

South Boulder Creek

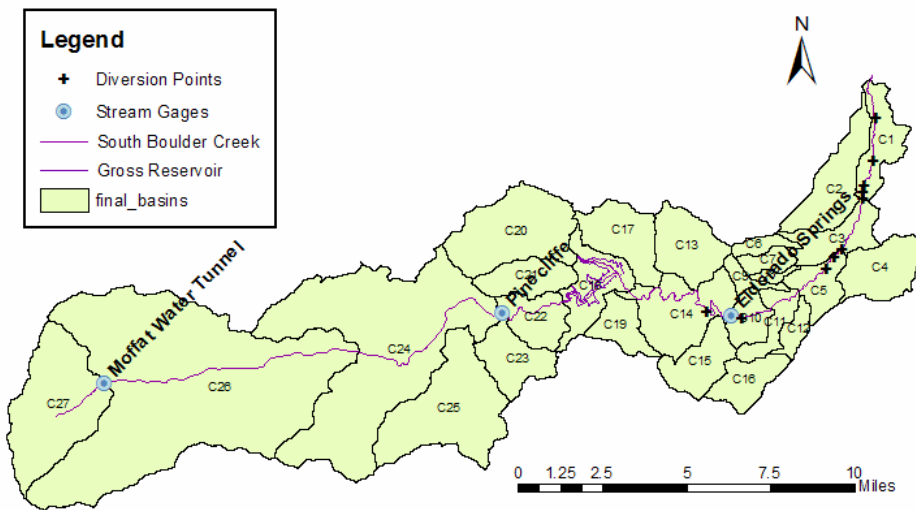
Hydrologic Impacts of Downstream Storm Centers

February 24, 2005

Background

Hydrology of the South Boulder Creek basin was developed using the MIKE FLOOD model. The model allowed the estimation of peak runoff discharges within the various sub-basins and flows along the mainstem of the Creek. This tool is the basis for the definition of flood quantities and the delineation of the floodplain for various events. The basin delineation for the hydrologic analysis is shown as Figure 1 – Basin Delineation.

Figure 1 – Basin Delineation



The flood hazard and regulatory floodplain for South Boulder Creek are traditionally defined by flood flows in the mainstem. As such, during the hydrologic analysis, the emphasis was on flows in the mainstem. Our focus was to define the most critical condition for floods along the mainstem of the Creek. However, the team and the community's technical representatives (the Peer Review Evaluation Panel – PREP) recognized that other types of flood hazards exist. Recognition of these potential hazards due to flooding off the mainstem is the purpose of this special investigation.

Hydrology

The hydrologic study performed for South Boulder Creek was intended to characterize the response of the watershed to extreme rainfall events. The climatological study defined the characteristics of storms that were likely to cause flooding along the mainstem of the creek. Two types of storms were defined, a general storm that falls over the entire watershed and a more localized thunderstorm that is more intense but has much smaller geographic coverage.

To assure that the model represented actual basin conditions, an extensive calibration effort was undertaken. During this calibration, recorded rainfall events were simulated and input into the model. The resulting computed peak flows at the Eldorado Springs stream gage were

compared with actual measured flows at that location. Model parameters were adjusted to develop a model that reflected actual response to the recorded rainfalls.

The developed design storms were then applied to the computer model to generate estimates of peak flood flows in South Boulder Creek. The application of the general storm was very straightforward in that it covered the watershed and demonstrated little variation in response as a result of variations in its location. The results of the general storm simulation also compared favorably to the estimated event discharges based on a stream gage analysis at Eldorado Springs (simulated 100-year discharge of 2770 cfs versus an estimated stream flow of 3140 cfs using the gaged flow record) .

The thunderstorm application required a more methodical approach to assure the proper application. Because the rainfall was very localized and more intense than the general storm, the location of the storm center could cause the runoff response to vary widely. The hydrologic modelers worked with the meteorologists to define a location that was meteorologically defensible and which produced the most stressing condition for the watershed. For the purposes of this study, the most stressing condition was the one that produced the highest peak flows along the mainstem of South Boulder Creek in the lower reaches, generally below the gage at Eldorado Springs. The results of this effort produced results that were very consistent with the discharge estimates based on a stream gage analysis at Eldorado Springs (simulated 100-year discharge of 3230 cfs versus an estimated stream flow of 3140 cfs using the gaged flow record) This storm location is shown in Figure 2 - Design Thunderstorm. The results of this analysis are shown in Table 1 - Thunderstorm Peak Flow Summary.

Figure 2 - Design Thunderstorm

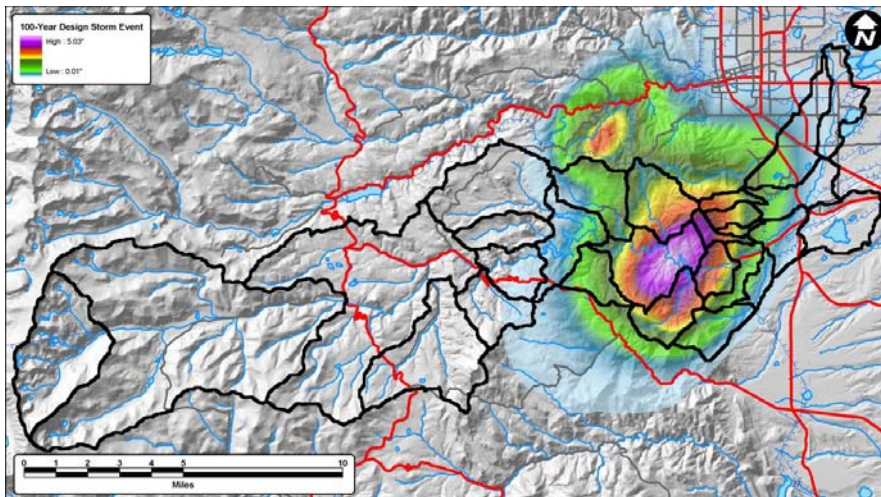


Table 1 - Thunderstorm Peak Flow Summary

Location	Discharge (cfs)
Eldorado	3230
Hwy-93	3900
US-36	3880
Baseline Rd	3870
Confluence	3850

Alternative centers

The work to locate the most stressing thunderstorm location also led to an important revelation; that the location of the storm center not only affected flows along the mainstem, but, in many cases, profoundly affected the runoff from the tributary watershed. While the most stressing condition for peak flows along the mainstem has been reported and used in the study, higher flows along the tributaries to the mainstem of South Boulder Creek may be generated in other parts of the watershed as a result of these alternative locations. In fact, in some cases, the highest hazard to properties located in the floodplain not immediately adjacent to the mainstem may be the result of a storm center at a location other than the one that was used to define the mainstem peak flow.

During the evaluation that defined the most stressing condition, two other storm center locations were evaluated. These locations, depicted in Figures 3 and 4, were generally located at the mouth of Eldorado Canyon and over the lower urbanized portions of the watershed, respectively.

Figure 3 – Eldorado Canyon Mouth Storm

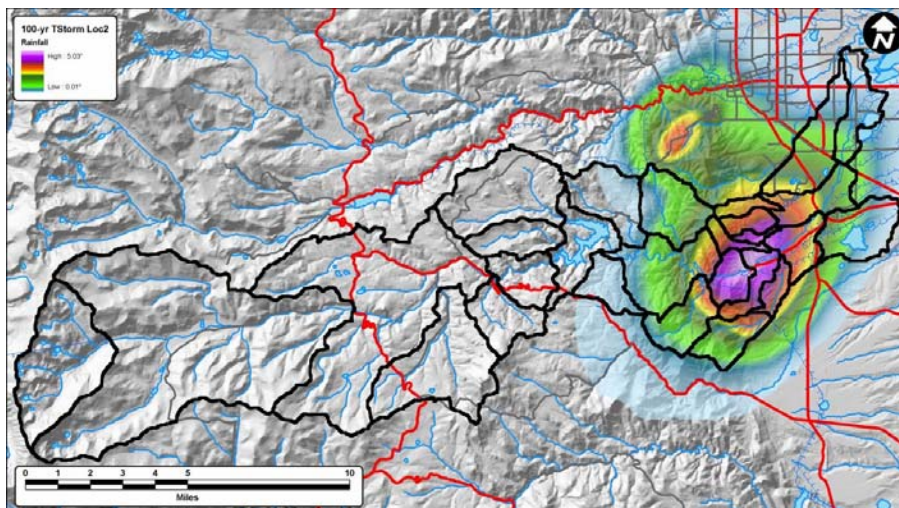
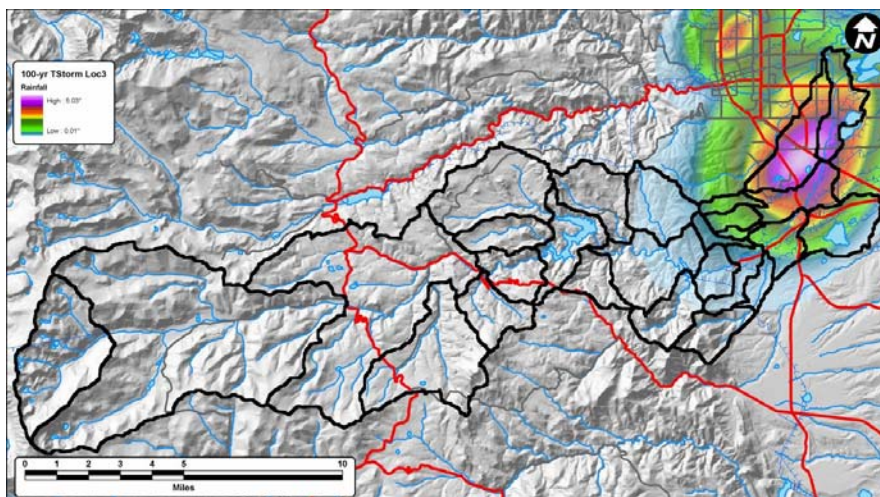


Figure 4 – Lower Urbanized Basin Storm



As reported, these storms did not produce the most critical condition along the mainstem, however, they did produce significantly different flows from the tributary watersheds. Table 2 – Tributary Discharges presents the summary of the instantaneous tributary peak flows resulting from the alternative storm center locations.

Table 2 - Tributary Discharges

Sub-Basin	Discharge (cfs)		
	Adopted Design Storm	Eldorado Canyon Storm	Lower Basin Urban Storm
C1	25	25	651
C2	38	118	1,658
C3	20	251	461
C4	21	21	30
C5	13	232	25
C6	81	83	15
C7	101	182	13
C8	30	112	5
C9	128	140	7
C10	339	714	18
C11	84	624	18
C12	12	291	12
C13	569	67	38
C14	1,892	199	52
C15	578	128	30
C16	29	156	24
C17	66	32	32
C18	8	7	7
C19	75	19	19
C20	55	55	55
C21	22	22	22
C22	23	23	23
C23	25	25	25
C24	40	40	40
C25	75	75	75
C26	55	55	55
C27	22	22	22

Results

As shown in Table 3 – Alternate Storm Peak Flow Summary, the peak flow along the mainstem is estimated using the highest mainstem values which correspond to the adopted design storm location. The alternative storms produce widely varied discharges from the tributary watersheds, as shown in Table 2. Of particular interest are the high peak flows in the lower sub-basins, C1, C2, and C3, for the storm entitled “Lower Basin Urban Storm”. These basins represent the urbanized, developed portions of the watershed and that area in which most of the residents reside. While this storm doesn’t represent the design event, it does produce significantly higher runoff from these sub-basins.

Table 3 - Alternate Storm Peak Flow Summary

Location	Discharge (cfs)		
	Adopted Design Storm	Eldorado Canyon Storm	Lower Basin Urban Storm
Eldorado	3230	800	560
Hwy-93	3900	3080	1650
US-36	3880	3300	1960
Baseline Rd	3870	3400	2480
Confluence	3850	3380	2750

The floodplain delineations that are a part of this study represent flooding resulting from the storms which cause the worst conditions along the mainstem. As the flood wave propagates downstream, the water level in the main channel rises. As this happens, water eventually overtops the stream banks and flows across the floodplain. This condition has been simulated and depicted in the animations that have been presented at public meetings and on the web site. While these conditions represent the mainstem flooding design condition, it may not represent the greatest risk to property off the mainstem.

Tributary inflow to the stream must flow from its point of origin to the stream. For the design event, these local inflows in the lower part of the watershed are very small and will probably not present a significant burden to the collection system. However, particularly for the lower urban storm center, the peak inflow from local basins may be 20 to 40 times higher than the design storm. These flows must also make their way to the mainstem but are very likely to create problems along the way. As an example, the peak flow in basin C2 alone is over 1600 cfs, a discharge of over 40% of the mainstem flows and 40 times the tributary inflow from the adopted design storm. The systems in the tributary are not likely to handle these high flows and are likely to cause localized flooding, some of which may be severe.

Recommendations

Flood hazard exists as a result of flows other than those emanating from the mainstem. In fact, as the discharge estimates in Table 2 point out, in some cases, the flood hazard from localized storms may far exceed the hazard associated with mainstem floods. While the evaluation of this tributary hazard is outside the scope of the current project, these impacts may be of greater concern to many of the residents within the lower portion of the watershed.

To address the hazard from the tributary watershed, we recommend a more site specific evaluation. This evaluation should consider a detailed look at the lower tributaries of South Boulder Creek, a detailed assessment of an appropriate design storm event, a more refined sub-basin delineation, an updated estimate of peak discharges, and an evaluation of the flood inundation hazard associated with this runoff. The City has already mentioned a storm drainage master plan or an outfall systems planning effort is being considered. We think such an evaluation is highly warranted based on the findings of our storm centers evaluation.

We think that the hazard associated with these lower sub-basin storms can be defined in a variety of ways: a modification of the MIKE FLOOD approach used in this study or a more conventional approach as favored by the UDFCD. In either case, the objective should be to

focus on the elements described above, but with a higher level of attention and resolution to the effects of the flow as it travels toward the South Boulder Creek mainstem rather than the impacts once in the mainstem. MIKE FLOOD offers the advantage of being able to identify the actual path of overland flows and to assess the hazard in an objective and very physically based way. The more conventional UDFCD approach provides the benefit of economy and convention, but must presuppose flow paths and model them accordingly. In the hands of an experienced hydraulic engineer, this is not inappropriate and can produce clear and acceptable results.

It is important to remember that the flood hazard associated with localized storms falling on other parts of the watershed should be defined and factored into any floodplain management and flood mitigation strategies.