

# RESILIENT WILMINGTON

PREPARING TODAY FOR TOMORROW'S CLIMATE RISKS





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Normal conditions along South Park Drive by the Brandywine River Raceway.



Flooding along South Park Drive by the Brandywine River Raceway.



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# FOREWORD



**Kelly A. Williams**

Commissioner  
Department of  
Public Works  
City of Wilmington

Weather conditions, including rain, tidal flooding, and extreme heat, are already impacting Wilmington residents. These events will continue to occur, and likely worsen, as the climate changes. The City of Wilmington launched Resilient Wilmington to help Wilmington plan for the impacts of climate change to its infrastructure and build a resilient future for its residents.

As the largest city in the State of Delaware, home to over 70,000 residents and the I-95, I-495 and Amtrak Corridor, Wilmington is an important city for Delaware and the region. At the same time, a significant portion of the City already resides within the 100-year floodplain including the Port of Wilmington, the Southbridge neighborhood, 7th Street Peninsula, and portions of Riverside, and Price's Run, with the floodplain expanding as sea levels rise. All of the City will feel the impacts of rising temperatures and changes in rainfall patterns related to climate change.

To respond to these climate risks, the City must assess its current and future risk from climate change, work with partners to develop recommendations in the near-, mid-, and long-term to mitigate and prepare for the effects to both residents and infrastructure, and begin to integrate climate resilience into applicable planning and capital expenditure mechanisms within the City.

The Resilient Wilmington Study builds on the great work already being done by the City and regional partners to mitigate and prepare for climate change, while also recognizing that additional planning and resources are needed to ensure that Wilmington has a resilient, prosperous, and equitable future. Together, we can take steps towards the following visions:

## **Vision 1:**

To incentivize and encourage smart and resilient economic growth for the City of Wilmington.

## **Vision 2:**

To ensure sewer and stormwater infrastructure can provide the same level of service in the future as it does today through both traditional and innovative green solutions.

## **Vision 3:**

To develop a transportation system with a smaller footprint on the environment while also protecting infrastructure from the risks posed by climate change.

## **Vision 4:**

Work with City Partners to connect residents to resources to stay safe from the risk posed by climate change.

By starting today and taking incremental steps towards this vision, we can ensure that Wilmington is a more resilient city for generations to come.

*Kelly A. Williams*



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# ACRONYMS

BFE	Base Flood Elevation
DELDOT	Delaware Department of Transportation
DHSS	Delaware Health and Social Services
DNREC	Delaware Natural Resources and Environmental Control
DPW	Department of Public Works
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
GHG	Greenhouse Gas Emissions
GI	Green Infrastructure
MHHW	Mean Higher High Water
NFIP	National Flood Insurance Program
UHI	Urban Heat Island
USDA	U.S. Department of Agriculture
SEPTA	Southeastern Pennsylvania Transportation Authority
SLR	Sea Level Rise
WILMAPCO	Wilmington Area Planning Council



# WHY WILMINGTON?

Wilmington, located about 30 miles south of Philadelphia and 100 miles north of Washington, D.C., is the largest and most populated city in Delaware. Located at the confluence of the Brandywine and Christina Rivers, the proximity to water has long been an economic driver for the city, both historically as an industrial waterfront and recently as a mixed-use cultural and entertainment district.

Climate change creates a new set of challenges. Sea level rise, worsening floods, rising temperatures, and changing precipitation threaten to inundate low-lying neighborhoods and overwhelm drainage infrastructure. Wilmington's vulnerability to climate change is already apparent by the increase in number of flooding events in recent years caused by heavier rainfall and higher tides.

To address these challenges, the City of Wilmington needs to **build resilience**. Taking action now will allow the City to leverage resilience measures to not only address vulnerabilities, but also drive economic growth.

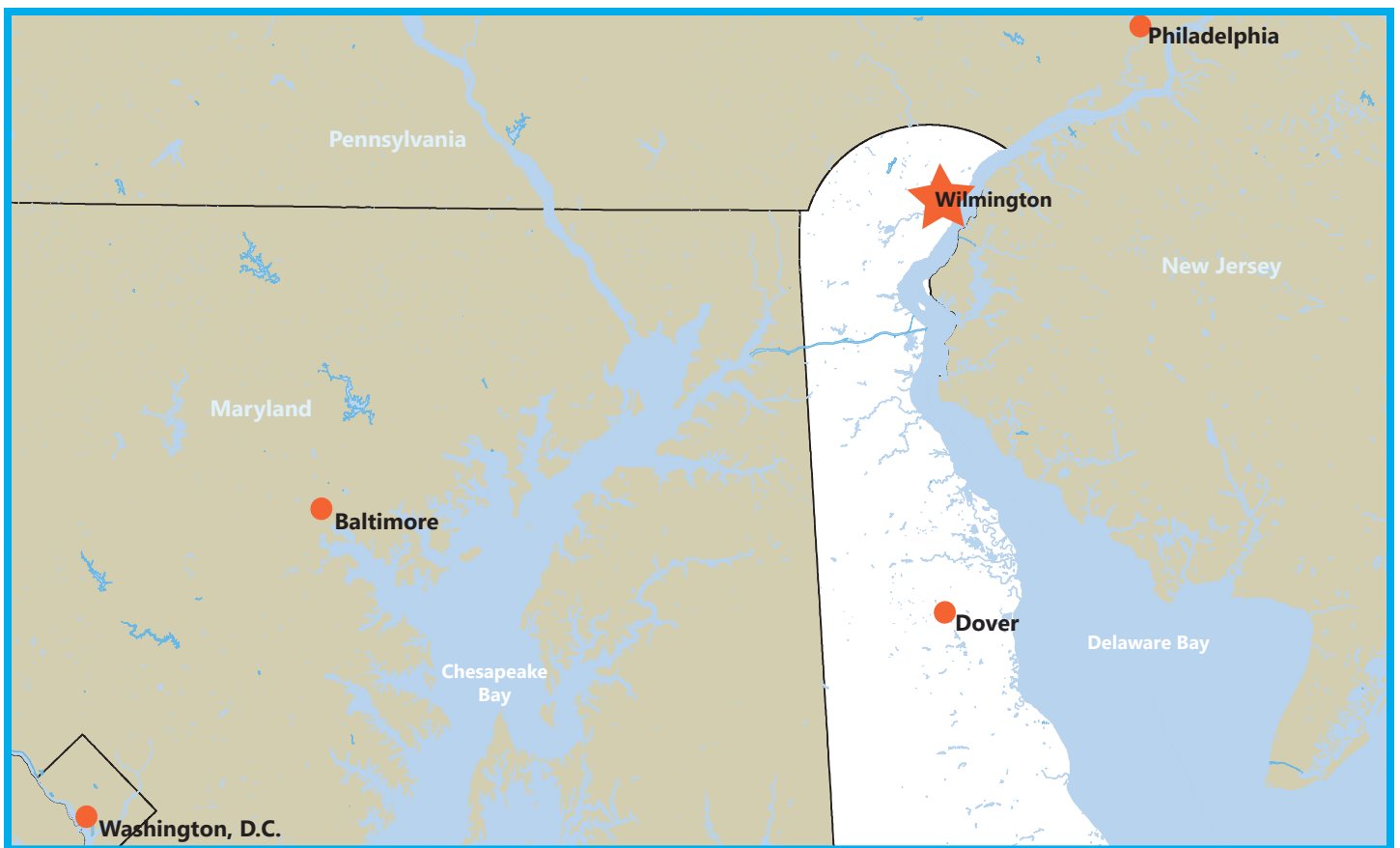
## GOALS OF THE STUDY

The City of Wilmington Department of Public Works, in collaboration with city agencies, the Department of Natural Resources and Environmental Control (DNREC), regional planning groups, non-profit, academic and environmental organizations, are conducting the Resilient Wilmington Study ("the Study"). The Study, which is informed by the best available climate science aims to:

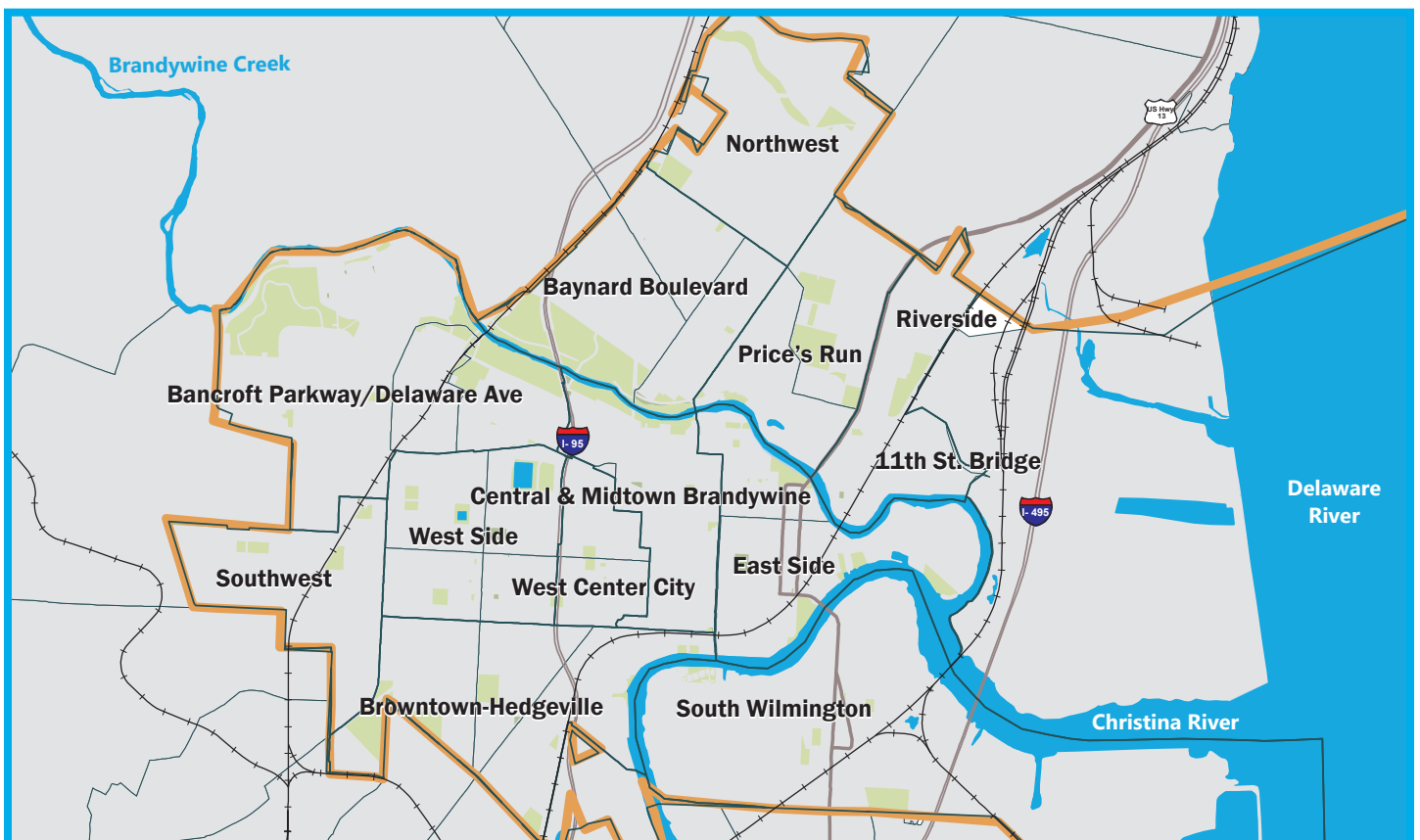
1. Assess Wilmington's current and future risk from climate change;
2. Develop recommendations to mitigate and prepare for the effects of climate change for different focus areas, including transportation, waterfront development, sewer and stormwater infrastructure, and public health and safety;
3. Engage a robust group of stakeholders to guide the development of recommendations; and,
4. Integrate climate resilience into applicable planning and capital expenditure mechanisms within the City.

## WHAT IS RESILIENCE?

Resilience is the ability of systems and individuals to **adapt to and withstand future shocks and stresses**. It will mean modifying physical structures and embedding neighborhoods with the capacity to turn challenges into opportunities.



Context map showing Wilmington, Delaware in relation to nearby major cities.



Neighborhood map of Wilmington, Delaware.



# **WHAT IS CLIMATE CHANGE?**

# CLIMATE CHANGE FACTORS



Flooding in Wilmington, DE.

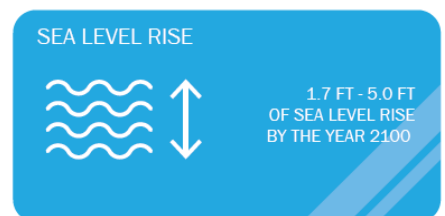
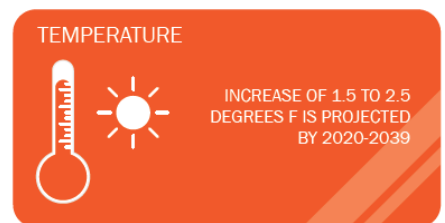
Climate change is the long-term transformation in normal weather patterns currently occurring throughout the world as a result of global warming. In the last century alone, the Earth has warmed by an average of 2-degrees Fahrenheit (F).<sup>i</sup> As the planet continues to warm, more extreme and unpredictable weather is likely to occur.

Global warming is largely attributed to increased levels of carbon dioxide in the atmosphere produced by using fossil fuels. Fossil fuels, like oil, coal and natural gas, release greenhouses gases (GHGs) when they are burned, which absorb infrared radiation and gradually warm the Earth's atmosphere and surface. At the same time,

deforestation is another contributor, as forests absorb massive quantities of carbon dioxide and release oxygen into the air. The destruction of forests means that there are fewer trees to absorb GHGs and release oxygen.

As global warming continues, Wilmington will experience significant changes in its climate over the coming years.

The following section discusses in greater detail how climate changes will likely impact Wilmington – including rising temperatures, changes in precipitation patterns, rising sea levels, and flooding from both acute and chronic storm events.





## TEMPERATURES CLIMBING

Delaware is tied with Arizona as the fourth-fastest warming state in the United States based on temperature trends since 1970, and is expected to warm another 1.5 to 2.5 degrees F by 2020 - 2039.<sup>ii</sup> As the region continues to warm, so will the frequency of heat waves and “dangerously hot days,” defined as days with a heat index above 105 F.<sup>iii</sup> Wilmington has already experienced an increase of almost 3 more calendar days above 90 F since 1970, and dangerously hot days are anticipated to increase from 5-6 days in 2017 to 22-48 days in 2100.

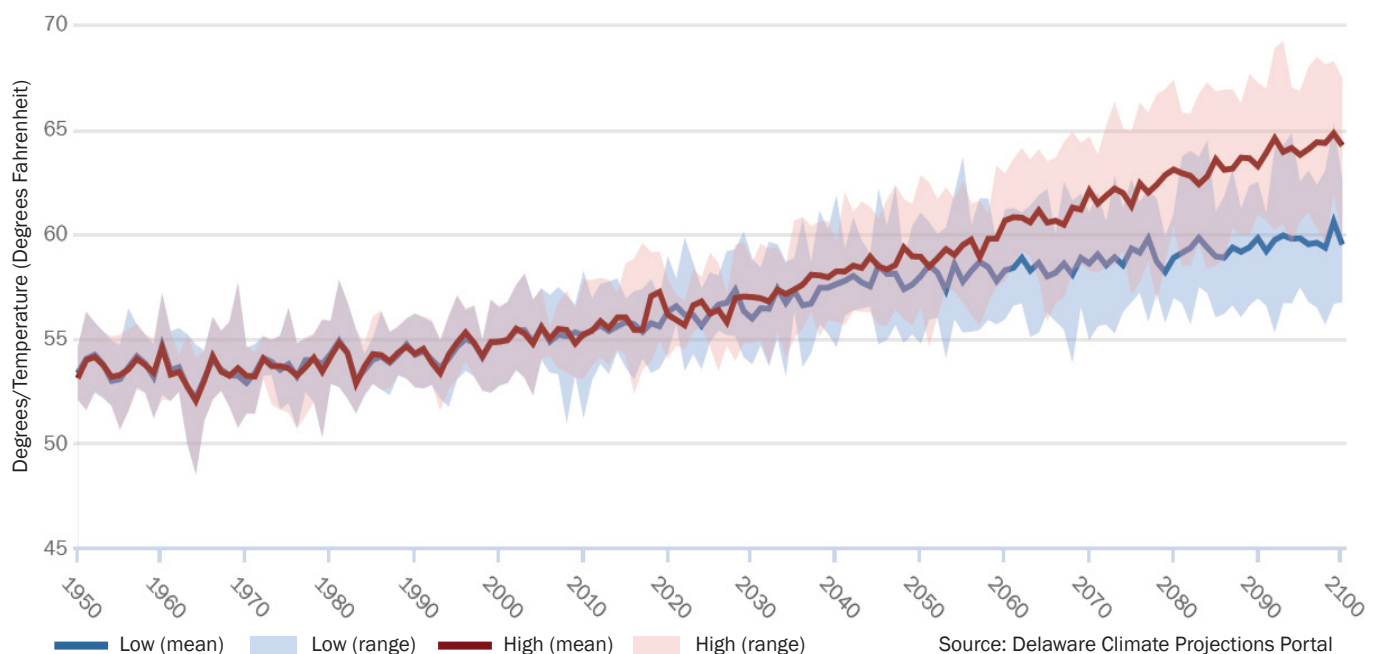
### URBAN HEAT ISLAND AND ITS EFFECTS

As temperatures increase, the effects of Urban Heat Island (UHI), or the “relative warmth of a city compared with surrounding rural areas” are expected to intensify.<sup>iv</sup> UHI occurs when a city experiences higher temperatures due to the characteristics of urban development, such as sidewalks, streets, parking lots, and tall buildings absorbing more heat than a rural area’s grass, trees and farmland.<sup>v</sup> Buildings, transportation, and people also produce energy, which creates heat, contributing to the UHI.

A UHI’s excessive heat can impact quality of life, resulting in heat-related illnesses and an increased energy demand will lead to greater emissions, thereby worsening air quality.<sup>v</sup>

Wilmington is particularly susceptible to UHI effects as it is approximately 60 percent impervious surfaces and has a tree canopy of just slightly greater than 20 percent.

### Average Temperatures in Wilmington (Wilmington Forter Station)



Graph showing **average temperature** increases in Wilmington from 1950 projected out to 2100

## CHANGING PRECIPITATION

Over the last few decades, Delaware has experienced minimal change in observed precipitation totals. The impact climate change will have on precipitation varies. However, looking forward, annual average precipitation in Delaware is expected to increase 10 percent by the end of the century, and seasonal precipitation changes are predicted to see the largest increase in winter.<sup>vi</sup>

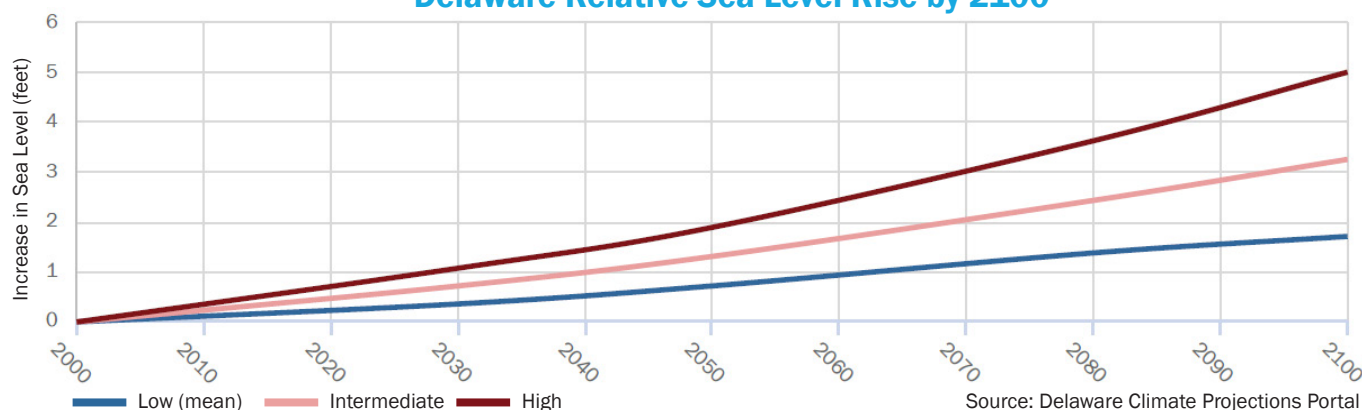
While precipitation totals have not varied significantly over the last few decades, climate change may alter the frequency, intensity, and duration of rainfall events.

As part of this study, a statistical analysis was completed based on the last seven years of rainfall data (2012-2018). The findings suggest that shorter duration intensities

happen more often than longer duration intensities. Less frequent rainfall events, like a rainfall that has a 10 percent chance of occurring in any given year, occurred three times in the last seven years.<sup>vii</sup>

Should storms become more intense, localized flooding may result as drainage infrastructure may be unable to convey peak flows.

## Delaware Relative Sea Level Rise by 2100



Graph showing low, intermediate, and high [sea level rise projections](#) through 2100 from DNREC.

## RISING SEA LEVELS

DNREC's Coastal Program has projected 1.7 - 5.0 feet of SLR by the year 2100. In addition to Delaware's low-lying topography, the state is experiencing land subsidence, or sinking. The present-day rate of land subsidence is 1.5 mm/yr to 3 mm/yr, the highest on the Atlantic Coast. (CITE) Together, low-lying topography and land subsidence make Delaware more vulnerable to SLR. Flooding exacerbated by SLR has the potential to inundate homes and businesses in Wilmington more frequently over time, particularly in low-lying neighborhoods.

### NUISANCE FLOODING AND SEVERE STORMS

Nuisance flooding, also called sunny day flooding or high tide flooding, is defined by the National Oceanic and Atmospheric Administration (NOAA) as flooding that leads to public inconveniences such as road closures, overwhelmed storm drains, and deterioration of public infrastructure such as roads. High tide flooding is becoming increasingly common as sea levels rise and land subsides in communities like Wilmington.

With just half a foot of increase in SLR, which could happen by the 2030s, areas, such as South Wilmington or 7th Street Peninsula, could experience more frequent

flooding events caused by high tides. SLR of 5 feet could result in over 10 percent of the City being inundated from the Christina and Brandywine Rivers during sunny day conditions. Sewer infrastructure may be impacted by SLR, exacerbating the flooding in low-lying areas.<sup>Viii</sup>

A large portion of Wilmington is already located within the floodplain, or the area that can expect to experience flooding during the 100-year event (defined in greater detail on the following page). According to the 2015 Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map, there are about 600 buildings in the 1-percent annual chance floodplain. In the 0.2-percent annual chance floodplain, there are about 1,000 buildings. With SLR, both the 1-percent and 0.2-percent floodplain will expand in height and geography.

### RISING WATER TABLE

Delaware as a whole has a relatively high ground water table, largely due to the flatness of the land. Rising sea levels can cause the water table to rise in elevation, negatively impacting buried infrastructure, limiting the soil's ability to absorb precipitation during storm events, and impacting the salinity of groundwater.

SLR will increase groundwater levels in Wilmington, most notably in areas near the Christina and Brandywine Rivers. This rise in water table may lead to problems with underground infrastructure, such as pipes and buried cables, as well as basement flooding. This rise in water table is also a challenge when it rains, as there is less capacity in the soil to absorb rainwater. This can lead to more frequent flooding.

Groundwater is also an important natural resource for Delaware, supplying both water for irrigation and public water supply. SLR may increase the salinity of groundwater, which can be harmful to many plants and animals, damaging ecosystems.



# HOW WILL CLIMATE CHANGE IMPACT WILMINGTON?



Development [along the Christina River](#).

To evaluate how climate change will impact Wilmington, specific planning scenarios and focus areas were selected.

The planning scenarios, presented on the next page, were selected in coordination with the City of Wilmington, DNREC, and the University of Delaware. The scenarios represent a variety of storm conditions that are likely to happen today and in the future.

Four focus areas - waterfront development, sewer and stormwater infrastructure, transportation, and public health – were also selected, as they represent a variety of resources that are critical to the future vitality of Wilmington.

Together, these planning scenarios and focus areas represent the foundation of the vulnerability analysis completed as part of the Resilient Wilmington Study.

Desktop analyses, as well as hydrologic and hydraulic modeling, were conducted to understand how changes in rainfall and SLR will impact flooding and infrastructure in Wilmington. A qualitative analysis on the overall impact that rising temperatures and extreme heat will have on the City was also completed.

# PLANNING SCENARIOS

## MEAN HIGHER HIGH WATER (MHHW) + 3 FEET

This planning scenario was selected as it represents near-term future conditions with a higher probability of occurrence. These include: mid-century SLR projections under sunny day conditions, small tidal storm events under future SLR conditions, or a coastal storm event under present day sea levels, like a Nor'easter, a common storm in Delaware.

## MEAN HIGHER HIGH WATER (MHHW) + 6 FEET

This planning scenario was selected as it represents long-term future conditions, as well as coastal storm events with a lower probability of occurrence. These include: end-of-century SLR projects under sunny day conditions, mid-century SLR projections coupled with a coastal storm event, like a Nor'easter, or less frequent storm events, such as tropical storms under present day sea levels.

## 1-PERCENT ANNUAL CHANCE FLOODPLAIN

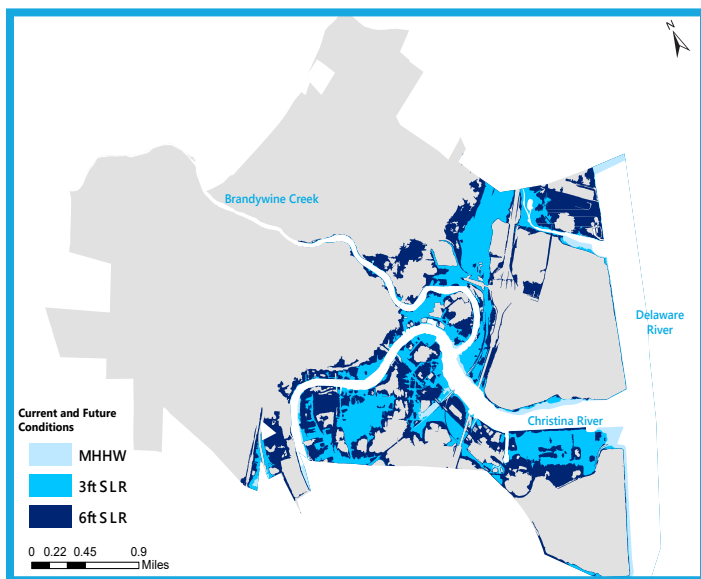
This planning scenario represents a storm that, in any given year, has a 1-percent chance of occurrence. This scenario was selected as it is the regulatory requirement mandated by FEMA for the elevation or floodproofing of structures. The Base Flood Elevation (BFE) is the height of flooding expected during the 1-percent annual chance flood. As new buildings are constructed in the floodplain, or the area that can expect to see inundation during the 1-percent annual chance floodplain, it is a requirement by the City to elevate the lowest floor to or above base flood elevation plus 18 inches. The relationship between the BFE and a structure's elevation determines the flood insurance premium on a building.

## 0.2-PERCENT ANNUAL CHANCE FLOODPLAIN

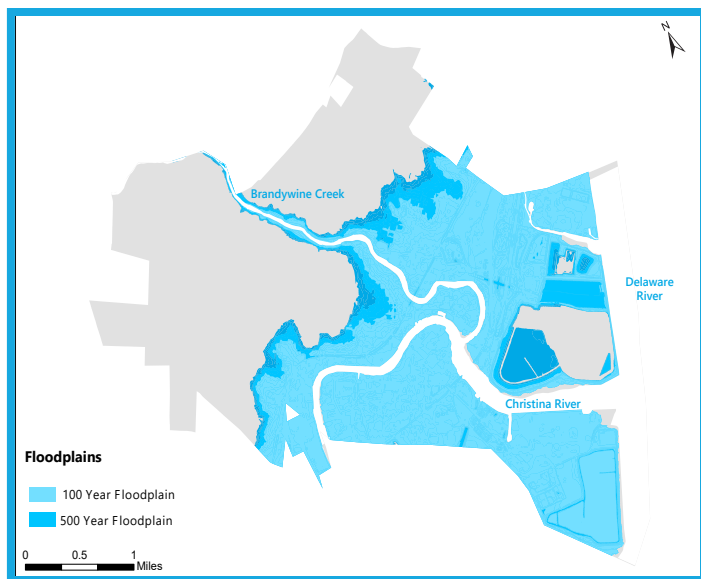
This planning scenario represents a storm that, in any given year, has a 0.2-percent chance of occurrence. This scenario was selected as it is the regulatory requirement mandated by FEMA for the elevation or floodproofing of structures that are considered critical facilities, such as hospitals. As new buildings are constructed in the floodplain, or the area that can expect to see inundation during the 0.2-percent annual chance floodplain, it is a requirement by the City to elevate the lowest floor to or above base flood elevation plus 18 inches.

## WHAT IS A PLANNING SCENARIO?

According to the American Planning Association, scenario planning is a process for preparing for unknown conditions. Planning scenarios allow a City to evaluate a number of potential future conditions and respond in the most resilient way. The four scenarios used in this study were chosen by looking at current conditions and future projections.



Current **MHHW levels** in Wilmington and projected 3ft and 6ft SLR



Current 100-year and 500-year **FEMA floodplains**



# WHAT DOES IT MEAN TO BE RESILIENT?

# MOVING AWAY FROM THE NORM

The City of Wilmington has started taking steps towards a more resilient future by integrating resilience into many planning projects currently underway, such as the Wilmington 2028 Comprehensive Plan, and addressing flooding in vulnerable communities, such as the South Wilmington Wetland Park. A map of a few of the key initiatives and projects underway is shown below.

However, to keep up with the pace at which the climate is changing and prepare for the effects that infrastructure and communities will experience, additional action is needed to identify assets and resources at risk, as well as prescribe incremental recommendations to ensure that Wilmington has a resilient, prosperous, and equitable future.

The following sections outline the impact climate change is currently having on each focus area – waterfront development, sewer and stormwater infrastructure, transportation, and public health and safety – as well as the latest science on what will happen as our climate continues to change. An overview of the strategies Wilmington can employ to mitigate the impacts are also presented.

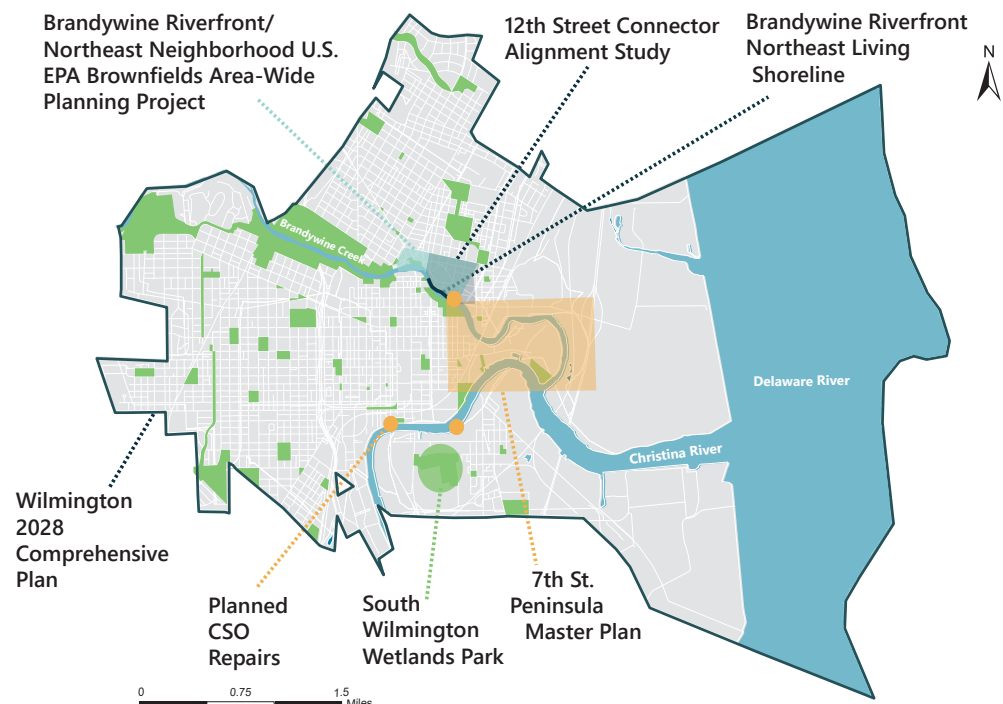
## STEERING COMMITTEE AND FOCUS AREA CHAMPIONS

From kick-off to completion, the Resilient Wilmington Study was informed and guided by the Study's Steering Committee, which included both city and state agencies. For each focus area, specific organizations ("champions") who

could provide additional guidance and feedback were also consulted. These champions include local advocacy groups, academic partners, and community voices. The feedback received from Steering Committee members and

Focus Area champions shaped the questions that drove the study as well as the strategies and recommendations put forth in the following sections.

## SELECT PROJECTS



# WATERFRONT DEVELOPMENT



Once a heavily polluted, industrial area, Wilmington's riverfront has been the focus of recent revitalization efforts, offering waterfront access, housing, new employment opportunities, economic activity, and recreation, while staying true to its industrial history. Guided by the Riverfront Development Corporation of Delaware (RDC), the Christina River has seen an impressive rebirth, transforming abandoned warehouses and contaminated landscapes into employment centers, restaurants, and retail shops, anchored by a beautiful shoreline and open space for activities.

The RDC and the City are currently planning for future phases of riverfront development, with an abundance of property ready for development. If not adequately

planned for, flooding and climate change could pose a major challenge to the future of waterfront development in Wilmington.

## IMPACT OF CLIMATE CHANGE

Addressing the risks posed by climate change, particularly extreme storms and SLR, is critical to ensuring the ongoing viability of waterfront development in Wilmington. Without further action, SLR will inundate existing development along the riverfront under sunny day conditions, putting existing residents and businesses at risk.

SLR will also increase the size of the floodplain, putting new areas at risk for flooding during extreme storm events. Floodplain maps do not incorporate flooding from urban drainage systems being

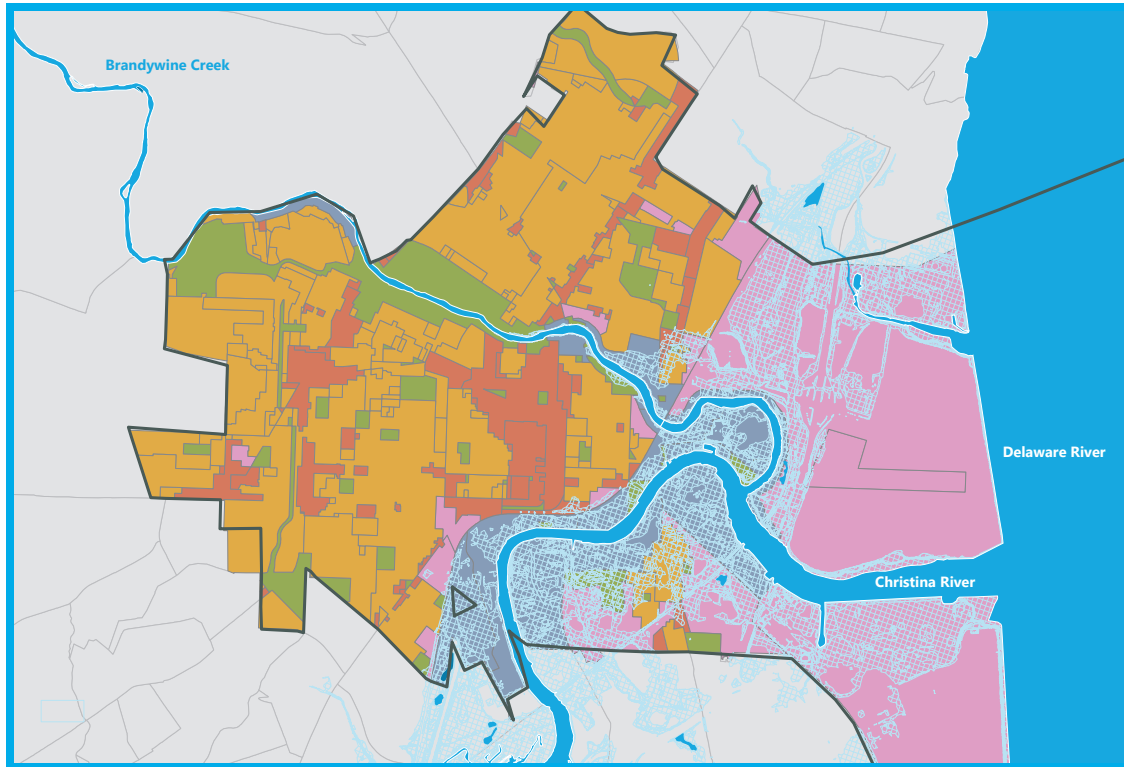
overwhelmed by large rainfall events, meaning the impact from climate change may be even greater in these areas. Research suggest that flood risks and climate change can have significant impacts on property values, thereby reducing the city's tax revenue. \$582 million dollars of property is vulnerable to SLR in New Castle County, according to the University of Delaware.<sup>xiv</sup>

In addition to the burgeoning riverfront district, Wilmington's waterfront is historically home to many manufacturing and industrial areas. Special focus must be placed on emergency management and managing hazardous materials in these areas in order to preserve jobs, ensure industries function as expected, and to avoid environmental damage.

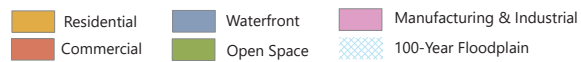




## CURRENT ZONING DESIGNATIONS AND THE CURRENT FLOODPLAIN

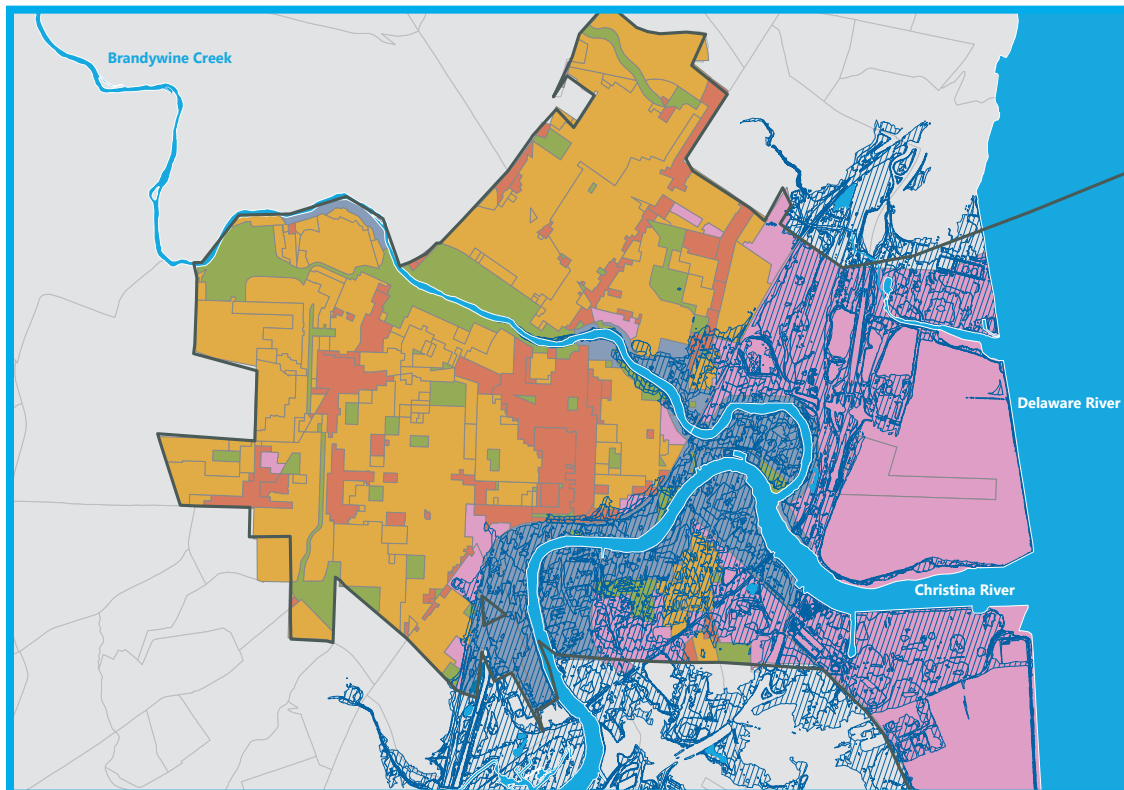


**Zoning in 100-Year Floodplain**

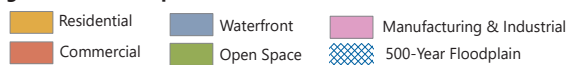


0 0.5 1 Miles

Current zoning designations in Wilmington within the 100-year floodplain.



**Zoning 500-Year Floodplain**



0 0.5 1 Miles

Current zoning designations in Wilmington within the 500-year floodplain.





# IMPACT ON CLIMATE CHANGE

In addition to the risks posed to property and future development by climate change; buildings also contribute significantly to greenhouse gas emissions. Buildings can have harmful environmental impacts due to their:

- Reliance on large amounts of energy to function
- Overuse of water
- Vast areas of impervious, non-reflective surfaces

Buildings consume vast amounts of electricity. In the United States, buildings are responsible for 70% of electricity usage and greenhouse gas emissions.<sup>xv</sup> Buildings account for 39% of carbon dioxide emissions in the United States, largely due to their lighting, heating, and cooling demands.<sup>xvi</sup>

As development continues, buildings will continue to consume large amounts of energy unless efforts are made to reduce the negative environmental impacts of buildings by adopting green building practices and energy-saving technologies.



SouthBridge Solar Park is a [1.15 megawatt solar farm](#) that provides clean, renewable energy to housing authority residents and saves the Wilmington Housing Authority \$1.2 million.<sup>xvii</sup> Photo Credit: City of Wilmington.



[Green roof](#) of the Christina Crescent Building, designed with a focus on environmental sustainability. Photo Credit: Rooflite.





# WHAT CAN WILMINGTON DO?

Wilmington can respond to climate change by adapting standards to minimize the risk of flooding and damage to current buildings and future development while simultaneously limiting its GHG emissions.

Action will need to be taken on both a large, city-wide scale and on a small, neighborhood-wide scale. This begins with land use planning that takes into account SLR scenarios. Site-scale measures like shoreline protection to defend against storm surge and increase land elevation can be implemented. Building-scale measures, like dry floodproofing, emergency power and pumps, and protection of mechanical systems can offer further risk reduction.

Neighborhood level adaptation plans and site-specific resilience measures will strengthen Wilmington's overall resilience by building on community networks to strengthen ties and commitments.

Adopting the actions mentioned above will allow the city to support economic growth while encouraging smart, resilient development.

## ADAPTATION

Adaptation is action that can be taken to adjust to new or emerging conditions such as sea level rise in order to minimize the consequences of climate change.

The 2028 Wilmington Comprehensive Plan, the City's next major planning effort, and other planning efforts must specifically acknowledge the need for resiliency in the planning, design, and construction of development.

## UPDATING STANDARDS

The current Waterfront Development Standards provide guidance for development along most of the waterfront, but they do not account for resiliency considerations. The standards can be adapted to incorporate resilience into future development and ensure a more resilient waterfront. Updates to zoning and building codes are essential to adaptation efforts. By requiring larger setbacks from flood-prone areas, higher elevations, and the raising of mechanical systems, the city can reduce the risk to development. Zoning can be updated to make sure buildings are able to incorporate stricter code standards in their design without facing barriers such as height or story limits, as well as provide incentives for exceeding code standards.

## USING ZONING AS A TOOL

Zoning can be used as a tool to set strong urban design standards. In key commercial and mixed-use redevelopment areas in the floodplain, zoning can be used to ensure that new resilient development promotes active streetscapes—avoiding blank

walls and elevated first floors, an unfortunate result of floodplain construction codes.

Higher standards for on-site retention of stormwater and incorporation of green infrastructure strategies, such as rain gardens or rain barrels, can help reduce flood risk from urban drainage and provide green spaces.

## MITIGATION

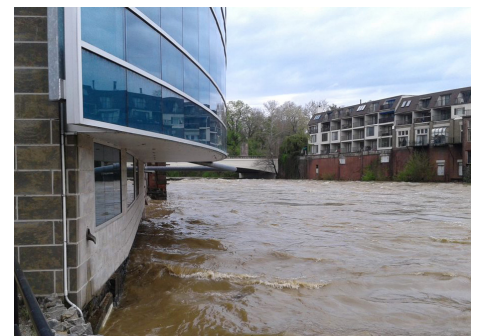
Mitigation includes efforts to reduce greenhouse gas emissions, increase energy efficiency of older equipment, or adopt new technology in order to reduce the impact of climate change. There are many viable solutions to mitigate the impact of buildings and reduce greenhouse gas emissions. The city can collect data on buildings' energy usage and set reduction goals. They can also improve faulty heating and cooling systems, use energy efficient lighting, and use renewable energy.

## PROMOTING ENERGY EFFICIENCY

As buildings consume an enormous amount of energy and contribute a large portion of carbon emissions to the environment, switching to



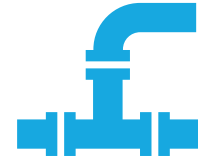
Riverfront development during **normal conditions**.



Riverfront development during **flood stage conditions**. Development will be increasingly subject to flooding due to rising sea levels.



# SEWER AND STORMWATER INFRASTRUCTURE



Existing underground sewer and stormwater infrastructure will face additional stress due to rising sea levels as well as more intense and frequent rainfall events, the expected effects of climate change. Sewer and stormwater infrastructure include assets such as pipes and pumps stations, as well as Combined Sewer Overflow (CSO) regulators and outfalls, which ensure wastewater receives treatment prior to discharge to protect nearby waterbodies. This infrastructure also ensures that stormwater is conveyed and does not flood streets and properties. Many of these assets were designed and installed to service the local community based on the conditions present during the late 19th and early 20th century.

Like many other industrial cities along the east coast, Wilmington is a CSO community serviced by a combined sewer network that utilizes the same pipes that convey rainwater runoff to also convey domestic sewage and industrial wastewater. On dry days and days with modest rain (less than 0.5 inches), the combined sewer system transports all stormwater runoff as well as household, commercial and industrial sewer flow to the wastewater treatment plant (WWTP), where it receives treatment prior to discharge into the Delaware River. However, during larger rainfall events (greater than 0.5 inches), the combined sewer flow (stormwater and sanitary) is greater than the capacity of the pipes to convey the flow to the WWTP. In order to protect the residents and businesses from

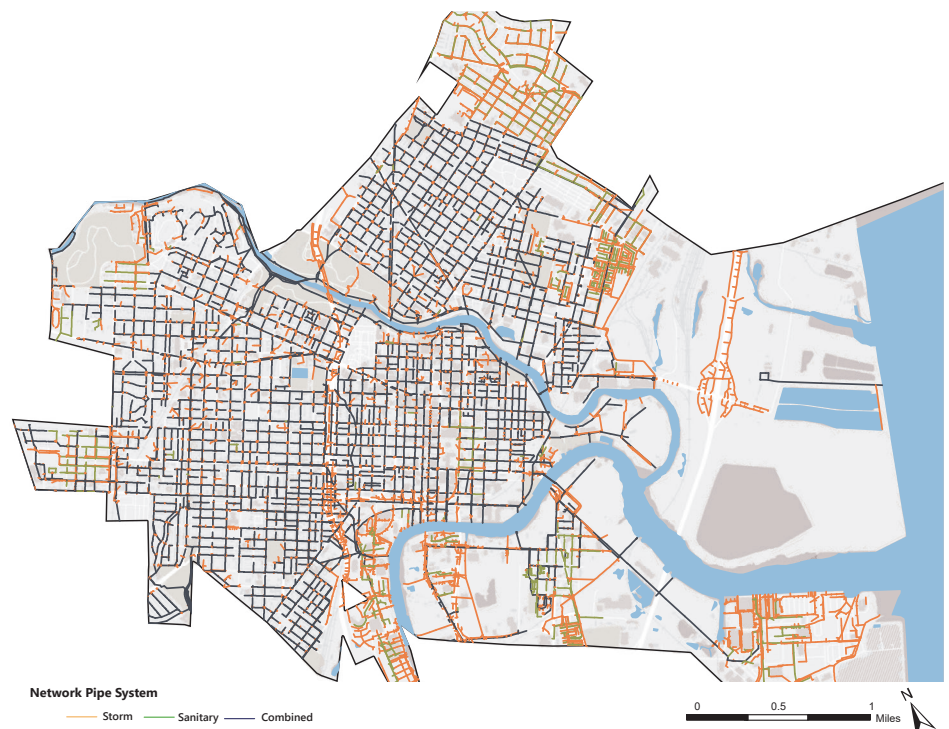
flooding and sewer backups, the excess combined sewer flow is discharged to the Brandywine and Christina Rivers. Collectively, these discharges are known as CSOs.

Changes in the intensity or duration of rainfall events, as well as rising sea levels, impact the performance of the combined sewer system. Wilmington's buried infrastructure was designed to operate based upon the intensities and volume of rainfall observed in the early 20th century. Climate change will bring more frequent high volume and high intensity rainfall events and will exceed the CSO system capacity, causing unwanted overflows and system failures. When the impact of sea level rise is factored in, many combined sewer outfalls will become submerged and unable to drain. As



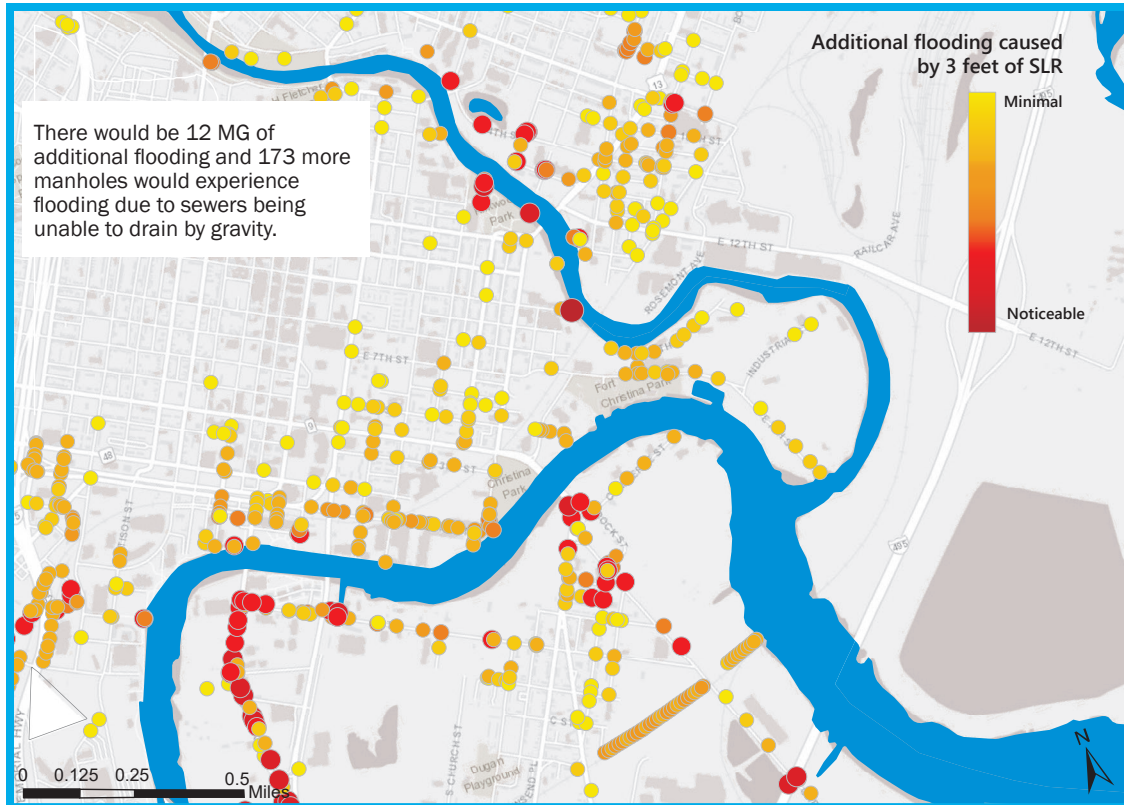
**Manhole Overflow** following a precipitation event.

As a result, the CSOs will shift from the river outfall locations to local street flooding and basement backups. Basement and street flooding from combined sewer overflows will place communities at risk, not only from flooding but also the health issues associated with untreated wastewater and pollution in the waterways, wetlands, and living spaces within the city.

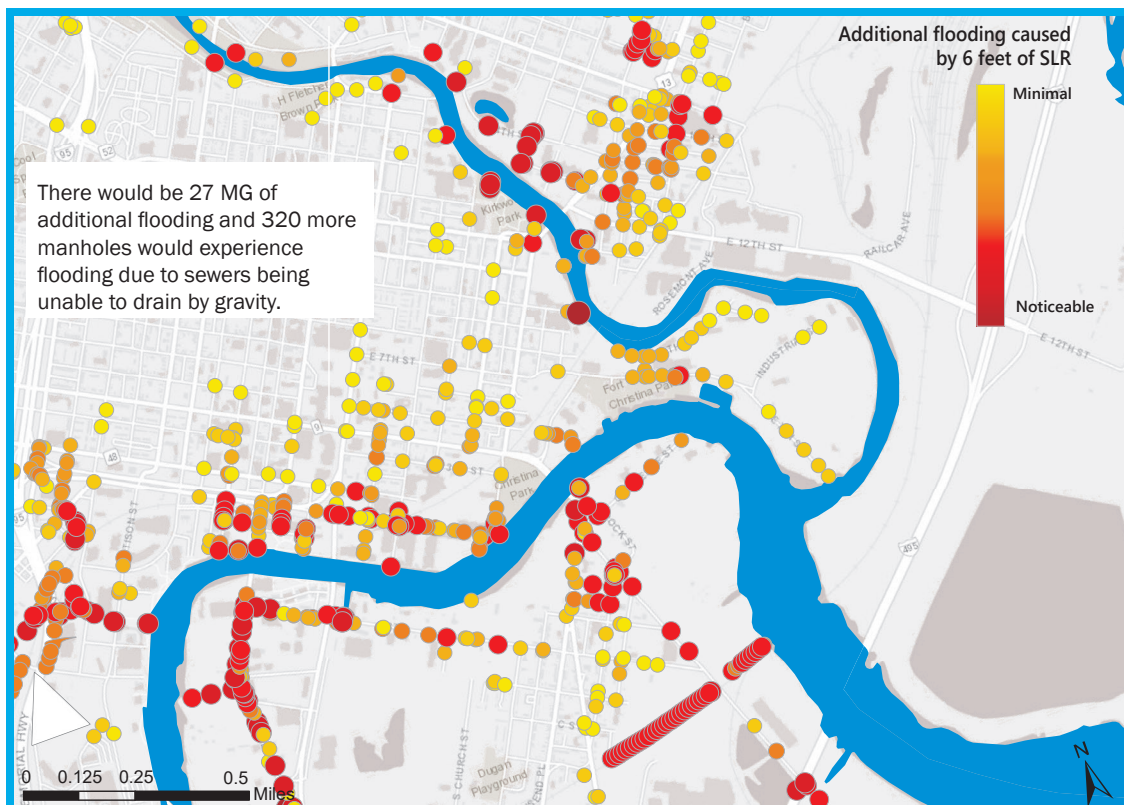


Map showing Network of **Wilmington's pipe system** of combined, sanitary, and storm pipes.

## ADDITIONAL MANHOLE FLOODING UNDER FUTURE SEA LEVEL RISE CONDITIONS



Map showing **increase in flooding volume** between Mean Higher High Water (MHHW) and MHHW + 3 feet of SLR during a 2-year 24-hour rainfall event. The manholes with the biggest increase in flood volume are shown in red, whereas smaller increases are shown in yellow.



Map showing **increase in flood volume** between MHHW and MHHW + 6 feet of SLR during a 2-year 24-hour rainfall event. The manholes with the biggest increase in flood volume are shown in red, whereas smaller increases are shown in yellow.



# SPOTLIGHT ON WILMINGTON

## TIDE GATE PROGRAM

A tide gate is a structure, usually located at the outfall to a river, that allows stormwater or CSO flow to discharge freely in one direction (out to the river), but closes to prevent high tide and floodwater from entering into the pipe and backing up into the streets and buildings. Many tide gates in Wilmington are accompanied by a diversion structure (CSO regulator) that is usually within 100 feet of the tide gate. The diversion structure works to direct dry weather flow (sanitary sewage) to the Wastewater Treatment Plant (WWTP) and away from the tide gate. During modest to large wet weather events (greater than 0.5 inches of rain), the diversion structure sends a portion of the flow to the WWTP and directs the excess combined sewage and

rainwater to the tide gate and out to the river. Most of Wilmington's tide gates were built between 60 and 100 years ago. Despite regular maintenance to clear debris from the tide gates and the diversion structures, many are aging and in need of repair or replacement.

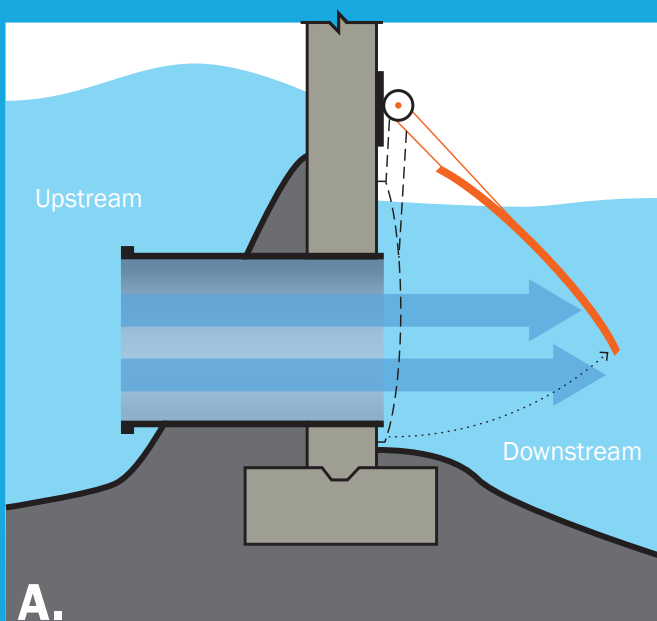
The Wilmington Tide Gate Program has included detailed expert inspections to identify the tide gates that are in the poorest conditions and allow tidal inflows, which consume the capacity of pipes reserved for CSO flow. Early inspection results showed that many tide gates will only require minor repairs, such as remounting of the gate to create a tighter seal. However, some of the tide gates will require significant rebuild of the concrete structure that keeps the gate functioning. Some tide

gates will require a re-design to address SLR and ensure that rising river waters do not interfere with the normal operation of the CSO system.

This program was initiated in the Fall of 2019, and will continue over the next 5 years to ensure that all tide gates are fully functional and prepared to address rising sea levels while protecting the City and its residents for years to come.



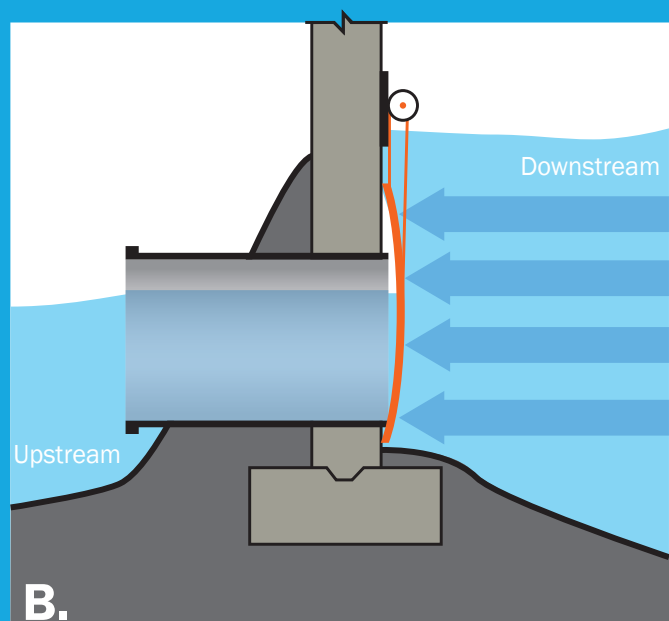
Wilmington's tide gate



Passive Tide Gate

A. Water level on upstream side is higher and pushes gate open

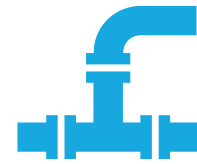
B. Water level on downstream side is higher and holds gate shut



B.



# WHAT CAN WILMINGTON DO?



Buried infrastructure in Wilmington is always being operated and maintained to meet the needs of city residents and uphold an expected level of service. The City is also investing in new policies, technologies and best management projects to improve the sewer system, such as:

- Creating a City-Wide Model to analyze and predict how the current sewer system works.
- Developing a Real Time Controls System to allow for large pipes to store combined sewer flows and alleviate unnecessary overflow events.
- Constructing the South Wilmington Wetlands Park to manage stormwater, restore and enhance existing wetlands, and create a new park for the community.
- Undertaking a Tide Gate Rehabilitation Program to assist in managing stormwater.

## INCREASING RESILIENCY OF DRAINAGE SYSTEMS

Additional steps the city can take to become more resilient include expanding the implementation of both green and gray infrastructure, as well as evaluating shoreline improvements.

### GREEN INFRASTRUCTURE

Green Infrastructure (GI), including rain gardens, bioswales, and rain barrels, are tools that can be implemented to manage rainfall and stormwater runoff before it enters the combined sewer system. While the City of Wilmington has invested in GI, much has been without a coordinated plan or vision. To date,

most has been implemented in relation to mitigating combined sewer overflows as part of the Long-term Control Plan (LTCP). As sewer and water infrastructure continues to age, and climate change and rising sea levels impact the system's ability to drain by gravity, green infrastructure is a useful strategy to help maintain the system's level of service.

### GRAY INFRASTRUCTURE

Gray infrastructure, including pipe up-sizing and pump station upgrades, are strategies that can be used to help convey a greater amount of flow via pipes so that localized flooding does not occur during storm events. Leveraging the City-Wide model, the Department of Public Works can more precisely understand critical areas that will be most impacted by SLR and target investments in these portions of the sewer system first.

## RAISING SHORELINES

While both green and gray infrastructure help mitigate flooding associated with rainfall events, SLR alone will impact low-lying communities, resulting in inundation from the Christina and Brandywine Rivers during even sunny day conditions. Implementing strategies, such as bulkheads and floodwalls, along vulnerable shorelines, will ensure that flooding does not occur regularly in these neighborhoods. The City is actively working with the state and federal government to identify funds to further study shoreline improvements, such as bulkheads and floodwalls, as well as evaluate sewer system upgrades, to ensure that drainage is not negatively impacted by any shoreline measure.



Shoreline Raising Priority ■ Near-Term ■ Mid-Term ■ Long-Term

Map of Wilmington riverfront showing **priority areas for shoreline raising**. Red areas should be raised first, followed by orange, and then yellow. These areas were chosen based on their vulnerability to projected future flooding and SLR.

# TRANSPORTATION



Transportation is essential to both the economy and the people of Wilmington. From traveling to work by foot, bicycle or car, to transporting goods by boat or rail, transportation is key to the city running smoothly. Wilmington is also a transportation hub for the mid-Atlantic region: the Port of Wilmington is a major center of commerce and employment and the Joseph R. Biden Jr. Railroad Station is home to a busy Amtrak stop and SEPTA Regional rail. A new transit center will soon also allow residents to travel by electric bus.

## IMPACTS FROM CLIMATE CHANGE

Transportation systems are already experiencing costly climate change related impacts from severe storms, like Nor'easters and intense rainfall events, leading to flooding. In Wilmington, many roads are already subject to repetitive flooding, causing obstacles to egress, including:

- Route 13 South of the City at the train overpass
- Route 9, south of the City
- 12th Street
- A street – A and S. Buttonwood
- 7th Street at the Peninsula
- North Park Drive

As the climate continues to change, the reliability and capacity of transportation systems will be

impacted. Low-lying roadways and railways, like US 13, State Route (SR) 9 and the Northeast Corridor are all at risk to SLR in the 2100 projections from DNREC. Similarly, the Joseph R. Biden Jr. Railroad Station, as well as structures at the Port, could be inundated with as little as 3 feet of SLR.<sup>ix</sup> Public transportation routes, like bus stops and evacuation routes will experience more interruptions caused by flooding. Moreover, more frequent high tide and extreme weather events will result in costly damage to roads, rails, and bridges.<sup>x</sup>

Rising temperatures will also impact transportation as most infrastructure is not designed for extreme temperatures. Heat could

cause stress in expansion joints on bridges and highways and asphalt pavement can rapidly deteriorate. Railways are also be impacted, with tracks buckling from the increased stress.<sup>ix</sup> Higher temperatures reduce the life of pavement, increasing maintenance needs and the cost of transportation.<sup>xi</sup>

Transportation systems are also vulnerable to disruptions caused by storm events. As chronic flooding worsens and sea levels rise, disruptions to travel and damages to infrastructure will have economic impacts due to the reliance of energy providers, food distributors, manufacturing industries, and other trade merchants on transportation networks.<sup>xii</sup>



Photos of [Market Street / 76ers Fieldhouse](#). Photo Credit: Bryan Lennon, Department of Public Works.



## IMPACT ON CLIMATE CHANGE



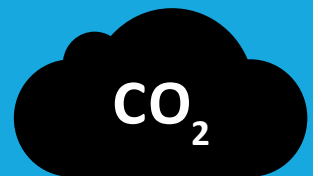
In addition to the risks climate change poses to transportation systems, transportation infrastructure is also a large contributor to GHG emissions and one of the most notable drivers of observed climate change in the 20th century. Some forms of transportation, most notably cars and buses, are larger contributors than other forms of transportation. Transportation systems as a whole comprise 26% of the total greenhouse gas emissions in Delaware.<sup>xiii</sup>

Emissions from transportation systems are generated mostly from burning fossil fuels for cars, trucks, ships, trains, and planes. Emissions are influenced by the type of fuel used, fuel efficiency of the vehicle, and the distance the vehicle travels. These emissions must be reduced to combat the impacts of climate change. Continued reliance on petroleum fuels will result in further warming of the planet and heighten the risk of disastrous effects from climate change. Delaware has led a strong effort to reduce greenhouse gas emissions in the transportation sector through various initiatives, including:

- Use of fuel-efficient vehicles
- Participation in the Clean Cities Coalition
- Propane-fueled school bus project

A continued push for cleaner forms of transportation and alternate options, such as walking and biking, will allow the city to move away from its reliance on cars. These options will expand transportation options more equitably throughout the city and reduce the contribution of transportation to greenhouse gas emissions.

## TRANSPORTATION CONTRIBUTES TO CLIMATE CHANGE



**26%**  
OF GREENHOUSE  
GAS EMISSIONS IN  
DELAWARE IN 2013



## TRANSPORTATION IS VULNERABLE TO CLIMATE CHANGE



Extreme heat can soften asphalt and buckle roadways and rails



Extreme storms can cause flooding and deteriorate roads over time



SLR inundation can disrupt transportation networks



# SPOTLIGHT ON CURRENT EFFORTS



## BIKE SHARE FEASIBILITY STUDY

Bike Wilmington was created to advise the City and help coordinate bike initiatives while also advocating for bicycle riding as a means of transportation. The City, along with DelDOT and consultants, conducted a study to understand the feasibility of implementing a bike share program in Wilmington. Bike share would serve as an environmentally friendly method of transportation, acting as an extension of the City's existing public transportation network.



## MOVING US FORWARD: A PLAN FOR BIKING IN THE CITY OF WILMINGTON

In July 2019, the City released a Bike Plan with the goal of increasing biking and walking throughout the City by developing safe, easily accessible bike infrastructure. The Plan was created with the vision of making biking more accessible across all age groups and abilities in order to make the City more livable and connected.

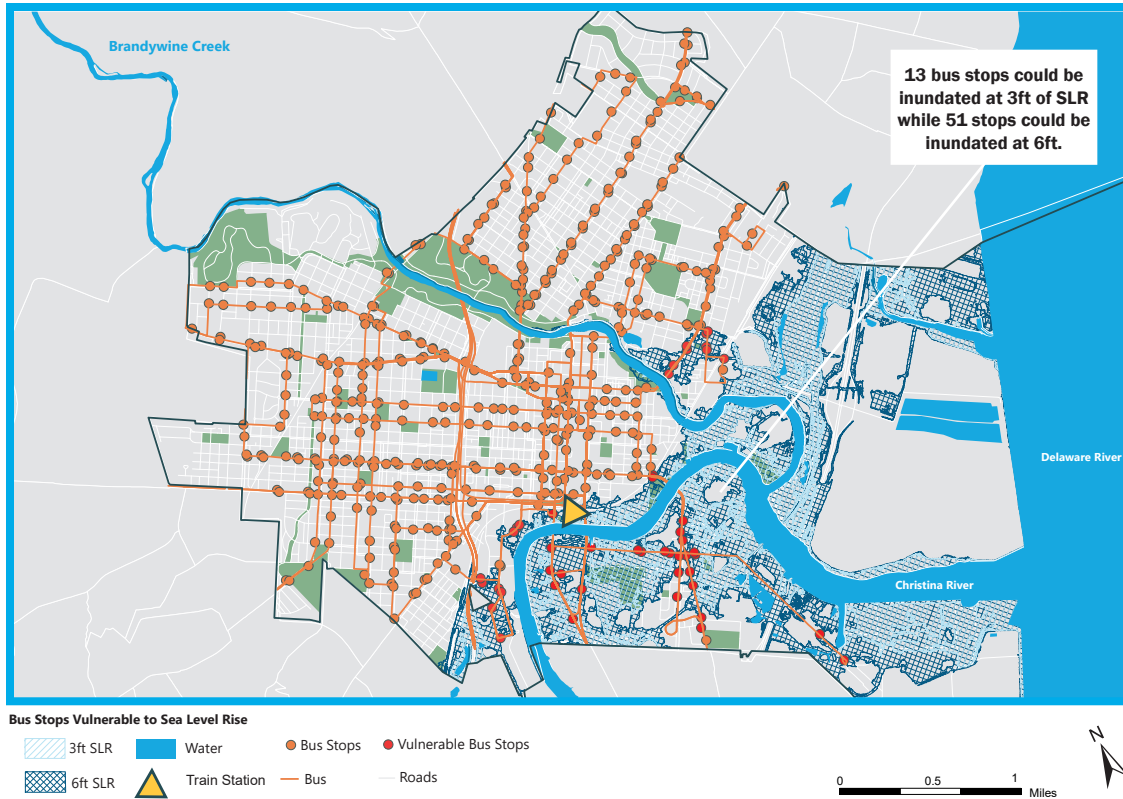
The Plan provides recommendations for a coordinated citywide bike network map, education and advocacy for safer biking, and greater access to biking. By expanding bike paths and making the City a safer place for biking, Wilmington can offer an affordable, reliable, and healthy means of transportation for all residents.

## WILMINGTON INITIATIVES

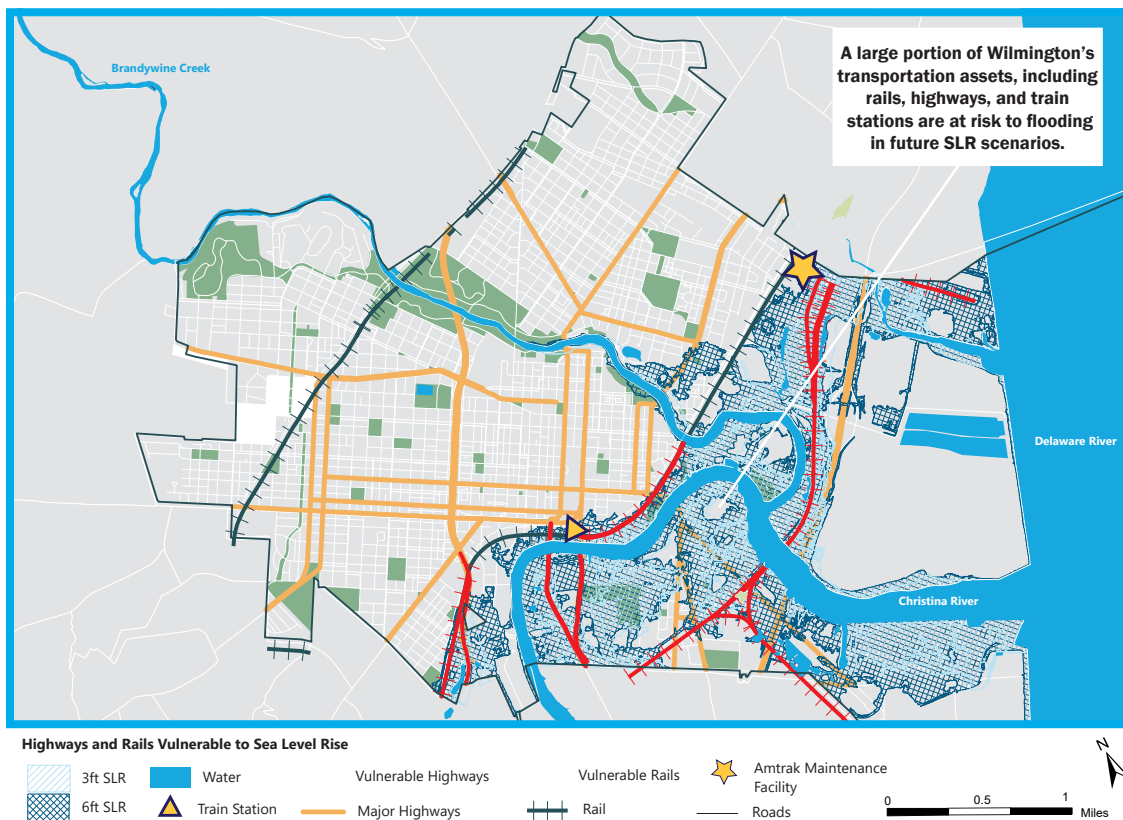
Created by Wilmington Area Planning Council (WILMAPCO), Wilmington Initiatives seeks to support projects that aid in providing a balanced transportation system by improving connections, diversifying modes of transportation, and enhancing livability. Wilmington Initiatives is supporting a robust and accessible transportation network in Wilmington. There has been a total of \$45 million projects thus far from a multi-agency partnership that includes the City of Wilmington, DelDOT, Delaware Transit Corporation, and WILMAPCO. Wilmington Initiatives has supported a number of projects, including the Wilmington Riverwalk, the 12th Street Connector Alignment Study, and the East 7th Street Peninsula Study. These projects will continue to provide resilient transportation options to benefit the City of Wilmington and its residents.



## AT-RISK TRANSPORTATION INFRASTRUCTURE



Map showing **bus stops and bus routes vulnerable to SLR**



Map showing **transportation routes**, including major highways, railways, and roads, that are **vulnerable to SLR**.

# WHAT CAN WILMINGTON DO?



The City of Wilmington, in partnership with the State of Delaware, needs to simultaneously be developing strategies to mitigate emissions from the transportation system while still providing safe and efficient transportation choices for residents.

Although the state of Delaware and regional organizations have taken several steps to understand transportation vulnerability and prepare for the impacts of climate change, there are still numerous measures Wilmington can adopt.

To mitigate emissions, the City can focus on promoting cleaner, multi-modal transportation options. For example, the City should:

- Advocate for introducing zero-emission electric buses or other zero-emission technology into the public transit fleet.

- Expand electric vehicle charging infrastructure by installing charging stations in public locations and workplaces, while also promoting electric vehicle charging in dense residential areas.

- Expand bicycle infrastructure by implementing a bike share program, similar to Philadelphia or Washington D.C., and promote the design of safe streets to encourage walking and reduce focus on cars.

- Advocate for broader train and public transit systems north and south in order to reduce reliance on cars.

Transportation infrastructure requires expensive, long term investments and coordinated planning from multiple stakeholders, including Wilmington Initiatives'

members, The City can also protect infrastructure from climate change related risks by taking the following actions:

- Identify critical roads at risk for future flooding and develop mitigation strategies. This will involve working collaboratively with key partners at the state and regional level to ensure climate change risks are incorporated into long-term planning efforts.
- Incorporate climate change into both near- and long-term transportation planning decisions.



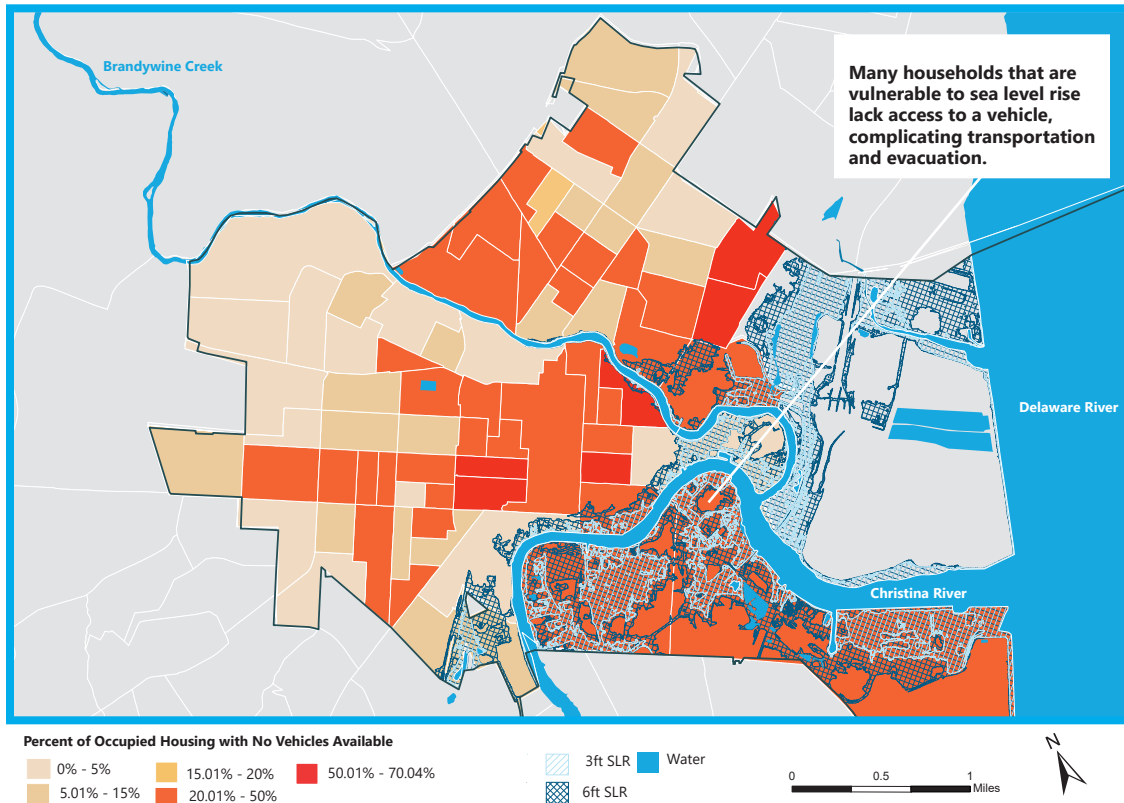
The Delaware Department of Transportation plans to have 20 **zero-or-low emission electric buses** statewide starting in 2021. Photo Credit: DNREC.



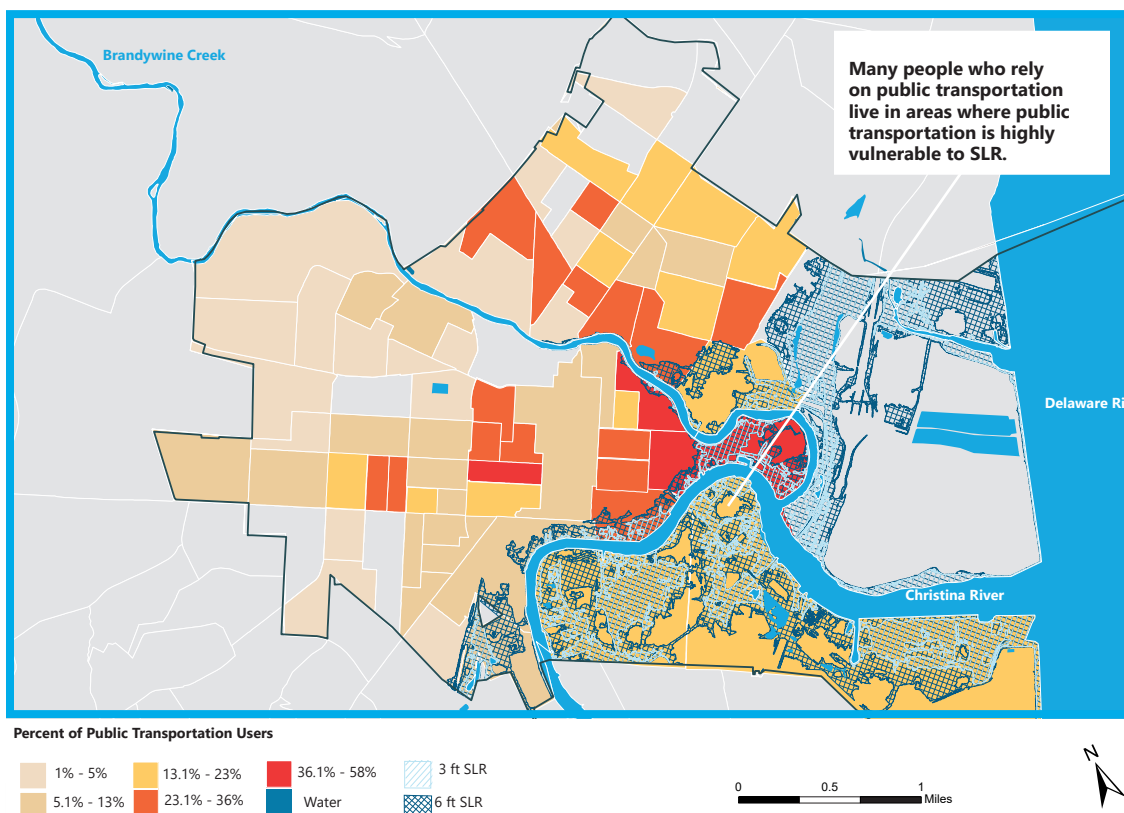
Electric vehicle **charging stations**. Photo Credit: University of Delaware.



## TRANSPORTATION VULNERABILITY AND SEA LEVEL RISE



Map showing percent of **occupied housing with no vehicles available**, per the 2013-2017 American Community Survey 5-Year Estimates by Census block group. Numerous block groups with no vehicle access could be inundated by SLR.



Map showing **percentage of people per block group who use public transportation as a means of transportation to work**, per the 2013-2017 American Community Survey 5-Year Estimates by Census block group. Numerous block groups heavily reliant on public transportation are vulnerable to SLR.

# PUBLIC HEALTH AND SAFETY



Public health considers the health of the population of the City of Wilmington as a whole, as well as the unique challenges and vulnerabilities of specific communities. Communities are subject to different health considerations based on:

- Environmental conditions
- Socioeconomic status
- Access to healthy food and outdoor space
- Health history, among other factors

A focus on public health is essential to the success of any city.

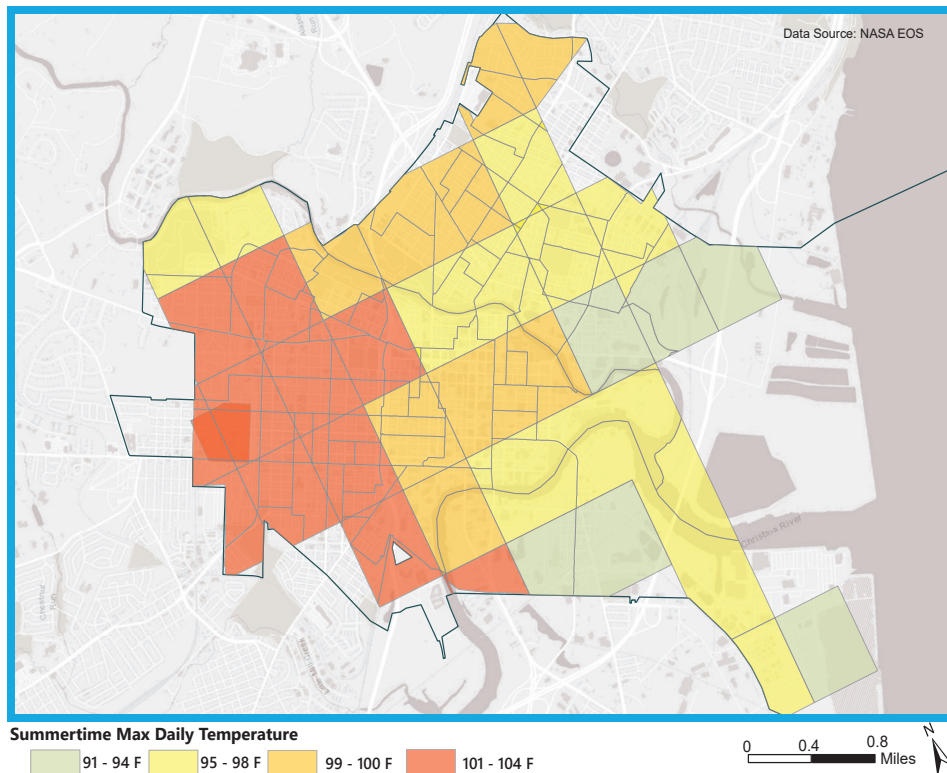
According to the World Health Organization, climate change affects the social and environmental determinants of health, impacting clean air, safe drinking water, enough food and secure shelter. The Lancet Commission on Pollution and Health found that air, water, and soil pollution is now the leading environmental cause of death and disability.<sup>xviii</sup>

Rising temperatures and flooding, could intensify existing health threats, increase the spread of vector-borne diseases, and threaten food supplies. The impact will be greatest on vulnerable populations, exacerbating health and social inequalities.

Climate change will specifically impact the following areas.

## EXACERBATING HEAT

Rising temperatures can have many negative health effects including increased heat-related illness, worsening chronic illnesses, increased injuries from dangerous weather



Map showing **average daily summertime temperatures in Wilmington**. Temperatures in the East Side, Baynard Boulevard and Browntown-Hedgeville often exceed 100 degrees. As temperatures increase, this could lead to dangerously hot conditions.

events, increased infectious diseases spread by mosquitoes and ticks, increased illnesses from contaminated food and water, and mental health problems.<sup>xix</sup> Extreme heat can cause dehydration, heat stroke, cardiovascular illnesses, and respiratory illnesses.<sup>xx</sup>

## WORSENING AIR QUALITY

Higher concentration of ozone and particulate matter due to warming temperatures will exacerbate existing poor air quality. This could result in diminished lung function, increased hospital admissions and emergency room visits for asthma, and increases in premature deaths.<sup>xxi</sup> Poor air quality is associated with higher risk of cardiovascular disease, and lung

cancer, and limits physical activity.<sup>xxii</sup> Climate change may also increase the length and intensity of pollen seasons, and increase other air pollutants exacerbating asthma and allergies.<sup>xix</sup>

## INCREASING RISK OF DISEASE

As temperatures warm and seasons are interrupted, vector-borne diseases will likely spread beyond their normal geographic range resulting in an increase in the risk of contracting an infectious disease.<sup>xxiii</sup> These diseases borne by vectors, such as fleas, ticks, mosquitoes, can spread pathogens that can cause illness, like Lyme disease and West Nile Virus.<sup>xxiv</sup> Additionally, there will be increases in non-communicable diseases and



## EXTREME HEAT

### IMPACTS

#### DRIVERS

- INCREASES IN TEMPERATURE
- SEA LEVEL RISE
- URBAN HEAT ISLAND EFFECT
- HEAT WAVES
- SEASONAL DISRUPTIONS

INCREASED SPREAD  
OF INFECTIOUS  
DISEASES

WORSENING  
CHRONIC ILLNESS

INCREASED HEAT  
RELATED ILLNESS  
(I.E. HEAT STROKE)

INCREASED  
ILLNESSES FROM  
CONTAMINATED  
FOOD AND  
WATER

WORSENING  
AIR QUALITY



## DISEASE

### IMPACTS

#### DRIVERS

- CHANGES IN PRECIPITATION
- SEA LEVEL RISE
- EXTREME WEATHER
- INCREASES IN TEMPERATURE
- SEASONAL DISRUPTIONS
- CHANGES IN VECTOR BEHAVIOR  
AND GEOGRAPHICAL RANGE

INCREASED  
SPREAD OF VECTOR  
BORNE DISEASES  
(I.E. LYME AND  
WEST NILE  
VIRUS)

MENTAL  
HEALTH IMPACTS

INCREASED RISK  
OF CARDIOVASCULAR  
ILLNESS



## AIR QUALITY

### IMPACTS

#### DRIVERS

- INCREASE IN TEMPERATURE
- CHANGES IN PRECIPITATION
- INCREASED POLLUTION
- INCREASED GHG EMISSIONS
- EXTREME WEATHER

INCREASED ALLERGY  
RELATED ILLNESS

INCREASED RISK OF  
CARDIOVASCULAR  
ILLNESS

LIMITS TO  
OUTDOOR PHYSICAL  
ACTIVITY

INCREASED  
ALLERGENS

LONGER  
ALLERGY  
SEASON

WORSENING  
ASTHMA  
AND RESPIRATORY  
ILLNESSES



## FOOD SECURITY & DRINKING WATER

### IMPACTS

#### DRIVERS

- CHANGES IN PRECIPITATION
- SEASONAL DISRUPTIONS
- EXTREME WEATHER
- INCREASES IN TEMPERATURE
- SEA LEVEL RISE

INCREASED RISK  
OF WATERBORNE  
ILLNESS

DECREASED  
NUTRITIONAL  
VALUE  
OF FOOD

DISRUPTIONS  
IN FOOD  
DISTRIBUTION

DISRUPTIONS  
IN FOOD  
PRODUCTION

CONTAMINATION  
OF DRINKING  
WATER

FOOD  
CONTAMINATION



illnesses transmitted by food and water. Sewage or water treatment systems overflow can increase the risk of water borne illnesses, such as cholera, cryptosporidium, dysentery, and giardiasis. These illnesses often cause severe dehydration, which can be deadly.<sup>xxv</sup>

## THREATENING FOOD SUPPLY

Wilmington has long struggled with access to healthy, affordable food according the USDA. Over 65% of residents live more than a half-mile from a grocery store.<sup>xxvi</sup>

Changes in precipitation, rising temperatures, and severe weather could impact global food production, even as global food demand rises 14% per decade.<sup>xxvii</sup> Crop yields may decline due to changes in rainfall, heat, drought, severe weather events, and increasing competition from weeds and pests on crop plants.<sup>xxviii</sup> There may be a decline in the nutritional value of food. Elevated atmospheric carbon dioxide will decrease the nutritional value of certain crops, like barley, soy, wheat, and rice by reducing protein. Warmer temperatures may increase the growth of bacteria and algal blooms, resulting in food contamination.

## IMPACTING MENTAL HEALTH

The severe weather conditions caused by climate change can have serious effects on mental health in addition to physical health. Weather related disasters are acutely traumatic events and the extent of effect on mental health is dependent on a person's age, coping capacity, and proximity to the disaster. A recent report on climate change and mental health noted that depression, anxiety, post-traumatic stress disorder, and substance abuse increase after a natural disaster.<sup>xxix</sup>

## PROTECTING DRINKING WATER

The City of Wilmington's drinking water source is the Brandywine Creek. The Brandywine Creek watershed, or the region that drains into the Creek, is made up of over 500 miles of streams between three Pennsylvania counties and New Castle County. Depending on the stream flow conditions, water can take anywhere from two to six days to travel from the headwaters in the Welsh Hills to the City's water intake on the Brandywine.<sup>xxx</sup>

The City of Wilmington actively protects the Brandywine River and its water quality, ensuring residents have access to clean drinking water. Taking steps to safeguard drinking water is important, as water supply and quality can be affected in the future by warming temperatures, changes in precipitation and runoff, and SLR.<sup>xxxi</sup> For example, increased volumes of water from heavy precipitation events could overwhelm infrastructure, increasing the amount of runoff and adding sediments, nutrients, pollutants and trash into the water supply.

## RISING COSTS

In addition to the health effects, rising temperatures will also have cost impacts. The increased need for air conditioning will drive up electric bills.<sup>xxxii</sup> Higher sea levels and more frequent flooding will increase the cost of flood insurance. Strains on the food supply will increase the cost of food, placing more strain on lower-income households.<sup>xxxiii</sup>

Around the world, cities are beginning to understand climate change's impact on public health and taking steps to build resilience into their public health systems.

# SPOTLIGHT ON WILMINGTON

## MY HEALTHY COMMUNITY PORTAL

The Delaware Environmental Public Health Tracking Network (EPHTN) was developed by the Delaware Department of Health and Social Services, with the help of DNREC funding. The tool was launched in May 2019 by the Division of Public Health to provide Delawareans with access to information regarding their community's health. By focusing in on the community level, the tool allows residents to better understand the overall health of their community, including population, social, and environmental health.<sup>xxxiv</sup>



## My Healthy Community

My Healthy Community provides community-level statistics and data that can be used to understand and explore health and related factors that influence health. Our health and the environment in which we live are inherently connected. Together, communities can use data to inform place-based approaches, support and facilitate data-informed discussions that describe and define population health priorities, and leverage data to transform communities by educating them about their community's health and the environment in which they live.

Current available data includes air quality, asthma incidence, public and private drinking water testing results, and drug overdose data.

An additional grant was awarded by DNREC to incorporate climate change-related datasets into the tool, including data such as temperature variations

and their impact on health, vulnerable populations, and zoonotic disease threats. The tool will allow Delawareans and officials to look at neighborhood health profiles to understand the health of communities and the impact of climate change on health in those communities.

# WHAT CAN WILMINGTON DO?



Addressing the impact of climate change on public health requires public engagement on the risks and collaboration across diverse agencies. The State of Delaware has been a leader in many climate change issues that directly impact public health, such as committing to the reduction of greenhouse gas emissions and convening experts to evaluate the impact of climate change on public health.

## COLLABORATING WITH LOCAL PARTNERS

Wilmington will need to continue to collaborate and coordinate with local organizations, state interests, local public health authorities, municipal governments and other related agencies to ensure the resilience of public health. These partnerships will allow Wilmington to improve emergency preparedness and address key health risks. Many organizations are already making strides to enhance the resiliency of Wilmington, including the Nature Conservancy, the Delaware Nature Society, and Southbridge Civic Association.

Additional steps that Wilmington can take to mitigate climate change impacts on public health must focus on community-wide adaptation strategies. To make the response to climate change economically feasible, these strategies should be multi-beneficial.

## PROMOTING ACCESS TO COMMUNITY RESOURCES

In addition to collaborating with local partners, community

resilience relies on promoting and enhancing access to resources. These resources include access to facilities, such as cooling centers during high heat days, development of physical warning tools, such as flashing lights on flooded roads, and education on climate risk through print and electronic materials. Expanding access to these resources will empower residents to keep themselves and their families safe from the risks posed by climate change.

## ENHANCING RESILIENCY OF FOOD SYSTEMS

A resilient food system can be achieved by promoting urban

agriculture, which can also stimulate the local economy. The Delaware Urban Farm & Food Coalition, which promotes healthy eating through community oriented urban agriculture projects, created Wilmington's first urban farm. By continuing to expand urban farms and providing increased access to healthy, affordable, and local food, the resiliency of the local food system can be enhanced.

Investing in climate resilience will also open up opportunities for new economic growth. Wilmington can develop policy to invest in green jobs in order to provide new opportunities for residents that will help the city achieve its climate goals while also expanding employment options.



Bright Spot Urban Farm's [Mobile Market](#) at Wilmington's Farmers' Market.

**MOVING  
TOWARDS  
A MORE  
RESILIENT  
WILMINGTON**



# THE FIRST STEP TOWARD A RESILIENT COMMUNITY

The Resilient Wilmington Study is the first step towards creating a more resilient community. The following section builds upon the overview of strategies presented for each focus area and presents a series of actionable next steps that the City can take in the near-, mid-, and long-term to lessen its contribution to greenhouse gas emissions, mitigate the impacts of climate change, and ensure that the community has access to the resources needed to thrive and prosper for decades to come.

While strategies are presented for each focus area, it is important to note that many have co-benefits that can be realized in another focus area. For example, implementing green infrastructure, such as a rain garden or wetland park reduces flooding from rainfall events while also improving air quality, as trees and plants absorb and filter particulate pollution, which also improves public health. Together, the strategies and steps presented generate multiple benefits including flood protection, greater access to resources, improved mobility, and smarter growth practices.

Along with the strategies and steps to become more resilient, key partners for each focus area are noted. Coordinated advocacy by the City, its academic and non-governmental partners, and the community will be fundamental to realizing these visions.



Rendering of [South Wilmington Wetland Park](#), courtesy of Oasis Design Group.

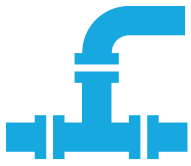


# WATERFRONT DEVELOPMENT

**Vision:** To incentivize and encourage smart and resilient economic growth for the City of Wilmington.

**Partners:** City of Wilmington, Riverfront Development Corporation.

GOALS	STEPS	PRIORITY	FUNDING
<b>REDUCE VULNERABILITY</b>			
<b>Incorporate resiliency and sustainability into the City's codes and planning and development review</b>	Streamline the development approval process by initiating a site plan review process that incorporates a flood risk evaluation for developments in vulnerable areas.	Near-term	\$
	Review existing zoning and building codes to promote and incentivize resiliency and sustainability design practices, such as increased level of floodproofing and stormwater management.	Near-term	\$
<b>Integrate resiliency into riverfront redevelopment</b>	Incorporate review of drainage and sea level rise into review process for large development projects.	Near-term	\$\$
	Conduct a financial impact analysis to understand the benefits and costs of building in future redevelopment areas.	Near-term	\$
	Coordinate with state and EPA to develop best practices for brownfield clean-up plans to address sea level rise for sites along the Christina and Brandywine Rivers.	Mid-term	\$
	Develop an interim plan for comprehensive flood protection (deployable flood barriers, etc.) as sites along the riverfront are developed.	Mid-term	\$\$
	Explore strategies for incorporating a seawall or elevated shoreline into the redevelopment plans and public Riverwalk on the southeast shore of the Christina River, including exploration of modifications to existing easements and waterfront standards, and explore models of public-private partnerships for financing and implementation.	Long-term	\$\$\$
<b>Improve resiliency of neighborhoods</b>	Explore participating in the Community Rating System, a voluntary incentive program that recognizes and encourages floodplain management activities that exceed the minimum National Flood Insurance Program (NFIP) requirements. This could lead to reduced flood insurance rates to reflect the reduced flood risk.	Near-term	\$
	To assist property owners who lack the financial means to retrofit buildings, create a resilience/ retrofitting fund or identify potential funding sources for flood-resilience measures such as removable flood barriers, dry and wet floodproofing, elevation, filling in basements, elevating mechanical systems, and wastewater backup valves.	Mid-term	\$\$\$
	Develop a resilience audit program to assist property owners in assessing the vulnerability of their buildings.	Mid-term	\$\$\$
	Identify neighborhoods most vulnerable to stormwater flooding and sea level rise and develop inter-agency plans and processes for neighborhood-based resiliency, including the development of retention and detention standards, identifying targeted areas for open space and stormwater management, and updates to Neighborhood Comprehensive Plans.	Mid-term	\$
	Develop design guidelines for retrofitting various typologies of common local buildings to help property owners in the 100- and 500-year floodplain mitigate risk, including: elevation; filling in basements and moving mechanical systems above base flood elevation; wet floodproofing; and dry floodproofing.	Long-term	\$
<b>Improve resiliency of industrial areas</b>	Work with businesses located in industrial areas to assess potential climate change related impacts, including management of hazardous materials, and incorporate those impacts into facility emergency action plans.	Near-term	\$
	Develop stronger codes and standards for industrial areas to incorporate resilience.	Mid-term	\$
<b>REDUCE CONTRIBUTION TO GHG EMISSIONS</b>			
<b>Increase resiliency and efficiency of city-owned buildings and other public facilities</b>	Assess flood risk and energy efficiency of all existing city-owned facilities and develop specific benchmark metrics for improvements.	Near-term	\$
	Develop guidance and policy for construction of new city facilities and the retrofit of existing facilities as part of the capital improvement process.	Near-term	\$
	For non-city owned buildings that provide critical community and health services, such as hospitals and other healthcare facilities, work with the state to convene private entities to create a collaborative, city-wide risk assessment and adaptation strategy.	Mid-term	\$
	Develop strategies for increasing the resiliency and sustainability of city-owned buildings and facilities, including floodproofing, green roofs, LED lighting, light-colored pavement, and stormwater management.	Mid-term	\$\$\$



# SEWER AND STORMWATER INFRASTRUCTURE

**Vision:** To ensure sewer and stormwater infrastructure is able to provide the same level of service in the future as it does today through both green and grey solutions.

**Partner:** City of Wilmington

GOALS	STEPS	TIME FRAME	FUNDING
<b>INCREASE RESILIENCE OF DRAINAGE INFRASTRUCTURE</b>			
<b>Expand education and outreach on stormwater management</b>	Promote programs currently offered by the City to reduce stormwater fees or replace damaged materials.	Near-term	\$
	Expand outreach and education on City's current stormwater credit program and other stormwater initiatives to increase participation and develop smart practices.	Near-term	\$
	Brand the City's Resiliency Program to promote education and awareness.	Near-term	\$
<b>Integrate resiliency planning into stormwater component of future projects</b>	Develop a system of coordination between the Department of Public Works and other projects (Wilmington Initiatives, Planning, DeIDOT) to ensure that necessary stormwater improvements can be incorporated into ongoing projects.	Near-term	\$
	Establish a system of evaluation projects and assign a green infrastructure score in order to prioritize the most vital project.	Near-term	\$
	Partner with DPW and Parks Department to ensure all projects consider GI or other stormwater improvements.	Near-term	\$
<b>Increase resilience of wastewater and stormwater systems</b>	Map elevations of outfalls and study impacts to drainage from sea level rise.	Near-term	\$
	Conduct additional detailed modeling to understand how changes in sea level rise will impact different neighborhoods, and pilot different strategies to mitigate flooding.	Near-term	\$
	Evaluate floodproofing sewer and stormwater assets, such as the 11th Street Pump Station, and elevating critical infrastructure, such as electric equipment, inside other critical assets.	Near-term	\$\$
<b>Expand gray infrastructure for storage and conveyance</b>	In coordination with detailed modeling, evaluate and prioritize areas for up-sizing pipes to convey more combined sewer flow during storm events in areas that experience flooding.	Mid-term	\$\$
	Evaluate and prioritize use of parallel storm sewers to collect stormwater prior to entering combined sewer system and routing directly to stormwater outfall.	Mid-term	\$\$
	In coordination with detailed modeling, evaluate existing capacity at pump stations and where additional pump stations may be necessary to ensure sewer system can drain with future sea level rise.	Mid-term	\$\$\$
<b>Expand green infrastructure implementation</b>	In areas where soil and groundwater conditions permit, expand use of rain gardens, and bioswales to help capture stormwater runoff prior to entering sewer system.	Near-term	\$
	Promote adoption of low impact development, such as permeable pavers and other site-specific measures, by homeowners and developers.	Near-term	\$
	Evaluate City Parks for implementation of green stormwater infrastructure systems.	Near-term	\$
	Prioritize other sites that may be viable for a wetlands park, similar to the South Wilmington Wetlands Park.	Mid-term	\$\$
<b>RAISING SHORELINES</b>			
<b>Raise shorelines in low-lying areas to prevent flooding</b>	Conduct a study to identify areas of the City shoreline that are vulnerable to inundation from high tide and sea level rise and evaluate the feasibility of implementing bulkheads and seawalls along the shoreline. This includes necessary stormwater management strategies, such as pumps, to enhance drainage behind the shoreline improvements.	Near-term	\$
	Define and adopt the City's target sea level rise scenario for planning purposes	Near-term	\$
	Assess impacts of raised shorelines on stormwater management and incorporate mitigation strategies, including gray and green infrastructure improvements.	Near-term	\$
	Implement shoreline protection measures in the highest priority locations.	Mid-term	\$\$
	Develop design guidelines for the repair and construction of bulkheads at various levels in the design process (new construction, update, etc.).	Mid-term	\$
	Implement integrated shoreline protection system.	Long-term	\$\$\$





# TRANSPORTATION

**Vision:** To develop a transportation system with a smaller footprint on the environment while also protecting infrastructure from the risks posed by climate change.

**Partners:** City of Wilmington, Wilmington Initiatives and growing partnership with DNREC.

GOALS	STEPS	TIME FRAME	FUNDING
<b>REDUCE VULNERABILITY</b>			
<b>Identify and evaluate future risks to transportation from climate change</b>	Convene stakeholders (e.g., DeIDOT, WILMAPCO, Amtrak) to collaboratively develop resilient transportation guidelines and strategies to be incorporated into the capital planning process.	Near-term	\$
	Assess physical critical transportation infrastructure (e.g., train stations, maintenance facilities) to determine what is at greatest risk of flooding from future sea level rise and evaluate potential need for relocation or future floodproofing measures.	Long-term	\$\$\$
	Assess non-physical critical transportation infrastructure (e.g., evacuation routes) to determine what is at risk of flooding from future sea level rise projections and evaluate potential need for future rerouting or review to ensure safe access and egress during storm events.	Long-term	\$\$
<b>REDUCE CONTRIBUTION TO GHG EMISSIONS</b>			
<b>Expand bike infrastructure to reduce carbon pollution</b>	Partner with private companies to implement a bike share program to increase neighborhood transportation options and decrease fuel emissions.	Near-term	\$
	Adopt complete streets program that offers multi-modal transportation options	Near-term	\$\$
	Implement Wilmington's Bike Share Program and expand outreach and education to encourage safe transportation alternatives.	Near-term	\$
<b>Promote safe and equitable multi-modal transportation options to reduce reliance on cars</b>	Improve sidewalk conditions and pedestrian connections to encourage walking.	Near-term	\$
	Incentivize car-share and carpool programs to reduce the number of cars on the road.	Near-term	\$
	Develop partnership with "Safe Routes to School Program" to encourage children to walk or bike to school in a safe, convenient, and fun environment in addition to decreasing traffic and air pollution.	Near-term	\$
	Advocate for broader train and public transit systems north and south and greater service frequency in order to encourage a reduction in car use.	Mid-term	\$\$
	Encourage mixed use zoning that supports greater walking and less reliance on cars by reducing the need to travel by car.	Mid-term	\$\$
<b>Reduce the City's carbon footprint by investing in, and advocating for, cleaner transportation options</b>	Advocate for DTC to deploy hybrid, zero-emission, or electric buses on city routes to maximize fuel efficiency of public transportation.	Near-term	\$
	Advocate for greater frequency of SEPTA trains and allowing bikes on trains during peak hours to encourage use of public transportation.	Near-term	\$
	Expand electric vehicle usage and charging stations in public locations and workplaces by (1) Identifying funding for public location charging stations and developing policy for managing stations and (2) Incentivizing workplace charging stations installation.	Mid-term	\$\$
	Develop policy for electric vehicle charging in residential areas where street parking is utilized.	Mid-term	\$
	Convert 20% of city car fleet to electric vehicles by 2025.	Long-term	\$\$



# PUBLIC HEALTH & SAFETY

**Vision:** Work with City Partners to connect residents to resources to stay safe from the risk posed by climate change.

**Partners:** City of Wilmington, Nature Conservancy, DEMA, DHSS, and DNREC.

GOALS	STEPS	TIME FRAME	FUNDING
<b>IMPROVING COMMUNICATION</b>			
<b>Improve emergency preparedness and planning, ensure adequate communication of public health emergencies</b>	Promote communication campaign that includes social media, TV, and radio to effectively warn residents of hazardous events, such as heat waves or flash flooding, and direct them to resources, such as cooling centers or emergency shelters.	Near-term	\$
	Update emergency evacuation plans and conduct community outreach surrounding evacuation plans.	Near-term	\$
	Expand physical flood warning tools, such as flashing lights on flooded-out roads, to warn drivers of potential hazards.	Mid-term	\$
	Integrate climate and health data tracking from Delaware Environmental Public Health Tracking Network into community planning efforts to further understand how climate change impacts public health.	Mid-term	\$
<b>Further education, outreach and partnerships to enhance community resilience</b>	Develop guidelines and tools to inform and educate property owners on insurance, mortgage, and other flood risk related information.	Near-term	\$
	Extend partnerships with local health departments, schools, churches, and nonprofit organizations to develop a resiliency education curriculum, focusing on heat risks and emergency preparedness.	Near-term	\$
	Identify community partners and potential public-private partnerships to expand public health education and resources for community members.	Near-term	\$
<b>ENHANCE ACCESS TO RESOURCES</b>			
<b>Implement strategies to reduce the risk of UHI and extreme heat</b>	Incentivize the installation of tree planting and green roofs by providing a simple and affordable approval process.	Near-term	\$
	Promote the use of pervious surfaces over impervious surfaces, such as selecting gravel over blacktop.	Near-term	\$
	Work with Wilmington's Urban Forest Administrator, as well as environmental advocacy groups, to further expand Wilmington's tree canopy.	Mid-term	\$\$
	Review effectiveness of cooling centers and other high heat day strategies and identify undeserved areas for increased expansion strategies or new strategies to mitigate the effects of high heat days,	Mid-term	\$\$
<b>Enhance resiliency of food systems</b>	Further study impact of climate change on food sources and food distribution in order to develop future strategies to protect the food supply.	Near-term	\$
	Evaluate how zoning and building code restrictions might limit urban agriculture in order to increase locally available food options via food gardens and further development of the local food economy.	Near-term	\$
	Partner with local groups, such as the Delaware Urban Farm & Food Coalition, to further promote urban agriculture.	Near-term	\$

# WHAT CAN YOU DO?

**Vision:** To ensure residents of Wilmington have access to the resources needed to learn more about climate change and its impacts, as well as take individual steps to become more resilient.

**Partners:** Residents of Wilmington

## TRANSPORTATION



1. Walk, bike, or use public transportation to reduce carbon pollution
2. Drive an electric or low-emission vehicle
3. Report sidewalk issues or other maintenance needs through the “Submit a Service Request” portal on the City of Wilmington website
4. In the case of inclement weather, check the DelDOT website or mobile app before leaving the house for notification of road closure or other hazards

## WATERFRONT DEVELOPMENT



1. Consider purchasing and maintaining flood insurance, even if your property is outside of the 100-year floodplain
2. Stay updated on latest FEMA floodplain maps
3. Use energy efficient building materials, such as adding insulation to your attic to improve your home's heating and cooling costs

## SEWER & WATER INFRASTRUCTURE



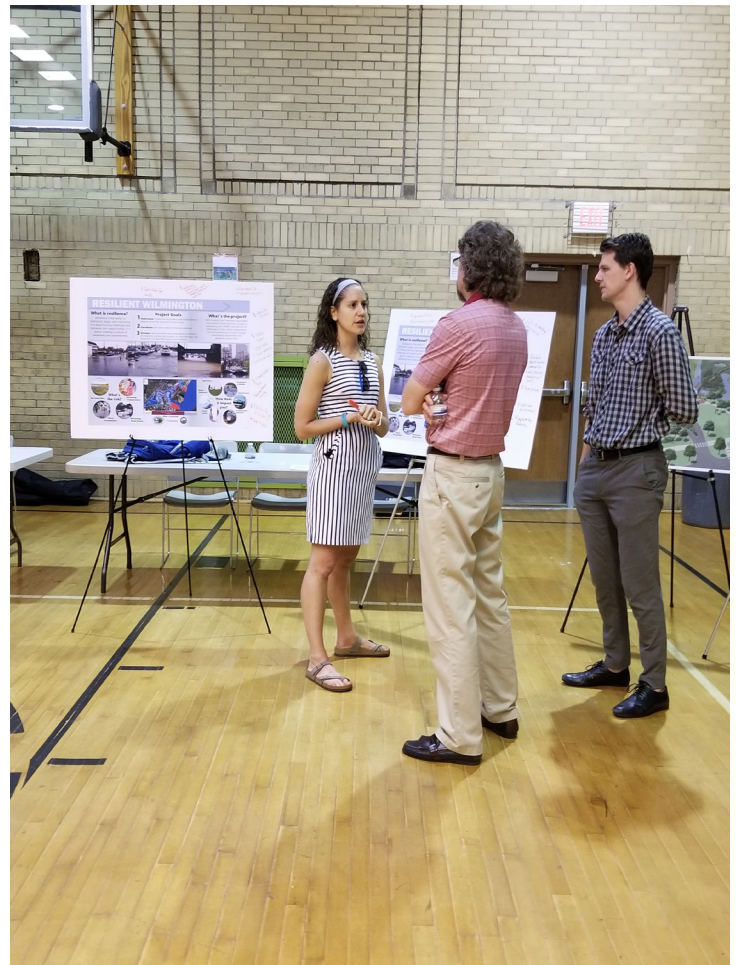
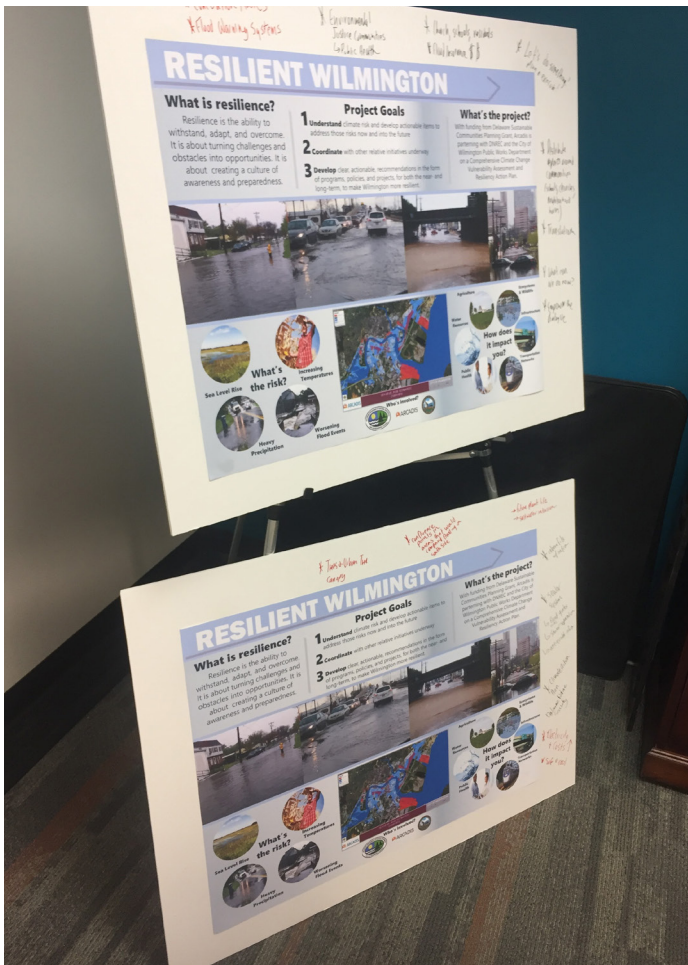
1. Have your voice heard by attending community meetings
2. Follow instructions provided in billing inserts
3. Understand Wilmington's stormwater fee and its purpose
4. Keep stormwater drains clean
5. Add rain gardens or other planters on your site to help capture rainfall

## PUBLIC HEALTH & SAFETY



1. Create an emergency plan for you and your family
2. Grow food in a community garden and support local farmer's markets
3. Monitor your AC and heat usage
4. Carry a reusable water bottle
5. Check on your neighbors during heat or storm events
6. Exercise and enjoy open spaces







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# DEFINITIONS

**100-Year Flood:** a flood that has a 1% chance (or 1-in-a-100 chance) of occurring in any given year.

**500-Year Flood:** a flood that has a .02% (or 1-in-a-500) chance of occurring in any given year.

**Adaptation:** action that can be taken to adjust to new or emerging conditions such as sea level rise in order to minimize the consequences of climate change.

**Bathtub Model:** a water surfaces model that maps flooding scenarios where the extent of inundation is estimated based on mean higher high water and land elevation. Bathtub models do not incorporate storm surges or future land conditions.

**Base Flood Elevation:** the determined elevation in feet to which floodwater is anticipated to rise during the base flood, or the 1 percent annual chance storm. It is the regulatory requirement for the elevation or flood-proofing of structures. Flood insurance is determined by the relationship between BFE and a structure's elevation.

**Climate:** long-term patterns of temperature, precipitation, and other weather variables. Generally described in a global or regional context rather than in specific locations; average of weather over time and space.

**Climate Change:** any significant change in climate variables and patterns of weather over an extended period of time.

**Datum:** a point line or surface used as a reference in measuring locations or elevations.

**Floodplain:** Nature's floodplain, which includes the Special Flood Hazard Area and other areas subject to flooding.

**Freeboard:** additional height above the BFE that provides additional safety due to mapping uncertainties associated with Flood Insurance Rate Maps (FIRMs) and rising sea levels.

**Groundwater:** water located beneath the surface in fractures or rock formations.

**Global Warming:** average increase in temperatures near earth's surface and in the lowest layer of the atmosphere. Increases in temperature in the atmosphere could contribute to changes in global climate patterns.

**Greenhouse Gases:** gaseous compounds that absorb infrared radiation, trap heat in the atmosphere, and contribute to the greenhouse gas effect. These include carbon dioxide, methane, nitrous oxide, and fluorinated gases

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# DEFINITIONS

**National Flood Insurance Program (NFIP):** federal program providing flood insurance to municipalities that enact floodplain management regulations that meet or exceed FEMA's criteria. Properties in special flood hazard area that have a federally-backed mortgage are required to buy flood insurance.

**Mean Higher High Water:** the average of the highest of the high-water heights of each tidal day observed over a 19-year period known as the national tidal datum epoch.

**Mitigation:** efforts to reduce greenhouse gas emissions, increase energy efficiency of older equipment, or adopt new technology in order to reduce the impact of climate change.

**Resilience:** The ability of systems and individuals to adapt to and withstand future shocks and stresses.

**Sea Level Rise:** the rise in sea level measured with respect to a specified vertical datum relative to the land, which also may be changing elevation over time. Local sea level rise is typically measured with a tide gauge.

**Storm Surge:** an abnormal rise in sea level that accompanies a coastal storm. The height of the storm surge is the difference between the observed level of the sea surface and the level that would have occurred without influence of the storm.

**Tide Gate:** a mechanical structure that allows water to flow freely when the tide is moving in one direction, but which closes to prevent water from flowing in the opposite direction.

**Tide Gauge:** a device that measures changes in sea level relative to a fixed land elevation. These devices measure daily tide heights and storm tide heights. Long Term tide gauge records can provide local long-term sea level trends.

**Urban Heat Island:** increased air temperature in urban areas as cities experience warmer temperatures than rural areas due to replacement of vegetation with buildings, roads, and other heat-absorbing infrastructure. Materials like asphalt, brick, and steel are dark colored and absorb more heat whereas rural areas are less developed and therefore reflect heat.

**Vulnerability:** the susceptibility of a resource and inability to cope with the negative impacts of climate change.

**Weather:** day-to-day state of the atmosphere and short-term variations from minutes to weeks.

