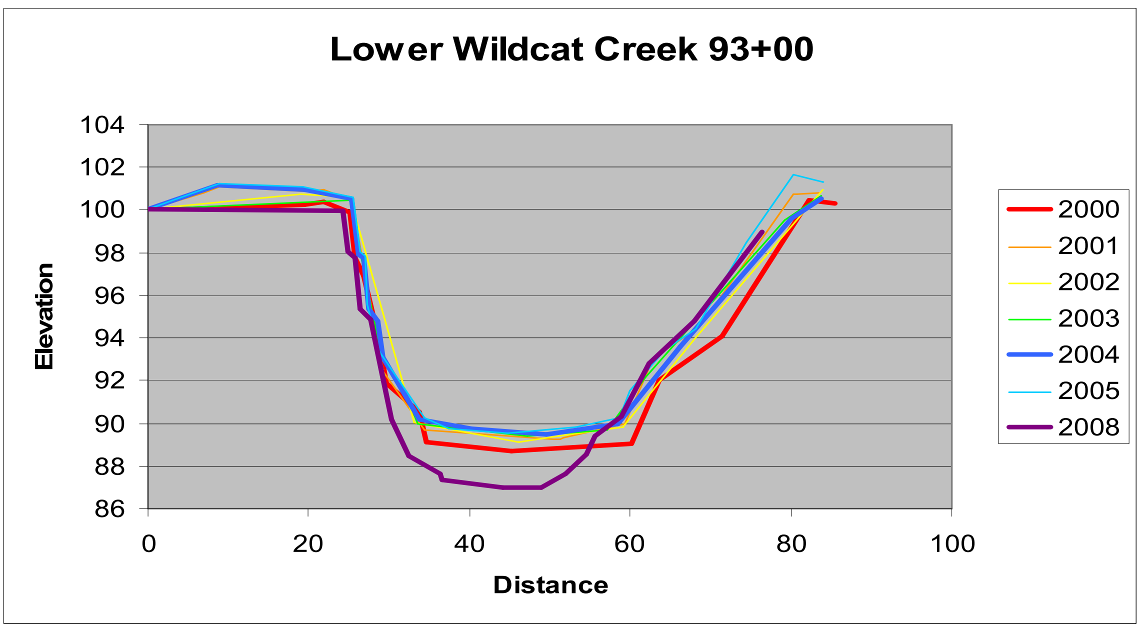

Figure 6: Cross section 9300 feet above San Pablo Bay. Looking upstream with distance zero on the right bank of the channel.

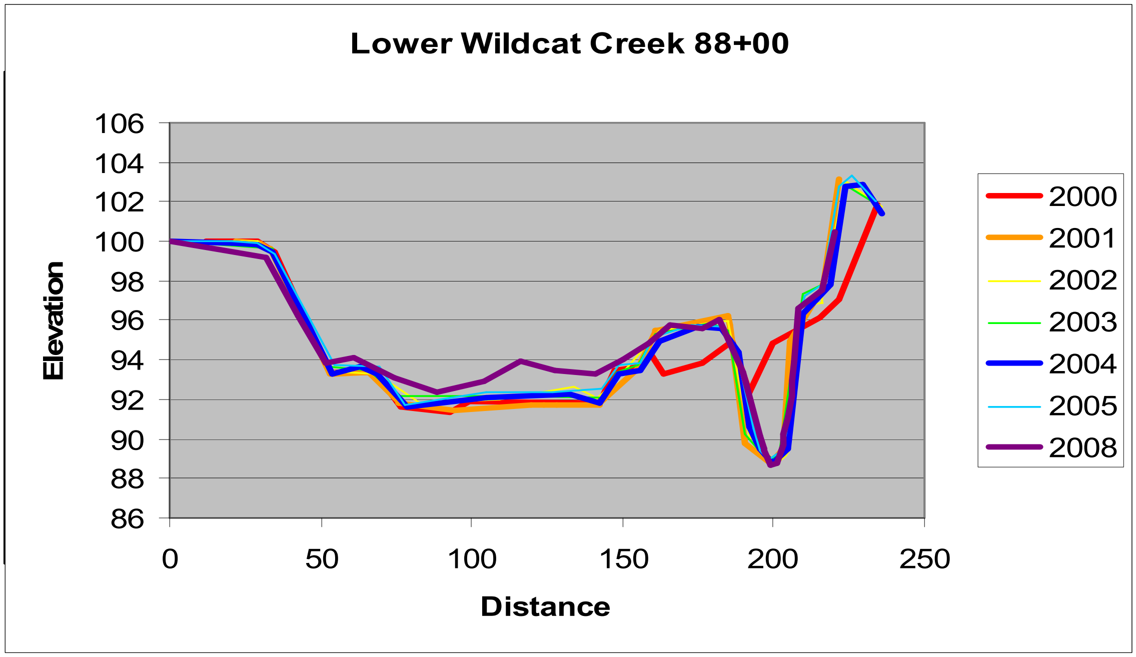

Figure 7: Cross section 8800 feet above San Pablo Bay. Looking upstream with distance zero on the right bank of the channel.

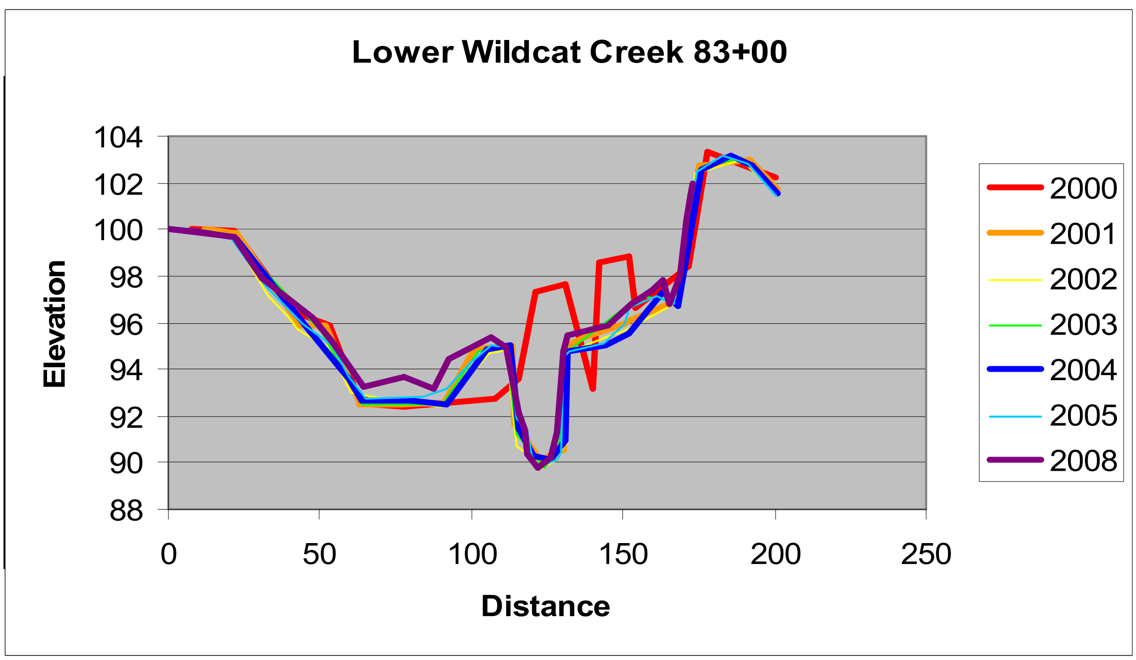

Figure 8: Cross section 8300 feet above San Pablo Bay. Looking upstream with distance zero on the right bank of the channel.

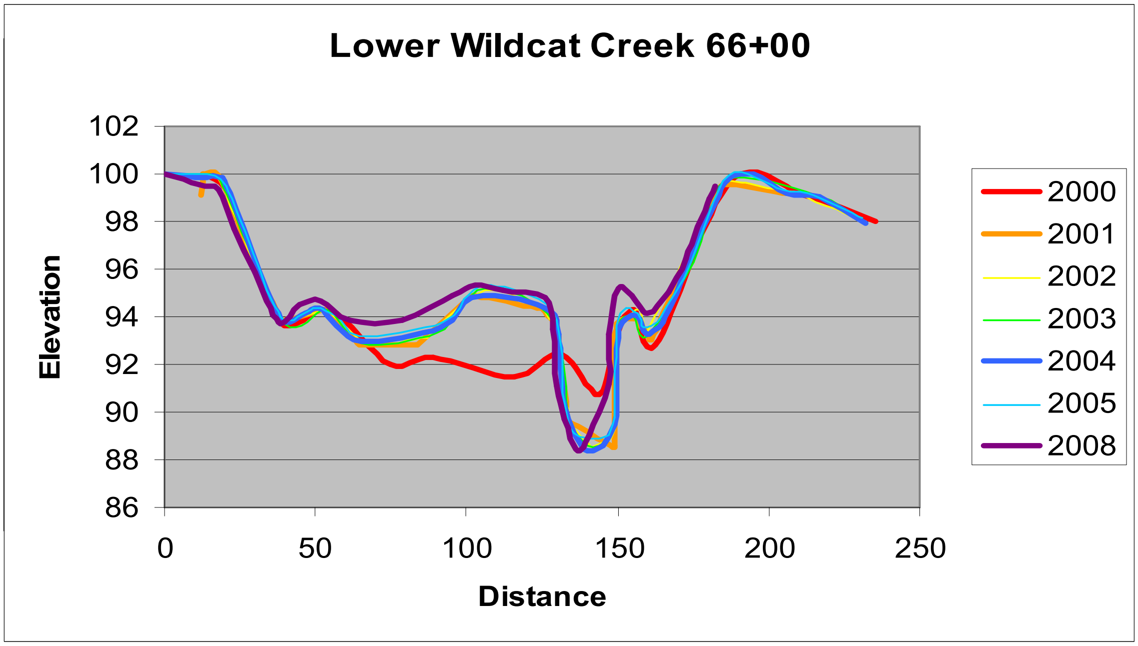

Figure 9: Cross section 6600 feet above San Pablo Bay. Looking upstream with distance zero on the right bank of the channel.

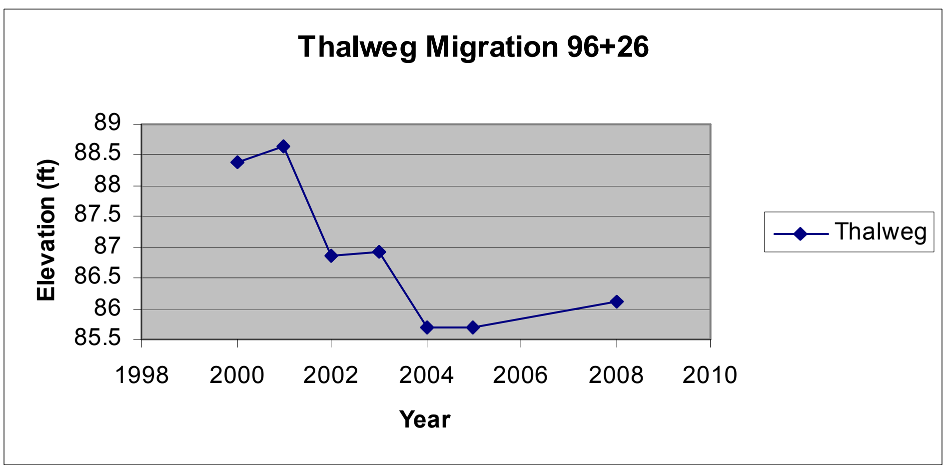

Figure 10: Vertical Thalweg migration of the channel 9626 feet above San Pablo Bay.

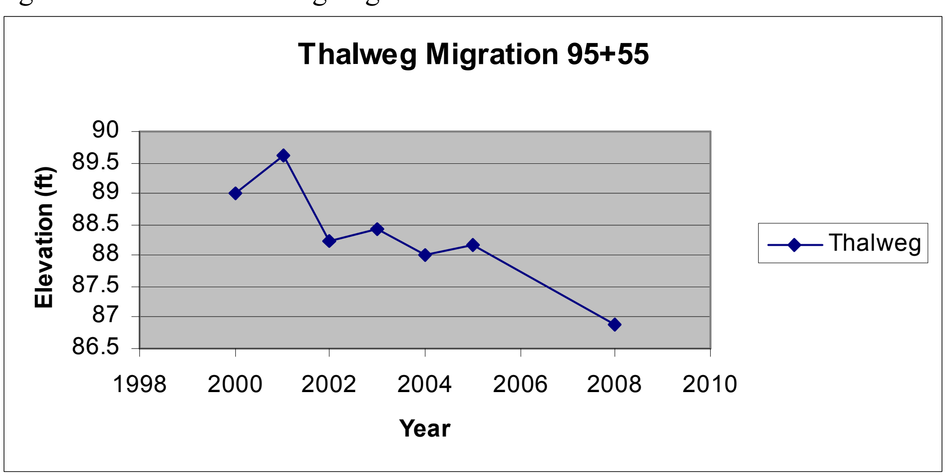

Figure 11: Vertical Thalweg migration of the channel 9555 feet above San Pablo Bay.

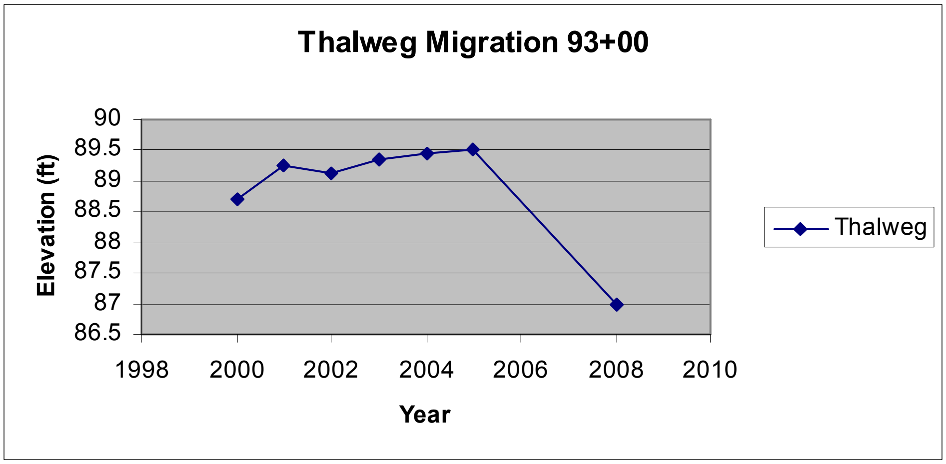

Figure 12: Vertical Thalweg migration of the channel 9300 feet above San Pablo Bay.

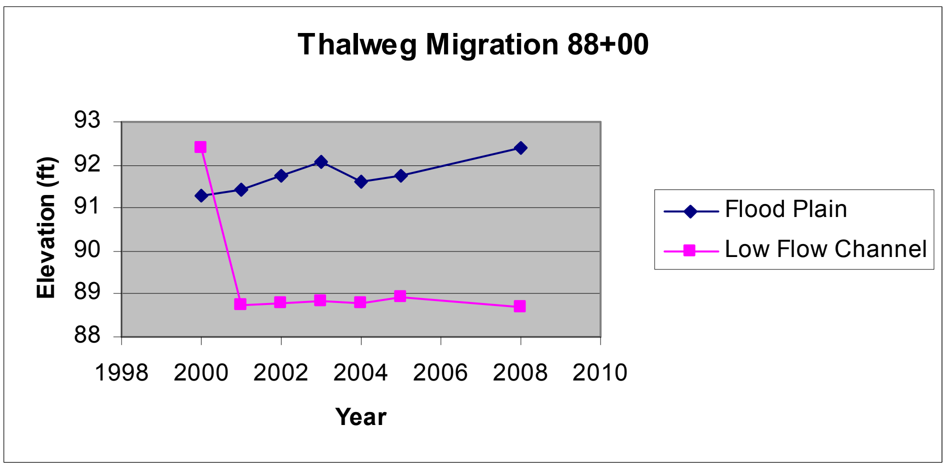

Figure 13: Vertical Thalweg migration of the flood plain and low flow channel 8800 feet above San Pablo Bay.

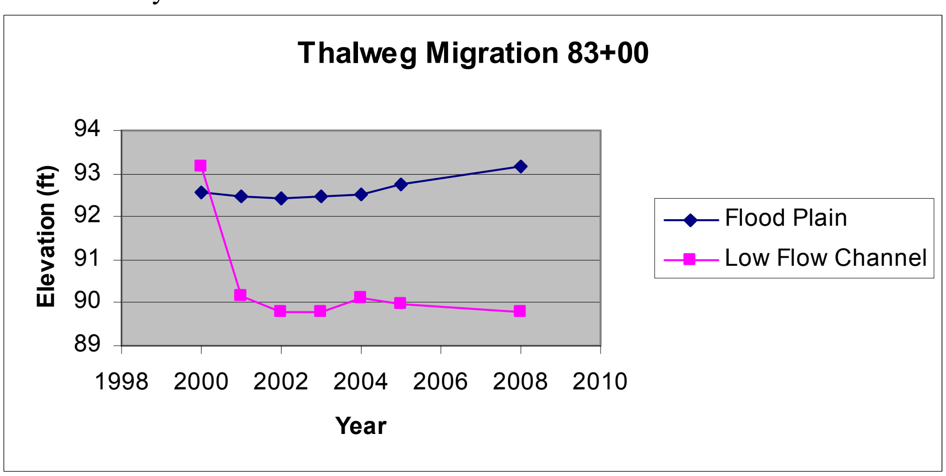

Figure 14: Vertical Thalweg migration of the flood plain and low flow channel 8300 feet above San Pablo Bay.

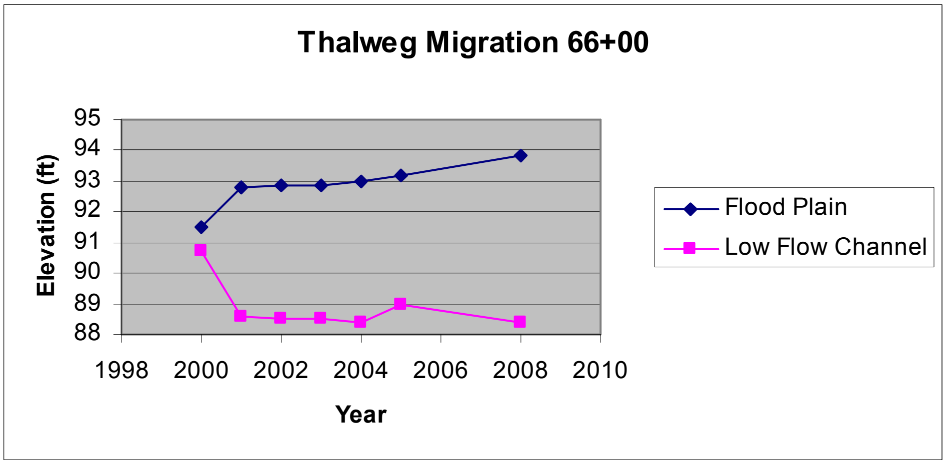

Figure 15: Vertical Thalweg migration of the flood plain and low flow channel 6600 feet above San Pablo Bay.

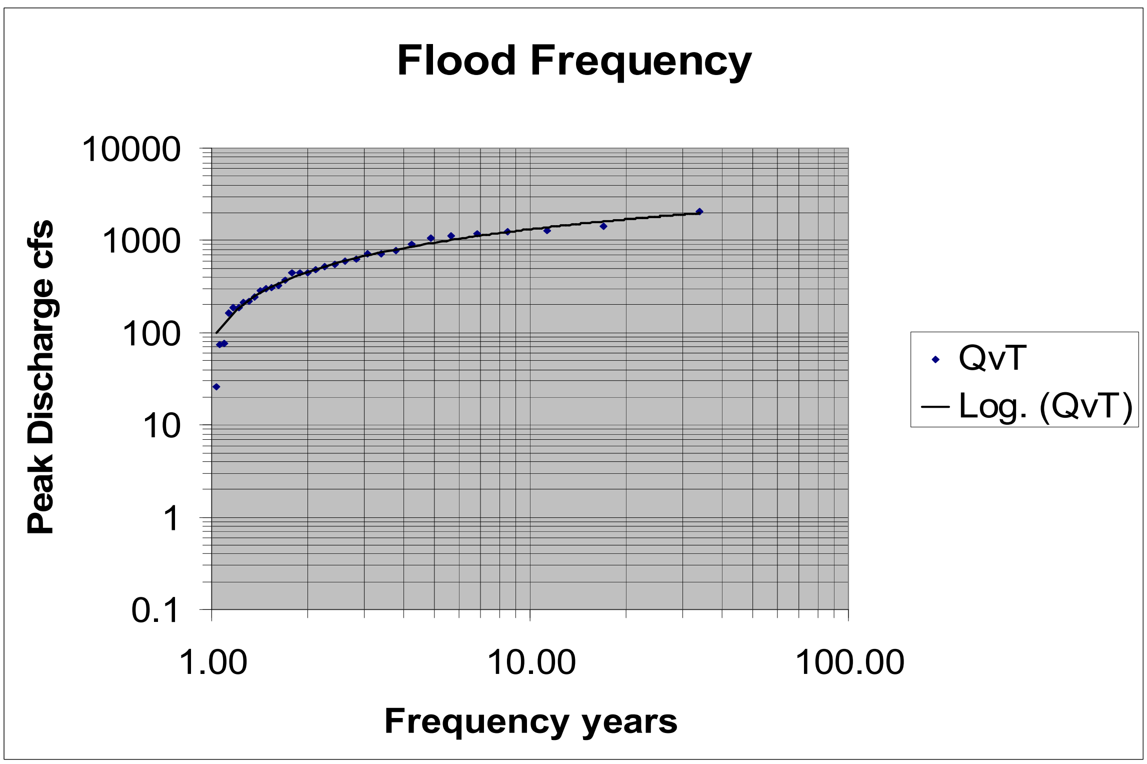

Figure 16: Flood Frequency Curve for Wildcat Creek based on USGS gauge data from 1965-1997

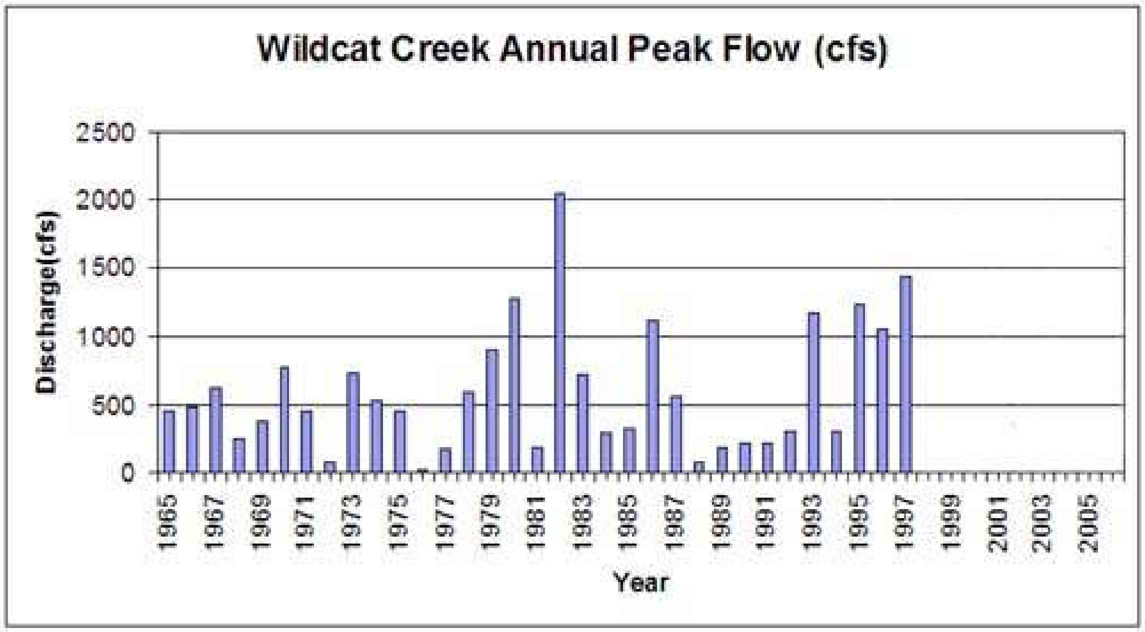

Figure 17: Wildcat Creek Annual Peak Flows 1965-1997 based on USGS gauge data

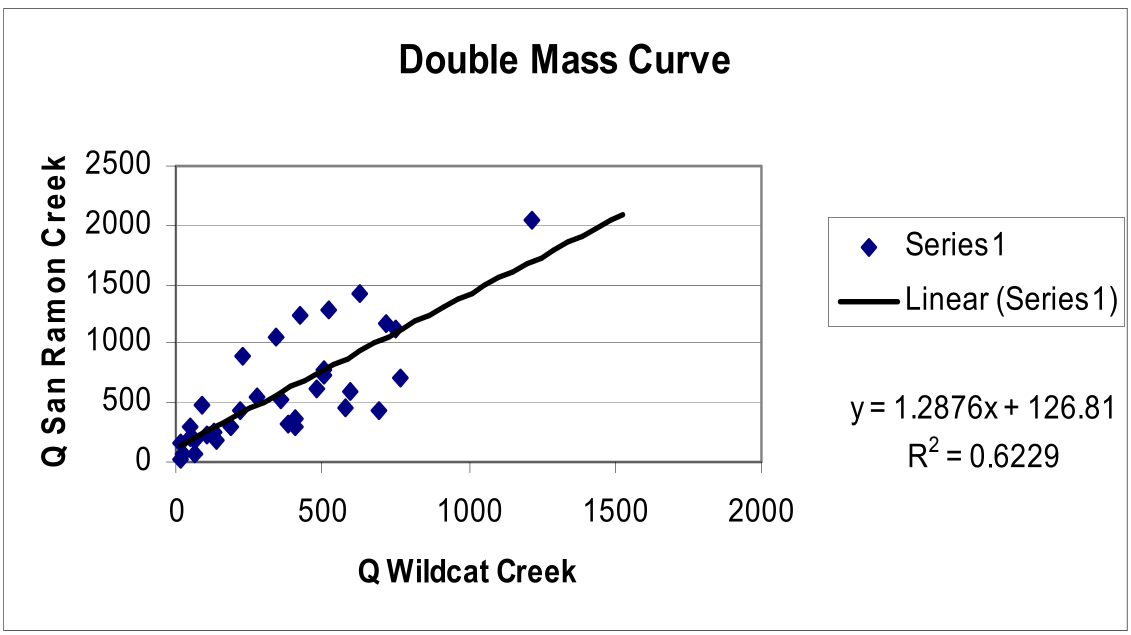

Figure 18: Double Mast Curve relating peak flow of Wildcat Creek to peak flow of San Ramon Creek.

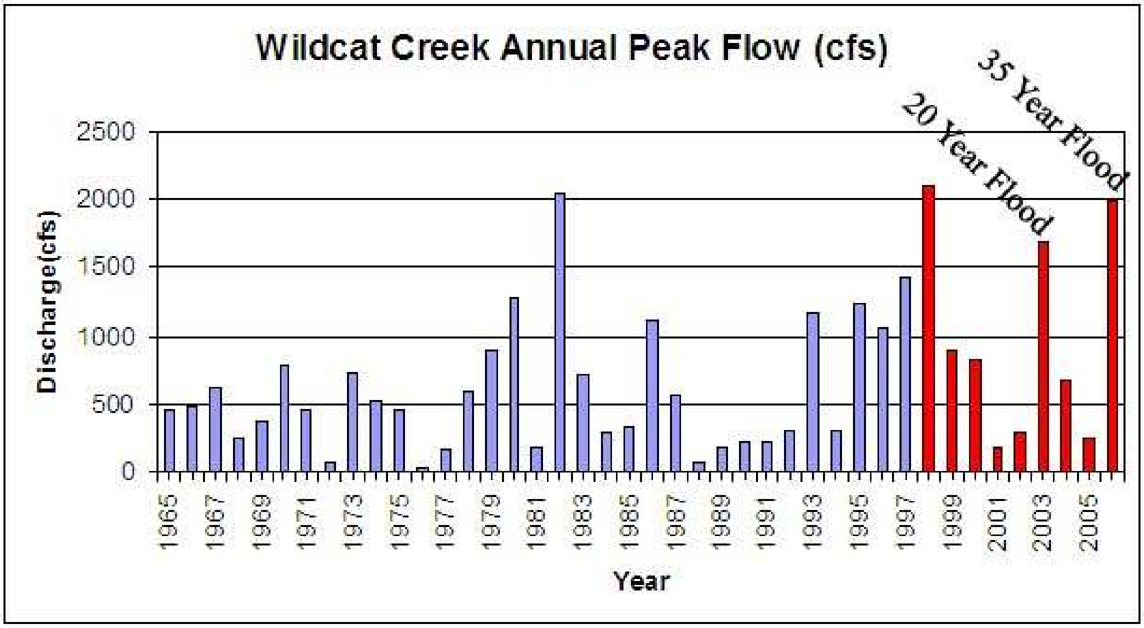

Figure 19: Wildcat Creek Annual Peak Flows 1965-2006 based on USGS gauge data and interpolation from San Ramon Creek USGS gauge data using the linear regression equation from the double mass curve(figure 18)

Appendix

Year	Wildcat Creek Peak Flow(cfs)	San Ramon Peak Flow(cfs)	Year	Wildcat Peak Flow(cfs)	San Ramon Peak Flow(cfs)
1965	450	579	1987	556	278
1966	482	92	1988	74	62
1967	622	484	1989	185	136
1968	246	131	1990	216	45
1969	375	407	1991	219	103
1970	776	504	1992	300	189
1971	446	219	1993	1170	718
1972	77	22	1994	309	45
1973	725	506	1995	1240	425
1974	523	356	1996	1060	346
1975	445	694	1997	1430	632
1976	26	16	1998	2096.838	1530
1977	165	19	1999	894.2196	596
1978	591	596	2000	828.552	545
1979	900	228	2001	177.0264	39
1980	1280	523	2002	296.7732	132
1981	187	68	2003	1684.806	1210
1982	2050	1220	2004	681.7656	431
1983	720	770	2005	254.2824	99
1984	289	411	2006	1993.83	1450
1985	327	382			
1986	1120	751			