Scaling and Application of Climate Projections to Stormwater and Wastewater Resilience Planning

Chesapeake Stormwater Network

Developing a Regional Resilience Framework

Summary

A regional effort to standardize stormwater practices within the Chesapeake Bay Watershed through the Chesapeake Stormwater Network (CSN) and affiliated partners. Seeking to establish best management practices (BMP) for future resilient designs that consider future climate change.

The Backstory

The Chesapeake Bay Watershed (Bay) consists of seven states across the Mid-Atlantic. The region primarily relies on NOAA's Atlas 14 Intensity Duration Frequency (IDF) curves for planning and design, which do not consider climate change projections that indicate future increases in precipitation volume and intensity. Planning and design of infrastructure that considers these expected increases in precipitation due to climate change will improve the resilience of stormwater infrastructure.

Climate change also poses a risk to current BMPs, most critically affecting water quality goals as outlined by the Chesapeake Bay Total Maximum Daily Load (TMDL). The CSN recommends using a regional approach to promote consistent use of future condition information in the context of projected climate impacts and leading BMP vulnerabilities.

The Challenge

The current standard for most Mid-Atlantic states is based on historic precipitation data (NOAA's Atlas 14 – Volume 2 uses observed data that is twenty years old). In many locations the NOAA Atlas 14 IDF curves underrepresent today's climate conditions. Using outdated precipitation information, compounded by varying design and performance standards across the states and state agencies, results in reduced infrastructure performance and inadequate stormwater policies.

While not all risks to BMPs are directly linked to climate change – proposed development and land use changes, for example – recent observations demonstrate that green infrastructure, conveyance systems, natural ponds and wetlands, and other restored spaces are already strained by increased flows that exceed today's design and performance standards.

These challenges demonstrate the need for updated future precipitation projections to better support and promote regional resilience. However, states and municipalities are facing real-time challenges today, with maintenance and operational needs that require immediate attention. Consideration of future climate change often takes a back seat to the pressing challenges of the present. Limitations in progress also arise from lack of funding, capacity, and guidance. These challenges not only require individual state action, but a greater regionwide framework where capacity is built up across multiple geographies, lessons learned can be shared, and best practices can be scaled up to support regional resilience.

The Approach

To better understand the current state of science, methods, and challenges, CSN initiated a comprehensive review of the state of the practice across the Mid-Atlantic. This review was documented across four reports designed to synthesize climate projections and implications for stormwater design in the region. The effort included a climate survey, review of design standards, climate projections, and a BMP vulnerability analysis. Conclusions and recommendations are presented (see section The Outcome).

In tandem with CSN's efforts, NOAA's MARISA team published the online Mid-Atlantic IDF Curve Tool where projected IDF curves have been developed for multiple stations in the Bay watershed. The tool was driven by the need to evaluate climate change implications on TMDLs at the county level. Data inputs include station-based observations (historical data) and projected precipitation from downscaled climate model ensembles (MACA, LOCA, and BCCAv2) and regional climate models (NA-CORDEX). Outputs consist of IDF curves and future change factors. The baseline for historic data was purposefully selected to align with NOAA's Atlas 14 historical period, 1950-1999. Two future time periods, 2020-2069 and 2050-2099 (i.e., 50-year periods) are available for future projections under the RCP 4.5 and 8.5 climate scenarios.

The tool enables users to search and download individual county scale IDF curve change factors for the 2-year to 100-year storm event (for 5 minute to 7-day durations) within the Chesapeake Bay Watershed and Virginia. Updates to the IDF curves will be made using the upcoming release of the full downscaled CMIP6 archive, more recent rainfall observations, updates to NOAA Atlas 14, and/or technical advancements which improve IDF curve estimation methods.

The Outcome

Over the next three to five years, CSN expects to launch four products to advance regional consistency based on the identified challenges. These efforts will work towards more climate resilient initiatives and provide states with the necessary information to make climate informed decisions. The following provide a high-level description of the future resources.

Vulnerability assessment tool
While some large cities have already completed a climate change vulnerability assessment, most smaller cities have not. This tool will specifically target cities with limited resources and serve as a checklist when reviewing regulatory policies, promoting a better understanding of future climate risks and the next steps to address vulnerabilities.

Expand projections
In many cases, understanding the implications associated with updating future precipitation projections is not straightforward, including deciding between the various climate trajectories and projections, associated uncertainties, and applicable standards. This enhanced decision support tool is anticipated to provide guidance on how to pair the right climate projections to the appropriate application or assessment need (e.g., pairing the most appropriate climate projection(s) with the relevant design or performance standard).

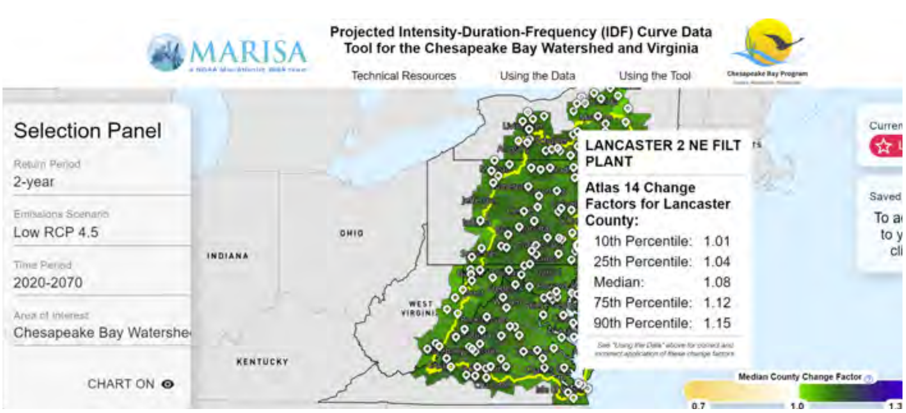
Menu of Resilient BMP Design Adaptations
Current design specifications date back to the early 2000s. Providing a menu of resilient design adaptations will allow states the opportunity to update theirspecifications for the most popular BMP types and increase performances in larger storms.

Edit future hydrology with climate change
There are knowledge gaps in understanding how future climate change will impact local hydrologic and hydraulic systems. The effects climate change may have on stormwater and wastewater systems (e.g., effects on influent and effluent) and BMPs (e.g., effects on flow bypass) require further exploration.

CSN's comprehensive review revealed that several states within the Mid-Atlantic region are individually working to address climate change impacts related to stormwater management and/or floodplain protection. Commonalities exist across the several state led efforts, such as completing vulnerability assessments, responding to changes in policy, and developing resources/tools. The following provides examples of select approaches:

Delaware

Since 2012, the state of Delaware has completed a series of sea level rise and vulnerability assessments. Following Executive Order 41 – requiring state agencies to include adaptive strategies that address increasing flood heights and sea level rise within project designs – a guidance document outlining a set of principles and instructions was published by the state. Similar to the MARISA tool, Delaware also produced a Climate Projections Portal where users can assess climate projections based on the CMIP3 and CMIP5 climate model archives.



Screen capture of the IDF Curve Data Tool, that provides easy access to IDF projections throughout the mid-Atlantic. (Image from https://midatlantic-idf.rcc-acis.org/, accessed December 29, 2022.)

District of Columbia

The Department of Energy and Environment (DOEE) is taking steps towards climate informed action, including completing vulnerability and risk assessments, assessing climate projections, identifying potential blue-green infrastructure strategies, and developing a climate adaptation plan. DOEE also put forth a framework for climate adaptation focused on transportation and utilities; buildings and development; neighborhoods and communities; and governance and implementation. DOEE is currently studying revisions to current floodplain regulations to account for sea level rise and more intense future storms. DOEE also plans to assess future stormwater performance standards to meet MS4 requirements.

Maryland

In 2021, Maryland's Stormwater Law was updated. It requires the Maryland Departmnet of the Environment (MDE) to report on the most recent precipitation data available, investigate flooding events since 2000, and update Maryland's stormwater quantity management standards for flood control. Maryland has also focused on assessing coastal hazards, including a two-part vulnerability assessment and an interactive map that documents future sea level rise and flood risks. The Eastern Shore Land Conservancy also released an extreme precipitation report that identifies risks associated with the increasing frequency of extreme precipitation events on Maryland's eastern shore. Guidance is provided for local governments seeking to incorporate future stormwater risks into planning and decision-making

Lessons Learned

1. Climate is nonstationary

Historical precipitation data, specifically NOAA Atlas 14 IDF curves, do not reflect today's non-stationary climate. Continued use of existing design standards will likely result in undersized stormwater management infrastructure in the future. Updating NOAA Atlas 14 will be a valuable next step for all communities. This update would increase consideration of future precipitation conditions within stormwater planning and design.

2. States and local governments need updated design standards

The findings of CSN's work highlight responses from practitioners, engineers, decision-makers, stakeholders, as well as climate-related progress in several states. Based on survey responses, there are climate change impact concerns related to both public and private infrastructure. There is also consensus on the need for updated engineering criteria and performance standards that consider future climate change.

3. Uniformity across the watershed is needed

Standards not only vary across states, but they can also differ within departments. There are often differences in how precipitation data is used and considered in planning and design. Developing uniform design criteria and performance standards would promote regional resilience and would also allow for easier sharing of best practices and lessons learned.

4. Guidance and support go beyond analytical needs

States and cities need support developing locally relevant climate projections. Climate projections must also be translated into effective and easily digestible language for decision-makers. Forward thinking decisions require actionable science that directly informs planning, design, and engineering applications. Actionable science can include both qualitative and quantitative formats and is a core facet of the CSN framework. Future tools and applications will best serve under-resourced states and localities if they are published and communicated with this in mind.