The Pipe vs. The Shed

Waste Water compared with Natural Hydrology in an Urban Setting

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Abstract:

The scope of this paper was to compare the hydrology of the East Bay Municipal District's Wastewater Treatment Plant in West Oakland with the adjacent stream watershed, Temescal Creek Watershed. These two systems vary greatly in scale and in water usage. This projects aims to look at the imported and piped water system in a similar way as one would approach a stream and watershed hydrology. Using stream flow data for the creek, it was scaled to the size of the whole watershed. The data was compared with precipitation to put perspective on a limited number of years of stream flow. The latest year of outflows from the WWTP was obtained. The data was compared via seasonal distribution, mean daily flow, and annual volume. The Temescal Creek Watershed flow was scaled to the same size of the WWTP service area (from 7.11sq.mi. to 88sq.mi.) to estimate local flow through the system versus imported flow. Peak flows for the stream gauge were scaled to the watershed and compared with the peak flow for the WWTP. Finally, pollutants found in both were compared. Flow and volume were found to be 35 times greater in the treatment plant than in the watershed. However, the peak flows through the watershed come close to the peak flows experienced in the WWTP. The correlations and differences look at greater questions of how we as humans use water in ways much greater than what is readily available around us.

Introduction:

The San Francisco Bay receives water from a number of natural and non-natural sources spread around the Bay Area. Many of the natural sources, such as streams and wetlands, have been modified to accommodate human needs. The non-natural sources have been created to concentrate flows from diffuse areas (taking water from places throughout the region and beyond) storing it for periods of low flow, distributing the water to a network of users, and again concentrating the water and simultaneously the release of the water in a particular location. In some ways, these non-natural sources may function hydrologically similar to natural sources; but in other ways, they may function differently.

The purpose of this project is to compare and contrast the hydrology of a non-natural source, the East Bay Municipal Utility District Treatment Facility in Oakland, CA to the hydrology of a natural source, the adjacent stream and watershed found north (Temescal Creek Watershed). Even with the major differences in the two systems, man-made versus human altered, the flow, magnitude, seasonal distribution, and peak events are still part of their basic hydrological functions. The aim was to quantify the scale of the two systems, examine the rate of flows into the San Francisco Bay, and compare information about the water quality in terms of pollutants and amount of sedimentation found. Lastly, this report examined possible ways in which future storm water and waste water can be dealt with through wetland restoration.

The East Bay Municipal Utility District (EBMUD) is the source of potable water for the area. EMBUD manages the water supply from the Mokelumne River Watershed in the Sierra Nevada. The EBMUD is the company which secures the water, delivers, and in a certain sector of the district is in charge of collecting and cleaning the residual wastewater. For this sector, the wastewater system and stormwater system are separated. Historically the wastewater used to overflow the stormwater, allowing contaminates from human waste and untreated wastewater to leak into the streams, creeks, and bay. Today different issues arise as peak flows in the streams overflow the storm drains causing stormwater to overflow into the wastewater treatment.

The main Wastewater Treatment Plant (WWTP) for EBMUD is located in West Oakland, CA in the southwest corner of the MacArthur Maze (Intersection of I-80, I-580, I-880, and the Bay Bridge). This facility serves 654,700 people in the cities of Kensington, El Cerrito, parts of Richmond, Albany, Berkeley, Emeryville, Piedmont, Oakland, and Alameda (Figure 1). Wastewater is collected by city sewer systems and then fed into the EBMUD line. The WWTP treats the water and releases it into the bay as soon as possible. The storage capacity is limited because of the volume of water which is serviced by only one treatment plant. The plant experiences approximately 20 days a year of 'wet weather flows' which are significant enough to divert water before completing treatment into the bay. Stormwater is usually separate but some point source contamination from industrial areas has led to certain areas of stormwater being diverted to the plant for treatment before being released into the bay. The outflow of treated water is pumped into the San Francisco Bay through a pipe, 5700ft off the shoreline, and 45ft below mean low water levels. The facility acts as the filter for 88sq.mi. of the East Bay Area. The following watersheds overlap with the service area: Cerrito Creek, Codornices Creek, Strawberry Creek, Schoolhouse Creek, Derby Creek, Temescal Creek, Ettie Street Pump Station Watershed, Oakland Estuary (including Glen Echo Creek and Lakeshore Watershed), Sausal Creek, East Creek, Lion Creek, Arroyo Viejo Creek, and San Leandro Creek.

Adjacent to the WWTP is the Temescal Creek. Once made the source of potable water for the Oakland area, the creek was modified in 1868 to create Lake Temescal along the sag pongs caused by the San Andreas Fault. Today the creek mostly runs through a culvert underground, fed by the stormwater system and terminates in a short stint of day-lighted flow by the bay in Emeryville. A small bay called “The Crescent” proposed to become part of the Eastshore State Park (between the Bay Bridge peninsula and the Emeryville Marina) surrounds the confluence before the water flows into the greater San Francisco Bay (Figure 2 and 3).

Research Approach & Methods:

Two primary methods were used for comparing the WWTP to Temescal Creek: site analysis and hydrologic data analysis. For site analysis, observations were made throughout the Temescal Creek Watershed. The main locations of observations were Lake Temescal, the location of the stream gauge, the daylighted portion at the discharge location along the bay, and the Temescal Creek Park where the culvert is visible. For hydrologic analysis, stream flow data for Temescal Creek was compared to the discharge records from the WWTP. Because of issues regarding the availability of stream flow records for Temescal Creek, namely, incomplete records and the gauge location in the upper portion of the watershed, the methods described below were used to place the limited data into a long-term context. The available data was then scaled to the entire Temescal Creek watershed.

Available Temescal Creek Stream flow data:

Daily stream flow data for Temescal Creek was gathered from the USGS website in order to see how much water flows into the bay. Mean daily flow data was only available for water years 1980, 1981, 1990-1993 and partial water year data for 1989 (from June through September.) In order to see the record of flow, hydrographs were created to better understand which months had lower and higher flows.

Temescal Creek Precipitation:

Precipitation data were obtained for Temescal Creek for a forty year time period between 1970 until 2010. In order to better understand and see whether or not precipitation affected stream flow, precipitation data from 1980, 1981, and 1991-1993 were further studied and compared to the stream flow data obtained for Temescal Creek. 1990 was not included in the comparison because no precipitation data was available for the month of February. Bar graphs for those individual years as well as a total combined average were created and studied next to stream flow hydrographs.

Scaling from Stream Gauge to Watershed:

The Temescal Creek Water Gauge from the USGS archives is located just above the junction of the main leg of the creek into Lake Temescal (Latitude: 37°50'38.00"N & Longitude: 122°13'35.00"W). The discharge area for the gauge is 1.74sq.mi. Using Janet Sower's Watershed Map of Oakland & Berkeley Area, the area of the watershed was determined. The Watershed Map was traced and overlayed on top of a USGS topographical satellite map from 1996. A NURBS modeling program (Rhinoceros) was used to find the area of the Watershed (7.11sq.mi; Figure 3).

In order to scale the discharge occurring at the stream gauge upstream to a total flow for the whole watershed the following methods were used. First the flow was scaled to the amount of infiltration expected for above the stream gauge and for the total stream gauge. For more infiltration, less total flow through the watershed is expected. Second the flow was scaled to the size difference of the discharge through the stream gauge, and through the whole watershed.

Infiltration assumptions were as follows. Using the USGS satellite map, three vegetative zones were determined within the watershed: vegetative zone (typical of the higher elevations of the watershed), larger lot residential (where there was high amount of vegetation, yet mostly dominated by housing), and smaller lot residential and commercial zone (where vegetation was not as plentiful). Each zone had separate assumptions on a *c* value for runoff. For the vegetative area, it was assumed that 75% of the area had a *c* value of undisturbed soil (0.15) and 25% was impervious pavement or other surface (0.9). For the large lot residential zone, it was assumed that 25% of the area was vegetative with disturbed soil (0.30) and 75% was impervious pavement or other surface (0.9). For the mixed residential and commercial zone, 12.5% of the area was assumed to be vegetative with disturbed soil (0.30) and 87.7% was assumed impervious pavement or other surface (0.9). The areas of each zone were determined for the whole watershed and for the area above the stream gauge. Ocular estimations were made for the areas of the three different zones. The daily stream flow data was then scaled by percent difference from the stream gauge area.

Temescal Creek Watershed		
Zone	Area sq.mi.	C Value
Vegetative	1.64	0.3375
Large Residential	3.45	0.75
Residential + Commercial	2.02	0.825
Total	7.11	0.676

Table 1 – Runoff Estimation for TCW

Temescal Creek Stream Gauge		
Zone	Area sq.mi.	C Value
Vegetative	0.37	0.3375
Large Residential	1.37	0.75
Residential + Commercial	0	0
Total	1.74	0.662

Table 2 – Runoff Estimation for above Stream Gauge

EBMUD Wastewater Treatment Plant:

The WWTP monitors inflow and outflows through the facility exhaustively. Given the regulated nature of the system, much data has been generated but not always accessible or retrievable. One current year of data (2010) was available. It was compared with a standard precipitation flow in the area as a simple method of comparing it with the stream flow data. The Wastewater treatment plant, as well as most of these types, measured its flow in million gallons per day (MGD). The flow was converted to cubic feet per second to compare with the stream flow data.

Comparison:

From the hydrographs of both the Temescal Creek Watershed and the WWTP, annual volumes were calculated. Annual flow volumes were assessed and compared. The scaled flow from the Temescal Creek Watershed was then contrasted to the 2010 data available from the WWTP (Figure 18). A projected distribution of a natural creek system was compared against the WWTP in order to analyze the flow distribution of the plant and what it would look like at that magnitude in a more natural system. The flow of the Temescal Creek was finally used to estimate the flow for the service area of the WWTP and used as a comparison tool. The latest permit report and the Friends of Temescal Creek Monitoring Program were compared to examine effluents and sediments within both the creek and the WWTP.

Results & Discussion:

Temescal Creek Data:

The stream gauge flow and precipitation data for the water years 1980, 1981, and 1991-1993 were examined in more detail. These results were useful in assessing the stream flow data as above or below the average expected flow. Hydrographs and precipitation graphs and tables were made for each year in order to make comparisons.

1980 (Figures 4 & 5)

Stream flow: highest peaks occurred between December and February with 25cfs in December, 24cfs in January, 27cfs in February and receded to 0.01 by September. Mean daily flow exceeded 10cfs for 9 days out of the year, and exceeded 5cfs for 18 days out of the year. Mean daily flow was at or below 0.01cfs for 21 days out of the year (September). Flow did not reach zero for this period. Average annual stream flow was 1.10cfs.

Precipitation: Highest precipitation occurred in February with 7.63 inches followed by second highest precipitation in December at 4.77 inches. Low precipitation for the months of May until September: 44 inches in May and .08 inches in July, no precipitation in June, August or September. Total annual precipitation was 28.5 inches.

1981 (Figures 6 & 7)

Stream flow: The highest peak occurred in January with 18cfs followed by a 9.4cfs peak in December, 7.9cfs peak also in January and receded down to 0.16cfs in September. Mean daily flow exceeded 10cfs for 1 day for the year, and exceeded 5cfs for 6 days out of the year. Mean daily flow was at or below 0.01cfs for 11 days out of the year (October, in conjunction with the low flow experience in wy80). Flow did not reach zero for this period. The average annual stream flow was 0.425cfs.

Precipitation: The highest precipitation occurred from December until March. January had the most precipitation with 6.15 inches followed by March, 4.41 inches and December with 2.42 inches. Little precipitation occurred in May until November: 0.1 inches in May, 0.08 in September, 0.13 in October and 0.2 in November. No precipitation in June, July and August. Total annual precipitation was 15.1 inches.

1990 (Figures 8 & 9)

Stream flow: The highest peaks occurred during January, October, November, and February. The peak flows were 16cfs January, 12cfs November, and 11cfs in October. For October and November, no other peak flows occurred besides those two. Most high flows subsequently occurred in January and February. Mean daily flow exceeded 10cfs for 5 days in the year, and exceeded 5cfs for 8 days. Mean daily flow was at or below 0.01cfs for 20 days out of the year (September). Flow reached zero for one day (Sept. 30th 1990). Average annual stream flow was 0.472 cfs.

Precipitation: Only partial precipitation data was available for wy90. The month of February was not complete. Precipitation data for all other months were on average 22% lower than the monthly precipitation averages. The months of October and March experienced higher than average precipitations. The months of December, July and August received no precipitations (usually 4.13in, 0.0535in, and 0.0766in respectively). Total precipitation without February was 11.8 inches. Average stream flow in February alone was 1.03cfs where as in wy91 it was 0.785cfs and in wy93 it was 2.00cfs. In those years, February precipitation was 3.49in and 3.94in respectively. By looking at the other years of stream flow and precipitation data, it was assumed that wy1990 was dry similarly to 1981 and 1991 (annual precipitations 15.1in and 14.7in). Assuming 3.58 inches of precipitation in February 1990 (determined by difference between flows in 1991 and 1993, precipitation for 1990 was estimated to be close to 15.4 inches.

1991 (Figures 10 & 11)

Stream flow: The highest peaks occurred between February and March with highest peak in March at 11cfs followed by 8.9cfs in February and 8.7cfs in March. Mean daily flow exceeded 10cfs for 1 day for the year, and exceeded 5cfs for 8 days out of the year. Mean daily flow was at or below 0.01cfs for 53 days out of the year (October, in conjunction with the low flow experience in wy90, mostly though in August and September). Flow reached zero for 6 days of the year (intermittently in September). Average annual stream flow was 0.391cfs.

Precipitation: The highest precipitation was in February and March with February reaching 3.5 inches and March reaching 7 inches and going down to 0.24 inches in June. No precipitation for July or September (only 0.19 inches in August). Total Annual Precipitation was 14.7 inches.

1992 (Figures 12 & 13)

Stream flow: The highest peaks were in October, then February through March. The October peak reached 30cfs; the February peak reached 22cfs; and the March peak reached 14cfs. Flow receded to 0.18cfs in September. Mean daily flow exceeded 10cfs for 7 days for the year, and exceeded 5cfs for 14 days out of the year. Mean daily flow was at or below 0.01cfs for 36 days out of the year (October, in conjunction with the low flow experience in wy91). Flow reached zero for 21 days out of the year (18 days in October, the rest in November). Average annual stream flow was 0.814cfs.

Precipitation: The highest rate of precipitation occurred in February at 7.5 inches, followed by 4.5 inches in March. No rain for May, July or September (0.3 inches were recorded in June and 0.03 inches in August) Total annual precipitation was 18.2 inches.

1993 (Figures 14 & 15)

Stream Flow: The highest peak in January occurred at 47 cfs, followed by 15 cfs in October (beginning of WY1993), 15 cfs in December and 13 cfs in February. The flow from April-September receded down to 0.02 cfs September. Mean daily flow exceeded 10cfs for 10 days of the year, and exceeded 5cfs for 18 days out of the year. Mean daily flow was never at or below 0.01cfs for the entire year. Average annual stream flow was 1.18cfs.

Precipitation: The highest rate of precipitation occurred in January with 8.9 inches, followed by December with 6.8 inches and 3.9 inches in February. There was no rain from July-September. Total annual precipitation was 26.7 inches.

Comparing both hydrographs and bar graphs for stream flow and precipitation, we were able to determine precipitation influenced and directly correlated with stream flow, except for 1992 where the highest peak flow occurred in October and the highest rate of precipitation for that year was in February. 1980 had the highest total annual precipitation followed by 1993, 1992, 1981, with 1991 being the driest year. 1993 had the highest average stream flow followed by 1980, 1992, 1981 and 1991. The average annual precipitation for those years was 20.7 inches (omitting 1990) and 19.8 inches (with the estimated value of 1990), compared with the average annual precipitation from 1960 through 2010 (POR equaling 39 years- missing data from some months were omitted in the average for the month, monthly averages were summed) 23.3 inches, the years where stream flow data was available had a 11% lower annual precipitation. The average for all 6 years of data was 15% lower annual precipitation (Table 3 & Figure 17).

Water Year	Average Discharge (cfs)	Scaled average Discharge (cfs)	Annual Volume (MG/Year)	Total Precipitation (in)*	Estimated Precipitation (in)
1980	1.10	4.63	1096	28.5	
1981	0.425	1.79	422	15.1	
1990	0.472	1.99	469	-99999	15.4

1991	0.390	1.64	387	14.7	
1992	0.814	3.42	810	18.2	
1993	1.18	4.96	1175	26.7	
Average	0.730	3.07	727	20.6	19.8
*Average for POR of 39 yrs is 23.3 inches				**	***
**Average with 5 years of precipitation data					
***Average with assumed 15.4in precip 1990					

Table 3 – Temescal Creek Watershed Calculations

An average hydrograph was produced (Figure 16) showing the average of the six years of data. The average mean daily flows were scaled to the whole watershed. The mean daily flow was found to be 3.08cfs. Total annual volume for the average mean daily flow came out to 727 MG.

EBMUD WWTP Data:

A hydrograph of mean daily flow was created from the one year of WWTP discharge data available. The data was arranged in the same format as the water years for Temescal Creek hydrographs but was October 2010 through December 2010 followed by January 2010 through September 2010 (Figure 20). First a comparison was made with the precipitation for that year. Precipitation for 2010 calendar year was found to be 30.5 inches (31% higher than the average, Figures 17 & 18). Since water usage through the WWTP was not determined as much by precipitation as the adjacent stream, this high difference was noted but didn't factor into any assumptions of total flow. Average mean daily flow into the bay was found to be 107cfs. Annual volume for the average mean daily flow was found to be 25,300 MG. Peak flow for 2010 was 277cfs in January. The next two highest flows were 266cfs and 252cfs in January and December respectively. Peak flow was during December through April. Mean daily flow was never lower than 75.8cfs.

Comparison of Treatment Plant to Temescal Creek:

The hydrographs of the average scaled flow for the Temescal Creek and the WWTP were compared to look at the seasonal distribution of flow throughout the year (Figure 20). The precipitations for all years of data were compared (Figure 19). Calendar year 2010 was much higher precipitation than the average precipitation or the average precipitation of the stream data period of record (Figure 17). The estimates for the Temescal Creek Watershed were on the low side. Whereas, the outflow data for the WWTP which was originally assumed to be not as influenced by precipitation was probably, given the scale of how high the precipitation for the year, a high estimate.

In order to better understand the seasonal flow, the watershed hydrograph was projected at the scale of the volume of output from the WWTP. The mean daily flows of the scaled Temescal Creek Watershed were projected 34.8 times higher and placed into a hydrograph. The WWTP hydrograph was placed over the same graph (Figure 21). The contrast outlined the constant flow present within the WWTP. Looking at both figures 20 & 21, one sees the drastic shift between the urbanized stream system and the municipal watershed (the Pipeshed).

The annual amounts of total flow into the bay were contrasted (Figure 22). The scale of the treatment plant was found to be 34.8 times greater than the estimated annual flow through the Temescal Creek Watershed (Table 4).

Area	Average Discharge (cfs)	Annual Volume (MGY)	% Difference
WWTP	107	25303	3483
TCW	3.07	727	100
88sq.mi. estimate	38	8992	1238

Table 4 – Comparison of discharge and volumes calculated

The mean daily flow of 3.07 cfs for 7.11sq.mi. was scaled to the whole 88sq.mi. for which the WWTP serves. The volume of water was estimated to be 12.4 times greater than the Temescal Watershed. The natural flow of the area would be estimated roughly to be a volume of 9000 MG annually. A comparison of this volume with the Temescal Creek and the WWTP can be seen in figure 22. The volume of water estimated by precipitation into the greater area serviced by the WWTP annually is two thirds that of the outflows from the WWTP.

Pollutants and Particulates:

Temescal Creek Pollutants:

Friends of Temescal Creek have volunteers who regularly check the water quality by taking samples at different points along the creek and sending the samples off for testing. The following pollutants have been reported to be found throughout the watershed: fecal coliform bacteria (e.coli), Chlorine, Nitrate/Nitrogen, Phosphate, Ammonia, and Nitrogen. FoTC have these monitoring programs in order to check that pollutants remain within an acceptable range. A cumulative report was drafted in 2007 (FoTC, 2007) indicating that fecal coliform bacteria found in the creek was within acceptable limits for “non-contact” recreation activities, however it was advised to not swim, to wash hands after having contact with creek water, and to not drink the water. In 2007, high levels of chlorine were also found, however the source for these excessive levels was unknown.

EBMUD Waste Water Treatment Process and Pollutants:

The EBMUD deals with seepage as well as food industry waste (dairy, high total dissolved solids (TDS) waste; animal processing waste; food grade fats, oils, and greases;

winery waste; municipal water and wastewater sludge; municipal food waste and groundwater, storm water and food scraps), which is then anaerobically digested in the treatment facility. The wastewater treatment involves odor control, grit removal, primary clarification, high purity oxygen activated sludge, secondary clarification, disinfection, dechlorination, and blending of primary and secondary effluent during periods of flows in excess of the secondary treatment capacity. That water is then discharged into Central San Francisco Bay.

EBMUD's Wastewater Control Ordinance regulates wastewater discharges into the system and includes discharge limits for select pollutants. These heavy metals, in limited amounts, are not necessarily harmful. Traces of the following pollutants have been found in the wastewater that's released back into the bay.

Arsenic	2 mg/L
Cadmium	1 mg/L
Total Identifiable Chlorinated hydrocarbons	0.5 mg/L
Chromium (total)	2 mg/L
Copper	5 mg/L
Cyanide	5 mg/L
Iron	100 mg/L
Lead	2 mg/L
Mercury	0.05 mg/L
Nickel	5 mg/L
Oil and Grease	100 mg/L
pH	not less than 5.5
Phenolic compounds	100 mg/L
Silver	1 mg/L
Temperature	150°F
Zinc	5 mg/L

Table 5 - Source: <http://www.ebmud.com/our-water/wastewater-treatment/wastewater-treatment-programs/wastewater-discharge-limits>

Some of these elements are actually necessary for humans in small amounts (cobalt, copper, chromium, manganese, nickel) while others (mercury, lead, arsenic, copper, cadmium, nickel, chromium) are toxic and can affect the central nervous system, kidneys, liver skin, bones, or teeth. Mercury, cadmium, lead, and chromium have a risk of building up concentration in aquatic organisms as it moves up through the food web which can lead to serious health risks.

Other pollutants found in the water include total suspended solids, oil and grease, fecal coliform bacteria, CBOD- carbonaceous biochemical oxygen demand:

Table F-3. Historic Conventional and Parameter Effluent Limitations and Monitoring Data

Parameter	Units	Effluent Limitations			Monitoring Data (From 1/04 – 9/09)		
		Monthly Average	Weekly Average	Daily Maximum	Highest Monthly Average	Highest Weekly Average	Highest Daily Discharge
Carbonaceous Biochemical Oxygen Demand, 5-day @ 20°C ($CBOD_5$)	mg/L	25	40	--	20	39	56
Percent Removal of $CBOD_5$	%	85/70[(1)]	--	--	89[(8)]	NA	NA
Total Suspended Solids (TSS)	mg/L	30	45	--	42	92	240
Percent Removal of TSS	%	85/70[(1)]	--	--	87[(8)]	NA	NA
Oil and Grease	mg/L	10	--	20	5.9	NA	5.9
Settleable Matter	ml/l-hr	0.1	--	0.2	ND	NA	ND
Total Chlorine Residual (TRC)	mg/L	--	--	[(2)]	NA	NA	ND
pH	Standard units	[(3)]	[(3)]	[(3)]	6.0-7.2		
Fecal Coliform Bacteria	MPN/100 ml	[(4)]	[(5)]	--	128[(9)]	220[(10)]	160,000
Acute Toxicity	% Survival	[(6)]	[(6)]	[(6)]	75[(11)]	95[(12)]	15[(13)]
Chronic Toxicity	TUc	[(7)]	[(7)]	[(7)]	8.4[(14)]	7.7[(15)]	8.4

Footnotes for Table F-3:

ND = Non-Detect

NR = Not Reported

NA = Not Applicable

(1) 85 percent removal required when influent flow is less than 120 MGD; 70 percent removal required when influent flows are greater than or equal to 120 MGD.

(2) For TRC, 0.0 mg/L was established as an instantaneous maximum effluent limitation.

(3) The pH shall not exceed 9.0 nor be less than 6.0.

(4) The 5-day log mean fecal coliform density shall not exceed 500 MPN/100 ml.

(5) The 90th percentile value of all samples in a given month shall not exceed 1,100 MPN/100 ml.

(6) An 11-sample median value of not less than 90 percent survival and an 11-sample 90th percentile value of not less than 70 percent survival.

Table 6 - Source: <http://www.ebmud.com/our-water/wastewater-treatment/wastewater-treatment-programs/wastewater-discharge-limits>

The fecal coliforms are not directly harmful, but they do lead to the risk of water-born gastroenteritis (stomach flu, stomach virus, etc.). Most oil and grease (aka sludge) are removed and sent to be further cleaned at separate facilities for human reuse or sent to the landfill. Total Suspended Solids are monitored and regulated and all settleable matter is removed before effluents are released into the Bay.

During peak wet weather flow conditions, the WWTP can accept up to 425 MGD (658cfs) of influent via five 85 MGD (132cfs) influent pumps. Since primary treatment design capacity is 320 MGD (495cfs), wet weather flows that are over the primary treatment capacity are stored on-site in an 11 MG wet weather concrete storage basin and are then returned to the plant influent when flows subside. During major storm events, the cities' sewer pipes fill up above capacity resulting in massive amounts of stormwater mixed with "raw sewage" being rushed to the EBMUD WWTP. The WWTP can only handle so much water; it's forced to discharge the mixture directly into the Bay before it is even treated.

Recently the San Francisco Baykeepers, the U.S. Environmental Protection Agency and the California Water Board filled a lawsuit against these cities. The court ordered the cities to develop their own plans to repair and better operate their sewage systems as of March 15, 2010.

Conclusions:

The scale of the Wastewater Treatment Plant was found to be a considerable amount greater than expected (35 times larger from annual volume to the Temescal Creek Watershed). However the average hydrograph peaks for Temescal Creek were much closer to the water flowing through the WWTP at the same time. The peak average mean daily flow was 59cfs for Temescal Creek. The peak mean daily flow for the WWTP was 277cfs, only 5 times larger than the stream. The individual peak events for water years ’80, ‘81, and ‘90-’93 were scaled to the watershed and plotted against the peak flow event for the WWTP in calendar year 2010 (Figure 23). The wettest years of stream flow data were 1993 and 1980. The precipitation for 1993, 1980, and 2010 were comparable (1993: 26.7in; 1980: 28.5in; 2010: 30.5in). Peak flows were higher in 1993 than in 1980. The peak flow for the watershed was 198cfs and the WWTP was 277cfs. Interestingly, the difference between the peak stream flow and the WWTP outflow (79cfs) was close to the base flow for the Treatment Plant (75.9cfs). The connection of the WWTP to the Watershed is definitely strong despite the attempt to separate the two systems. It would be interesting to further monitor the flow and research the WWTP and the Temescal Creek Watershed to look at the correlation between stream flow and WWTP outflow. The study here highlights the difference in human use of imported water with natural flow of the watershed.

Currently the system is to alter the watershed of a far away system and to not incorporate (even ignore by hiding in culverts) the hydrology of immediate watersheds for our water uses. Further research should be done to understand the lag time of the flow from the WWTP infrastructure. If the system is to adapt with changing water demands, and increasing unpredictability of storm conditions the play between the stream and the sewer are going to become increasingly important. The investigation of their hydrology will need to become ever more integrated and cohesive.

One element we did not take into account was the groundwater levels at any of the periods of record. It would be interesting to note how high the water table was in these two different hydrological systems since the water table shouldn’t affect the wastewater system as much as it would affect the stream flow

Before the water reaches the treatment plant other measures need to come into play. More research on BMP’s (Best Management Practices) in relation to water quality, hazardous materials, and spillage are needed in order to adjust current industry and households to better relation with watershed. Outreach and education to customers can inspire people to care about their surroundings and can lead to a decrease in the intensity of treatment needed. Reducing the loads on the system, in quantity or in quality can produce a twofold effect.

Once loads are minimized, the treatment plant can expand its area into adjacent underutilized places. A potential future solution to deal with excess stormwater is to (re)create a wetland park, which could slow flows down and help to further distil some pollutants, such as the one created in South Park, Los Angeles (The South Los Angeles Wetland project). A wetland park can be constructed to help treat and remove phosphorus, excess metals, ammonia, nitrogen as well as general contaminants. During a major storm event, the excess rain water and waste water/sewer water can be pumped into the wetland at which point treatment can begin.

Not only would a wetland park, BMP’s, and/or LID’s help further filter and slow discharge of the wastewater down, but it would also add more park space for people to enjoy (along with the benefit of providing education on water quality issues), and ultimately create more habitat space for animals. These goals would bring the water system back around to meeting the needs of the people and animals of the area.

Sources:

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<http://www.firehydrant.org/info/ebchina.html>

<http://www.psomas.com/about/news/TransformingUrbanBlightIntoWetlandsOasis-SVargas-Feb11.pdf>

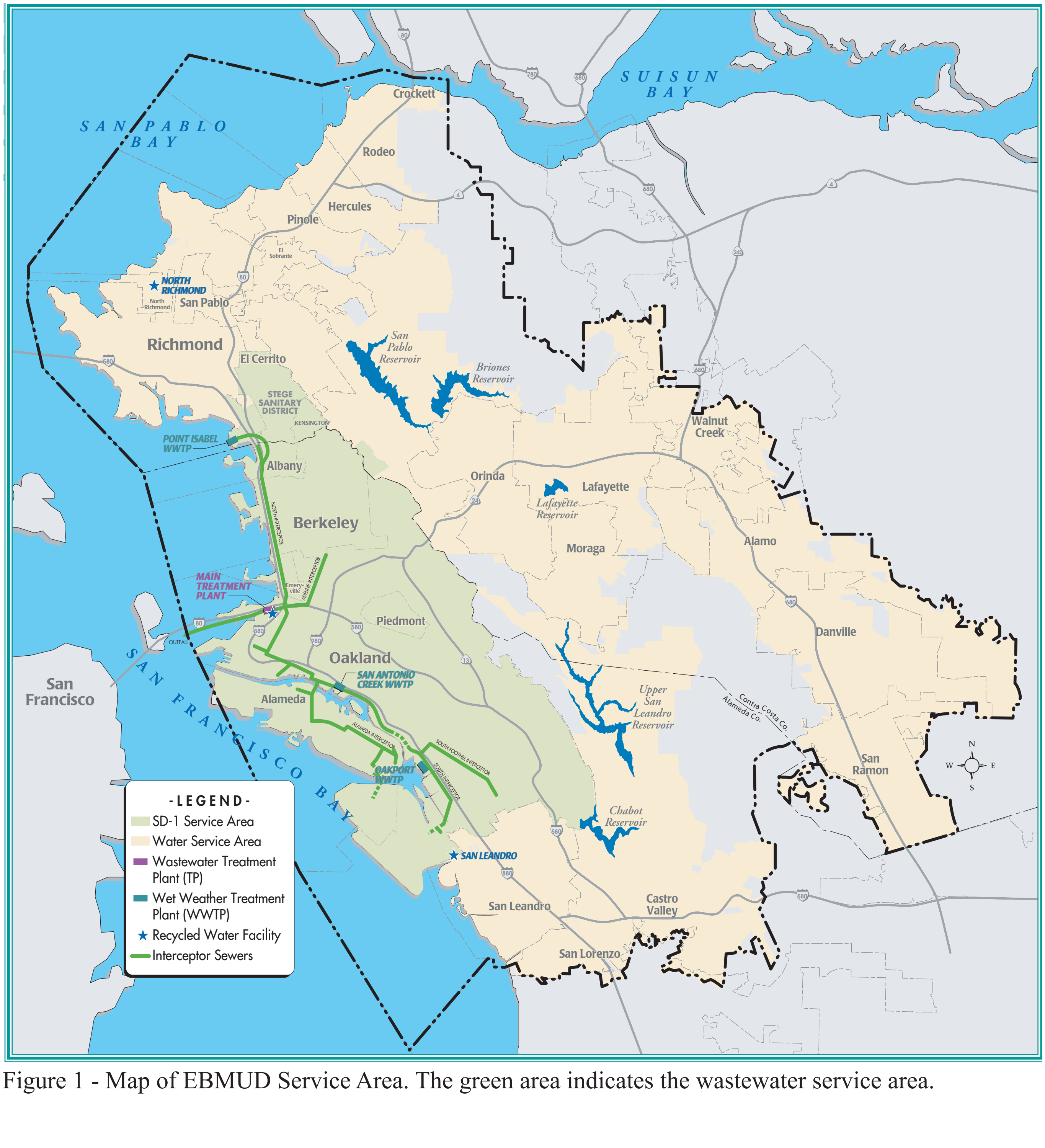


Figure 1 - Map of EBMUD Service Area. The green area indicates the wastewater service area.

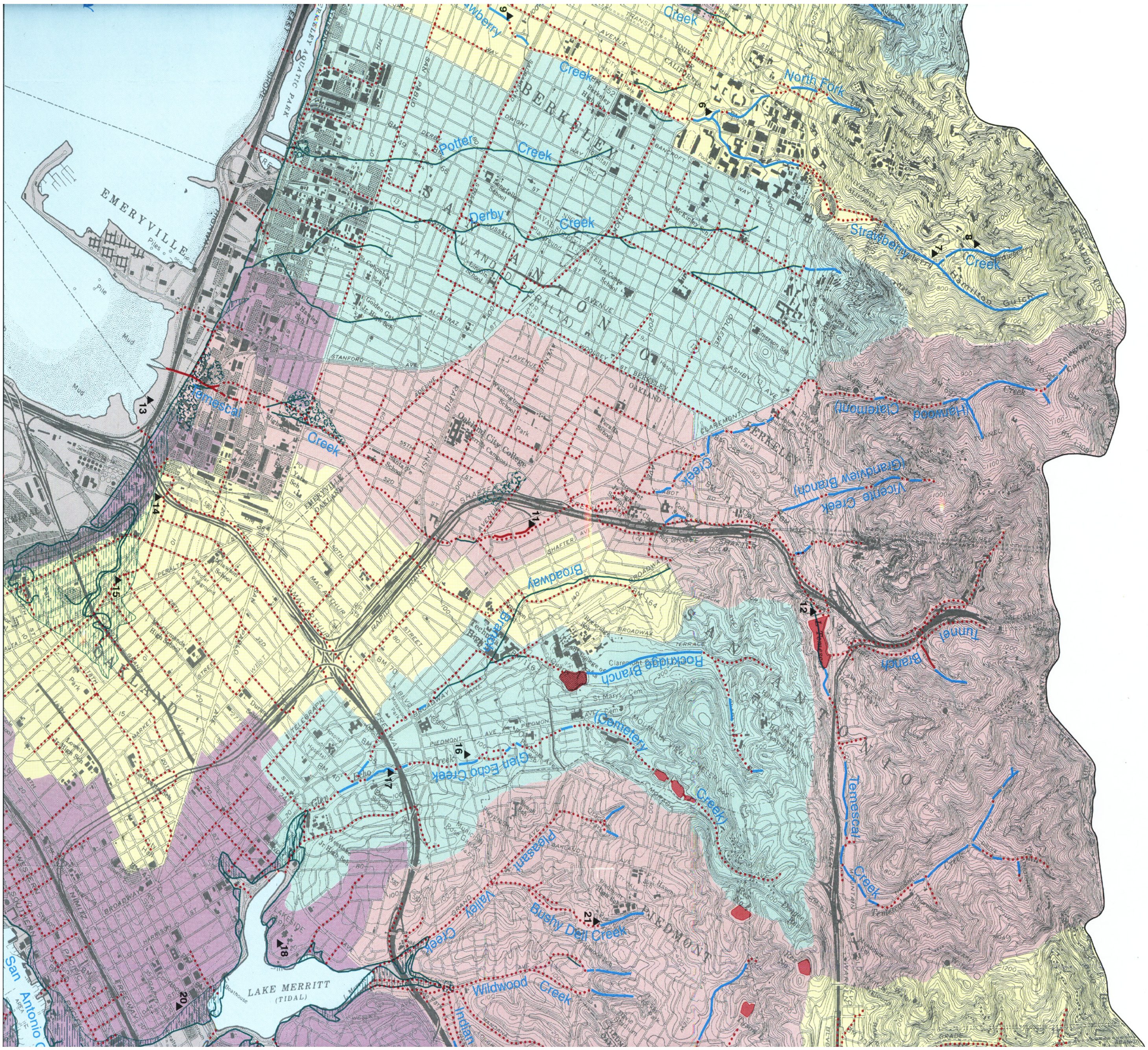


Figure 2 - Watershed and Creek Map of Oakland and Berkeley: The Temescal Creek Portion. Light pink running across the page is the Temescal Creek Watershed.

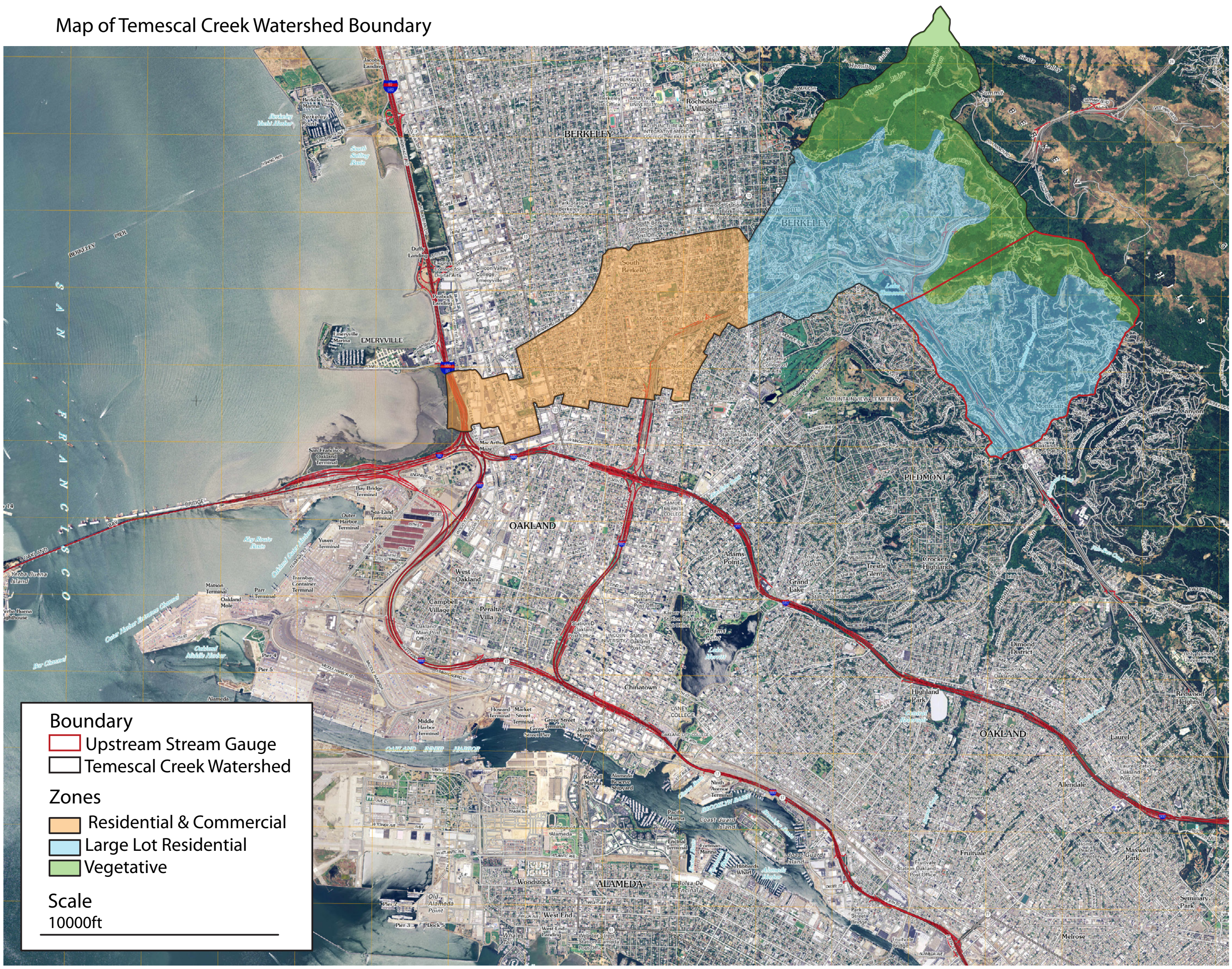


Figure 3 - Zone deliniations for the Temescal Creek Watershed

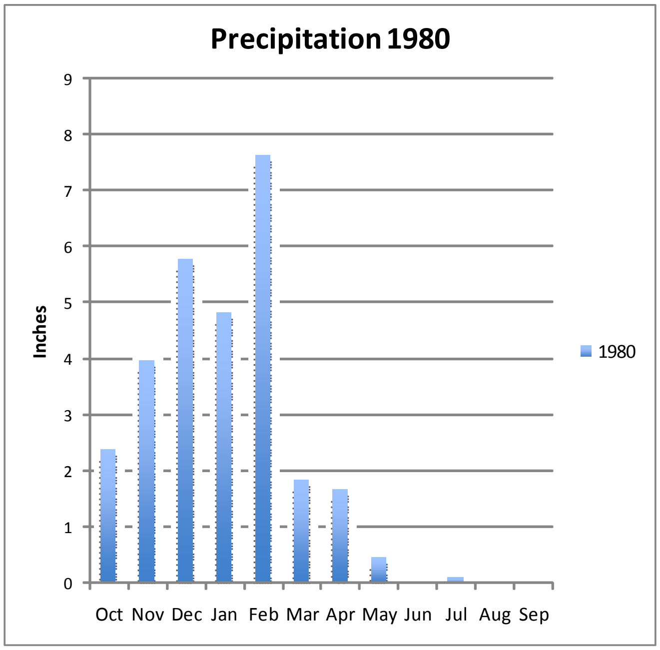


Figure 4 - Seasonal Distribution of Precipitation, 1980

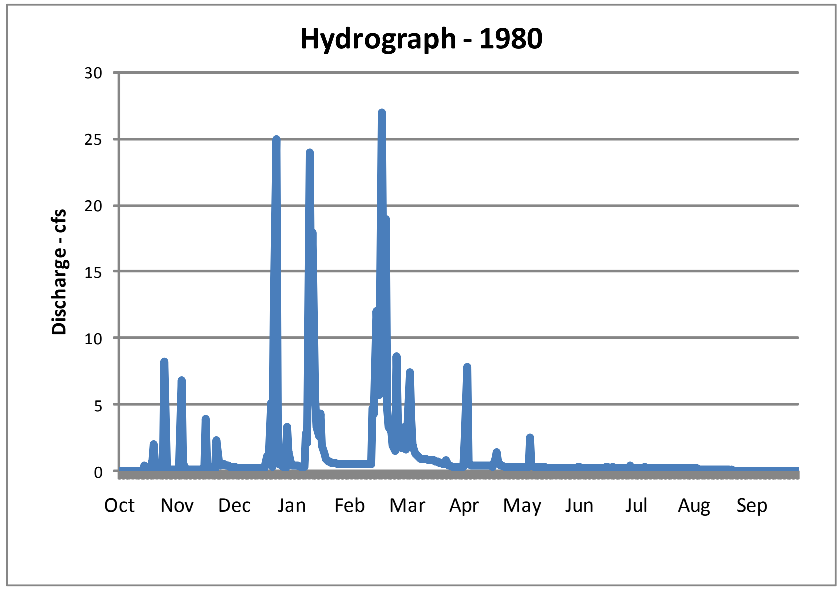


Figure 5 - Seasonal Distribution of Flow, 1980

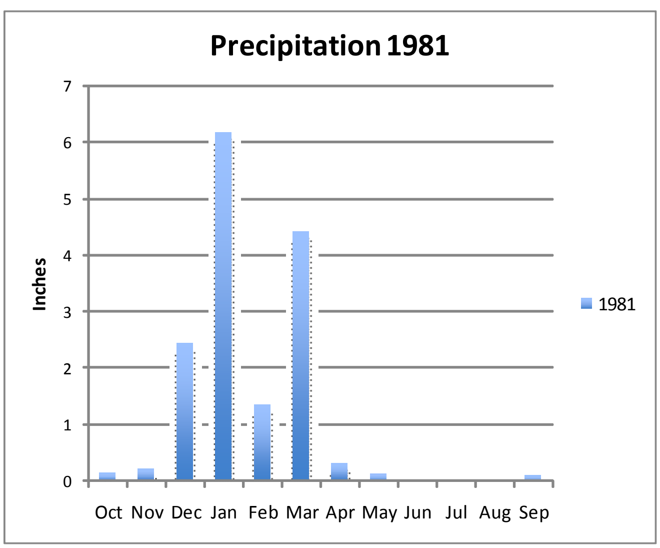


Figure 6 - Seasonal Distribution of Precipitation, 1981

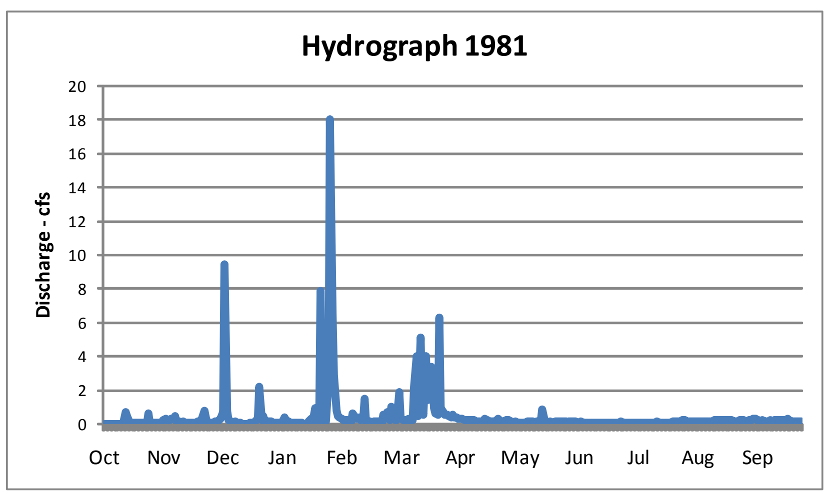


Figure 7 - Seasonal Distribution of Flow, 1981

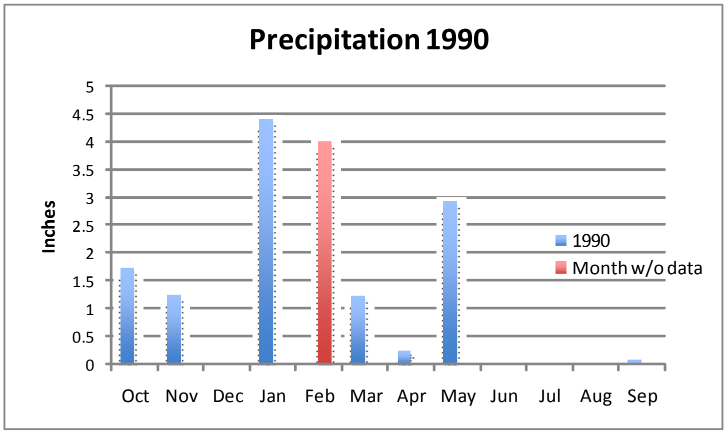


Figure 8 - Seasonal Distribution of Precipitation, 1990

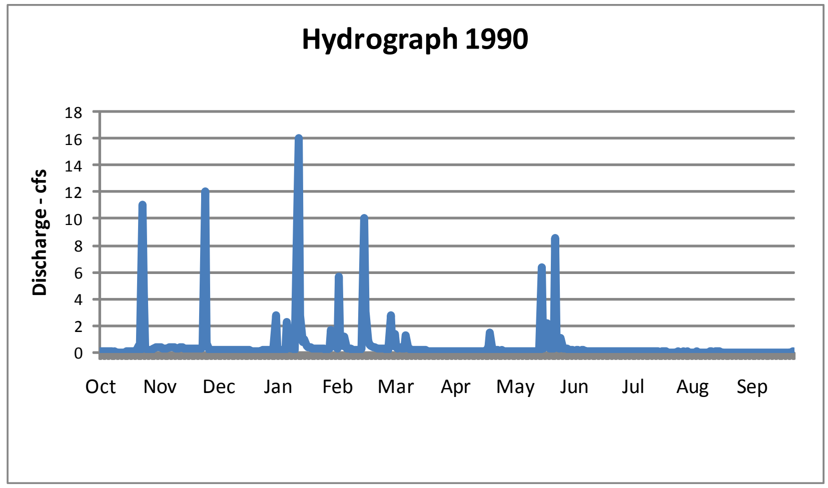


Figure 9 - Seasonal Distribution of Flow, 1990

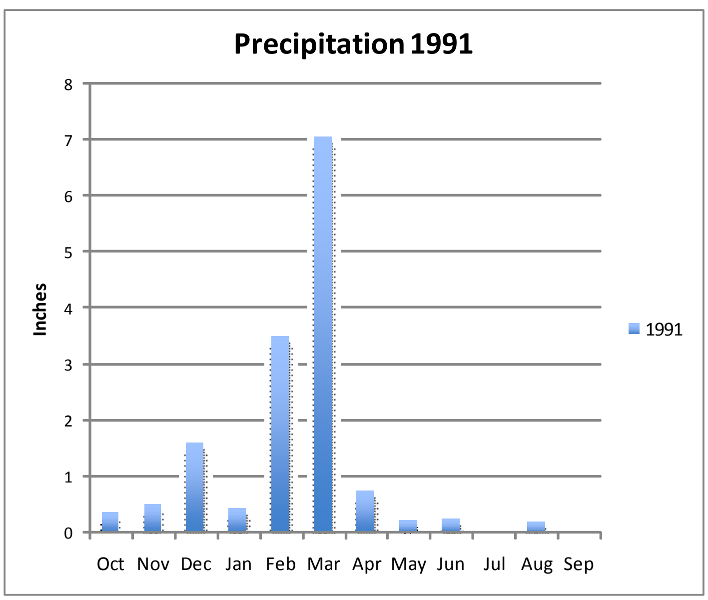


Figure 10 - Seasonal Distribution of Precipitation, 1991

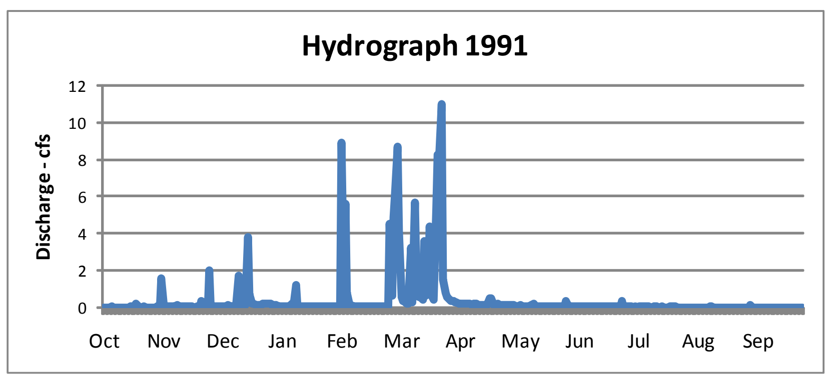
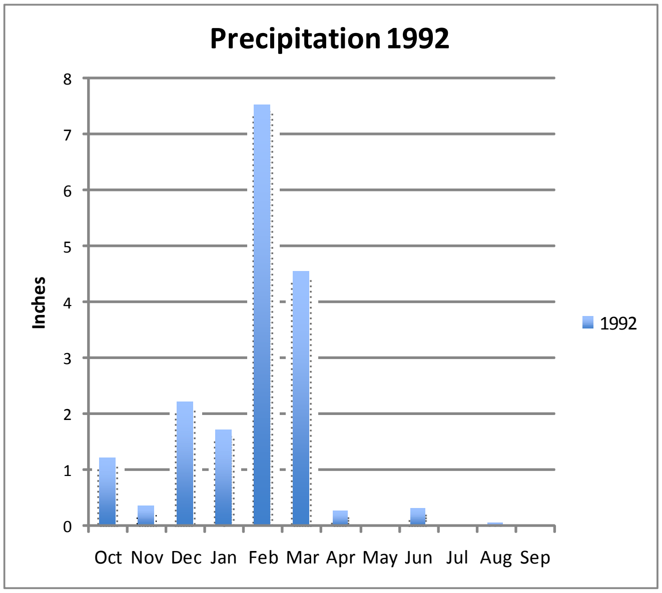


Figure 11 - Seasonal Distribution of Precipitation, 1991



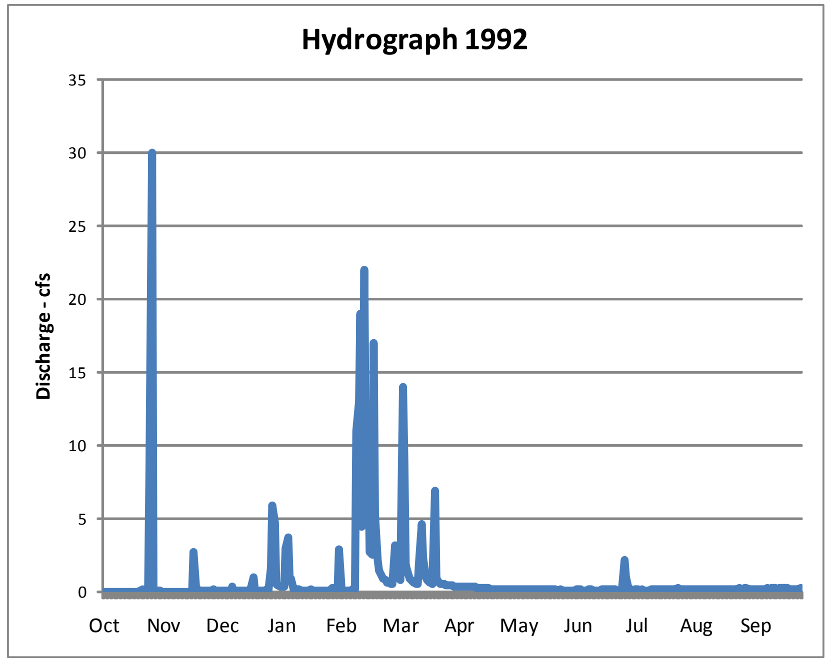
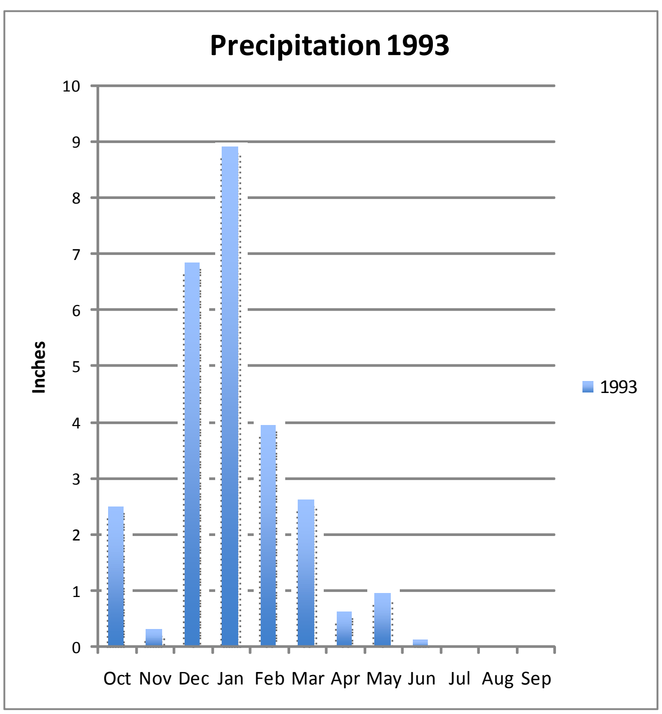


Figure 12 - Seasonal Distribution of Precipitation, 1992

Figure 13 - Seasonal Distribution of Flow, 1992



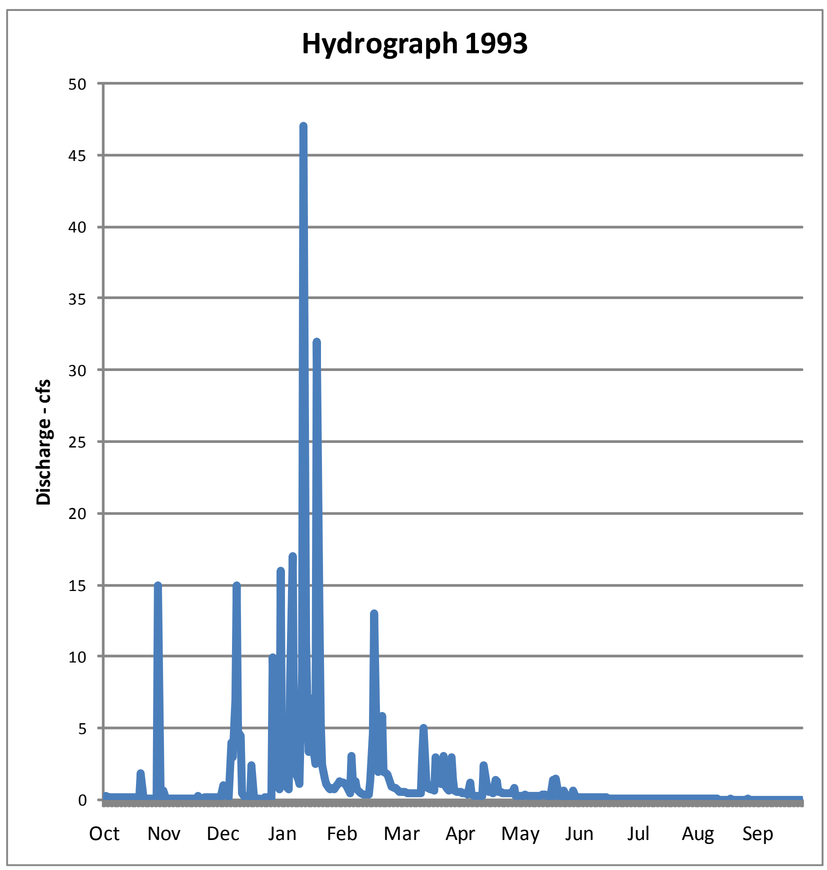


Figure 14 - Seasonal Distribution of Precipitation, 1993

Figure 15 - Seasonal Distribution of Flow, 1993

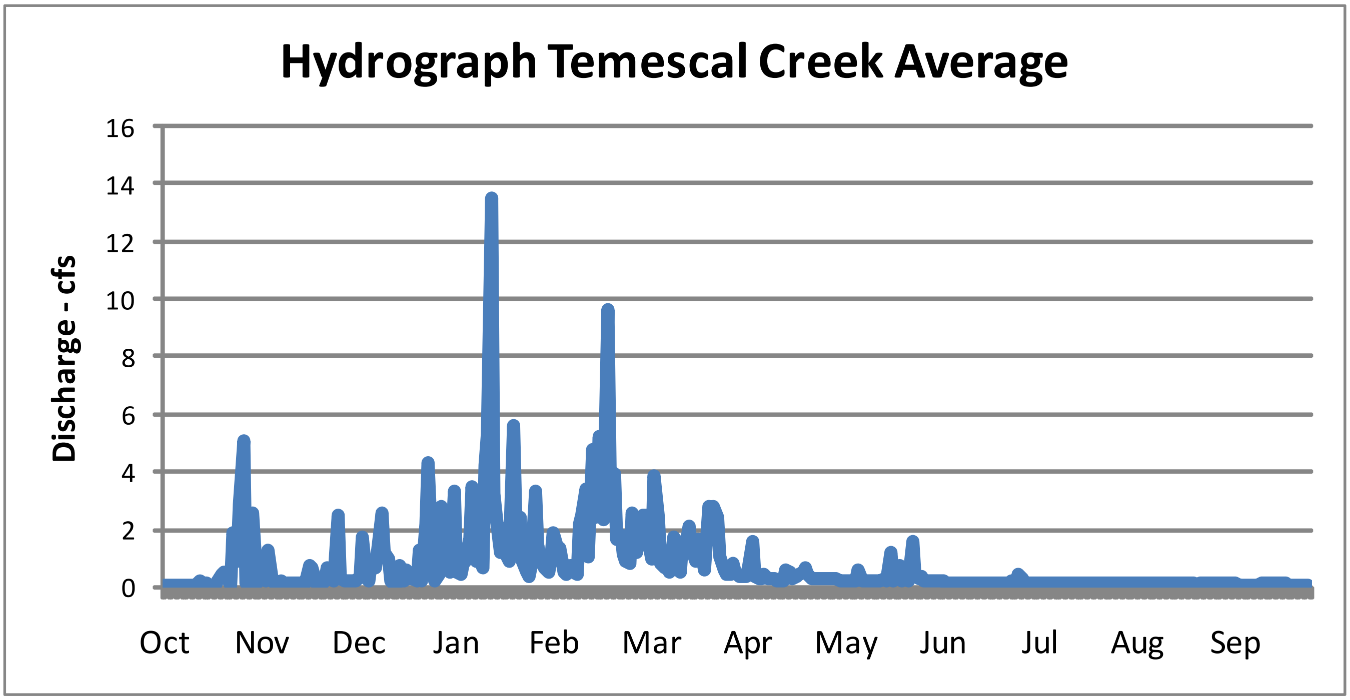


Figure 16 - Seasonal Distribution of Flow POR: 6 years

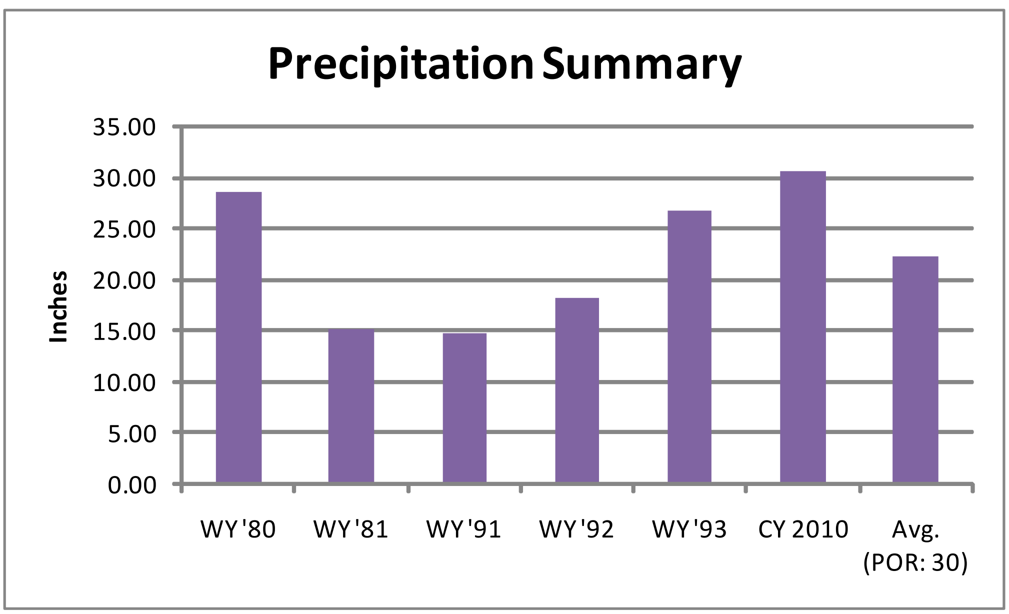


Figure 17 - Precipitation for years of record and 30 Year Average

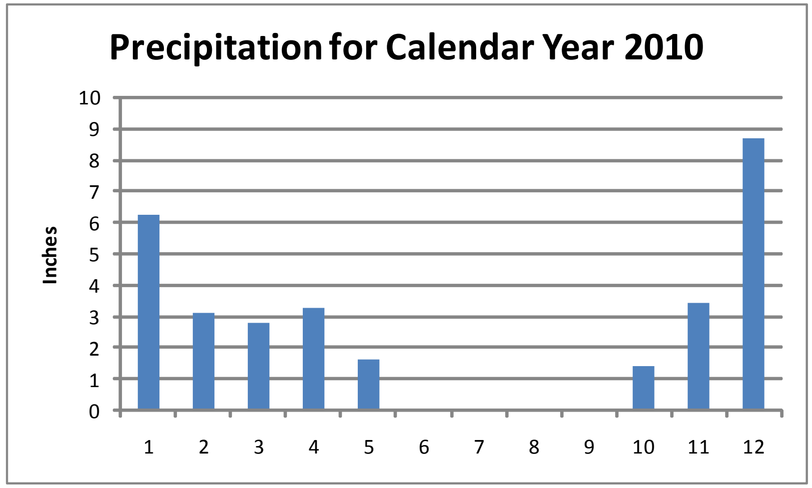


Figure 18 - Seasonal Distribution of Precipitation, Jan-Dec 2010

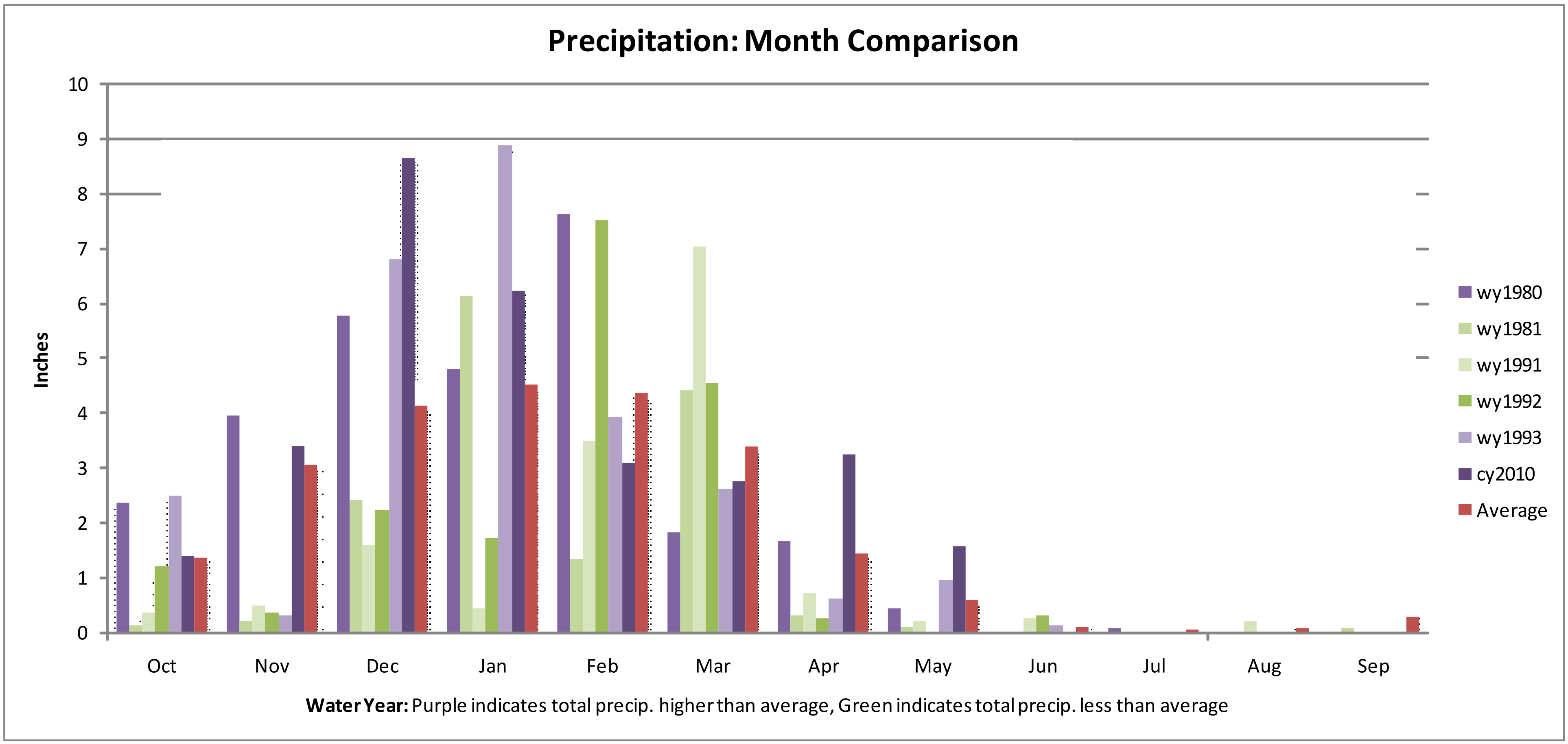


Figure 19 - Comparison of the Precipitation in years of stream flow data of Temescal Creek Watershed and outflow data for the WWTP with the average monthly precipitations

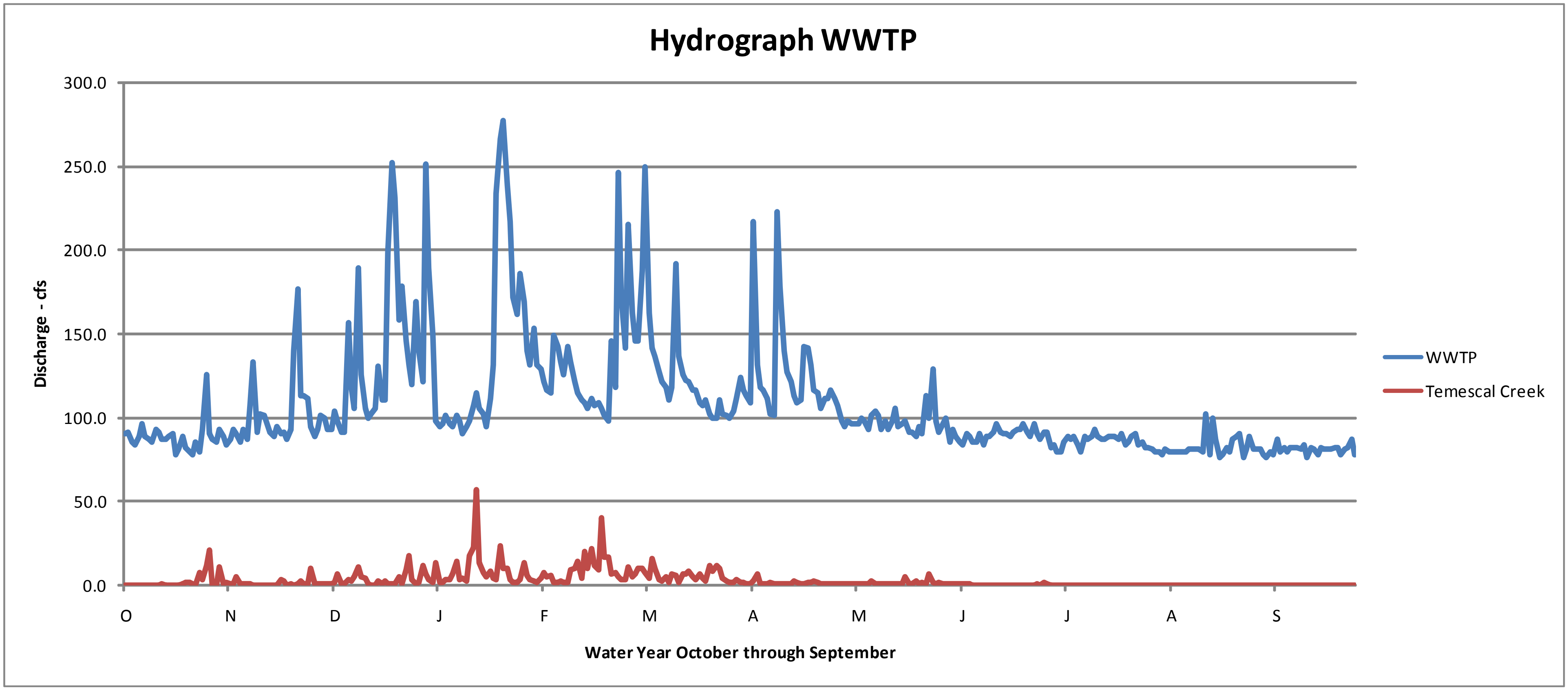


Figure 20 - Comparison of the Hydrograph of the WWTP with the average hydrograph scaled to the extent of Temescal Creek Watershed

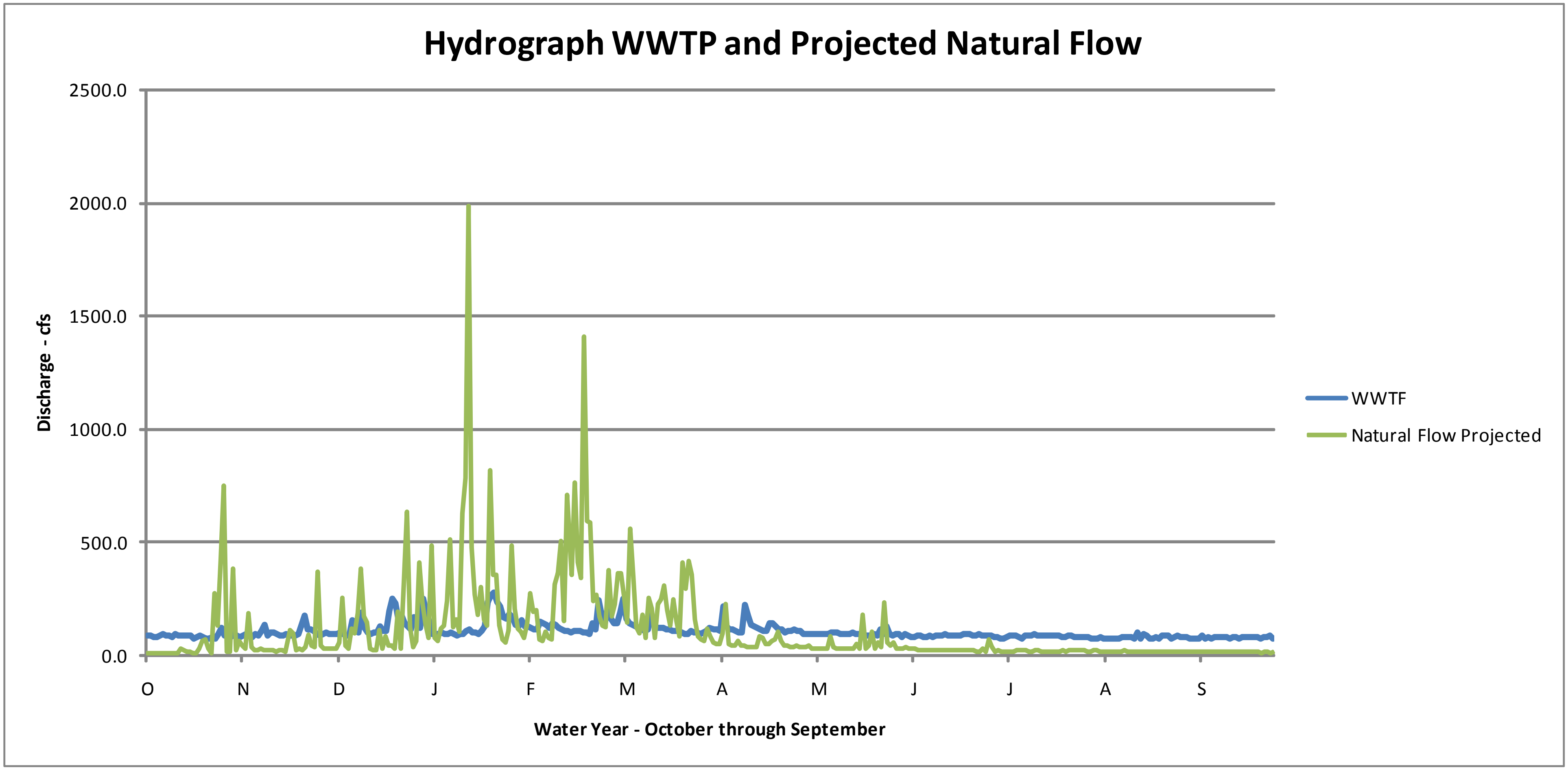


Figure 21 - Comparison of the Hydrograph of the WWTP with the average hydrograph of TCW projected to the same annual volume

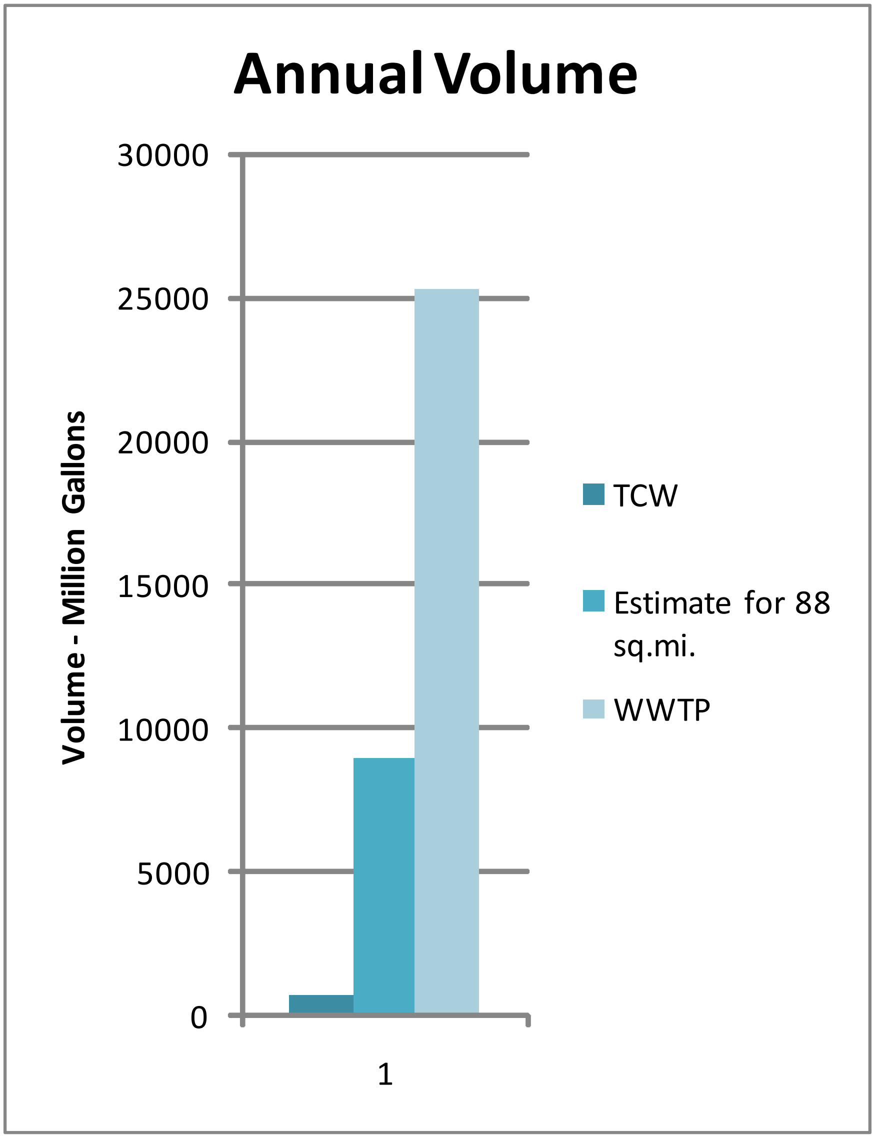


Figure 22 - Annual volume amounts in MGY

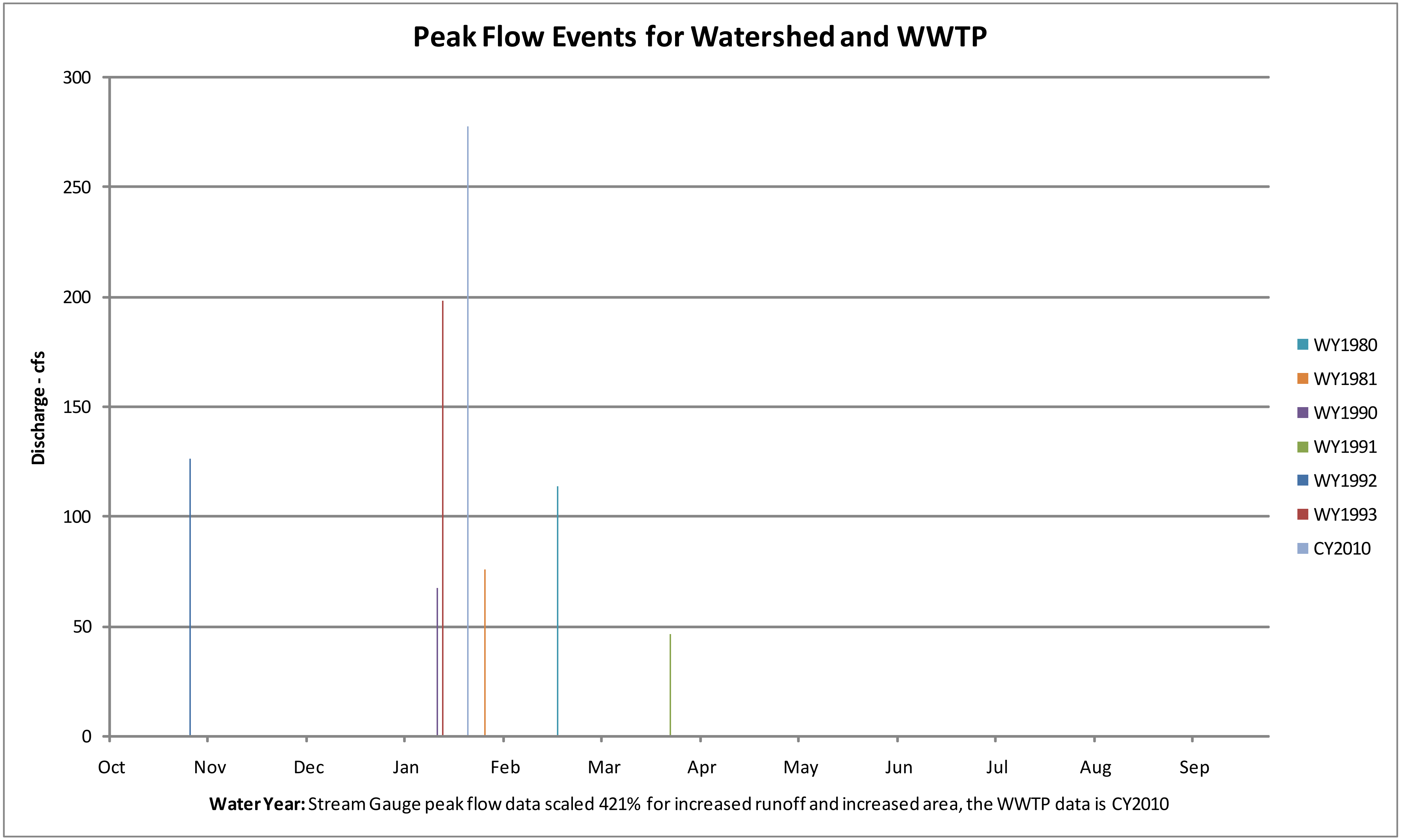


Figure 23 - Peak flow scaled to the Temescal Creek Watershed compared with the peak flow for the WWTP in 2010.