APPENDIX 3: DATA ANALYIS RESULTS

Correlation between Unsafe Conditions and Rainfall at Select Locations in Three Watersheds

Staff conducted an analysis of the correlation between "unsafe conditions" (using velocity and depth) and daily rainfall amounts to determine whether rainfall is an adequate proxy for unsafe conditions. Specifically, staff used five years of data (water years 1998-2002) to match days above the Level 1 Alert rainfall thresholds of ½ inch or 1 inch (depending on local antecedent moisture condition) with corresponding physical conditions in several local channels. The physical conditions examined were those that could result in "unsafe" conditions, i.e. velocity and depth.

The results of this analysis demonstrate that a significant percentage (63% on average and as much as 83%) of unsafe days (as determined using the USGS protocol [1]) occur on days where rainfall the prior day was greater than ½ inch. [2] (The counterpoint to this is that on average 37% of unsafe days occur on days outside of the defined wet weather conditions.) Finally, the analysis shows that on average 82% of days and as high as 100% of days with rainfall greater than ½ inch were followed by "unsafe" days. (Again, the counterpoint to this is that on average 18% of days with rainfall greater than ½ inch were *not* followed by unsafe days.) See Table 1 below.

This analysis supports the use of rainfall events of greater than 1/2 inch, regardless of ground conditions (saturated vs. unsaturated) as a reasonable proxy for "unsafe" conditions in engineered channels the day following the rain event.

To compare the benefit of using a 1/2-inch rain event versus the 1-inch event, it is important to compare the respective statistics using both rain events. Both statistics are important:

- % "Unsafe" Days Preceded by Rain Days > X inch
- % Days with Rain > X inch that were Followed by "Unsafe" Days

Regarding the first bullet, the results of this analysis show that 63% of days that were considered unsafe occurred when greater than ½ inch of rain fell the preceding day. This statistic drops to 29% when rainfall was greater than 1 inch on the preceding day. Regarding the second bullet, on average 82% of days with rain greater than ½ inch were followed by "unsafe" days. This statistic rises to 94% for days with rainfall greater than 1 inch. Since both statistics listed are important, it is clear that using a 1/2 inch of rain as a trigger for the suspension results in higher percentages when considered cumulatively than the cumulative statistics for 1 inch. Therefore, it is more appropriate to use 1/2 inch of rain as a proxy for unsafe conditions; that is, a significant number of unsafe days would not be captured using 1 inch of rainfall as a proxy for unsafe conditions. While it is necessary to use a prediction of rain to allow time to prepare for unsafe conditions, the implementation of the suspension would be based on actual rainfall data from the closest rain gage with adequate data.

---

[1] The USGS uses the following calculation as a "rule of thumb" for determining whether it is safe for monitoring personnel to be in a channel (Al Caldwell, USGS, San Diego office, personal communication, 2003). The calculation is the peak depth (ft) * peak velocity (ft/sec). If the result is greater than or equal to 10 then it is considered unsafe. The County of Orange, Environmental Resources Division, has adopted this "rule of thumb" into their practices (County of Orange, 2001).

[2] In the data analysis, staff compared the preceding day's rainfall to conditions on the target day. Staff chose this approach due to the lag time associated with storm flows. See Figures 1 through 3 for examples of this lag time. Had staff compared both the preceding day's rainfall as well as rainfall on the target day to conditions on the target day, the percentages above may have been slightly higher.

APPENDIX 3: DATA ANALYIS RESULTS

Table 1: High Flow Conditions at Select Stations in Three Watersheds In Region 4 (Water Years 1998-2002)

Station*	Watershed	# "Unsafe" Days	# Days with Rain >0.5 in.	# Days with Rain >1.0 in.	# Unsafe Days preceded by days with rain >0.5 inch	% "Unsafe" Days preceded by days with rain >0.5 inch	% Days with Rain >0.5 in. followed by "Unsafe" days	# Unsafe Days preceded by days with rain >1.0 inch	% "Unsafe" Days preceded by days with rain >1.0 inch	% Days with Rain >1.0 in. followed by "Unsafe" days
F34	LAR	19	25	11	13	68%	52%	10	53%	91%
F342	LAR	45	32	11	29	64%	91%	11	24%	100%
F285	LAR	35	30	13	29	83%	97%	13	37%	100%
F37	LAR	39	21	7	20	51%	95%	7	18%	100%
AVG	***LAR***	35	27	11	23	67%	84%	10	33%	98%
F274	SGR	30	23	9	17	57%	74%	8	27%	89%
F304	SGR	25	23	8	20	80%	87%	8	32%	100%
F312	SGR	21	20	7	12	57%	60%	5	24%	71%
AVG	***SGR***	25	22	8	16	65%	74%	7	27.7%	86.7%
F38	B	56	23	8	23	41%	100%	8	14%	100%
AVG	**ALL**	34	25	9	20	63%	82%	9	29%	94%

Notes: *See Table 1A for a description of each station.

APPENDIX 3: DATA ANALYIS RESULTS

Table 1A. Description of Stream Gaging Stations used in Data Analysis

Station	Watershed	Name	Channel Dimensions*	Assumptions
F34D-R	LAR	LOS ANGELES RIVER below Firestone Blvd	Concrete, with rip-rap side slopes, trapezoidal in section, with trapezoidal low flow channel. Top width is 265 feet. Height is 17 feet. Side slopes not given nor bottom width.	Low flow channel is 28 feet wide, no height given. Assumption that flows will not go out of low flow channel except during extreme events, none of which occurred during this five-year period. So treated cross section as a rectangle with width of 28 feet.
F342-R	LAR	BRANFORD STREET CHANNEL below Sharp Avenue	Trapezoidal, 10 feet wide at bottom and 7.5 feet deep with 1.5 to 1 side slopes.	No assumptions needed.
F285-R	LAR	BURBANK WESTERN STORM DRAIN at Riverside Dr.	Concrete rectangular section with 60 feet width and 12 feet in height.	No assumptions needed.
F37B-R	LAR	COMPTON CREEK near Greenleaf Drive	Concrete rectangular section, 60 feet wide by 13 feet deep.	No assumptions needed.
F274B-R	SGR	DALTON WASH at Merced Avenue	Concrete rectangular section, 60 feet wide, 14.5 feet tall.	No assumptions needed.
F304-R	SGR	WALNUT CREEK above Puente Avenue	Concrete rectangular section, 50 feet wide, 13.5 feet tall.	No assumptions needed.

APPENDIX 3: DATA ANALYIS RESULTS

Station	Watershed	Name	Channel Dimensions*	Assumptions
F312B-R	SGR	SAN JOSE CHANNEL below Seventh Avenue	Grouted rip-rap side slopes with natural bottom, trapezoidal section.	225 feet wide as the upper width, 16 and 17 feet as the maximum height on two sides. No dimensions for channel base or side slopes given. Assumed that side slope was 1.5:1 with base of 175 feet.
F38C-R	Ballona	BALLONA CREEK above Sawtelle Blvd.	Concrete ruble, trapezoidal in section	95 feet wide as the upper width, 23 feet tall in middle of channel. No base width given nor side slopes given. Assumed that side slope was 1.5:1 with base of 26 feet.

*Channel dimensions obtained from the Los Angeles Department of Public Works web site at http://www.ladpw.org/wrd/runoff/.

APPENDIX 3: DATA ANALYIS RESULTS

Illustration of Lag Time between Rainfall and Runoff

Figure 1: Ballona Creek above Sawtelle Blvd.

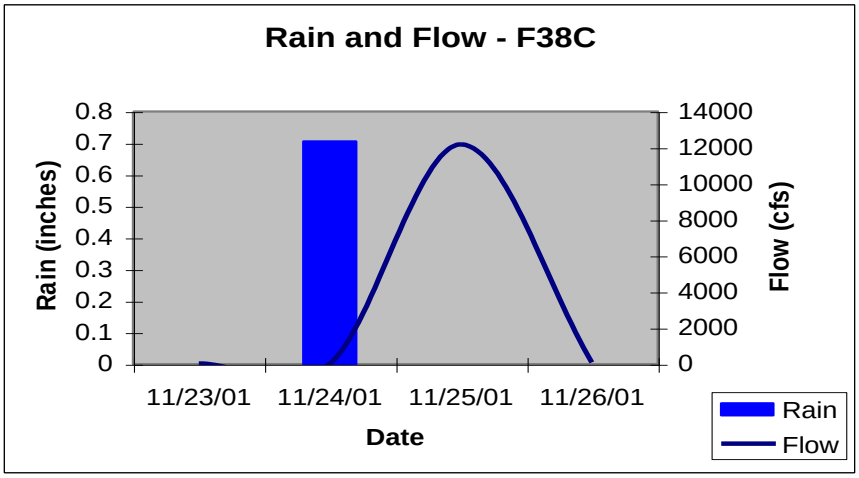
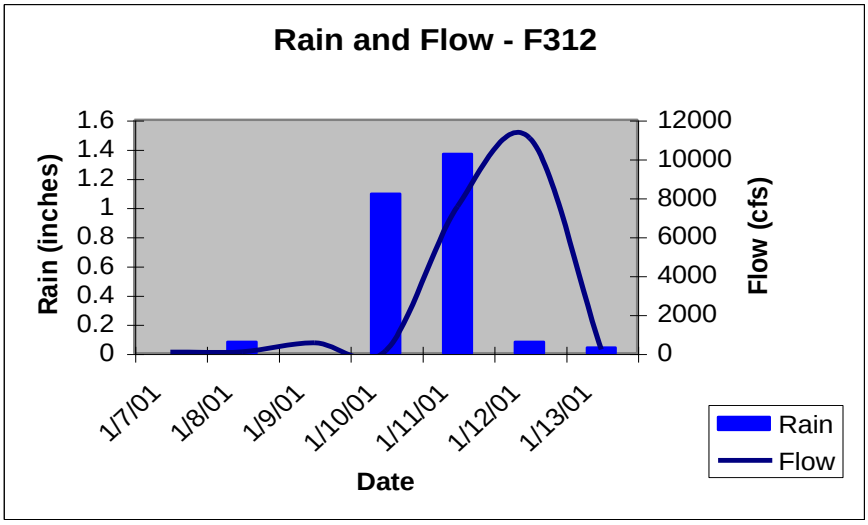
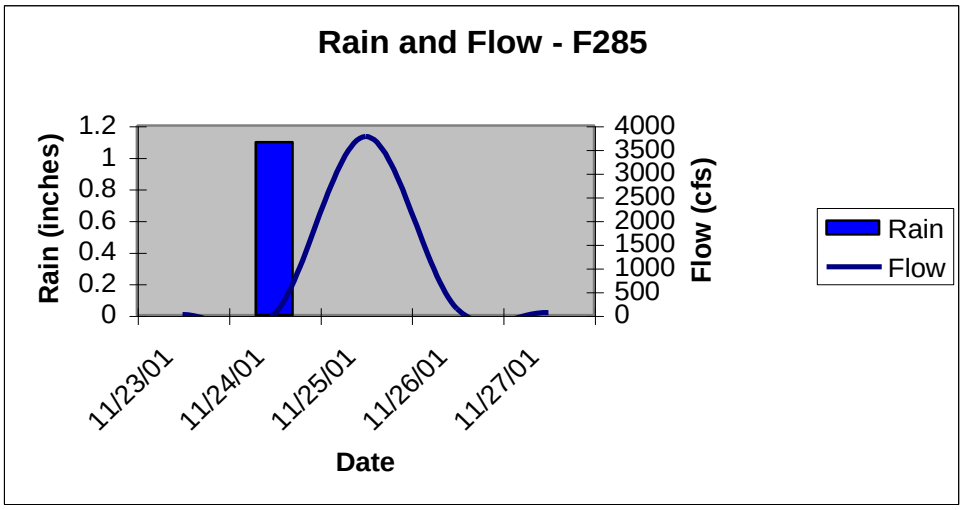


Figure 2: San Jose Channel below Seventh Ave.



APPENDIX 3: DATA ANALYIS RESULTS

Figure 3: Burbank Western Channel at Riverside Dr.



APPENDIX 3: DATA ANALYIS RESULTS

Rescue Dates, Locations and Conditions for 2001 and 2002

In Los Angeles County, protocols for locking access gates to flood control channels and preparing for possible swift-water rescues in these channels during defined storm events have been set by the Los Angeles County, California Multi-Agency Swift Water Rescue Committee. This committee is made up of the County and City Fire Departments, the Sheriff's Department, Lifeguards and the Department of Public Works. The Los Angeles County Fire Department is the chair of the committee and retains records of the locations, dates and times of historic swift-water rescues.

Staff analyzed two years of rescue data (water years 2001-2002) to match days on which there were swift-water rescues with corresponding flow, depth, velocity and rainfall data in several local channels. Staff concluded that 71 percent of the rescues occurred on days that were considered "unsafe".[3] Thirty-six percent of swift-water rescues from 2001 to 2002 occurred on days when the rainfall on that day or the preceding day was greater than ½ inch, while 27 percent occurred on days when the rainfall on that day or the preceding day was greater than 1 inch.[4] See Table 2 below. Table 3 provides minimum, maximum and mean statistics for the flow, velocity and depth values associated with the rescue data.

[3] Staff could not evaluate all rescue dates with respect to the USGS rule-of-thumb, since in some cases the necessary flow data was not recorded.

[4] Eighty-two percent of swift-water rescues from 2001 to 2002 occurred on days when rainfall on that day or the preceding day was greater than 0.1 inch.

APPENDIX 3: DATA ANALYIS RESULTS

Table 2: Rescue Dates, Locations[5] and Conditions for 2001 and 2002

Rescue Date	Nearest Stream-gage	Water Body	Water-shed	Total Daily Rain	Rain Day B/F	"Unsafe" V*D>10	Peak Flow	Peak Depth	Peak Velocity
01/11/01	F354	Coyote Creek	SGR	1.02	1.30	not recorded			
01/12/01	F354	Coyote Creek	SGR	0.32	1.02	not recorded			
03/05/01	F34D-R	LA River	LAR	0.39	0.039	81.82	2290.98	3.13	26.14
03/06/01	F34D-R	LA River	LAR	0.31	0.39	543.45	15216.62	5.14	105.73
04/07/01	F34D-R	LA River	LAR	0.71	0	8.42	235.70	2.13	3.95
04/27/01	F274B-R	San Dimas Wash	SGR	0	0	3.77	226.47	0.84	4.49
04/30/01	F262-R	San Gabriel R.	SGR	0	0	not recorded			
12/21/01	F64R	Rio Hondo	LAR	0.27	0.08	Gage taken off-line in 1996.			
11/30/01	F274B-R	San Dimas Wash	SGR	.078	0.24	63.33	3800	3.83	16.54
11/30/01	F274B-R	San Dimas Wash	SGR	.078	0.24	63.33	3800	3.83	16.54
12/16/02	F354	Coyote Creek	SGR	1.41	0	11.05	16200	7.81	34.57

SGR = San Gabriel River
LAR = Los Angeles River

[5] Exact locations were provided by the LACFD but are not included on this table.

APPENDIX 3: DATA ANALYIS RESULTS

Flow, Velocity and Depth Conditions during "Unsafe" Conditions, Rescues and Specified Rain Events

Staff analyzed some basic hydrologic parameters associated with select channels of concern during various weather and safety conditions. These hydrologic conditions included flow, velocity and depth. The minimum, maximum and mean peaks of these three parameters were recorded.

It is interesting to note that the averages for peak flow, peak velocity and peak depth were similar in magnitude for the "unsafe" days and for the days following a rain event greater than 1/2 inch, regardless of ground conditions (i.e. saturated vs. unsaturated). This seems to support the idea that rain events greater than 1/2 inch are a good proxy for "unsafe conditions."

The correlation between these parameters for days with rescues and days following rain events greater than 1/2 inch is not so strong. While the ranges are comparable, the averages for peak flow, peak velocity and peak depth are approximately 1.5 - 2 times larger during rescue conditions as compared to events where rain the day prior is greater than 1/2 inch. In other words, most rescue days seem to have conditions that are far more dangerous than those associated with the average 1/2-inch rain event.

APPENDIX 3: DATA ANALYIS RESULTS

Table 3: Flow, Velocity and Depth Conditions during "Unsafe" Events, Days with Rescues and Specified Rain Events (Los Angeles River, San Gabriel River and Ballona Creek Sites)

Condition	Peak flow (range & average)	Peak velocity (range & average)	Peak depth (range & average)
Days "unsafe"	(117.31 - 12,483.72) 2,143.29	(4.06 - 121.31) 13.15	(0.19 - 9.33) 2.59
Days w/ rescues	(226.47 - 16,200.00) 5,967.11	(3.95 - 105.73) 28.90	(0.26 - 7.81) 3.37
Days following rain>0.5	(27.02 - 12,483.72) 2,150.59	(0.42 - 58.83) 12.44	(0.37 - 9.33) 2.57
Days following rain >1.0	(27.02 - 12,483.72) 3059.68	(0.42 - 58.83) 15.34	(0.37 - 9.33) 3.10

APPENDIX 3: DATA ANALYIS RESULTS

Summary of Days of Rainfall ≥1/2 inch and ≥1 inch plus the 24-hours following based on Historical Records

At each of four rain gage stations in Los Angeles and Ventura Counties, rainfall greater than or equal to 1/2 inch occurred an average of 18 days per year over the periods of record. This number drops to 7.75 days, where the rainfall criterion is greater than or equal to 1 inch. In percentages, 4.75% of the 365 days per year were days over the rain criterion of 1/2 inch. The percentage drops to 2.25% when using the criterion of 1.0 inch of rainfall.

The ranges and medians are broken down by station in the two tables below. Table 4 applies to the 1/2-inch threshold. Table 5 applies to the 1-inch threshold.

The significance of these tables is that they indicate the number of days per year that the high flow suspension of the REC-1 and REC-2 beneficial uses would apply.

APPENDIX 3: DATA ANALYIS RESULTS

Table 4: Summary of Days of Rainfall ≥ ½ Inch plus the 24 Hours Following Based on Historical Records[6]

Rain Gage	Max No. of Days / year (% of Year)	No. of Days in 1993 (% of Year)	Min No. of Days / year (% of Year)	Median No. of Days / year (% of Year)
LAX[7]	48 (13%)	26 (7%)	2 (0.5%)	16 (4%)
Ojai – Stewart	64 (18%)	Not calculated	0 (0%)	22 (6%)
Simi	56 (15%)	Not calculated	2 (0.5%)	18 (5%)
VD	34 (9%)	Not calculated	0 (0%)	16 (4%)

Notes: The Max, Min, and Median numbers may be overestimates because staff has assumed that no day with rainfall greater than or equal to ½ inch was followed by a second consecutive day of rainfall greater than or equal to ½ inch. If one or more days of rainfall greater than or equal to ½ inch were followed consecutively by a day(s) of rainfall greater than or equal to ½ inch, these numbers would be smaller. The number of days in 1993 is an exact calculation.

Table 5: Summary of Days of Rainfall ≥ 1 Inch plus 24 Hours Following Based on Historical Records[8]

Rain Gage	Max No. of Days / year (% of Year)	No. of Days in 1993 (% of Year)	Min No. of Days / year (% of Year)	Median No. of Days / year (% of Year)
LAX[9]	24 (7%)	15 (4%)	0 (0%)	6 (2%)
Ojai – Stewart	38 (10%)	Not calculated	0 (0%)	12 (3%)
Simi	30 (8%)	Not calculated	0 (0%)	8 (2%)
VD	18 (5%)	Not calculated	0 (0%)	7 (2%)

Notes: The Max, Min, and Median numbers may be overestimates because staff has assumed that no day with rainfall greater than or equal to 1 inch was followed by a second consecutive day of rainfall greater than or equal to 1 inch. If one or more days of rainfall greater than or equal to 1 inch were followed consecutively by a day(s) of rainfall greater than or equal to 1 inch, these numbers would be smaller. The number of days in 1993 is an exact calculation.

[6] Note that the period of record for the LAX analysis was from 1948 to 2000. For the Ventura Downtown (VD) and Ojai-Stewart gages the period of record was 1956 to 2001. For the Simi gage the period of record was 1956 to 1971.
[7] Note that the water year used for the LAX analysis was from November 1 through October 31st. The rest of the rain gage analyses were based on a water year that runs from October 1 through September 30th.
[8] See Footnote 6 above.
[9] See Footnote 7 above.