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In Colorado’s high elevation mountain terrain, traditional Probable Maximum Precipitation (PMP) and flood hydrology approaches often result in spillway design floods that are perceived to be unreasonably large, ranging up to two orders of magnitude larger than floods of record. The USBR’s Flood Hydrology Manual (Cudworth, 1989) noted a lack of extreme flood data when they developed their hydrologic response parameters for the Rocky Mountains. Yet they judged two different unit hydrographs were needed for this region, one for low-intensity rain and another for high-intensity rain. In 2008 Colorado Dam Safety developed new hydrologic basin response guidelines, which departed from Cudworth (1989) and allowed for higher physically-based rainfall losses. The September 2013 Colorado high elevation flood event provided an extreme case to test these new methodologies. Modeling showed that the flooding could not be reproduced using current hydrology methods. For Colorado’s mountain basins, traditional methods tend to overestimate infiltration-excess (i.e. Horton) runoff due to use of low infiltration and surface retention losses. Better results have been obtained by using the higher physically-based initial abstractions and infiltration rates allowed by Colorado’s 2008 guidelines; however, additional procedures were necessary to account for associated interflow and saturation-excess runoff mechanisms. A new simple procedure was developed to adjust infiltration rates to limit simulated infiltration volumes to the soil profile storage capacity. The recent Site Specific PMP and hydrology study for Denver Water’s proposed Gross Dam enlargement provided an opportunity to compare the proposed methods to traditional methods in a spillway hydrology study. Three historical floods were simulated at three different stream gage locations. The hydrologic model based on the proposed advances outperformed the traditional approach. For example, using proposed advances the September 2013 flood simulation calibrated to a zero percent error on runoff volume and -6% error on the peak flow, versus 338% and -5% errors, respectively, from the traditional approach. Following model calibration and verification, the proposed methods yielded Probable Maximum Flood estimates nearly half of those from the traditional model. Results indicate that the proposed methods better reproduce the hydrologic processes that are occurring in mountain basin floods.