“Why Worry About Your City’s Stale Design Plans”

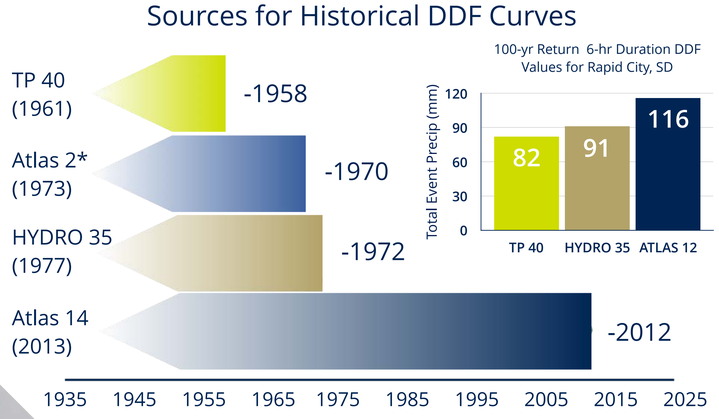
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BACKGROUND

As climate changes into the 21st Century, we expect rainfall events over the United States to intensify. Adapting to these changes requires reassessing existing floodplains. However, local municipalities often rely on floodplain plans using precipitation depth-duration-frequency (DDF) curves derived from outdated sources for today’s conditions, let alone those developed for future climates.

In this case, we are exploring Rapid City, SD, which experienced a city-transforming flood in 1972. While the city made significant zoning changes, replacing buildings on the flood plain with a relatively new concept, the greenway, the city, and neighboring communities continue to have storm design a storm design plan that, ironically, source DDF curve data that precedes 1972, the NWS HYDRO-35 (published in 1977) superseding the earlier Atlas 2 [Western US only] and NWS Technical Paper 40. The estimated event rainfall with each updated DDF source increases, as shown here.



Even when not accounting for potential further changes to extreme storm event frequency, there remains value in demonstrating the impact of alternative sources of design storm data on both major events and smaller, but more frequent, nuisance events that slowly erode local infrastructure and impact property owners by incurring damages beneath insurance deductibles. Here, we shall show such impacts using historical storm curves along with future curves derived from downscaled CMIP6 data.

SOUTH DAKOTA MINES

DATA SOURCES

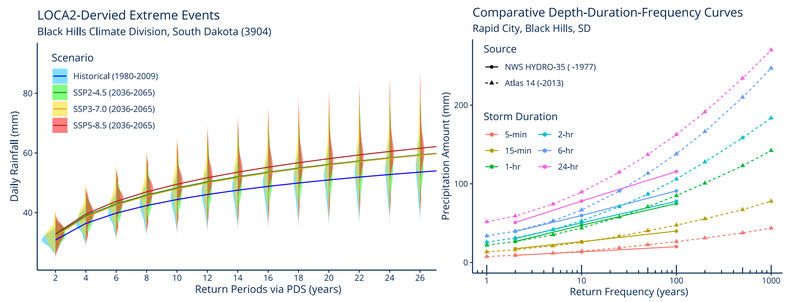
Historical cases use the current Rapid City Infrastructure Design Manual guidelines, which source the HYDRO-35 DDF curves, and as an alternative, the more recent Atlas 14 DDF Curves for the Rapid City area and the South Dakota Black Hills.

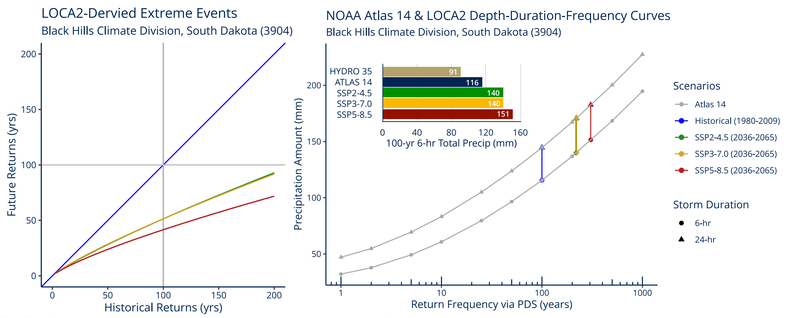
The successor to Atlas 14, Atlas 15, due for release in 2026/7, will include updated contemporary and future DDF curves. This study uses the CMIP6 global climate model ensembles downscaled over the US using Locally-Constructed Analogs (LOCA2) aggregated over the South Dakota Black Hills to account for variations in convective events. Future scenarios use the SSP2-4.5, SSP3-7.0, and SSP5-8.5 for all available centers’ models using each center’s top-performing historical simulation to create probabilistic outcomes to account for predictive uncertainty. Future scenarios are for the 2036-2065 mid-21st-century period to compare against a historical baseline of 1980-2009.

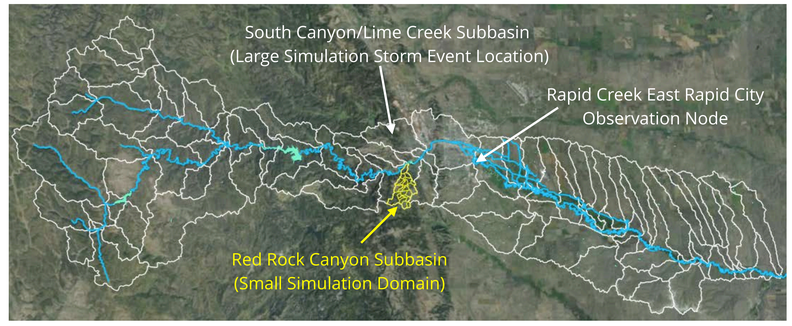
Following the Rapid City ICDM guidance, the modeled design storms use a triangular 100-yr return, 6-hr duration event hyetograph.

CREATING FUTURE DDF PROJECTIONS

As LOCA2 downscaled products have a frequency of 24 hours, to obtain the required shorter duration curves, first associate the change of event return time between a historical return frequency and the return frequency of a future event of the same total rainfall. These changes in 24-hr duration frequency vs rainfall amounts are then applied to the 24-hr and 6-hr to downscale the DDF temporally.

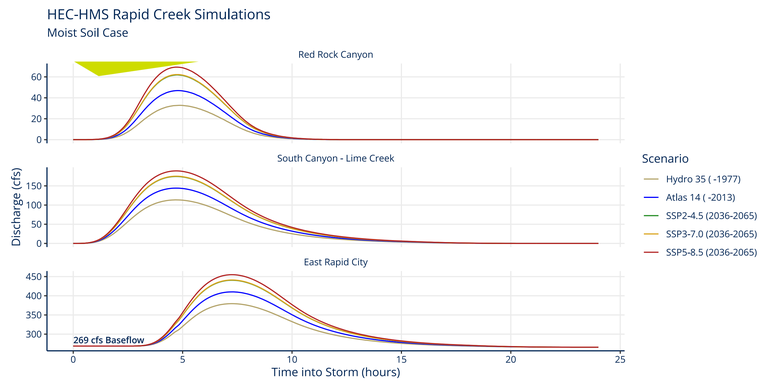






HEC-HMS STORM EVENT RUNS

HEC-HMS simulations used two domains, one designed for the Rapid Creek watershed (white basin polygons), and a smaller one covering the intermittent but vulnerable Red Rock Caynon Creek subasin (yellow basin polygons). The simulations exposed catchments to 100-year storm events, presuming a convective event falling over the marked polygons above. Shown are two cases, one a single test case over Red Rock Canyon, evaluated at the canyon’s mouth, and a storm concentrated over the South Canyon/Lime Creek subbasin, assessed at the subbasin’s mouth and also downstream on Rapid Creek in eastern Rapid City. As shown here, the resulting hydrographs show a strong differentiation between the *contemporary* products, not to mention significant changes in discharge from both the local downstream observation points.



CONTINUING WORK

Continuing work includes integrating future storm projections into related projects, such as the USACE Silver Jackets HEC-RAS flood models, which use HEC-HMS to provide climate-driven boundary conditions, alternative land use management, and model output for decision-support applications.

ACKNOWLEDGMENTS

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