

Memorandum

To: Kevin Stewart, UDFCD
From: Mark Mitisek
Date: 05/20/2012
Project: Boulder Creek HydroModel
Subject: Fourmile Creek Model Calibration

At the request of Urban Drainage Flood Control District (UDFCD) the Boulder Creek hydromodel has been recalibrated to better represent the observed travel times within the Fourmile Creek watershed. On July 13th, 2011 the Fourmile Creek watershed experienced its first significant flood event due to the hydrologic changes as a result of the Fourmile Creek wildfire. Fourmile Creek at Crisman was the primary forecasted design point used in this calibration. The goal was to reduce the estimated time of peak flow by approximately 30 minutes at Crisman to better represent the timing of the flood event. Notably the original estimated peak flows at the design point were representative of the event and should not be altered significantly.

The July 13th, 2011 flood event was well documented by UDFCD, including stage/discharge and the timing of peak flows at different design points throughout the basin. **Table 1** below is a summary of the observed information and corresponding modeled design points that were used for recalibration:

Table 1 - July 13, 2011 Observed Peak and Time of Peak

Design Point	Observed Peak (CFS)	Observed Time of Peak
Fourmile Creek at Salinas	810	N/A
Fourmile Creek at Logan Mill Road	820	7:17 PM
Fourmile Creek at Orodell	770	8:06 PM
Boulder Creek At Orodell	674	8:00 PM
Boulder Creek At Bridge	1280	8:10 PM
Boulder Creek At Canyon Mouth	1020	8:45 PM

Approach

Muskingum-Cunge routing method is used to represent the hydrograph timing in this hydromodel. Travel time was the primary parameter altered to better represent the estimated time to peak flow. The original travel times were estimated based on reach lengths and average estimated velocities. New travel times were recalculated using additional information about channel geometry and the flood event for each basin. **Table 2** below is a summary of basin parameters used to estimate representative travel times in each basin. Note top width (W) was calculated based on basin drainage area (A) using the equation $W(\text{ft}) = 8.7A(\text{mi}^2)^{0.22}$ as developed by Vieux & Associates and all channels were assumed to have a trapezoidal geometry.

Table 2 - Basin Parameters

Basin Name	Basin	Reach Length (ft)	Channel Slope (ft./ft.)	Drainage Area (Mi ²)	Top Width (ft)
Upper Fourmile Creek	Basin_12A	10681.44	0.11	2.43	10.58
Long Gulch	Basin_12B	13622.4	0.14	1.58	9.62
Fourmile Creek blw Emerson Gulch	Basin_12C	4868.16	0.06	0.95	8.60
Emerson Gulch	Basin_12D	9192.48	0.18	0.45	7.29
Fourmile Creek abv Salina	Basin_12E	10818.72	0.11	1.71	9.79
Upper Gold Run	Basin_13A	10280.16	0.15	1.41	9.38
Lower Gold Run	Basin_13B	7175.52	0.11	0.63	7.86
Ingram Gulch	Basin_13C	6262.08	0.27	0.45	7.29
Sweet Home Gulch	Basin_13D	4577.76	0.25	0.27	6.54
Fourmile Creek abv Crisman	Basin_14A	7529.28	0.08	0.66	10.00
Sunbeam Gulch	Basin_14B	5216.64	0.18	0.63	7.85
Short Cut & Sand Gulch	Basin_14C	7756.32	0.15	0.76	8.18
Lower Fourmile Creek	Basin_14D	16774.56	0.10	3.50	11.46

To establish a range of acceptable travel times for each basin the velocity was calculated based on the parameters above and using a Mannings n of 0.033-0.045, representing the maximum and minimum natural channel. Mannings velocities were then used to estimate travel time (k) as (k = Reach Length (5/3*velocity)). These are an estimate of the shortest travel times possible in each basin. **Table 3** below is a range of travel times representative of each basin in the Fourmile Creek watershed.

Table 3 – Range of Acceptable Travel Times

Basin Name	Basin	Reach Length (ft)	Mannings $n = 0.033$		Mannings $n = 0.045$	
			Velocity (fps)	Travel Time (Min)	Velocity (fps)	Travel Time (Min)
Upper Fourmile Creek	Basin_12A	10,681	23	5	17	6
Long Gulch	Basin_12B	13,622	25	5	19	7
Fourmile Creek blw Emerson Gulch	Basin_12C	4,868	16	3	12	4
Emerson Gulch	Basin_12D	9,192	26	3	19	5
Fourmile Creek abv Salina	Basin_12E	10,819	22	5	16	7
Upper Gold Run	Basin_13A	10,280	27	4	19	5
Lower Gold Run	Basin_13B	7,176	21	3	16	5
Ingram Gulch	Basin_13C	6,262	33	2	24	3
Sweet Home Gulch	Basin_13D	4,578	30	2	22	2
Fourmile Creek abv Crisman	Basin_14A	7,529	19	4	14	5
Sunbeam Gulch	Basin_14B	5,217	27	2	20	3
Short Cut & Sand Gulch	Basin_14C	7,756	25	3	19	4
Lower Fourmile Creek	Basin_14D	16,775	23	7	17	10

Using the calculated range of acceptable travel times each basins, the travel times were adjusted to match the observed time to peak at corresponding design points. Consequently, a reduction in travel times increased the estimated peak flows in some basins. **Table 4** below is a table of the recalibrated travel times, estimated time to peak, and peak flow for all Fourmile and Boulder Creek design points below Orodell compared to observed. Note that some travel times are modeled in series, therefore some travel times are cumulative.

Table 4 - Calibration Results

Design Point	Routing Sheet	Calibrated Travel Time (Minutes)	Observed Peak (CFS)	Calibrated Peak (CFS)	Observed Time of Peak	Calibrated Time of Peak
Upper Fourmile Creek/Long Gulch	Basin_12BR	7	N/A	32	N/A	7:25 PM
Upper Fourmile Creek/Emerson	Basin_12DR	14	N/A	121	N/A	7:25 PM
Fourmile Creek abv Salina	Basin_12ER	28	N/A	126	N/A	7:55 PM
Upper Gold Run	Basin_13AR	7	N/A	218	N/A	7:15 PM
Ingram Gulch	Basin_13CR	7	N/A	241	N/A	7:15 PM
Lower Gold Run	Basin_13BR	4	N/A	643	N/A	7:20 PM
Sweet Home Gulch	Basin_13DR	2	N/A	163	N/A	7:10 PM
Fourmile Creek at Salina	Salinas	1	810	824	N/A	7:20 PM
Sun Beam Gulch	Basin_14BR	2	N/A	2	N/A	7:00 PM
FMC Near Crisman	Basin_14AR	3	820	847	7:17 PM	7:20 PM
Sand Gulch	Basin_14CR	3	N/A	30	N/A	7:20 PM
CO119/FMC Near Orodell	Basin_14DR	32	770	755	8:06 PM	7:55 PM
Boulder Creek At Orodell	N/A	N/A	674	674	8:00 PM	N/A
Boulder Creek At Bridge	DP_ER	12	1280	1409	8:10 PM	8:10 PM
Boulder Creek At Canyon Mouth	Basin_15R	30	1020	1356	8:45 PM	8:40 PM

Results

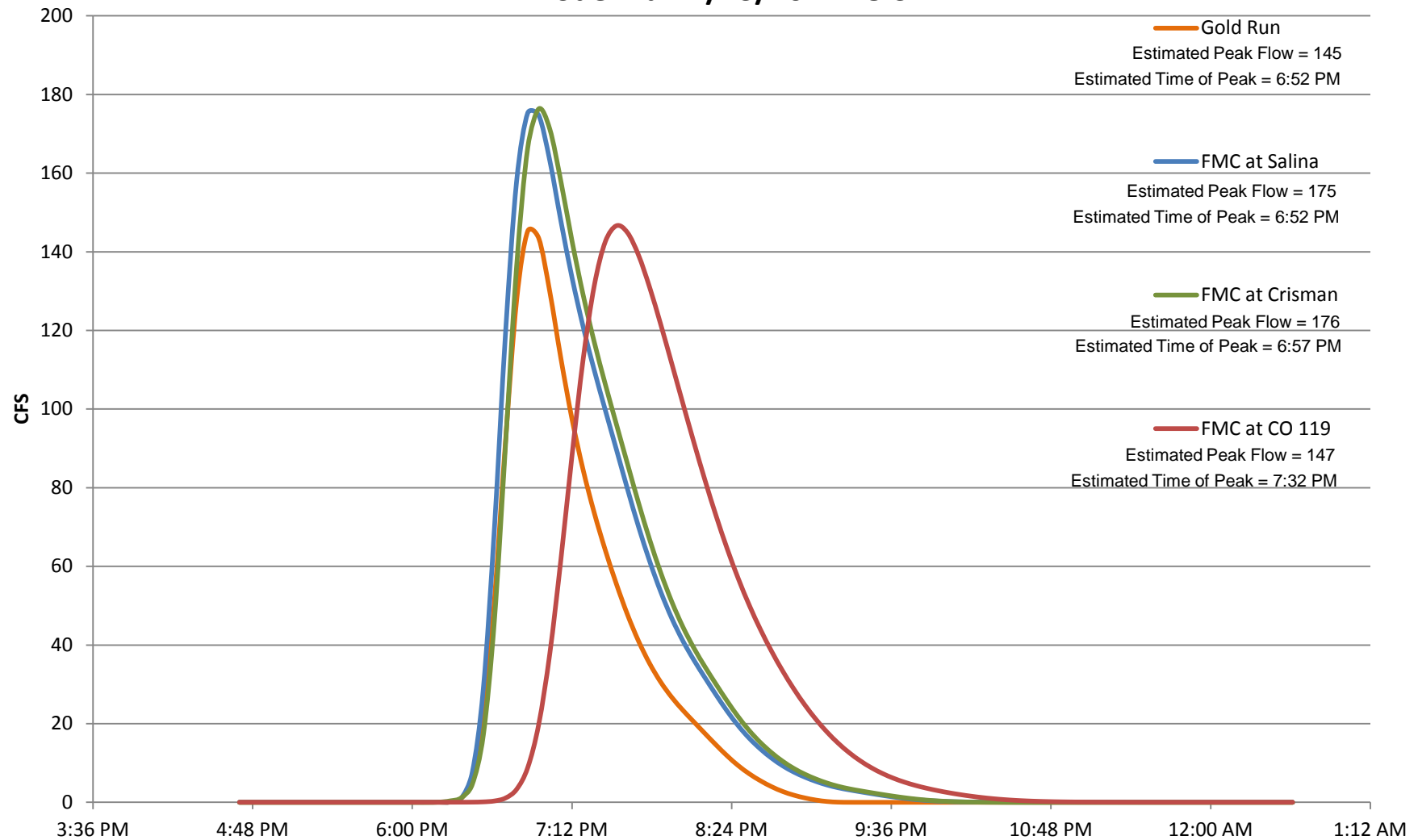
The figures attached are the results for the recalibrated hydrographs for the primary Fourmile Creek design points. The design points represented in the graphics include Gold Run, FMC at Salina, FMC at Crisman, and FMC at CO 119. The hydrographs represent the forecasted modeled results for July 13th, 2011 storm event beginning at 6:37 PM and ending at 7:36 PM. Below is a summary of observations of the recalibrated model:

- The recalibration of travel times reduced the estimated time of peak by 25 minutes at Crisman (7:47 PM to 7:22 PM), but the change in timing increased the estimated peak by 90 cfs (760 cfs to 850 cfs) exceeding the observed peak by 30 cfs.
- The recalibration of travel times reduced the estimated time of peak by approximately 25 minutes at Fourmile Creek at CO 119 (8:22 PM to 7:57 PM), but the change in timing increased the estimated peak by 40 cfs (715 cfs to 755 cfs), which is 15 cfs below the observed.
- There were no significant changes to timing on Boulder Creek, but the changes made to Fourmile Creek reduced the estimated time of peak more closely matching the observed.
- The 200 cfs rise at Crisman occurred at 6:43 PM increasing the flood warning lead time from 35 to 40 minutes.

Conclusion

The Boulder Creek hydromodel is a unit graph lumped parameter model. Although the shape of the hydrographs cannot be manipulated to model the abrupt rising limbs seen in the observed data, the changes to travel times used in this analysis provided a more representative estimation of time to peak and peak flow of the July 13th 2011 flood event on Fourmile Creek. A continued evaluation of model parameters is recommended as more runoff data becomes available.

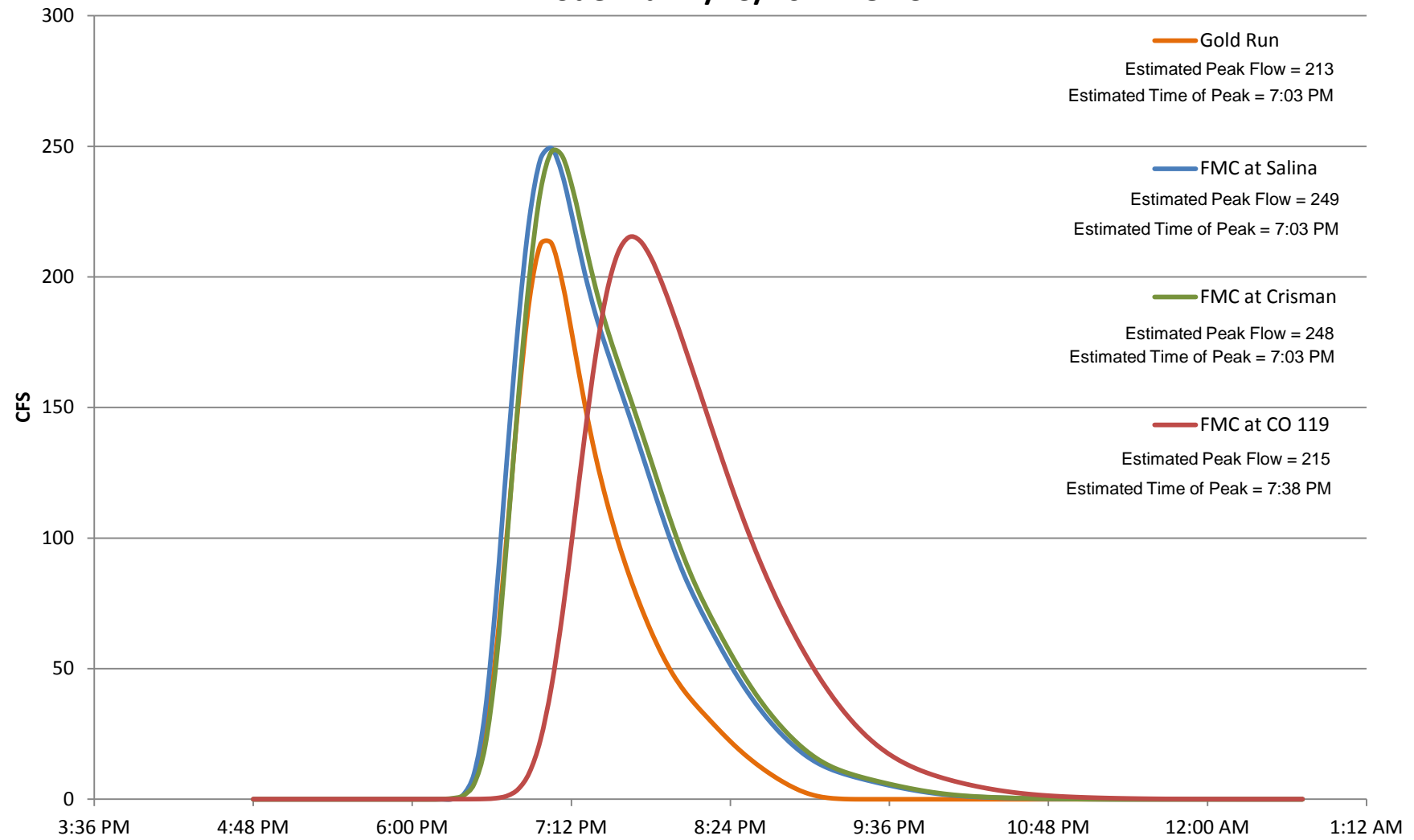
Boulder Creek Hydromodel - July 13, 2011
Fourmile Creek Design Points
Model Run 7/13/2011 18:37



Boulder Creek Hydromodel - July 13, 2011

Fourmile Creek Design Points

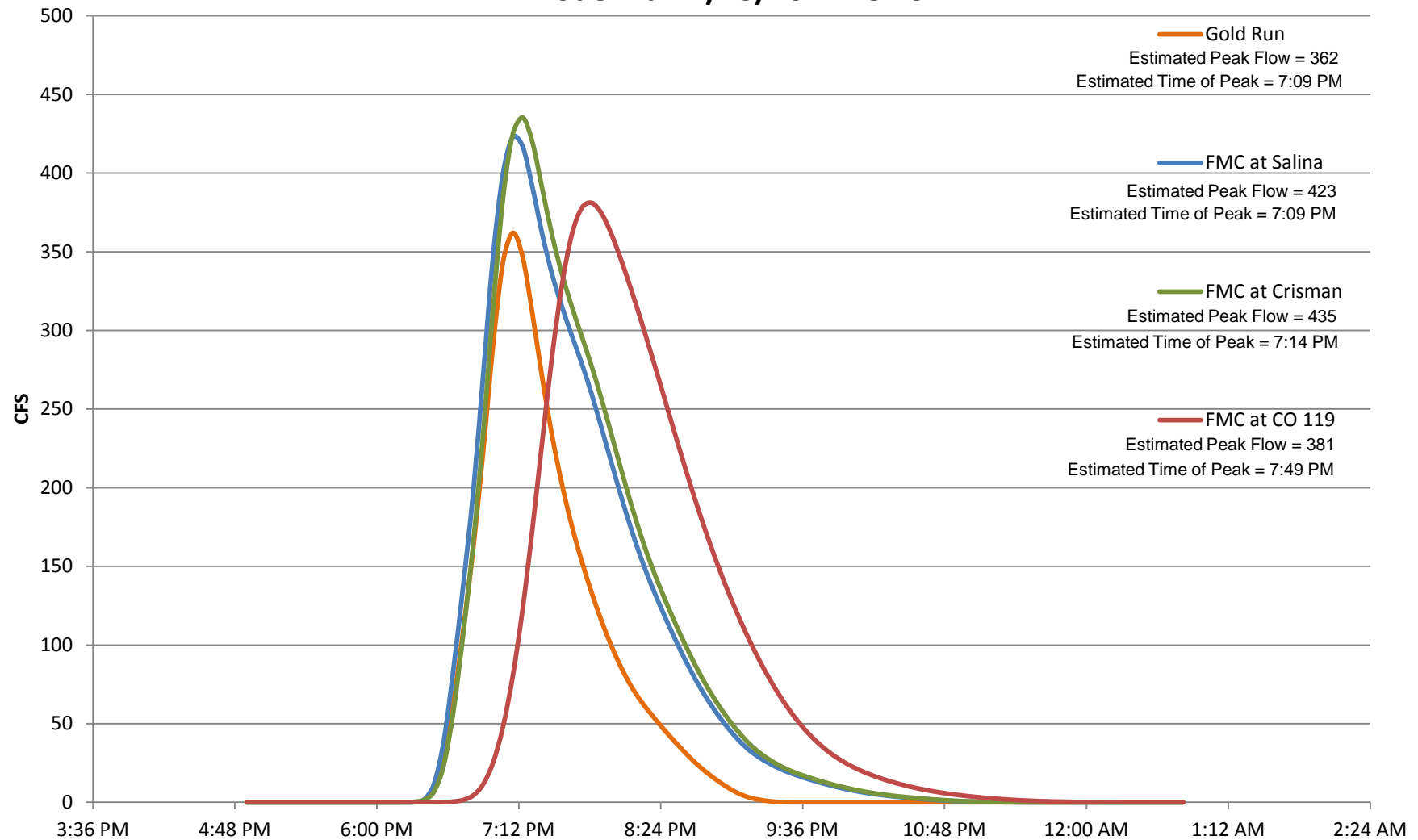
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Boulder Creek Hydromodel - July 13, 2011

Fourmile Creek Design Points

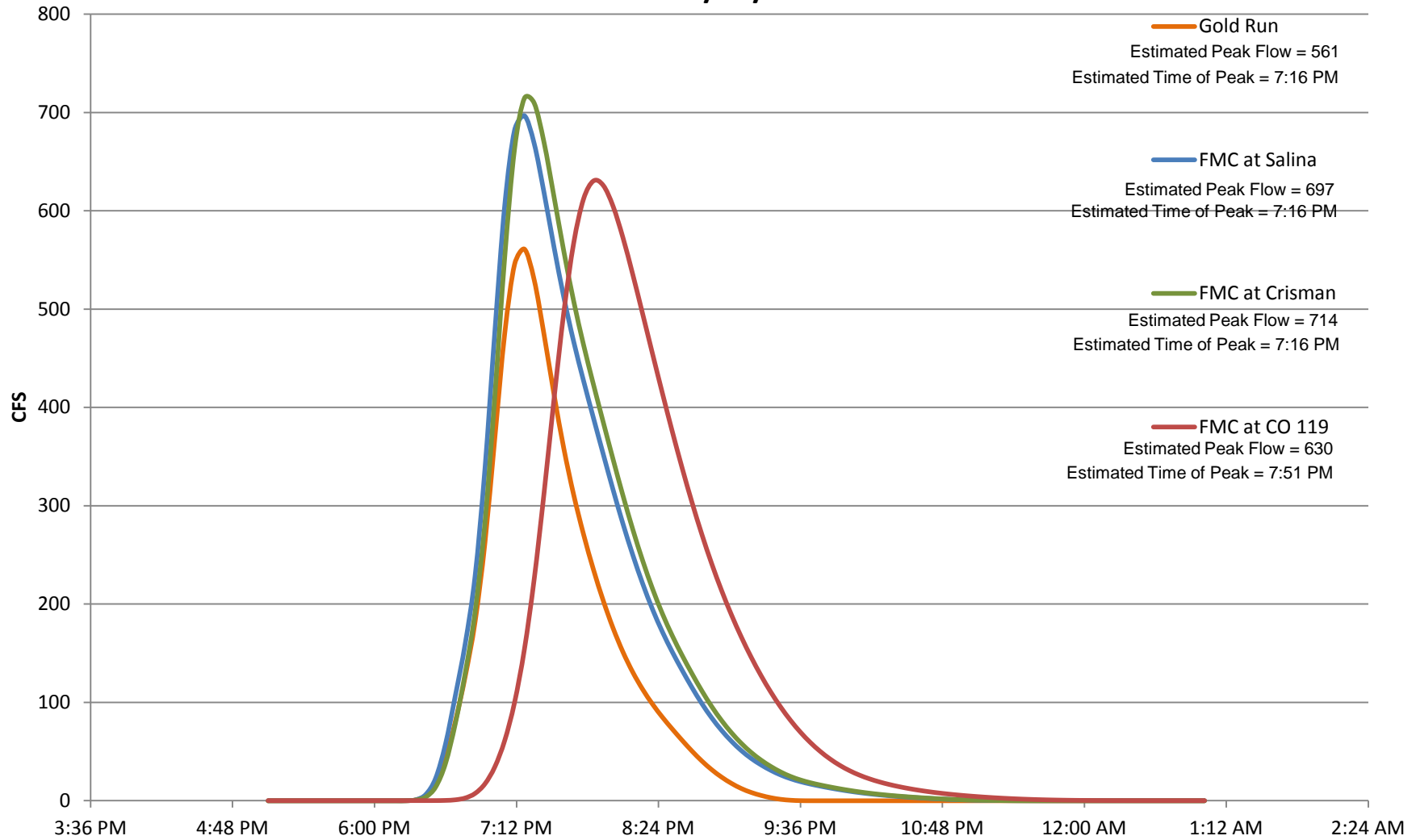
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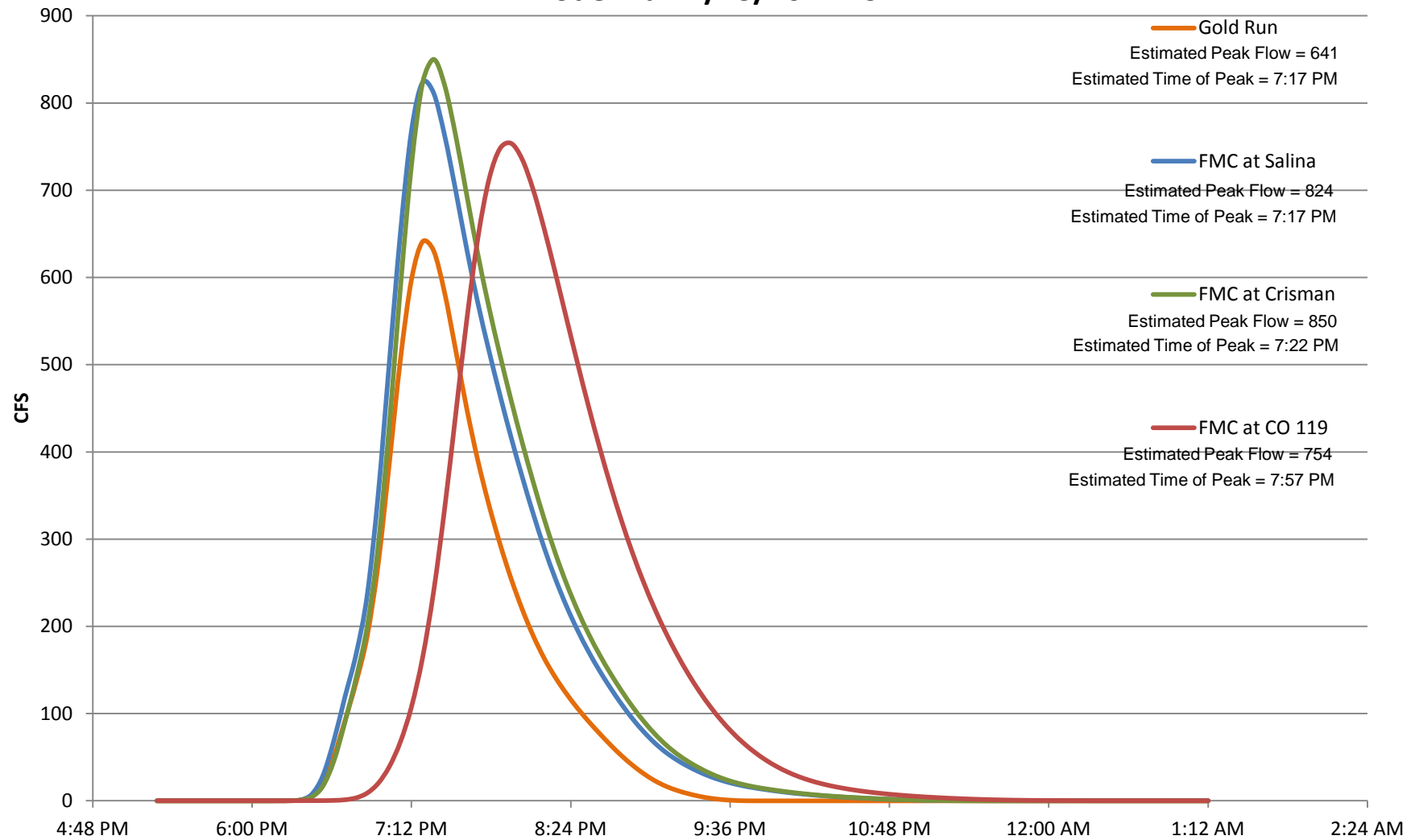
Boulder Creek Hydromodel - July 13, 2011

Fourmile Creek Design Points

Model Run 7/13/2011 19:01



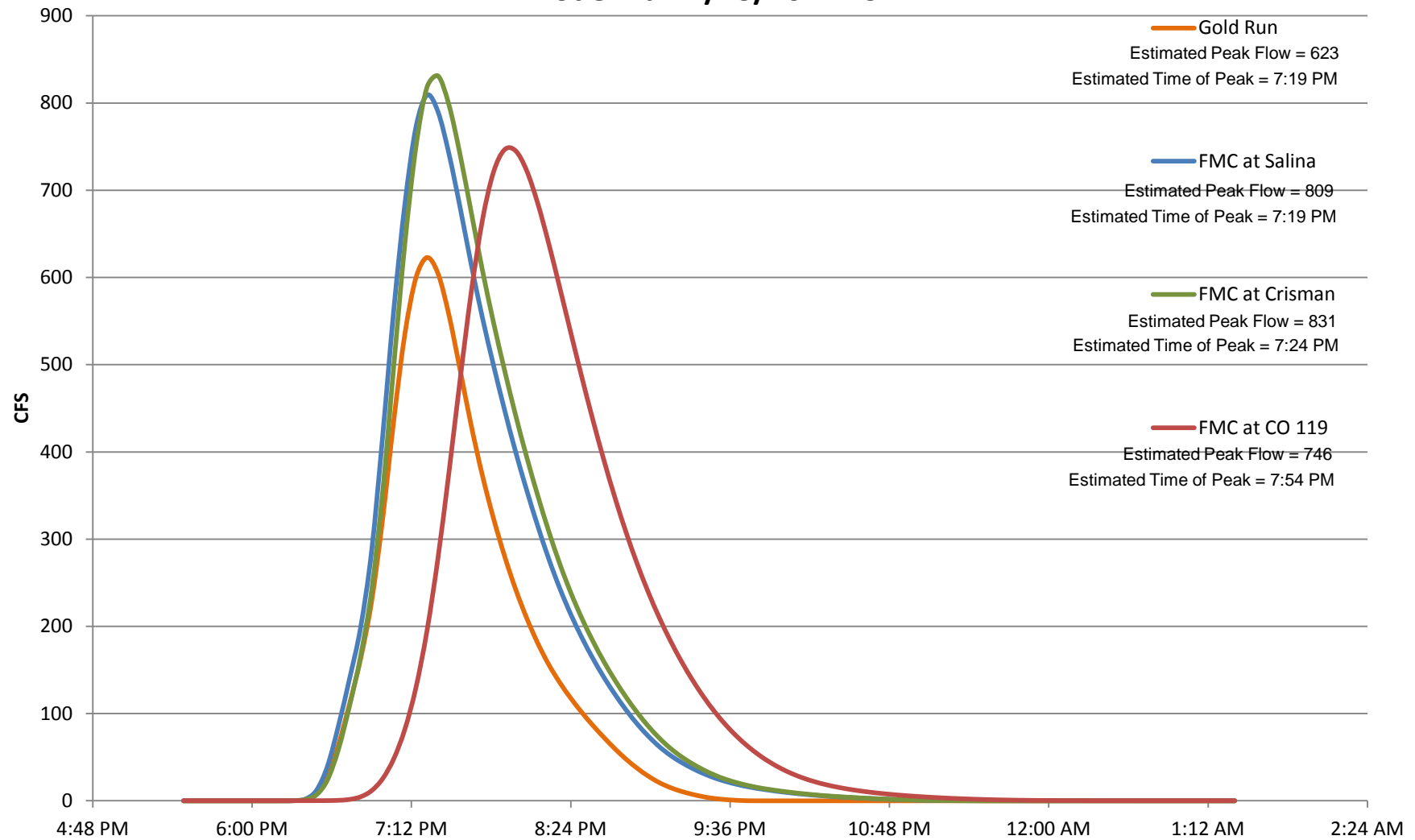
Boulder Creek Hydromodel - July 13, 2011
Fourmile Creek Design Points
Model Run 7/13/2011 19:12



Boulder Creek Hydromodel - July 13, 2011

Fourmile Creek Design Points

Model Run 7/13/2011 19:24



Boulder Creek Hydromodel - July 13, 2011
Fourmile Creek Design Points
Model Run 7/13/2011 19:36

