Stormwater & Flooding

Introduction

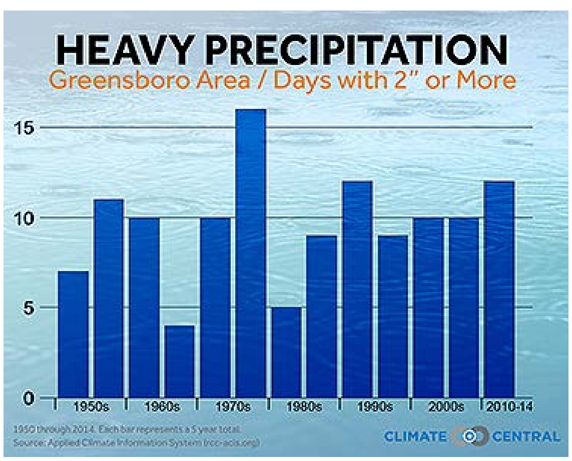
One of the associated impacts of climate change is an increase in precipitation extremes. As temperatures increase globally, water that is held in the ocean and other water bodies, plants, and soils, evaporates more quickly, which results in a greater average of annual rain and snowfall. A warmer atmosphere also means that it can hold more moisture, which contributes to more intense downpours (Climate Reality Project, 2011).

Heavy precipitation can pose substantial risks to local communities. It can result in flash floods, as well as longer-duration floods, which can cause property damage, impact infrastructure, and disrupt livelihoods. In extreme cases, such as tropical cyclones, flooding can even threaten lives. 2017's hurricane season highlighted just how devastating tropical storms and resulting flooding can be. Hurricane Harvey caused up to 60 inches of rainfall in some areas of Texas and resulted in over $180 billion in damages (Fritz, 2018). As the frequency of extreme events continues to increase, these risks become even greater.

Observed & Projected Trends

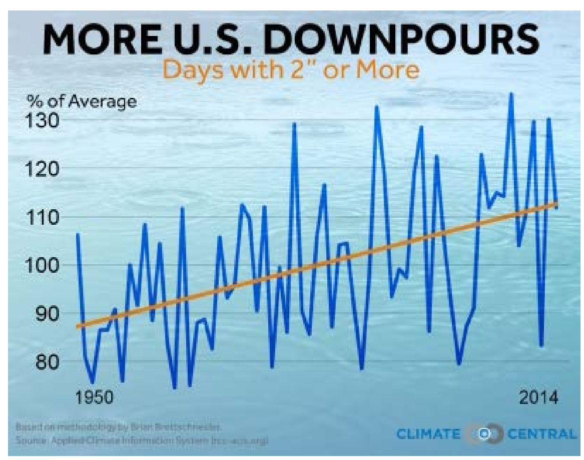
As mentioned earlier in this report, average rainfall varies greatly across North Carolina. While there have been no clear long-term trends in overall precipitation across North Carolina, there is evidence to suggest that the frequency of extreme precipitation events is increasing (Frankson et al. 2017, Carter et al. 2014). Since 1950, the Piedmont Triad has observed a 20% increase in the number of days with two inches or more of rainfall (States at Risk, 2014). A higher number of days with heavy rainfall means more flooding for the region, as well as greater stress on local water systems and infrastructure. It is anticipated that this trend of more frequent and intense precipitation will persist as global temperatures continue to rise.

Figure 23: Heavy Precipitation in the Piedmont Triad



Source: States at Risk, 2014

Figure 24: Heavy Precipitation in the U.S.



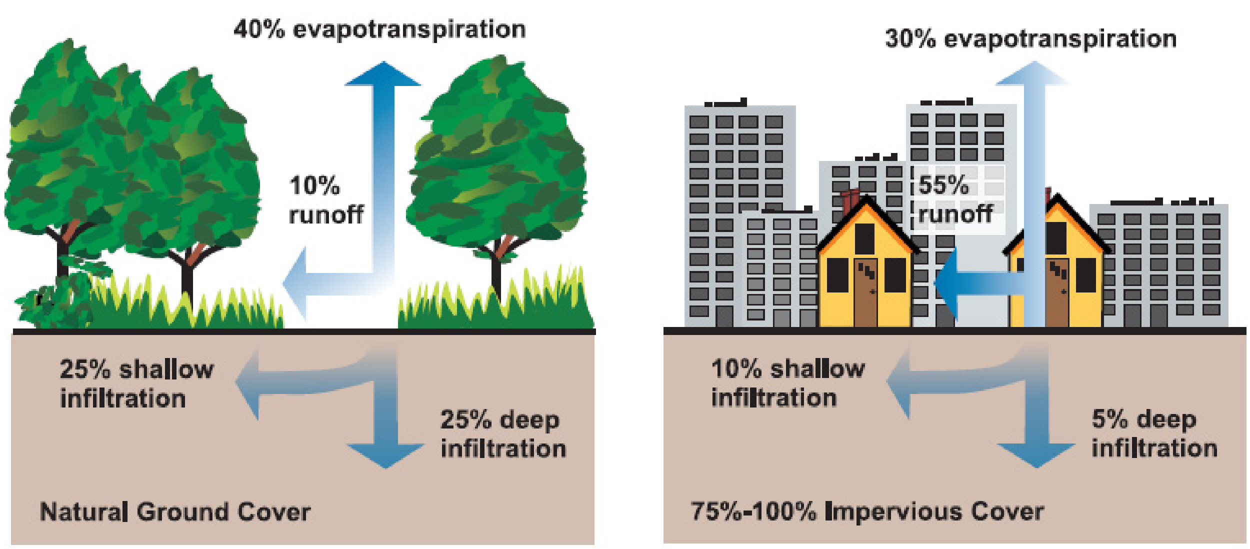
Source: States at Risk, 2014

Based on the recent scientific evidence, it is very likely that the "frequency, intensity, and/or amount of heavy precipitation will continue to escalate through the 21st century" (IPCC, 2014). In North Carolina, annual precipitation is projected to increase, especially in the winter and spring, by as much as 6% (NC ILT, 2012; Frankson et al. 2017). This could mean more stormwater runoff and flooding throughout the

Piedmont Triad. Climate Central, an independent organization of leading scientists and journalists, estimates that inland flooding could increase by as much as 20-40% in North Carolina by 2050. Similarly, flood severity is anticipated to increase by around 30% in North Carolina by 2050 (States at Risk, 2014).

However, it is not just the amount of rainfall that determines the risk of inland flooding. Soil composition, topography, land use and land cover also influence how much water runs off into nearby water bodies. Impervious surfaces such as roads, parking lots, and buildings prevent water from being absorbed back into the ground, which results in higher amounts of stormwater runoff and greater flood risks in urban areas. The amount of people living within the floodplain is another important factor to consider when evaluating the risks associated with heavier precipitation.

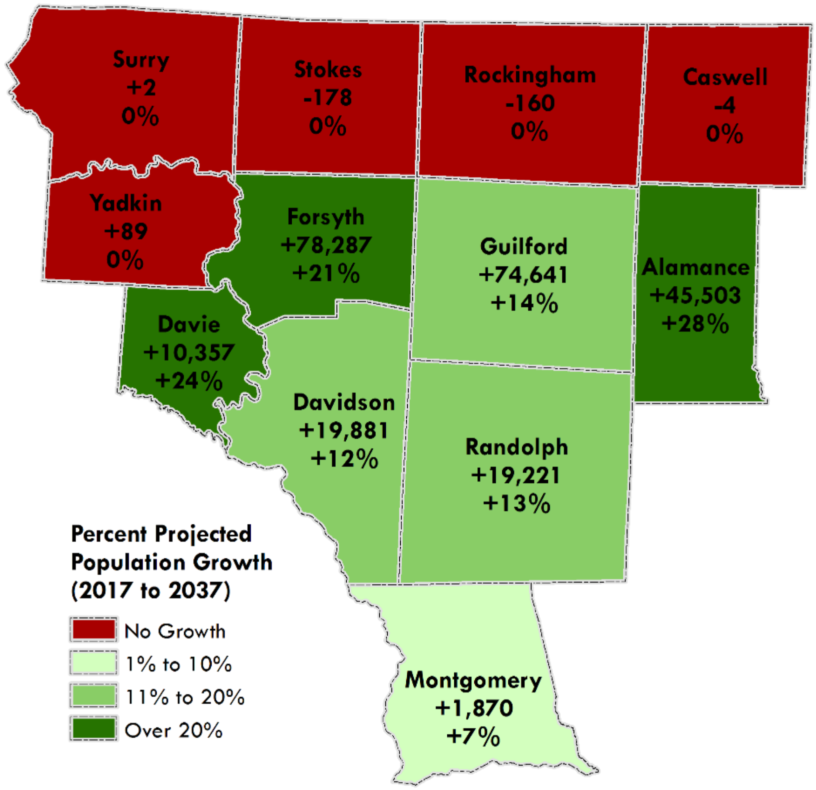
Figure 25: Relationship Between Impervious Cover and Stormwater Runoff



Source: FISWRG, 1998

Between 2017 and 2037 the Piedmont Triad region is expected to gain around 250,000 new residents, an increase of 14.6% from the current population (N.C. Office of State Budget & Management, 2017). Historically, population growth has not been equally distributed across the region. Urban areas throughout the Piedmont Triad have typically seen the fastest rates of growth, while rural counties have experienced more modest growth rates. This trend is expected to continue as more and more people move to the region. However, as urban development increases, so do the risks of flooding. The region will need to seek innovative development strategies to help mitigate the compounding impacts of more frequent and intense precipitation and urban expansion.

Figure 26: Map of Projected Population Growth in the Piedmont Triad



Source: N.C. Office of State Budget & Management, 2017

Potential Impacts

Property Damage

More frequent and intense precipitation and flooding could have a variety of impacts on the Piedmont Triad. One of the most significant impacts associated with heavy precipitation and flooding is damage to property and infrastructure, especially in low lying areas. The Federal Emergency Management Agency (FEMA) reports that each year approximately 90% of all disaster-related property damage results from flooding, averaging $3.5 billion in total costs per year (Rogers, 2006). While the Piedmont Triad does not face the same level of threats as coastal communities, it has over 2,000 streams, rivers, lakes, and other water bodies that pose risks from flooding due to excessive rainfall or snowmelt.

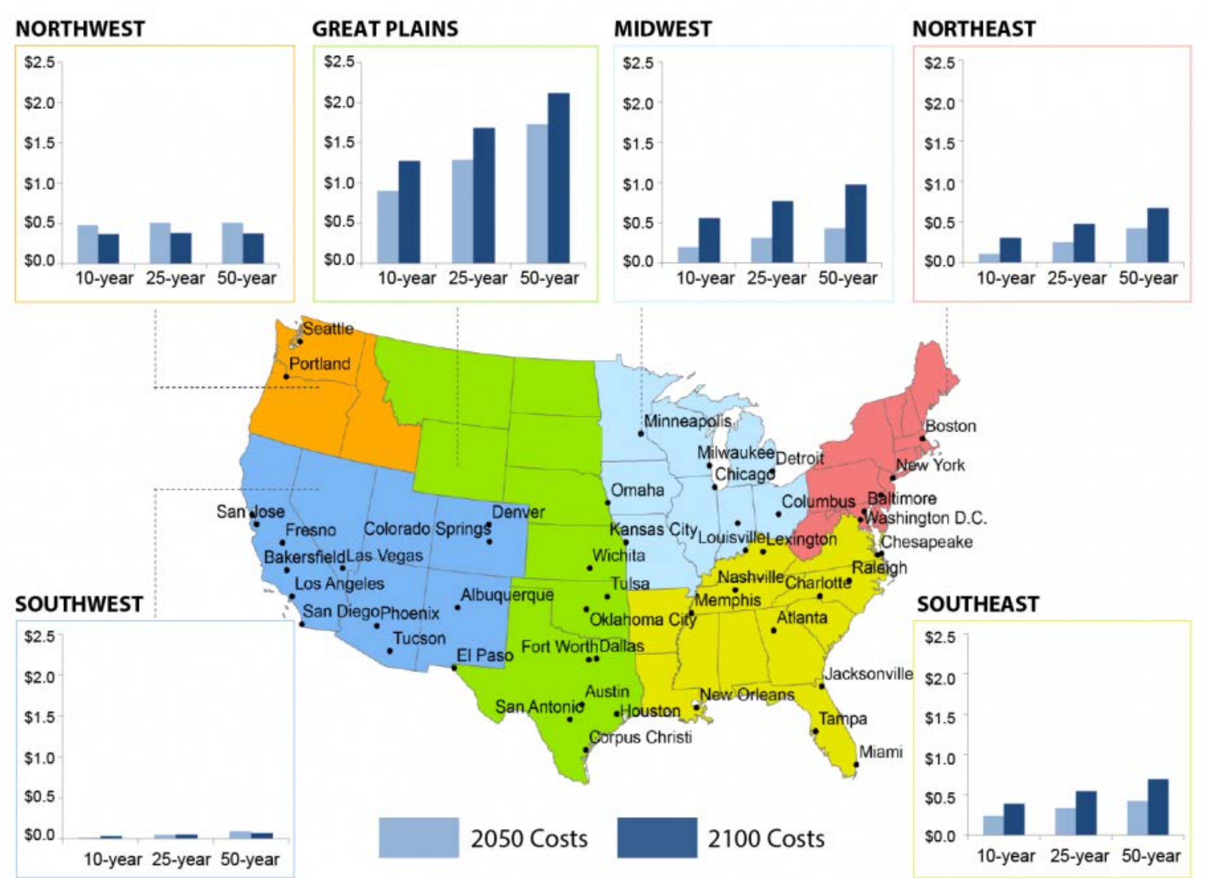
Insurance

As weather patterns continue to shift, more frequent and intense precipitation will establish a new norm in which there is a greater overall risk of flooding. This could not only mean more people are at risk from floods, but it could also increase the costs of flood insurance. According to a 2013 study that evaluated FEMA's National Flood Insurance Program (NFIP), floodplain depths and areas are anticipated to increase by an average of 40% by the year 2100 (AECOM, 2013). This would result in an increase in the overall number of NFIP policies by 80-100%, and an increase in average costs by approximately 50-90% by the year 2100 (AECOM, 2013). Such a demand increase could devastate an already overstretched flood insurance program. The NFIP currently owes close to $25 billion as a result of borrowing from the U.S. Treasury to cover damage claims (Haymon, 2017). Many suggest that this is because property owners do not currently bear the full cost of flood risks, which encourages people to rebuild in hazardous areas. A large proportion of flood-risk maps are also outdated and do not reflect the ever-increasing risks from changing weather patterns.

Infrastructure

Most of the infrastructure that we rely on for transportation, water, and other public services have been designed to withstand a certain level of a flood event. For example, stormwater conveyance systems are typically designed to bear a 10-year storm, while bridges or culverts are often designed to withstand a 50 to a 100-year storm. More intense rainfall events could produce higher flood heights that could overload stormwater systems, water or wastewater treatment facilities, as well as inundate roads, bridges, and rail lines, disrupting the mobility of people and goods. Emergency access can also be impeded, creating threats to human safety if transportation corridors become unnavigable. This problem is exacerbated by the fact that many areas of the Piedmont Triad have aging infrastructure and limited budgets for replacements and upgrades. However, there could be substantial costs, if local governments do not begin taking the steps necessary to proactively address these concerns. The U.S. EPA evaluated 50 cities within the U.S. and estimated that climate change could increase the costs to upgrade urban drainage infrastructure by as much as $700,000 (U.S. EPA, 2015).

Figure 27: Projected Costs of Unmitigated Climate Change on U.S. Drainage Systems



Source: U.S. EPA, 2015

If rain events are strong enough, they can also cause dams and flood control structures to overtop or fail. Many of the reservoirs throughout the Piedmont Triad serve as sources of municipal drinking water. Damage to intake structures or dams could produce a cascading series of damaging impacts, including a loss of drinking water, public health risks, or additional flooding downstream.

Agriculture & Forestry

It is not just the built environment that can be impacted by stormwater and flooding, but agriculture and forestry as well. In agriculture and forestry, increased soil erosion may occur as a result of more frequent heavy rainfall events. Crop productivity may decrease as a result of more frequent flooding of fields and delays to planting and harvesting. Forest productivity could also be affected because flooding affects trees at every stage of their development, from seed germination and flowering to sprouting and vegetative growth.

Figure 28: Runoff Leads to Soil Erosion

Source: Hatfield, 2014

Water Quality

Increased storm intensity and frequency may also have a negative impact on local water quality. Intense storms can erode streambanks and other exposed surfaces, loading waterways with excess sediment. Too much sediment can harm aquatic life and habitat, as well as clog drainage ditches, stream channels, and water intakes and reservoirs. Sediment is already one of the leading causes of water quality impairment in the Piedmont Triad. If storms continue to intensify, it could exacerbate water quality issues.

Stormwater can also carry a variety of other nutrients and contaminants into nearby streams, rivers, and reservoirs. Nutrients, such as nitrogen and phosphorus, stimulate algae and plant growth. In excess, these nutrients can cause algal blooms and eutrophication, which negatively impacts fish and other aquatic species. Litter and debris can also be picked up during heavy rains, which if left unmanaged can further pollute water resources and clog drainage systems.

Figure 29: How Stormwater Runoff Transports Pollutants

Source: Heal Our Waterways, 2018

More frequent overflows of wastewater systems, such as sewage systems, toxic waste facilities, or livestock waste lagoons are another potential concern. Intense rainfall over an extended length of time can quickly overload wastewater systems, especially if there are cracks in underground pipes or faulty covers or connections. This can cause untreated waste to be directly released into drinking water sources.

Figure 30: Sewer Overflow

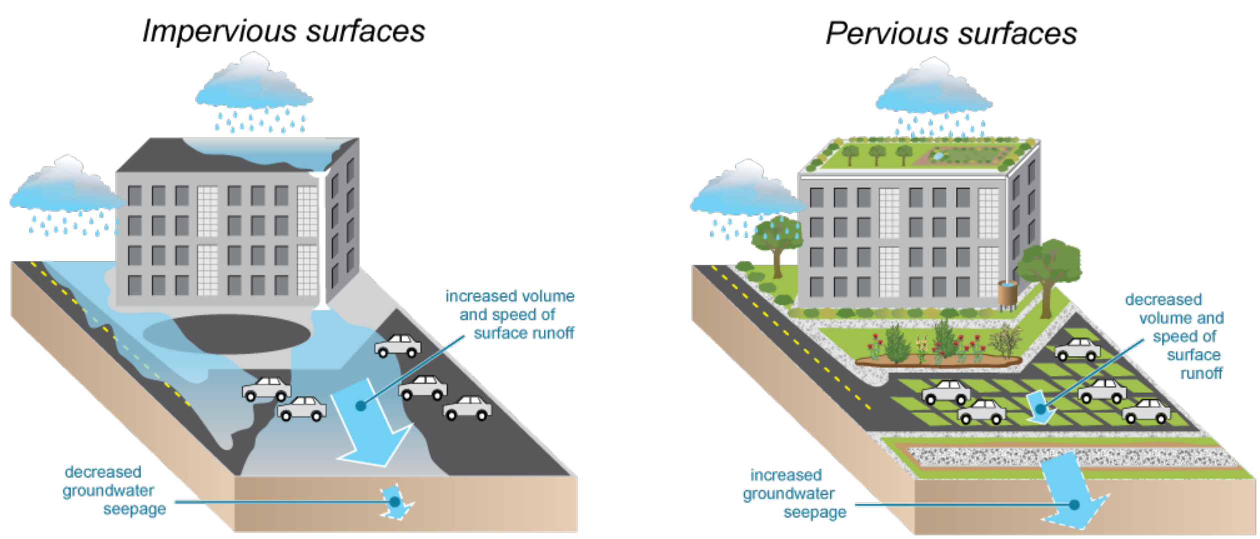
Source: Doremus, 2016

Adaptation Strategies

Modify Land Use

One strategy local governments can use to help mitigate climate change and reduce stormwater and flood risks is to increase the amount of green space in their community. Impervious surfaces, such as roads, buildings, and parking lots prevent water from being absorbed into the ground, which can compound stormwater issues and flooding. In contrast, naturally vegetated areas help retain and absorb water, reducing overall stormwater loads and flood risks. Trees and other vegetation also help remove carbon dioxide from the atmosphere, which is one of the primary causes of recent climate shifts.

Figure 31: Impervious Surfaces vs Pervious Surfaces



Source: Chesapeake and Atlantic Coastal Bays Trust Fund, 2013

Communities can increase green space in a variety of different ways – by increasing the amount of parks, trails, vegetated buffers, or conservation land, by incorporating street trees and other vegetation into urban areas, or by requiring stormwater control measures or best management practices. Best management practices are structural, vegetative, or managerial practices used to treat, prevent, and/or reduce stormwater and water pollution. By developing policies that prioritize green space, local governments can improve opportunities for stormwater retention and help mitigate stormwater or flooding impacts from climate change.

Integrate Climate Projections into Capital Improvements

Another way local governments can better prepare to address climate-related drainage issues is to begin integrating climate projections into capital improvement plans and projects. It is clear that precipitation throughout the Piedmont Triad will become more varied and intensify over the upcoming century, leading to more stormwater runoff and higher flood risks. However, not all communities are recognizing this threat and incorporating new knowledge into infrastructure improvements and their prioritization process. Local governments may save money in the long-term by making strategic investments now, rather than waiting until the local climate patterns have changed even further. There are a variety of tools that engineers have already begun using to incorporate climate predictions into projects, such as the U.S. EPA's Storm Water Management Model – Climate Adjustment Tool (SWMM-CAT, which can help weigh the costs or benefits of making infrastructure improvements to address climate projections.