

City of New Castle
Resilient Community Partnership

Vulnerability Assessment and Adaptation Plan

March 2018

Submitted to:
City of New Castle

Submitted by:
**AECOM and
Delaware Coastal Programs**



This report was prepared by AECOM using Federal funds under awards NA16NOS4190168 from the Delaware Coastal Programs and the Office for Coastal Management (OCM), National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the OCM NOAA or the U.S. Department of Commerce.

[Page left intentionally blank]

City of New Castle
Resilient Community Partnership

Vulnerability Assessment and Adaptation Plan

This is a community-based plan designed to adapt the historic New Castle community to minimize the risks associated with flooding. Whether it is a coastal storm or the long-term reality of sea level rise, private properties, public buildings, and roads will be at risk, and the flood hazard area will likely expand. Conservative projections indicate that an increase in sea level and flood elevations of 2 feet with worst case of 5 feet by 2100 can be anticipated. Vulnerabilities have been identified and prioritized to develop a vision and recommended action plan to improve New Castle's resiliency for decades to come.

Acknowledgments

New Castle City Preparedness Task Force Members

Gail Seitz	City of New Castle City Planning Commission
Drew Hayes	Foresight Associates Inc.
Tom Clayton	Good Will Fire Company
David Majewski Sr.	Good Will Fire Company
Ron Vukelich	The Strand
Jamie Rogers	City of New Castle Police Department
Daniel Citron	New Castle Historical Society
Paula Stockton	Buttonwood
Jeffrey Bergstrom	City of New Castle Building and Zoning

Resilient Community Partnership

City of New Castle
Delaware Coastal Program (DCP)

Consultant

AECOM

This report was prepared by AECOM using Federal funds under awards NA16NOS4190168 from the Delaware Coastal Programs and the Office for Coastal Management (OCM), National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the OCM NOAA or the U.S. Department of Commerce.



Contents

Acronym List

Executive Summary	i
1.0 Introduction	1
2.0 Document Review	2
2.1 Dike Maintenance and Emergency Planning Report	3
2.2 Battery Park Bulkhead Replacement	4
2.3 Coastal Protection Concept Study	4
2.4 Downtown Development District Plan	5
2.5 New Castle County All Hazards Mitigation Plan Update	6
2.6 City of New Castle Emergency Operations Plan	6
2.7 City of New Castle Comprehensive Plan 2009 Update	7
2.8 Summary	8
3.0 Vulnerability Mapping	9
3.1 Data Analysis and Methodology	9
3.1.1 Mean Higher High Water (MHHW)	9
3.1.2 1-Percent-Annual-Chance Event	10
3.1.3 DNREC Sea Level Rise Projections	12
3.2 Vulnerability Scenarios and Maps	14
3.2.1 1-Percent-Annual-Chance Event with Current Sea Level	14
3.2.2 Future Sea Levels in Years 2050 and 2100	15
3.2.3 1-Percent-Annual-Chance Event with Future Sea Level Rise in Years 2050 and 2100	16
3.2.4 Summary of Vulnerability Mapping Results	16
3.3 Existing Dikes	21
4.0 Identification and Prioritization of Vulnerabilities	22
4.1 Current Mitigation Measures	22
4.2 Vulnerability Matrix of Critical Structures	23
5.0 Public Engagement	25
5.1 Community Outreach	25
5.2 Formation of the City Preparedness Task Force	25
5.3 Initial Public Workshop	25
5.4 Resilient Community Day Public Workshop	26
6.0 Recommended Actions or Activities	27
6.1 Near-Term Standalone Actions or Activities	27
6.1.1 Planning	27
6.1.2 Community Engagement	28
6.1.3 Regulatory	28
6.1.4 Economic	29
6.2 Near-Term Sequential Actions or Activities	29
6.2.1 Information Gathering	29
6.3 Mid-Term Standalone Actions or Activities	29
6.3.1 Modelling	29
6.4 Long-Term Standalone Actions or Activities	30
6.4.1 Capital Infrastructure	30
6.4.2 Capital Natural Resource Projects	30
6.4.3 Acquisitions and/or Demolitions	30
7.0 References	33

List of Figures

Figure 1: Example of tide elevation recorded at NOAA's Delaware City tide gage	9
Figure 2: Percent chance for one or more floods of a given magnitude being equaled or exceeded in a 30-year mortgage.....	11
Figure 3: Example of FEMA FIRM in the City of New Castle	11
Figure 4: Sea level rise projections for Delaware developed by DGS and DNREC (2017).....	12
Figure 5: Illustration of inundation scenarios under current conditions and due to sea level rise	13
Figure 6: Illustration of bathtub calculations performed for each structure.....	13
Figure 7: Summary of potential impacts	15
Figure 8: Future potential floodplain in the Ferry Cutoff area under the high sea level rise scenario by the Year 2050.....	19
Figure 9: Representation of the topography and dikes compared to the FEMA BFEs along the City of New Castle shoreline....	21
Figure 10: Survey results.....	26

List of Tables

Table 1: Impact Summary from Dike Maintenance and Emergency Planning Report	3
Table 2: SLOSH Flood Elevation and FEMA Base Flood Elevation data for the City of New Castle	10
Table 3: Vulnerabilities	17
Table 4: Vulnerabilities - Critical facilities.....	17
Table 5: New Castle Resilient Community Partnership example critical structures vulnerability matrix.....	24

List of Exhibits

Exhibit 1: City of New Castle Resilient Community Partnership Actions or Alternatives	v and 31
---	----------

List of Appendices

Appendix A: Maps

Appendix B: Meeting Minutes

Appendix C: Analyses of Surveys and Sticky Dot Voting

Acronym List

Acronym	Explanation
BFE	Base Flood Elevation – elevation to which floodwater is anticipated to rise during the base flood and is the regulatory requirement for the elevation or floodproofing of structures.
CRS	Community Rating System – a voluntary program for NFIP-participating communities to reduce flood losses, facilitate accurate insurance rating, and promote the awareness of flood insurance.
DCP	Delaware Coastal Programs – a cooperative program between the State and NOAA that helps manage Delaware's federal coastal zone and balance the use and protection of its resources.
DGS	Delaware Geological Survey – a science-based, public-service-driven State agency at the University of Delaware (UD) that conducts geologic and hydrologic research, service, and exploration.
DNREC	Delaware Department of Natural Resources and Environmental Control – State agency responsible for the State's natural resources, public health and the environment, and quality outdoor recreation.
FEMA	Federal Emergency Management Agency – Federal agency that supports citizens and first responders to ensure the building, sustaining and improving of the capability to prepare for, protect against, respond to, recover from and mitigate all hazards.
FIRM	Flood Insurance Rate Map – the official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community.
FIS	Flood Insurance Study – compilation and presentation of flood risk data for specific watercourses, lakes, and coastal Special Flood Hazard Areas within a community that contains detailed flood elevation data in profiles and tables.
GIS	Geographic Information System – mapping and database software that enables the visualization, analysis, and interpretation of geographic and other data to understand relationships, patterns, and trends.
IPCC	Intergovernmental Panel on Climate Change – an intergovernmental body with the backing of the United Nations dedicated to providing objective, scientific views of climate change and its political and economic impacts.
LiDAR	Light Detection And Ranging – a surveying method to determine topographic and other features using pulsed laser light from an airplane and measuring the reflected pulses with a sensor. The 2009 USGS LiDAR data used in this study was compiled to meet 15-centimeter vertical accuracy and 2-meter horizontal accuracy at a 95% confidence level, which meets or exceeds FEMA Accuracy standard for use in flood mapping and remapping work.
LiMWA	Limit of Moderate Wave Action – the inland limit of the area expected to receive 1.5-foot or greater breaking waves during the 1-percent-annual-chance flood event.
MSC	City of New Castle Municipal Services Commission – responsible for the provision of water and electric services within the City.
MHHW	Mean Higher High Water – the average of the higher high water height measured at tide gages for each tidal day
NAVD88	North American Vertical Datum of 1988 – the only official vertical datum in the United States and the basis for FEMA floodplain mapping
NFIP	National Flood Insurance Program – FEMA program that aims to reduce the impact of flooding on private and public structures by providing affordable insurance to property owners, renters and businesses and by encouraging communities to adopt and enforce floodplain management regulations.
NOAA	National Oceanic and Atmospheric Administration – a division of the U.S. Department of Commerce that focuses on the conditions of the oceans and the atmosphere.
SFHA	Special Flood Hazard Area – The FEMA Special Flood Hazard Area is the area where the National Flood Insurance Program's (NFIP's) floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies.
SLOSH	Sea, Lake and Overland Surges from Hurricanes model – computerized numerical model developed by the National Weather Service to estimate storm surge heights resulting from hurricanes.

[Page left intentionally blank]

Executive Summary

Overview

The City of New Castle is particularly at risk due to its location along the Delaware River, which makes it susceptible to upstream flooding, downstream tidal surges, and a combination of the two. A significant portion of the City is in the coastal floodplain and forecasted sea level rise inundation areas. The four earthen dikes within and near the City (Buttonwood Dike, Broad Dike, Gambacorta Marsh Dike, and Army Creek Dike) were first built in the late 1600s and are believed to be the oldest in the country.

The City sought a partnership with the Delaware Coastal Programs (DCP) to help it correlate the recommendations from prior studies and reports, clarify opportunities, identify knowledge gaps, develop a clearer path forward, engage citizens and businesses, and articulate its vision and action items. This comprehensive Vulnerability Assessment and Adaptation Plan is the end result.

Document Review

Documents reviewed for this report fall into two general categories. First are those general in nature and prepared by various State and Federal agencies. Second are those specific to the City of New Castle prepared by multiple public or private entities.

These documents provided general guidance and topic formulation. Of particular note were Part V: Identifying and Prioritizing Vulnerabilities and Part VI: Understanding, Selecting and Prioritizing Actions from the Natural Hazard and Climate Change Adaptation Tool Kit for Delaware Communities (Delaware Sea Grant, January 2014), which formed the bases for the assessment in Sections 4.0 and 6.0, respectively.

Some common themes emerged from the document review. Multiple documents note the role that regulatory changes can play in creating resilience. Of particular note are the regulatory strategies articulated in the Comprehensive Plan 2009 Update. The needs and benefits of public engagement and outreach are also described in several documents. Section 2.0 summarizes the documents that were reviewed.

Vulnerability Mapping

The study team performed an analysis of future flood conditions to understand where the City of New Castle would be most vulnerable to flooding. The analysis built upon existing datasets including Federal Emergency Management Agency's (FEMA's) Flood Insurance Study (FIS) for New Castle County, tidal records and analysis from the National Oceanic and Atmospheric Administration (NOAA), and Delaware Department of Natural Resources and Environmental Control's (DNREC's) projections of sea level rise.

Multiple data sources were used to develop a comprehensive picture of flood risk in New Castle. This information was leveraged to create datasets describing the extent and depth of flooding for two benchmarks, mean higher high water (MHHW) and the 1-percent-annual-chance flood event, at three periods in time: current, 2050, and 2100.

MHHW is colloquially referred to as high tide and represents a water level that the City of New Castle would experience on a daily basis. The 1-percent-annual-chance flood event is commonly referred to as a 100-year storm as it has a 1 in 100 chance of occurring in any given year. The 1-percent-annual-chance event represents a large storm like a hurricane or nor'easter that creates substantially higher than normal water levels. The study team combined DNREC's sea level rise scenarios with datasets representing MHHW and a 1-percent-annual-chance flood event to understand the City's vulnerability and develop recommendations for future flood mitigation actions.

The 1-percent-annual-chance flood event is commonly referred to as a 100-year storm as it has a 1 in 100 chance of occurring in any given year.

In tidally-influenced areas, like the City of New Castle, the FEMA Flood Insurance Rate Maps (FIRMs) are based on the combined effects of storm surge and wave hazards. Storm surge is the rise of water above normal tide levels generated by a storm. Waves develop atop the storm surge due to wind, increasing the base flood elevation. The FEMA FIS and resulting FIRM are based on modeling informed by historical storm behavior; therefore, the magnitude of the

1-percent-annual-chance event in the City of New Castle is influenced by the size and frequency of storms that have affected the area.

In 2016, DNREC and the Delaware Geological Survey (DGS) led the development of a Sea Level Rise Technical Committee composed of local and regional experts to evaluate if updates to Delaware's 2009 projections of sea level rise were warranted. The committee determined that updates were needed and developed a total of three planning scenarios. The "high" describes a sea level rise scenario that has a 95% chance of not being met or exceeded and was chosen for planning purposes as it represents a "worst-case" situation.

DNREC has a high (95%) level of confidence that the sea level rise in New Castle will be less than 2 feet by 2050 and 5 feet by 2100.

To combine the sea level rise scenarios with the MHHW and 1-percent-annual-chance data, an approach known as the "bathtub method" was used. The bathtub method assumes that sea levels will increase uniformly and can be added to a water level like MHHW or FEMA's 1-percent-annual-chance event to represent the combined effects. The bathtub method also assumes that wave hazards won't be affected by sea level rise.

To help identify and visualize the areas that are at risk, a series of maps were created that display the current and projected high tide and Special Flood Hazard Areas overlaid with development features and demographic data.

The hazards and inundation areas are generally mapped in three categories::

- Present day flood hazards
- Future high tide due to sea level rise
- Future flood hazards due to sea level rise

The vulnerability maps are in Appendix A.

1-Percent-Annual-Chance Event with Current Sea Level. Per the FEMA data layers, approximately 870 acres, or 40% of the City's total area, are in the FEMA Special Flood Hazard Area and are at risk of coastal flooding. Additional areas are vulnerable to flash flooding or drainage-related flooding. Approximately 264 principal structures, or about 17% of all principal buildings in the City, are located in the Special Flood Hazard Area and currently considered to be at high risk of flooding under the National Flood Insurance Program (NFIP) if no flood protection measures are in place.

Future Sea Levels in Years 2050 and 2100.

Currently, the usable land area within the City boundary that is inundated with water at high tide is minimal and does not impact any structures or roads. Sea level rise is anticipated to increase this high tide area nominally by 2050. By the Year 2100, future high tide area increases substantially as approximately 872 acres would be inundated, which is about 40% of the total City area. Under the high sea level rise scenario, the number of principal buildings within the future high tide increases from zero in the present day to 202 by the end of the century, which is about 13% of all principal structures.

1-Percent-Annual-Chance Event with Future Sea Level Rise in Years 2050 and 2100.

The high sea level rise scenario is anticipated to increase this Special Flood Hazard Area from 40% (present day) to 50% by 2050. The number of principal structures that would be impacted almost doubles to 474, and 30% of all buildings, from the present day. The miles of road are projected to be impacted with 6 inches or more of flood depth increases to 9 miles, or about 34% of all roads in the City. About 7 miles of these roads are owned and maintained by the City, and the remaining 2 miles are owned by the State.

By the end of the century, the high sea level rise scenario is anticipated to increase the Special Flood Hazard Area to 60% of the total City area. The number of principal buildings within the projected Special Flood Hazard Area increases to 747, or 47% of all buildings, from the present day. This would be almost half of all the principal structures in the City. The roads that would be impacted with 6 inches or more of flooding increase to 13 miles, which is almost half of all the roads in the City. Eleven miles owned and maintained by the City.

Summary of Vulnerability Mapping Results

The vulnerability maps assist to identify the highest areas of concentration of these following susceptible groups: those who live in poverty and presumed to have less income to adapt or rebuild after a damaging event; those who do not have a vehicle and therefore may need to rely on public transit or a share a ride to evacuate the City; and the elderly and who may require additional assistance in general.

While a significant portion of the outer edges of the Historic District are projected to be within the future high tide and Special Flood Hazard Area, there is only one property on the National Register of Historic Places, the Glebe Cemetery, which is potentially at risk to extreme flood events. In addition, wetlands, marshlands, and protected public land are forecasted to be exposed to the high tide using the high sea level rise scenario.

Evacuation Routes. The evacuation routes for New Castle are Route 141 North (Washington Street) and Route 273 West (Frenchtown Pike), and shown as a red and white hatched line on all of the maps. The following key intersections are within the present day Special Flood Hazard Area and are projected to be inundated by high tide by 2100:

- Delaware Street and Ferry Cut-Off
- 6th Street (Route 9) and Ferry Cut-Off/Chestnut Street
- 7th Street (Route 9) and Washington Street

Existing Dikes. The dikes represent a critical component to flood management in the City of New Castle. In 2014, the dikes were repaired and raised to an elevation of 8.5 feet NAVD88 (previously they had deteriorated to an elevation of 5 to 6 feet NAVD88). The raised elevation is below the 1-percent-annual-chance event flood elevations along the Delaware River. Consequently, the dikes would not offer significant protection from storm surge during a 1-percent-annual-chance event and are not recognized as certified flood control structures by FEMA. However, they do offer some attenuation of wave energy and protection during smaller flood events. In their current state, the effectiveness of the dikes will decrease as sea level increases. As sea level increases relative to the crest of the dikes, the size of storms that they can protect against will decrease



Gambacorta Dike
Post construction of the Battery
Park Trail and Gambacorta Dike.
Photo Credit: DNREC

Identification and Prioritization of Vulnerabilities

New Castle has already undertaken numerous mitigation initiatives. The spreadsheet of critical structures and flood depths was used to populate a Vulnerability Matrix based on the Delaware Sea Grant Tool Kit. This spreadsheet assessed each structure for sensitivity and adaptive capacity.

Sensitivity is the degree to which a built, natural or human system is directly or indirectly affected by natural hazards and climate change. Adaptive capacity is the degree and ability of built, natural or human systems to accommodate or withstand changes in climate (including climate variability and climate extremes) or experience a natural disaster with minimal potential damage or cost. The Project Team added a third category for assessment: criticalness of the structure, which assesses a structure's importance in providing public safety.

Using this scoring process, the City of New Castle Municipal Services Commission (MSC) office on Chestnut Street and the Police Department building on Wilmington Road would be ranked as the most vulnerable critical structures in the City with Public Works Yard and MSC building and garage adjacent to the Police Department also ranked highly. Additional investigative work as described in Section 6.0 would need to be performed before investments are made in these locations.

Sensitivity – the degree to which a built, natural or human system is directly or indirectly affected by natural hazards and climate change. If a system is likely to be affected as a result of projected natural hazards or climate change, it should be considered sensitive to climate change.

Adaptive Capacity – the degree and ability of built, natural or human systems to accommodate or withstand changes in climate (including climate variability and climate extremes) or experience a natural disaster with minimal potential damage or cost.

Public Engagement

The team first began the general public outreach campaign with an announcement about the project to City Council at the Town Hall on May 9, 2017. Outreach continued over the summer with the release of a project overview one-pager and invitations to City residents and stakeholders to the first public workshop through a newspaper listing (City of New Castle Weekly), website and social media postings (DNREC Delaware Coastal Programs and the City of New Castle websites and facebook pages), and signage posted in several locations around the City.

For additional in-depth community engagement, the team formed the New Castle City Preparedness Task Force in September 2017. This group includes members who represent several City boroughs that currently experience flooding on a regular basis, as well as City stakeholders from sectors that will be involved in future flooding response and adaptation efforts.

The City Preparedness Task Force met several times over the course of the project with the project team to vet findings and the vulnerability maps. The Task Force also held discussions on potential adaptation and mitigation recommendations, providing feedback on their feasibility, capacity to be implemented, and overall benefit to resiliency. The City of New Castle will continue to host meetings of the Task Force on a regular basis after the conclusion of this project in order to move forward with implementing the project's final adaptation recommendations.

The first public workshop was held on Thursday, September 7, 2017 at the New Castle Elementary School, which is a local school within the City limits, to describe an assessment of the community's vulnerability to flooding caused by storms and sea level rise. The workshop was attended by 55 stakeholders and residents of the City of New Castle, including City Council and Planning Commission officials. It also provided participants an opportunity to give input on which City sectors the City Preparedness Task Force should focus on first when addressing flooding risks.



Public Workshop

Photo Credit: DNREC

At the end of the workshop, participants turned in a survey that asked them several questions about how concerned they are about flooding in the City, how they are personally affected by flooding, and about what they have done so far to adapt to flooding on their own personal property.

A second public workshop to report the final findings of the project was held on Wednesday, March 14, 2018, at a local school within the City limits, Carrie Downie Elementary School. This event was an opportunity to present the final results of the project and the adaptation and mitigation recommendations. This workshop also served as an informational session to promote a safe, more prepared community by connecting City residents with flood preparedness information, with tips for increase resiliency to flooding for personal property, and with subject matter experts from additional agencies and organizations outside the project team.

Recommended Actions or Activities

Through input received from the residents at the two public hearing, comments from task force members at multiple task force meetings, review of documents, and numerous meetings of the project team, numerous actions or activities are being recommended. Please see Exhibit 1 (below) for a "snapshot" of these actions or activities. In many ways, these actions or activities represent the City's vision for resiliency for decades to come.

The actions or activities are categorized as follows:

- **Near-Term Standalone:** Planning, Community Engagement, Regulatory, and Economic actions or activities that can be initiated in the near future without need for any predecessor tasks and are generally independent of other actions or activities.
- **Near-Term Sequential:** Information Gathering tasks that could also be initiated in the near future without need for any predecessor tasks and would be needed before subsequent actions or activities are undertaken.
- **Mid-Term Sequential:** Modelling efforts that would build upon the obtained information.
- **Long-Term Sequential:** Capital Infrastructure, Capital Natural Resources, and Acquisitions, which are the culmination of predecessor actions or activities.

EXHIBIT 1

CITY OF NEW CASTLE RESILIENT COMMUNITY PARTNERSHIP ACTIONS OR ALTERNATIVES

	Action or Activity	Private Property	Public Safety	SWM Systems	Emergency Services	Shoreline Protection	Public Utilities	Historic Structures	Transportation	Public Services	Costs
NEAR-TERM STANDALONE ACTIONS OR ACTIVITIES											
Planning	PL1. Adopt land use policies and strategies that would guide growth away from high risk areas. Ensure technical expertise on team reviewing City's Comprehensive Plan Update such that it can be the impetus to appropriate policies.	✓						✓		✓	\$
	PL2. Update City's Emergency Operations Plan.		✓		✓		✓		✓	✓	\$
	PL3. Identify areas where cars could be parked in advance of likely flooding events.	✓	✓		✓				✓	✓	\$
Community Engagement	CE1. Transition Flood Preparedness Task Force into standing committee with long-term role in advising City on future actions and further engaging residents and businesses.	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$
	CE2. Continue to Refine Community Rating System (CRS) Status as an improved program translates to improved resilience and lower insurance premiums for residents.	✓						✓		✓	\$
	CE3. Designate City staff persons to serve as community resiliency specialists. One focused on outreach and the other on more technical aspects. Make phone numbers readily available.	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$
	CE4. Identify specific approaches homeowners can take to mitigate flood risks which can lead to a reduction in flood insurance premiums.	✓						✓		✓	\$
	CE5. Sponsor a community-wide outreach event each year on emergency preparedness at the start of hurricane season.		✓							✓	\$
Regulatory	CE6. Develop a resiliency checklist or webpage for all residents.	✓	✓							✓	\$
	CE7. Provide access to interactive tools, and websites, in addition to trained staff for residents and businesses such that they can determine the extent of their vulnerability to sea level rise.	✓						✓		✓	\$
	CE8. Encourage area schools to prepare lesson plans regarding sea level rise and resiliency planning (such as poster contests).		✓		✓					✓	\$
Economic	RE1. Amend City Code by making adjustments to include sea level rise adaptation strategies, remove any barriers that would prohibit additional flood protection, and minimize future hazards.	✓	✓					✓		✓	\$
	EC1. Provide incentives to homeowners and businesses to implement flood management strategies that would lessen the City's costs for disaster mitigation.	✓								✓	\$
NEAR-TERM SEQUENTIAL ACTIONS OR ACTIVITIES											
Information Gathering	IG1. Develop near and long-term funding strategies.	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$
	IG2. Perform additional surveying to obtain first floor and adjacent ground elevations as well as determine the presence or absence of basements / crawlspaces for critical public structures likely to be impacted to fine-tune modeling.		✓		✓		✓	✓		✓	\$
	IG3. Perform additional surveying to obtain first floor and adjacent ground elevations as well as determine the presence or absence of basements / crawlspaces for private structures likely to be impacted to fine-tune modeling.	✓								✓	\$
	IG4. Perform additional surveying of tops and inverts of drainage inlets, sizes and materials of pipes, and inverts and configurations of outfalls as needed to complete inventory.			✓			✓		✓	✓	\$
	IG5. Perform study to determine the potential impacts to the City's ecosystems resulting from various sea level rise scenarios. Need partnership with DNREC.			✓		✓				✓	\$

EXHIBIT 1 (Continued)
CITY OF NEW CASTLE RESILIENT COMMUNITY PARTNERSHIP
ACTIONS OR ALTERNATIVES

	Action or Activity	Private Property	Public Safety	SWM Systems	Emergency Services	Shoreline Protection	Public Utilities	Historic Structures	Transportation	Public Services	Costs
Information Gathering	IG6. Perform economic analyses to maximize benefit / cost ratio of actions or alternatives that have both public and private costs and benefits.	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$\$\$
	IG7. Install water surface elevation sensors / monitors / cameras to help predict roads or other areas likely to be inundated.		✓	✓	✓		✓		✓	✓	\$\$\$
MID-TERM SEQUENTIAL ACTIONS OR ACTIVITIES											
Modelling	MO1. Perform dynamic modelling of coastal storms to more accurately model impacts from various sea level rise scenarios and waves.	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$\$\$
	MO2. Perform dynamic modelling of storm drainage system to better determine incidents of localized flooding from drainage constraints (not coastal storms) and determine future capacity issues.	✓		✓	✓		✓		✓	✓	\$
	MO3. Perform groundwater modelling to determine changes to elevations and extents of inland migration of saltwater resulting from various sea level rise scenarios.			✓			✓			✓	\$
LONG-TERM SEQUENTIAL ACTIONS OR ACTIVITIES											
Capital Infrastructure, Capital Natural Resource Projects, and Acquisitions would only be undertaken or implemented if the results of Short-Term Sequential Actions or Activities and / or Mid-Term Sequential Actions or Activities support the technical feasibility and financial efficacy of doing so.											
Capital Infrastructure	CI1. Further raise dikes and / or add additional dikes at Battery Park and The Strand to provide better protection for more storm events and sea level rise scenarios.	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$\$\$\$
	CI2. Raise or otherwise protect select roads to secure emergency access routes.		✓	✓			✓		✓	✓	\$\$\$\$
	CI3. Raise or floodproof select public structures to protect those essential to public safety and wellbeing.		✓		✓		✓	✓		✓	\$\$\$
	CI4. Increase floodplain storage and existing storm sewer system capacities (depending on results of modelling).	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$\$\$
Capital Natural Resource Projects	CN1. Anchor shorelines and / or install wave attenuation devices to protect from erosion from increased water surface elevations and / or wave action.			✓		✓				✓	\$\$\$
	CN2. Implement wetland restoration program to enhance the City's adaptive capacity by embracing the beneficial effects of restored natural environments.			✓		✓				✓	\$\$\$
	CN3. Increase use of green infrastructure throughout the City (e.g. Delaware Street redesign).			✓					✓	✓	\$
Acquisitions and / or Demolitions	AC1. Lessen the risk and improve the resilience of properties clearly vulnerable to future inundation from sea level rise through land acquisitions and / or demolition of structures located on them to maximize community benefits, habitat connectivity, and resilience.	✓	✓	✓	✓		✓	✓		✓	\$\$\$\$

1.0 Introduction

The City of New Castle was the first city founded along the Delaware River in 1651. The New Castle Green was laid out as a town common a few years later and is located just blocks away from the site where William Penn first landed in America in 1682. In recognition of its historic significance, a portion of the City was designated as a National Landmark in 1967. It became part of the First State National Monument under the Antiquities Act of March 25, 2013, and was subsequently designated as the First State National Historical Park by Congress. New Castle currently is comprised of about 5,400 residents as well as vibrant commercial and industrial districts.

The City is particularly at risk due to its location along the Delaware River, which makes it susceptible to upstream flooding, downstream tidal surges, and a combination of the two. A significant portion of the City is in the coastal floodplain and forecasted sea level rise inundation areas. The four earthen dikes within and near the City (Buttonwood Dike, Broad Dike, Gambacorta Marsh Dike, and Army Creek Dike) were first built in the late 1600s and are believed to be the oldest in the country.

Though rehabilitation (vegetation removal, placement of rip-rap, leveling, etc.) was recently completed at each dike, their tops are at approximate elevations of 8.5 NAVD88, which are below the FEMA 100-year flood elevation and well below future elevations given sea level rise considerations. Operation and Maintenance (O&M) Plans were developed for each of the dikes as part of the rehabilitation project, which includes maintenance of the dike embankments, maintenance of the tide gates, and operation. The City also has tide gates and extensive marshes as part of its flood management strategy.

The threat of dike failure or overtopping continues with the added recognition that precipitation and coastal storms appear to be more frequent and more intense. The City also recognizes that sea level rise is expanding high tide inundation areas and increasing flood hazards. Sea level rise, which is projected to increase water elevations in the Delaware Bay between 2 and 5 feet by 2100, will almost certainly increase the occurrences of damaging events. Dike overtopping or failure would result in very sudden rapid, forceful flows with little or no warning. The tidal river overtopped the dikes 18 times in the five years prior to their restoration.

New Castle can be impacted by both coastal and riverine flooding and the greatest hazard occurs when those two individual hazards are combined. The potential for damage was best exemplified by Hurricane Sandy in October 2012, which destroyed a pier, demolished a large section of the walkway in Battery Park, damaged the four dikes, and led to the deposition of debris after the tide had subsided.

While Hurricane Sandy was an extreme event, New Castle can be impacted by more frequent storms as well. Two major thoroughfares, Route 9 at the southern end of Dobbinsville and Wilmington Road (also Route 9) where it crosses over Broad Marsh, both flood periodically. Route 9 near Dobbinsville can remain flooded for days at a time rendering that point of ingress and egress to the City unpassable. This can effect evacuation routes and emergency response times and result in higher road maintenance costs.

The City sought a partnership with the Delaware Coastal Programs (DCP) to help it correlate the recommendations from prior studies and reports, clarify opportunities, identify knowledge gaps, develop a clearer path forward, engage citizens and businesses, and articulate its vision and action items. This comprehensive Vulnerability Assessment and Adaptation Plan is the end result.



New Castle Commons

The statue of William Penn in New Castle Commons represents the City's values for protecting its rich history and common use of land.

2.0 Document Review

Documents reviewed for this report fall into two general categories. First are those general in nature and prepared by various State and Federal agencies. Second are those specific to the City of New Castle prepared by multiple public or private entities.

General guidance documents reviewed included the following:

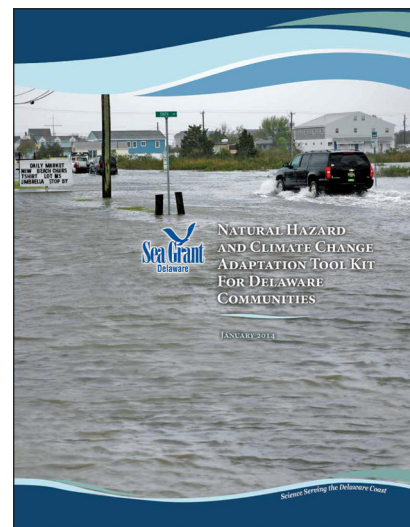
- Natural Hazard and Climate Change Adaptation Tool Kit for Delaware Communities (Sea Grant Delaware, January 2014)
- Coastal Delaware Resiliency (Sea Grant Delaware and the University of Delaware, February 2017)
- Preparing for Tomorrow's High Tide - Recommendations for Adapting to Sea Level Rise in Delaware (DNREC Delaware Coastal Programs, September 2013)

These documents provided general guidance and topic formulation. These documents provided general guidance and topic formulation. Of particular note were Part V: Identifying and Prioritizing Vulnerabilities and Part VI: Understanding, Selecting and Prioritizing Actions from the Natural Hazard and Climate Change Adaptation Tool Kit for Delaware Communities (Delaware Sea Grant, January 2014), which formed the bases for the assessment in Sections 4.0 and 6.0, respectively.

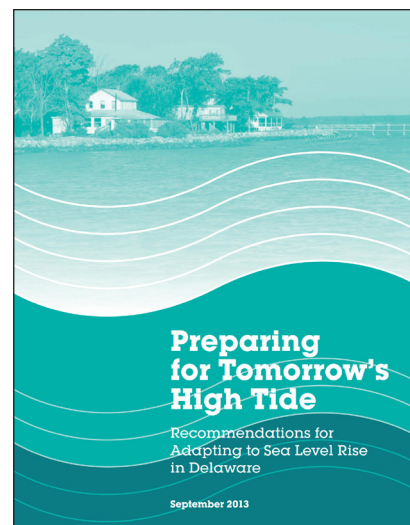
Documents specific to the City of New Castle included the following:

- Dike Maintenance and Emergency Planning Report (Greenstone Engineering, January 2011)
- Battery Park Bulkhead Replacement – Conceptual Design & Permitting (Foresite Associates – est. May 2016)
- Coastal Protection Concept Study (Duffield Associates, April 2014)
- Downtown Development District Plan (AECOM, May 2016)
- New Castle County All Hazards Mitigation Plan Update (Vision Planning and Consulting LLC, February 2015)
- City of New Castle Emergency Operations Plan (Sumter Consulting, August 11, 2008)
- City of New Castle Comprehensive Plan 2009 Update (URS Corporation, now AECOM, July 14, 2009)

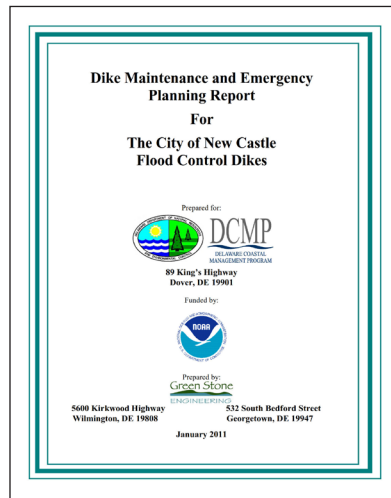
Note that several of these documents use the “100-year event” or “100-year flood” as the basis for their assessment. This Vulnerability Assessment and Adaptation Plan uses the term “1-percent-annual-chance flood event” instead. As described in Section 3.1, these two terms are inter-changeable for the purposes of this plan.



Natural Hazard and Climate Change Adaptation Tool Kit for Delaware Communities
Sea Grant Delaware, 2014



Preparing for Tomorrow's High Tide - Recommendations for Adapting to Sea Level Rise in Delaware
Delaware Coastal Programs, 2013



Dike Maintenance and Emergency Planning Report

Greenstone Engineering, 2011

2.1 Dike Maintenance and Emergency Planning Report

This document reported the results of a study overseen by the DCP and the City of New Castle to 1) complete an assessment of the four dikes (Buttonwood Dike, Broad Dike, Gambacorta Marsh Dike and Army Creek Dike) that protect the City from flooding; 2) develop a multi-year planning tool to ensure long-term stability and proper maintenance of these dikes; and 3) establish emergency planning and response protocols in the event of a dike breach. The primary purpose of this effort was to perform a physical assessment of the dikes, evaluate the risks and consequences of a dike failure, and develop planning and response tools in the event of a dike failure.

The approach used in this Vulnerability Assessment and Adaption Plan was similar to the one used in this planning report: flood elevations were predicted by taking the current FEMA 100-year flood elevation of 9.0 feet and adding projected sea level rise scenarios. This Vulnerability Assessment and Adaptation Plan uses the term “1-percent-annual-chance flood event” instead of the “100-year event” (see Section 3.1 for details). The impacts from three scenarios were assessed:

- Low sensitivity projects: FEMA elevation + 0.5 meters (1.64 feet) = 10.64 feet
- Medium sensitivity projects: FEMA elevation + 1.0 meter (3.28 feet) = 12.28 feet
- High sensitivity projects: FEMA elevation + 1.5 meters (4.92 feet) = 13.92 feet

The report included estimates of areas of inundation and number of structures within those areas for each scenario. For high sensitivity projects, the following was determined for each of the four dikes.

Table 1: Impact Summary from Dike Maintenance and Emergency Planning Report

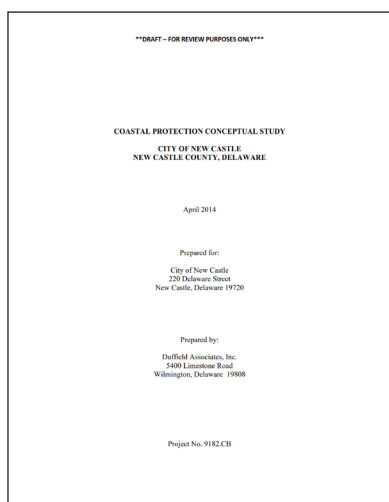
	Inundation Area (acres)	Inundation Area Percentage (%)	Number of Homes Inundated
Buttonwood	260	11.5	250
Broad	646	28.6	311
Gambacorta	175	7.7	119
Army Creek	487	21.6	34

The dikes were subsequently raised, so this assessment would need to be performed again. However, floodplain elevations are still several feet higher than the new heights of the dikes. There may or may not be substantive differences if the assessment is performed again. The information generally correlates to the analyses described in Section 3.0.

The study also assessed the economic impact of the dike rehabilitation using the Benefit-Cost Analysis Program (BCA) promulgated by FEMA. Per the report, a project is designated as feasible if the ration of costs of damages to costs of improvements is greater than one. The calculated ratios for each of the four dikes ranged from 3.96 to 67.82. Again, while useful, these analyses would need to be recomputed as it is doubtful the costs for additional raising could be linearly extrapolated.



Battery Park Bulkhead Replacement
Foresite Associates, est. 2016.



Coastal Protection Concept Study
Duffield Associates, 2014

2.2 Battery Park Bulkhead Replacement - Conceptual Design & Permitting

The report and accompanying conceptual design addressed an approximately 50-foot section of a wooden bulkhead near the Delaware Street wharf parking lot that is well beyond its service life and in need of repair/replacement. The scope of the project was to re-think the replacement and incorporate more green technologies such as a living shoreline in the area of bulkhead replacement as well as extensions along the shoreline to increase ecosystem services and shoreline resilience. The study involved literature review and site, hydrodynamic, and ecological inventories. It resulted in a concept plan and design strategies including the following:

- Groin Structure: This structure is a wooden groin at the edge of the wharf to reduce the energy from boat and wind angled waves that interact with the site.
- Bulkhead Planter Box: The box extended the proposed shoreline beyond the depth of the concrete wharf to increase ecosystem services and habitat value.
- Marsh Sills: One sill was installed near the toe of the existing marsh peat line, and the other was installed further out from shore closer to the mean lower low tide location.
- Tiered Crib Ruins: These ruins are similar to existing crib ruins elsewhere along the shoreline that have resisted wave impacts for hundreds of years.
- Gabion Curb: The curb is used to delineate the extent of the living shoreline and provide a more uniform edge to the shoreline where it abuts the River Walk.
- Overlooks: The overlooks are for educational purposes by providing opportunities for people to get closer to the structures to understand their ecological function.

The report also identified the need for monitoring of structural and functional attributes of restoration sites as well as the minutes from a Joint Permit Processing Meeting at DNREC. Costs were estimated to be between \$400,325 and \$825,000.

2.3 Coastal Protection Concept Study

This study involved a conceptual coastal protection evaluation for a large portion of the City's waterfront area that is unprotected from future flood events. The unprotected area was identified as being between the Gambacorta Dike to the south and the Broad Marsh Dike to the north, which are both mainly lower than the FEMA 100-year flood elevation of 9.0 feet. Fifty percent of the unprotected area is within Battery Park, and the remaining fifty percent is property of homeowners along The Strand whose rear yards back to the Delaware River.

FEMA-generated storm surge data were reviewed against existing topography and site base plans to identify and rank potential impacts to the study area from coastal flooding events. Several coastal protection concepts were developed that could be effectively applied to both the privately and publically owned property. The study area was within the FEMA Velocity Zone (VE-12), which the study defined as representative of possible wave action of an additional 3 feet above the 100-year flood elevation. The study noted that protection against both the 100-year flood elevation and the wave action associated with the Velocity Zone would necessitate coastal protection measures be constructed to at least elevation 12.0 feet, which was determined to not be cost-effective.

Recommended projects were earthen berms at Battery Park and flood log system at Delaware Street. For The Strand, various options for protecting properties were evaluated. It was noted that some properties on The Strand already have flood protection measures and a "protection gap" may remain after installation of recommended practices.

2.4 Downtown Development District

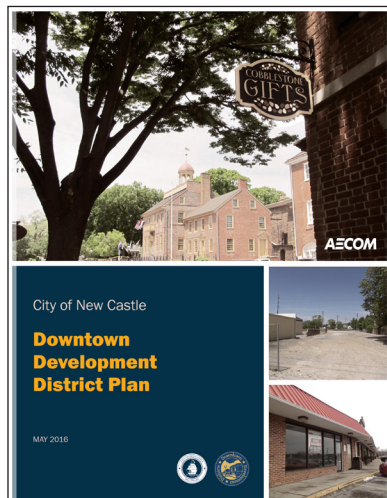
The Downtown Development District (DDD) Plan advanced recommendations in the City's Comprehensive Plan to encourage redevelopment in designated areas (e.g., the Downtown Gateway Zoning District). The plan drew attention because much of the City and the redevelopment areas are susceptible to flooding associated with upstream drainage and downstream tidal surges. It stated that 51 acres (60%) of the proposed DDD is within the FEMA Zone AE flood hazard zone. Certain areas experience nuisance flooding events such as repeated flooding of streets and property and are also at risk for occasional extreme flooding events due to strong coastal storms. The Plan also recognized that sea level rise is expanding high tide inundation areas and increasing flood hazards in the redevelopment areas.

The plan noted that there are opportunities for City staff to continue to work with property owners in the floodplain to better understand flood damage reduction measures, FEMA programs, and potential savings in flood insurance premiums. In addition, the plan noted that City staff is reviewing its Floodplain Ordinance to ensure that it meets basic Federal and State requirements and provides suitable protection of life and property while also allowing the type of development envisioned in the Comprehensive Plan and the District Plan.

The District Plan set forth goals, objectives, and strategies to mitigate flood hazards and sea level rise:

- Goal: Reduce New Castle's vulnerability to natural hazards, particularly flooding and sea level rise.
- Objectives:
 - Financial and technical assistance will be available to elevate or floodproof buildings in flood prone areas.
 - Residents will understand how to get information about natural hazard events and will have information about shelters and evacuation routes.
- Strategies:
 - Enforce appropriate safeguards to minimize risks to flood hazards.
 - Evaluate measures to ensure that new development is resistant to current and future hazards and minimizes contributing stormwater run-off to flood water receiving areas.
 - Provide public awareness and outreach to current residents, developers, and prospective homebuyers on flood hazards and sea level rise risks and flood protection measures.

An amendment to the District Plan, including revised District boundaries, is currently underway. It is anticipated that the revised boundary will no longer include large vacant lands that are significantly impacted by flood hazards.



Downtown Development Plan
AECOM, 2016

2.5 New Castle County All Hazards Mitigation Plan Update

This plan update provides a historical synopsis of floods as well as hurricanes and tropical storms that have impacted the County since the early 1990s and includes a table of Relevant Plans and Programs in Place. This table shows the City of New Castle as being the only municipality in the County with each listed plan or program already in place.

The main recommendation relevant to coastal resiliency is its encouragement for municipalities to use the LiMWA (defined by Update to be "limited wave action" but the actual description is "limit of moderate wave action") line to adjust mitigation projects to a higher code to protect communities from future sea level rise conditions and for new projects in A zones. Also, it recommends that the City of New Castle develop a detailed flood vulnerability study for the entire City along the Delaware River and Bay to focus on coastal/riverine flooding from severe storm events and sea level rise.

Finally, it includes a reference to the document "Preparing for Tomorrow's High Tide – 2014 Sea Level Rise Workshop Proceedings and Interim Implementation Plan" and notes that the document contains the results of the workshop held in March 2014 regarding how jurisdictions can develop specific implementation actions for the sea level rise adaptation recommendations.

2.6 City of New Castle Emergency Operations Plan

This plan is fairly generic and does not offer many specifics regarding the City of New Castle. It does mention the use of remote sensing technology, risk assessment, and predictive and plume modeling tools among examples of preparedness activities and describes mitigation activities including public education and outreach, structural retrofitting, code enforcement, and encouraging citizens to purchase flood insurance.

It includes a section on flooding and mentions the historical flooding of Route 9 east of the City and how modelling has shown a Category 1 hurricane would flood Route 9 not only east of the City but west as well leaving Routes 273 and 141 as the only major routes of ingress or egress. The Plan also includes a description of past hurricanes but describes impacts on more of a Statewide basis than within the City.

New Castle County All Hazard Mitigation Plan



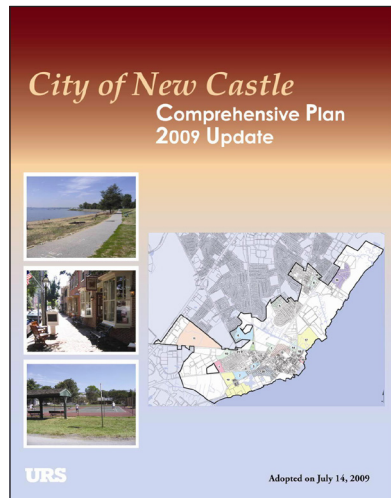
Plan Executive Summary

January 6, 2010

New Castle County Department of Public Safety
Office of Emergency Management

New Castle County All Hazards Mitigation Plan Update

Vision Planning and Consulting LLC, 2015



City of New Castle Comprehensive Plan,
URS (now AECOM), 2009

2.7 City of New Castle Comprehensive Plan 2009 Update

An update to the 2009 Plan is currently underway as of the date of this report and the City intends to incorporate elements as appropriate to enhance resiliency. Multiple sections relevant to coastal resiliency include Land Use, Transportation, and Environmental Protection.

In the section entitled Land Use, the 145-acre parcel owned by the Trust on Route 273 behind New Castle Middle School was identified along with the recommendation that it be kept as open space to preserve flood storage and wetlands.

In the Transportation Plan section, the monitoring of the implementation of DeIDOT Route 9/River Road Area Flood Remediation Project (DeIDOT CIP FY 2008-FY 2013) was presented as a strategy.

The section on Environmental Protection has numerous references and goals pertaining to flooding. It notes that ideally, floodplains should remain free from obstructions but historically floodplains have been built on. However, regulations now exist concerning construction within floodplains, and additional permitting for construction is required. The plan mentions the numerous wetlands that exist up and down the Delaware River's edge, which act as floodwater storage areas and pollution filters as well as habitat for various species of birds and fish. Finally, it ties the issue of stormwater runoff to flood protection and healthy wetlands.

Among the plan's goals are the following:

- Preserve the capacity of the floodplain to carry floodwaters with a strategy to continue to enforce the city's current standards for construction in the floodplain and creating a management plan for unused open space considering how to decrease runoff through using native species and unmown areas.
- Conserve environmentally sensitive areas with multiple strategies including the following:
 - Develop overlay zoning ordinances, environmental performance standards, design criteria and/or mitigation requirements to protect environmentally sensitive areas including encouraging LEED criteria in zoning and development standards.
 - Amend the zoning code to prohibit development in wetlands and require a riparian buffer zone along wetlands and stream banks.
 - Amend the zoning code to include an environmental protection overlay district that will encourage and, where appropriate, require conservation subdivision standards to protect environmental features on individual parcels.

2.8 Summary

This Vulnerability Assessment and Adaptation Plan essentially accomplishes one of the recommendations in the New Castle County All Hazards Mitigation Plan Update as it relates to the City of New Castle because it focused on coastal/riverine flooding from severe storm events and sea level rise.

Some common themes emerged from the document review. Multiple documents note the role that regulatory changes can play in creating resilience. Of particular note are the regulatory strategies articulated in the Comprehensive Plan 2009 Update. The needs and benefits of public engagement and outreach are also described in several documents.

As noted in the introduction, the dikes have been an integral part of flood protection in New Castle since the City's founding. The Dike Maintenance and Emergency Planning Report demonstrated that raising of the dikes to their current elevation of 8.5 was cost effective from a benefit cost perspective. Unanswered questions at this time include whether or not further raising of these dikes would also be cost effective. There is also the issue of the area or gaps between these dikes. The *Battery Park Bulkhead Replacement- Conceptual Design & Permitting* and *Coastal Protection Concept Study* each identified options for addressing these gaps in a resilient fashion.

Many of the goals, strategies, and recommendations are being reiterated in the Recommended Actions or Activities in Section 6.0.

3.0 Vulnerability Mapping

3.1 Data Analysis and Methodology

The study team performed an analysis of future flood conditions to understand where the City of New Castle would be most vulnerable to flooding. The analysis built upon existing datasets including FEMA's Flood Insurance Study (FIS) for New Castle County, tidal records and analysis from the National Oceanic and Atmospheric Administration (NOAA), and DNREC's projections of sea level rise. Multiple data sources were used to develop a comprehensive picture of flood risk in New Castle. This information was leveraged to create datasets describing the extent and depth of flooding for two benchmarks, mean higher high water (MHHW) and the 1-percent-annual-chance flood event, at three periods in time: current, 2050, and 2100.

MHHW is colloquially referred to as high tide and represents a water level that the City of New Castle would experience on a daily basis. The 1-percent-annual-chance flood event is commonly referred to as a 100-year storm as it has a 1 in 100 chance of occurring in any given year. The 1-percent-annual-chance event represents a large storm like a hurricane or nor'easter that creates substantially higher than normal water levels. The study team combined DNREC's sea level rise scenarios with datasets representing MHHW and a 1-percent-annual-chance flood event to understand the City's vulnerability and develop recommendations for future flood mitigation actions.

The analyses described herein were partially based on ground elevations derived from LiDAR, which has an inherent inaccuracy. Furthermore, floor elevations of

structures were not known or obtained. Observations have been made based on mapping intended for planning purposes only. Potential impacts to individual structures would need to be assessed with engineering analyses or modeling.

The 1-percent-annual-chance flood event is commonly referred to as a 100-year storm as it has a 1 in 100 chance of occurring in any given year.

3.1.1 Mean Higher High Water (MHHW)

The City of New Castle experiences two high tides on a daily basis, similar to the sample tide record for the Delaware City tide gage (NOAA, 2017) provided in Figure 1. The MHHW is a tidal benchmark that represents an average of the higher of those two daily high tides. NOAA has performed a statistical analysis to determine the MHHW (and other tidal benchmarks) for all of its gages throughout the country and provides a software package called Vertical Datum Transformation (VDATUM) to interpolate tidal benchmark information between gage locations. These data are based on historical water levels and therefore do not include any future sea level rise.

For the City of New Castle, the present-day MHHW elevation is 3 feet NAVD88, which inundates the marsh areas within the City and can impact some of the low-lying roads that cross them including River Road and East 6th Street.

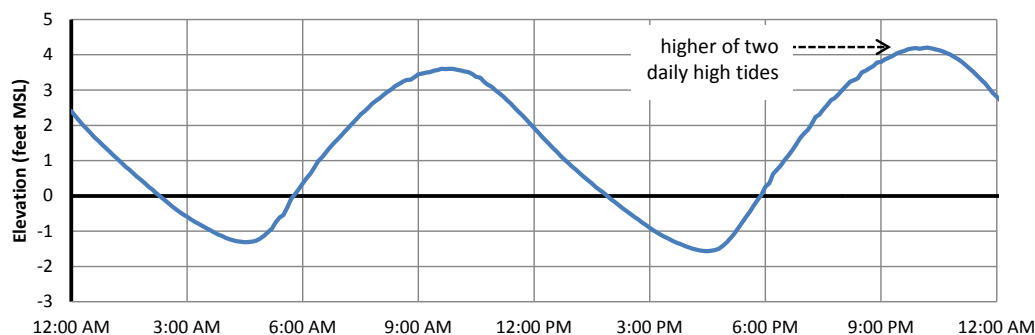


Figure 1: Example of tide elevation recorded at NOAA's Delaware City tide gage
<https://tidesandcurrents.noaa.gov/waterlevels.html?id=8551762>

3.1.2 1-Percent-Annual-Chance Event

FEMA's FIS for New Castle County (2015) is part of a nationwide program to evaluate flood risk. Each FIS produces a map, called a Flood Insurance Rate Map (FIRM), depicting the geographic extent of flooding, referred to as a floodplain and the elevation of flood waters, referred to as the Base Flood Elevation (BFE) associated with a 1-percent-annual chance event. As described above, the 1-percent-annual-chance event has a 1 in 100 chance of occurring in any given year. From a probability standpoint, there is a 63% chance of more than one 1-percent-annual chance event occurring in any 100-year timeframe and a 26 percent chance of occurring over the course of a 30-year mortgage (see Figure 2). An example of a FEMA FIRM within the City of New Castle is provided in Figure 3 below.

In tidally-influenced areas, like the City of New Castle, the FEMA FIRMs are based on the combined effects of storm surge and wave hazards. Storm surge is the rise of water above normal tide levels generated by a storm. Waves develop atop the storm surge due to wind, increasing the base flood elevation. The FIRMs describe the magnitude of waves throughout the floodplain using a zone designation of either VE or AE. Areas designated as Zone VE are expected to experience a wave height of 3 feet or larger during a 1-percent-annual-chance event. In the City of New Castle, Zone VEs are limited to areas near the Delaware River. Areas designated as Zone AE are expected to experience a wave height between 0 and 3 feet. Zone AE areas can be further subdivided by a FIRM feature called the Limit of Moderate Wave Action (LiMWA), which delineates the location of the 1.5 feet wave height contour. Therefore, Zone AE areas inland of the LiMWA have a wave height of 0 to 1.5 feet, and Zone AE areas seaward of the LiMWA have a wave height between 1.5 and 3 feet.

The FEMA FIS and resulting FIRM are based on modeling informed by historical storm behavior; therefore, the magnitude of the 1-percent-annual-chance event in the City of New Castle is influenced by the size and frequency of storms that have affected the area. The FEMA FIS also relies upon the existing conditions in a study area, including the following:

- Current sea level
- State of the shoreline, which is subject to change due to storms and other natural processes or man-made alterations
- Extent and health of marsh-lands, which can deteriorate with increasing sea levels
- Density and extent of development, which are subject to change as a community develops over time
- Upland topography, which can subside gradually over time or change due to man-made alterations

Please note that these maps do not include changes that may result from sea level rise, weather patterns, or development.

Changes to these conditions can influence how a storm affects an area and potentially change the 1-percent-annual-chance event. Consequently, FEMA recommends accounting for potential increases through regulations requiring freeboard and other flood mitigation actions.

The study team also investigated NOAA's Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model data as an alternative to FEMA's FIS data. For the City of New Castle, NOAA has generated SLOSH modeling that describes the flood extent and elevation associated with hurricanes ranging from category 1 through 4, as defined by the Saffir-Simpson scale. Table 2 describes the flood elevations from SLOSH and from FEMA. The study team ultimately chose to use FEMA's FIS data as the data provided a probability of occurrence (not available for SLOSH data), included the effects of waves (not included with SLOSH data), and had more relevance to the City of New Castle as they regulate flood insurance rates.

Table 2: SLOSH Flood Elevation and FEMA Base Flood Elevation data for the City of New Castle

Hurricane Category [feet NAVD88]	SLOSH Flood Elevation	FEMA BFEs [feet NAVD88]
1	5.4-5.5	Delaware River: VE 12-13
2	10.2-10.3	
3	15.6-16.3	Inland areas: AE 8-10
4	22.3-22.9	

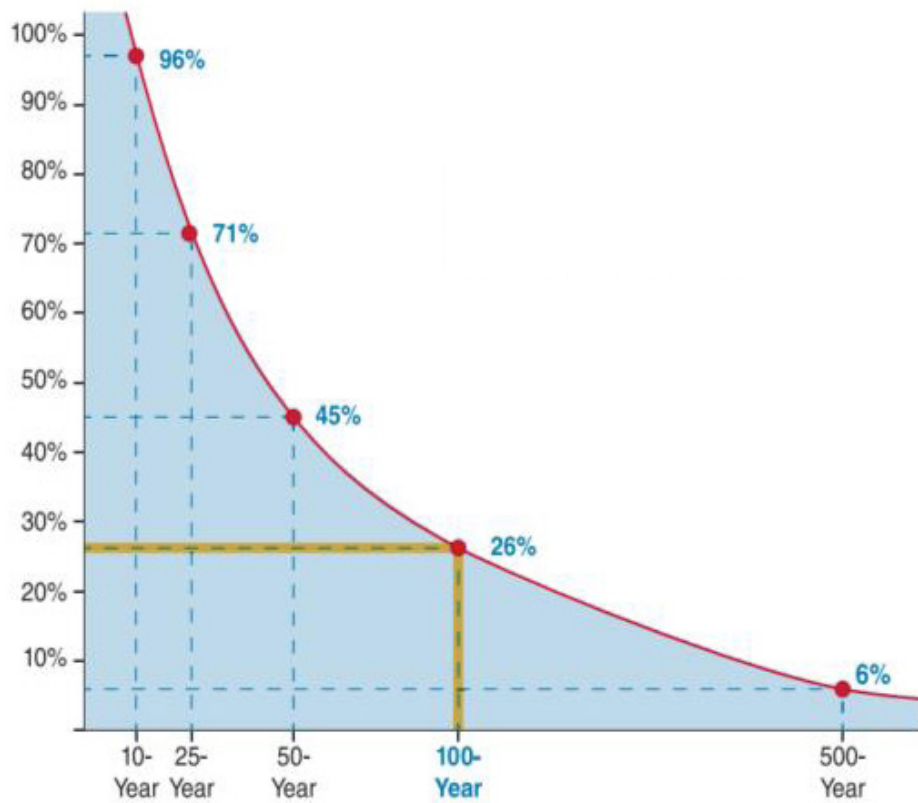


Figure 2: Percent chance for one or more floods of a given magnitude being equaled or exceeded in a 30-year mortgage



Figure 3: Example of FEMA FIRM in the City of New Castle
<http://fema.maps.arcgis.com/home/webmap/viewer.html>

3.1.3 DNREC Sea Level Rise Projections

In 2016, DNREC and the Delaware Geological Survey (DGS) led the development of a Sea Level Rise Technical Committee composed of local and regional experts to evaluate if updates to Delaware's 2009 projections of sea level rise were warranted (see Figure 4). The committee determined that updates were needed and developed a new set of projections based on a combination of the latest physical climate modeling from the Intergovernmental Panel on Climate Change (IPCC) and local tide gage data.

The committee developed a total of three planning scenarios:

- "Low" describes a sea level rise scenario that has a 5% chance of not being met or exceeded; this scenario represents the lowest projected increases in sea level.
- "Intermediate" describes a sea level rise scenario that has a 50% chance of not being met or exceeded.
- "High" describes a sea level rise scenario that has a 95% chance of not being exceeded; this scenario represents the highest projected increases in sea level.

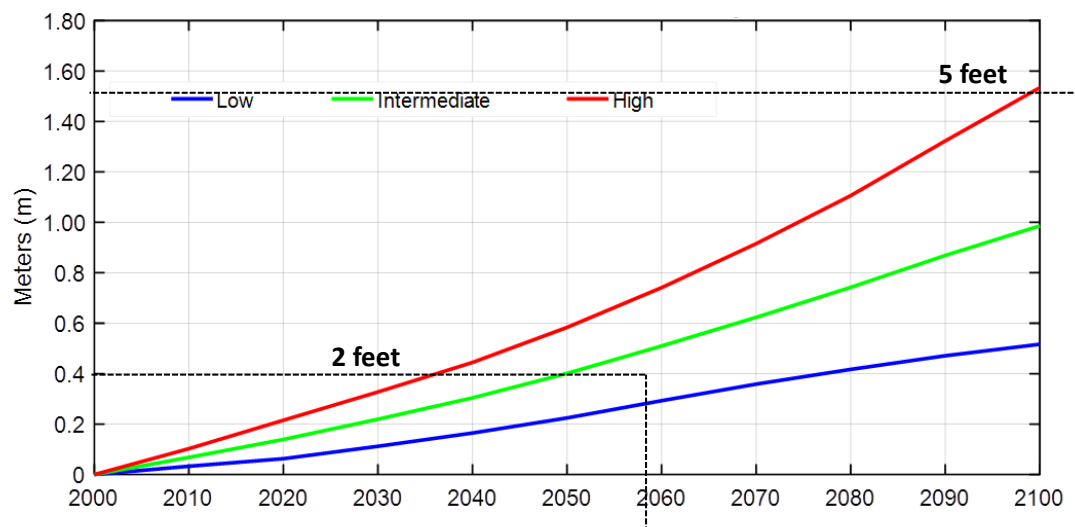
These scenarios are depicted in Figure 5. More information on the development of the sea level rise projections can be found on the DGS and DNREC websites. The primary goals of this project were to identify vulnerabilities and to start planning for adaptation. Therefore, the high scenario was chosen as it represents a "worst-case" situation.

To combine the sea level rise scenarios with the MHHW and 1-percent-annual-chance data, an approach known as the "bathtub method" was used.

The bathtub method assumes that sea levels will increase uniformly and can be added to a water level like MHHW or FEMA's 1-percent-annual-chance event to represent the combined effects. For example, the current MHHW of 3 feet NAVD88 combined with 2 feet of sea level rise (2050 projection) would produce a future MHHW of 5 feet NAVD88. An illustration of this methodology is provided in Figure 6. The bathtub method also assumes that wave hazards won't be affected by sea level rise. In other words, waves associated with the present-day 1-percent-annual-chance event would also be associated with a 1-percent-annual-chance event in the Year 2100.

DNREC has a high (95%) level of confidence that the sea level rise in New Castle will be less than 2 feet by 2050 and 5 feet by 2100.

Figure 4: Sea level rise projections for Delaware developed by DGS and DNREC (2017)



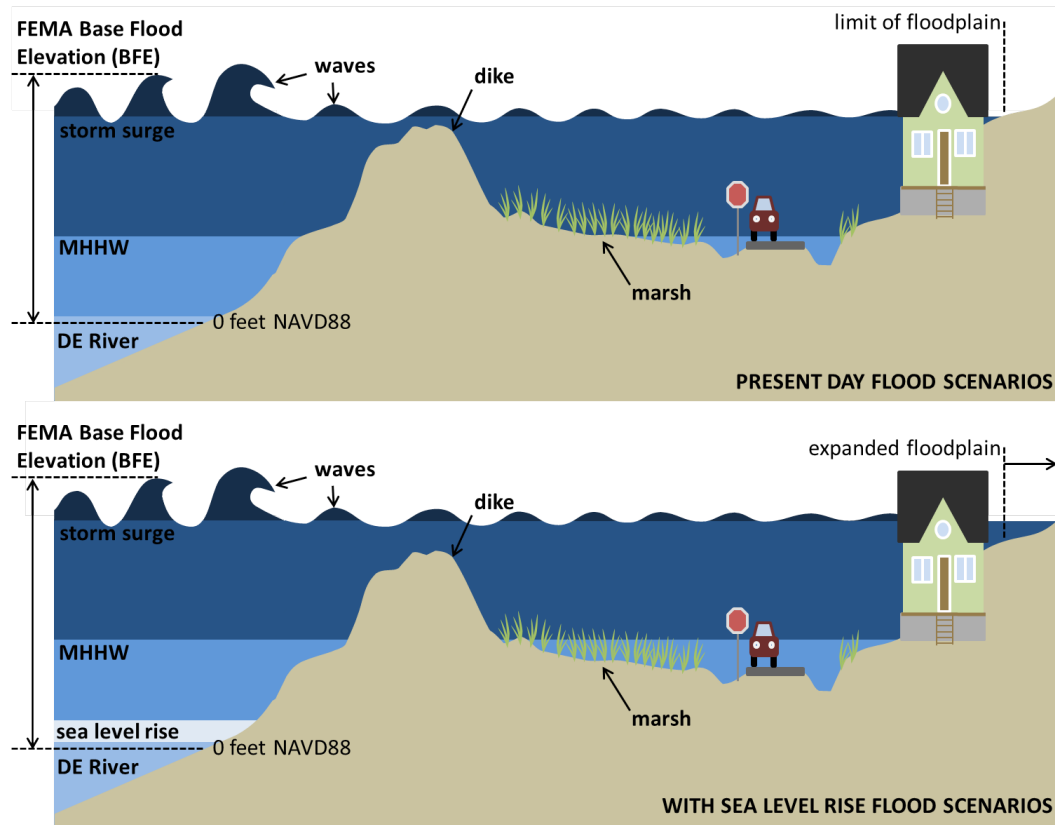


Figure 5: Illustration of inundation scenarios
Present day inundation scenario (top) and increase in inundation due to sea level rise using the bathtub methodology (bottom)

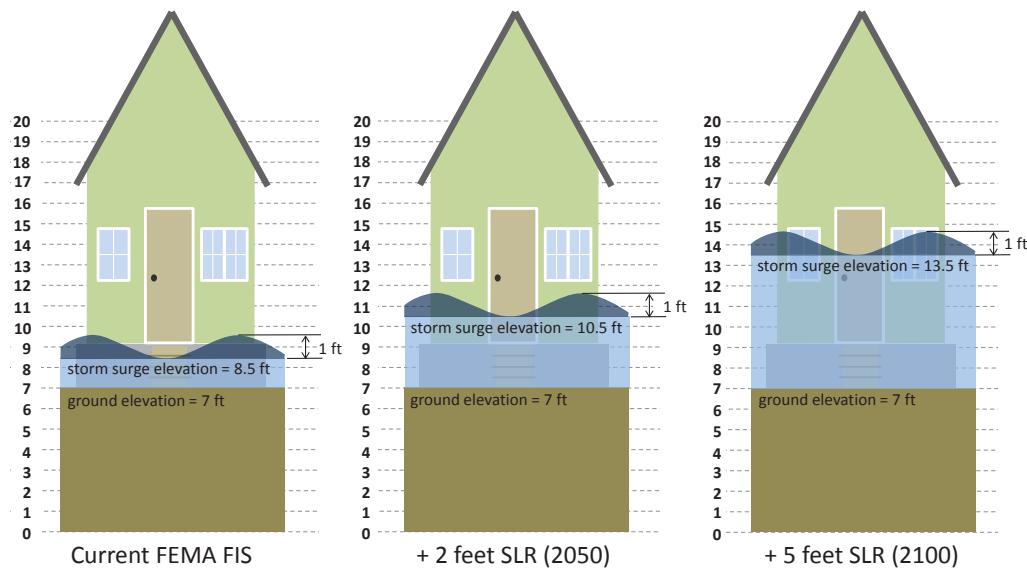


Figure 6: Illustration of bathtub calculations performed for each structure

3.2 Vulnerability Scenarios & Maps

Given that a significant portion of New Castle is already susceptible to coastal flooding, the City is particularly vulnerable to future flooding due to sea level rise inundation. Sea level rise is expanding the current high tide inundation and flood hazards in developed areas near the Delaware River and its tributary streams and marshes. Using the high sea level rise scenario, an eighth of all of the developed areas in the City could experience repeated nuisance flooding events due to rising tides by the end of the century, while almost half are at risk to extreme flooding events due to coastal storms.

To help identify and visualize the areas that are at risk, a series of maps were created that display the current and projected high tide and Special Flood Hazard Areas overlaid with development features and demographic data. The hazards and inundation areas are generally mapped in three categories:

- Present day flood hazards
- Future high tide due to sea level rise
- Future flood hazards due to sea level rise

The maps display and quantify the structures, facilities, infrastructure, populations, and natural resources that are vulnerable to flooding and inundation. The mapping analysis further assists to assess and prioritize the hazard risk level based on sensitivity and adaptive capacity and further discussed in Section 4.0. The vulnerabilities are identified on these maps in the following categories:

- Critical Facilities: The following structures are deemed critical towards public health, safety and welfare:
 - Municipal Service Commission office and maintenance building; Police Department, and Goodwill Fire station; churches, schools, wastewater pumping stations, water towers and wells, electrical substations, senior center, public library, and buildings on the National Historic Register.
- Structures: All principal buildings within the City limits. Accessory buildings such as detached garages and sheds are not included in this analysis.
- Roads: All State, City and privately owned roads within the City. Road vulnerabilities are identified as those that would experience 6 inches of flood depth during a flood event, which could impede travel, evacuation and emergency response.

- Vulnerable Demographic Groups: Based on U.S. Census American Community Survey data, Block Groups, 2015. The groups are as follows:
 - People below the Poverty Rate
 - Households without Vehicles
 - People older than 65
- Natural Features: Delaware State designated wetlands based on the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI) and publicly protected lands that may offer open space for flood attenuation.

The following vulnerability maps are in Appendix A:

- Map 1: 1-Percent-Annual-Chance Event with Current Sea Level
- Map 2: Future Sea Levels in Years 2050 and 2100
- Maps 3 to 7: 1-Percent-Annual-Chance Event with Future Sea Level Rise in Years 2050 and 2100
 - Map 3: Critical Facilities, Structures, and Roads
 - Map 4: People below the Poverty Rate
 - Map 5: Households without Vehicles
 - Map 6: People older than 65
 - Map 7: Natural and Cultural Resources

3.2.1 1-Percent-Annual-Chance Event with Current Sea Level

Scenario Description

The 1-percent-annual-chance event was described in Section 3.1.2. This first scenario is included in part to establish baseline conditions in New Castle. See left-hand exhibit in Figure 6 entitled "Current FEMA FIS."

The FEMA FIRM maps show a range of BFEs throughout the City. Along the Delaware River, the FEMA FIRM shows Zone VE with BFEs of 12 and 13 feet NAVD88, reflecting the larger waves expected within and near to the water body. The FEMA FIRMs typically show Zone AE with BFEs ranging between 8 to 10 feet NAVD88 on the inland side of the dikes and throughout the City. Most developed areas have a BFE of 8 or 9 feet NAVD88 with the exception of homes along The Strand and other structures directly adjacent to a marsh area that have a BFE of 10 feet NAVD88.

Vulnerability Map

Map 1 - Vulnerability to Flooding – Present Day displays the present day vulnerabilities to the current FEMA Special Flood Hazard Area, as described in Section 3.1.2. The current Special Flood Hazard Areas in the City include Zone AE with Base Flood Elevations (BFEs) ranging from 8 to 10 feet (NAVD88), Zone VE (12 and 13 feet), and LiMWA, which shows the extent of potentially damaging 1.5 foot high waves. The blue layers on the map depict the FEMA 1-percent annual chance event (i.e., flood event or Special Flood Hazard Area), with the base flood elevation (BFE). The orange layers are the structures and roads located within the floodplain, with the red outline indicating that the City has identified this structure as being a critical facility. Due to the public importance of these facilities, the City encourages usage of the highest sea level rise scenario during any future modifications.

Hazard Impacts

Per the FEMA data layers, approximately 870 acres, or 40% of the City's total area, are in the FEMA Special Flood Hazard Area and are at risk of coastal flooding. Additional areas are vulnerable to flash flooding or drainage-related flooding. Fortunately, much the developed area of the City is built on higher elevations and the majority of the floodplain (approximately 510 acres) is within State designated wetlands and therefore protected from further development. Still, approximately 360 acres of the floodplain is currently developed or may be developed in accordance with the City's zoning, subdivision, and floodplain management regulations and State regulations.

Approximately 264 principal structures, or about 17% of all principal buildings in the City, are located in the Special Flood Hazard Area and currently considered to be at high risk of flooding under the National Flood Insurance Program (NFIP) if no flood protection measures are in place. Eight of these structures are considered Critical Facilities. Refer to Map 1 and Section 4.0 for the list of critical facilities. Approximately 7 of 27 miles of road within the City, or about 25%, are modeled to be impacted with 6 inches or more of flood depth during a flood event. About 5 miles of these impacted roads are owned and maintained by the City and about 2 miles are owned by the State. About 1 mile is within the LiMWA.

3.2.2 Future Sea Levels in Years 2050 & 2100

Scenario Description

DGS, in partnership with DNREC and DelDOT, developed a set of maps describing the inundation of several scenarios ranging from current MHHW to 7 feet above current MHHW, in 1-foot increments (2016). These maps leveraged NOAA's information on MHHW throughout the state of Delaware and used the bathtub methodology, as described in Section 3.1.3, to incorporate the effects of sea level rise. For the City of New Castle, the study team used the MHHW + 2 feet and MHHW + 5 feet to represent the 2050 and 2100 high tide scenarios, respectively. More information on the development of these maps can be found on the DGS and DNREC websites.

Vulnerability Map

Map 2 - Vulnerability to Sea Level Rise Inundation from High Tide displays the projected vulnerabilities due to rising high tides associated with the high sea level rise, as described in Sections 3.1.3. and 3.2.1. The current average daily higher high tide (MHHW), as described in Section 3.1.1., is also displayed on this map for a comparison to the present day. The blue layers on the map depict the current and projected high tides. The orange and yellow layers are the structures and roads forecasted to be exposed to the high tide by the Years 2050 and 2100, respectively. The red outline indicates critical facilities.

Hazard Impacts

Currently, the usable land area within the City boundary that is inundated with water at high tide is minimal and does not impact any structures or roads. Sea level rise is anticipated to increase this high tide area nominally by 2050. Only two principal structures are within the forecasted inundation area. However multiple properties that border the Delaware River would be partially inundated. By the Year 2100, future high tide area increases substantially as approximately 872 acres would be inundated, which is about 40% of the total City area. It is noted that this future high tide area generally falls within the Special Flood Hazard Area and therefore development in this area will be governed by the City's floodplain regulations.

Under the high sea level rise scenario, the number of principal buildings within the future high tide increases from zero in the present day to 202 by the end of the century, which is about 13% of all principal structures. Ten of these are identified as critical facilities. Refer to the Map 2 and the Critical Facilities Vulnerability Matrix table for the list of critical facilities. The roads that are forecasted to be within the future high tide are the same roads that are already within the present day Special Flood Hazard Area, which is about a quarter of all the roads in the City.

3.2.3 1-Percent-Annual-Chance Event with Future Sea Level Rise in Years 2050 & 2100

Scenario Description

The study team used the “bathtub method” to generate data and maps describing the projected 1-percent-annual-chance event combined with DNREC’s high sea level rise scenario for two different years: 2050 and 2100. With GIS software, the FEMA FIS data, Delaware LiDAR data and the GIS datasets describing the City of New Castle’s buildings and streets were used to develop an excel spreadsheet describing the ground elevation, storm surge elevation, wave height, and total flood depth at each structure in the City. Following the bathtub method, new flood depths were computed for 2050 and 2100 by increasing the storm surge by 2 feet and 5 feet, respectively. The wave height was kept consistent across all time periods. The same procedure was followed for all roads within the City and nearby evacuation routes; however, roads were divided into segments in between intersection and then split into equal parts at approximately 250 feet in length for the analysis.

The FEMA FIS data and Delaware LiDAR data were also used to create new 1-percent-annual-chance event floodplains for 2050 and 2100 using GIS software. For each time period, the projected sea level rise value was added to the FEMA FIS data describing the storm surge associated with the 1-percent-annual-chance event. The storm surge plus sea level rise datasets were intersected with the ground elevation data (represented by the Delaware LiDAR) to identify the boundary between inundated and not-inundated areas as defined by locations where the local storm surge plus sea level rise value was equal to the local ground elevation value. The floodplain boundary was reviewed to remove any low-lying areas that were not hydraulically connected to flooding from the Delaware River. The resulting boundary is displayed on the vulnerability maps described in this section.

Vulnerability Map

Map 3 - Vulnerability to Flooding with Sea Level Rise displays the vulnerable features forecasted to be exposed to flooding during a 1-percent annual chance event (i.e. Special Flood Hazard Area) combined with the high sea level rise scenario. The hazard data layer is described in Sections 3.1.3. and 3.2.2. The current Special Flood Hazard Area, as described in Section 3.1.2., is also displayed on this map, as a blue and white dotted line, for a comparison to the present day risk areas. The blue layers on the map depict the projected Special Flood Hazard Area by the Years 2050 and 2100. The orange and yellow layers are the structures and roads forecasted to be within the Special Flood Hazard Area, respectively. The red outline indicates critical facilities.

Hazard Impacts

As previously noted, approximately 40% of the City’s total area is in the present day Special Flood Hazard Area (see Figure 7). The high sea level rise scenario is anticipated to increase this Special Flood Hazard Area to 50% by 2050. The number of principal structures that would be impacted almost doubles to 474, and 30% of all buildings, from the present day. Fourteen of these buildings are considered to be critical facilities. Refer to Table 3 for list of vulnerabilities. Refer to Map 3 and Table 4 for the list of critical facilities. The miles of road are projected to be impacted with 6 inches or more of flood depth increases to 9 miles, or about 34% of all roads in the City. About 7 miles of these roads are owned and maintained by the City and the remaining 2 miles are owned by the State.

By the end of the century, the high sea level rise scenario is anticipated to increase the Special Flood Hazard Area to 60% of the total City area. The number of principal buildings within the projected Special Flood Hazard Area increases to 747, or 47% of all buildings, from the present day. This would be almost half of all the principal structures in the City. Nineteen of these structures are identified as critical facilities. The roads that would be impacted with 6 inches or more of flooding increase to 13 miles, which is almost half of all the roads in the City. Eleven (11) miles are owned and maintained by the City.

3.2.4 Summary of Vulnerability Mapping Results

General

The high sea level rise inundation scenario was used as the basis for identifying the City’s vulnerability to flooding by the Years 2050 and 2100, and the potential hazards that may impact property, facilities, infrastructure, and natural resources. Within the sea level rise inundation area are homes, businesses, schools, the police and fire stations, a church, pump stations, an electrical substation, and other buildings that are critical to the City’s public health, safety, and welfare. Specific potential impacts to New Castle include human injury and harm, damage to buildings and private property, impassable roads impeding evacuation and emergency response, and the loss of wetlands. Potential impacts also include overstressed stormwater management systems and poor drainage, as well as saltwater intrusion affecting water wells.

In all scenarios, the risks are generally higher for neighborhoods and properties that border the tidal waterways of the Delaware River, and the Broad Dyke, Buttonwood, Gambacorta, and Army Creek marsh areas. Buttonwood, Van Dyke Village, New Castle Manor, Bull Hill, the Strand, and the 7th and Washington Street commercial area appear to be at the greatest risk due to their low elevation and proximity to a tidal flooding source. See Table 3 and Figure 7, for a breakdown of structures and roads within the current vulnerabilities as well as the future vulnerabilities by the Years 2050 and 2100.

Table 3: Vulnerabilities

	Current MHHW	Current MHHW	Current Flood Event	Current Flood Event	2 FT SLR MHHW Year 2050	2 FT SLR MHHW Year 2050	2 FT SLR Flood Event Year 2050	2 FT SLR Flood Event Year 2050	5 FT SLR MHHW Year 2100	5 FT SLR MHHW Year 2100	5 FT SLR Flood Event Year 2100	5 FT SLR Flood Event Year 2100	Total in City (Approx.)
Buildings (#)	0	0%	264	17%	2	0%	474	30%	202	13%	747	47%	1,587
Critical Facilities (#)	0	0%	9	25%	0	0%	14	39%	9	25%	19	53%	36
Roads (miles)	0	0%	7	27%	0	0%	9.5	37%	13.3	51%	13.3	51%	26

Table 4: Vulnerabilities – Critical facilities

Structure ID	Critical Facility Type	Critical Facility Name	Current 100 Year Flood	2 FT SLR Year 2050	5 FT SLR Year 2100
99	Schools	New Castle Elementary School			1
117	Schools	St. Peter Catholic School	1	1	1
183	Schools	Reach Academy for Girls	1	1	1
1698	Historic Register	Glebe House and Cemetery			1
2220	Library	New Castle Public Library			1
139	Public Works	MSC Main Office	1	1	1
148	Public Works	MSC Utility Building and Garage		1	1
151	Public Works	Public Works Yard	1	1	1
152	Public Safety	Police Department	1	1	1
136	Public Safety	Goodwill Fire Fire Station		1	1
134	Community	Senior Center		1	1
119	Community	St. Peters Catholic Church	1	1	1
1268	Public Utility	NCC Pump Station		1	1
1291	Public Utility	NCC Pump Station			1
2050	Public Utility	NCC Pump Station	1	1	1
2333	Public Utility	NCC Pump Station	1	1	1
1131	Public Utility	Delmarva Primary Electrical Substation	1	1	1
1669	Public Utility	Wilmington Road Substation Electrical Substation		1	1
738	Public Utility	MSC - Gray Street Water Tank Building			1
			9	14	19

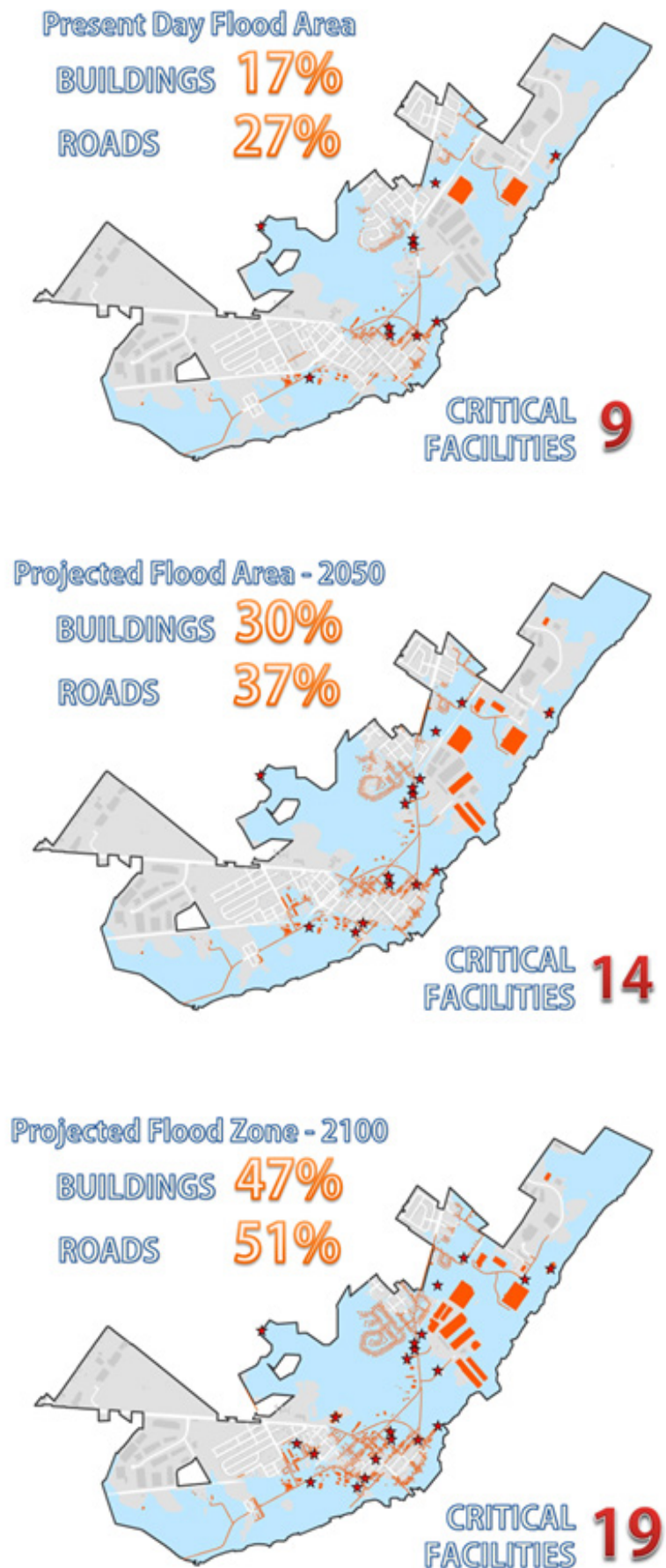


Figure 7: Summary of potential impacts
Present Day Flood Area (top);
Future potential floodplain in Year 2050 (middle);
Future potential floodplain in Year 2100 (bottom).

Vulnerable Demographic Groups

Maps 4 to 6 display the projected Special Flood Hazard Area overlaid by U.S. Census Bureau data of demographic groups per census block groups who are potentially more susceptible to the risks of an extreme flooding event. The vulnerability maps assist to identify the highest areas of concentration of these following susceptible groups: those who live in poverty and presumed to have less income to adapt or rebuild after a damaging event; those who do not have a vehicle and therefore may need to rely on public transit or a share a ride to evacuate the City; and the elderly and who may require additional assistance in general. As shown on Map 4, the Shawtown and Deemer's Landing area (U.S. Census Tract 162 Block Group 2) has the highest number of households that are below the poverty status and in the projected Special Flood Hazard Area. This area also has the highest housing and population density in the City. Map 5 shows that the downtown area has the highest number of households without a vehicle; however, this demographic is fairly evenly distributed throughout the City and adjacent neighborhoods. Map 6 shows the following neighborhood areas with the highest number of residents older than 65 years of age, which are Washington Park (Tract 162 Block Group 3), Deemer's Landing (Tract 162 Block Group 2), and Van Dyke Village and Buttonwood (Tract 161 Block Group 1).

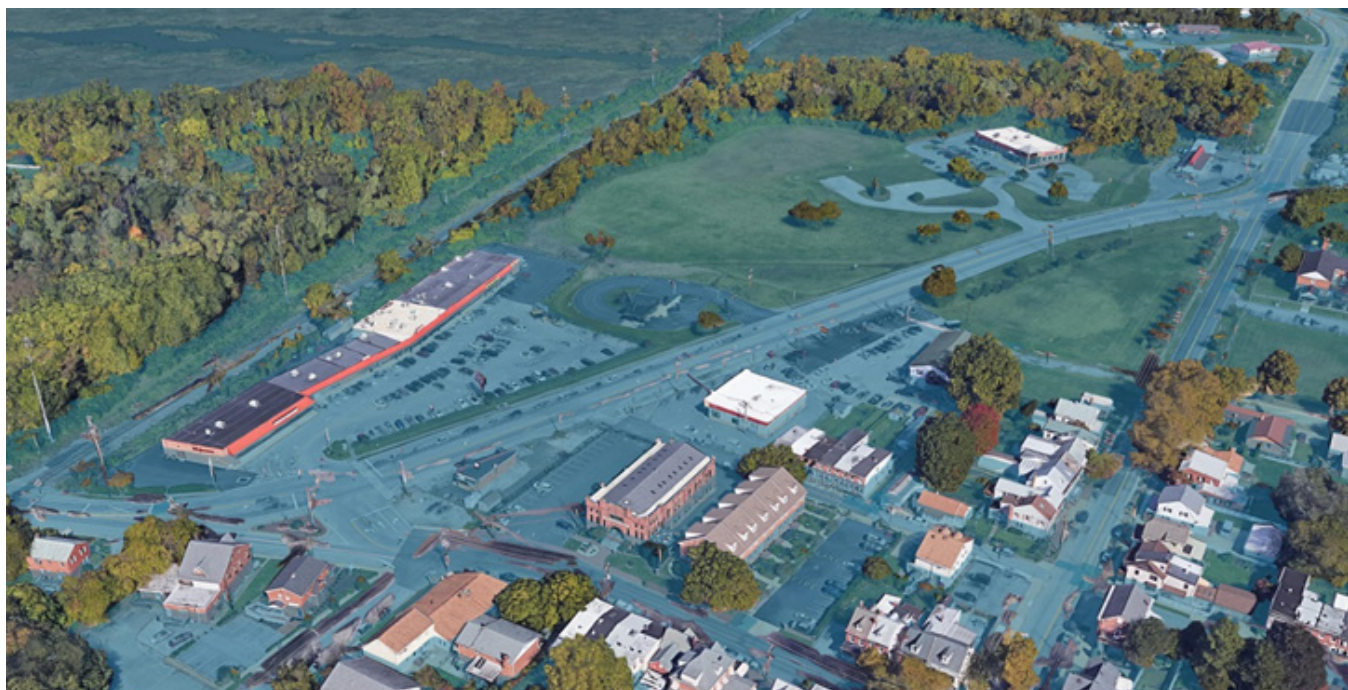
Redevelopment Areas

The current Special Flood Hazard Area and the future high tide area also include a few large vacant and underutilized parcels within the Ferry Cut-off area and 7th and Washington Street commercial areas, which are identified in the City's 2009 Comprehensive Plan as priority redevelopment areas and subsequently zoned Downtown Gateway Zoning District, which permits higher density and pervious coverage than other zoning districts in the City (see Figure 8). The redevelopment areas are also within the City's proposed Downtown Development District, which seeks to incentive economic and community development within a designated boundary. The City is currently amending this District boundary to remove the large vacant and flood prone lands.

Historic Places

Map 7 – Natural and Cultural Resource Areas displays the City of New Castle Historic District boundaries. While a significant portion of the outer edges of the Historic District are projected to be within the future high tide and Special Flood Hazard Area, there is only one property on the National Register of Historic Places, the Glebe Cemetery, which is potentially at risk to extreme flood events. The historic house is actually located outside of the projected inundation area; however, the cemetery and property could be impacted. It will be important for the City to consider long-term sea level rise impacts that correspond to the City's long-term plan to protect the contributing structures within the historic district.

Figure 8: Future potential floodplain in the Ferry Cutoff area under the high sea level rise scenario by the Year 2050



Natural Resources

Map 7 – Natural and Cultural Resource Areas displays the wetlands, marshlands, and protected public land that are forecasted to be exposed to the high tide using the high sea level rise scenario. The City recognizes that as sea level rises, the wetlands may migrate inland, groundwater levels may rise, and saltwater intrusion may increase. The City understands that saltwater can migrate into the groundwater aquifer and affect the drinking water supply. The City also recognizes that the extensive wetlands and marshland in the City are necessary for proper drainage and natural stormwater management. The vegetation and root mats slow and distribute floodwaters, which help to absorb storm surges, prevent erosion, and reduce flooding, as well as absorb pollutants and provide a natural habitat. As mentioned earlier, the future high tide area generally falls within the Special Flood Hazard Area; therefore development in this area will be governed by the City's floodplain regulations. Similarly, high tide areas are also within the State designated wetlands and protected from further development. It is anticipated that the high tide will increase as sea level rises, which will result in a smaller wetlands over time if they have nowhere to migrate naturally. In general, a smaller wetland area will result in less nutrient uptake and less reduced flood attenuation, which therefore reduces overall water quality and increases vulnerability to flood hazards. It is further noted that much of the marshland in the region have been degraded by invasive vegetation, such as phragmites.

While the current environmental protection regulations are helping to protect wetlands and floodplain areas, more action will be needed to allow wetlands to migrate inland where possible, to restore wetlands, and to protect the City's drinking water quality.

Evacuation Routes

The evacuation routes for New Castle are Route 141 North (Washington Street) and Route 273 West (Frenchtown Pike), and shown as a red and white hatched line on all of the maps. There are couple key intersections, which the majority of City residents must travel through to get to the evacuation route, that could experience daily high tide flooding and also be impassable during a severe flood event. The following key intersections are within the present day Special Flood Hazard Area and are projected to be inundated by high tide by 2100:

- Delaware Street and Ferry Cut-Off
- 6th Street (Route 9) and Ferry Cut-Off/Chestnut Street
- 7th Street (Route 9) and Washington Street

If these intersections are impassable, evacuating the downtown area would be very difficult. In addition to the daily nuisance flooding, almost the entirety of 7th Street could be impassable during a significant storm event, hindering travelers from the Dobbinsville area to get to the evacuation route, as well as impede emergency response in and out of the area.

3.3 Existing Dikes

The dikes represent a critical component to flood management in the City of New Castle. In 2014, the dikes were repaired and raised to an elevation of 8.5 feet NAVD88, which at the time was the elevation of the 1-percent-annual-chance event flood (previously they had deteriorated to an elevation of 5 to 6 feet NAVD88). Subsequently FEMA released new maps and the current elevation is below the 1-percent-annual-chance event flood elevations along the Delaware River. Consequently, the dikes would not offer significant protection from storm surge during a 1-percent-annual-chance event and are not recognized as certified flood control structures by FEMA. However, they do offer some attenuation of wave energy and protection during smaller flood events.

In their current state, the effectiveness of the dikes will decrease as sea level increases. This is illustrated in Figure 7, which compares the elevations of the dikes and the surrounding City of New Castle shoreline to the current BFEs along the Delaware River and to those BFEs increased by 2 feet and 5 feet (see Figure 9). As sea level increases relative to the crest of the dikes, the size of storms that they can protect against will decrease.

Raising the dikes again and adding new dikes or other measures in areas between the dikes to protect against impacts from future flood events and/or sea level rise represents a high level of a decision tree. A multitude

of engineering and property issues would need to be resolved. However, if funding could be secured, the need mitigation on a case-by-case may be reduced or even eliminated. Conversely, mitigation efforts such as floodproofing individual structures, would likely be less problematic to implement and could be more cost-effective in the long run.

The issues of the dikes and alternative measures form many of the Recommended Actions or Activities described in Section 6.0, particularly those categorized as Sequential Actions or Activities.



Gambacorta Dike

Post construction of the Battery Park Trail and Gambacorta Dike.

Photo Credit: DNREC

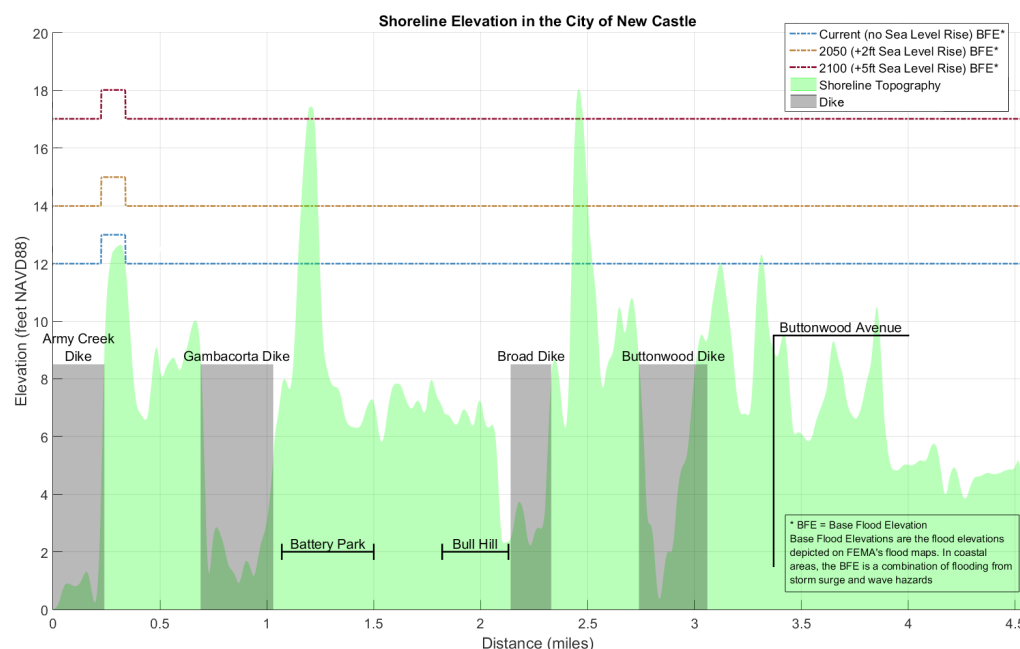


Figure 9: Representation of the topography and dikes compared to the FEMA BFEs along the City of New Castle shoreline

Note the BFEs represent the flood elevations on the Delaware River side of the levees, not the land side of the levees.

4.0 Identification & Prioritization of Vulnerabilities

4.1 Current Mitigation Measures

New Castle has already undertaken numerous mitigation initiatives that have included the following:

- Assessment and subsequent maintenance and raising of the four dikes, which included the formation of the New Castle Dike Management Advisory Committee (2011-2014). The City also repaired the Broad Dike flood gate (~2014).
- Evaluation of the feasibility and development of a conceptual plan for a living shoreline project at an eroded stretch of shoreline in Battery Park (2016).
- Retrofitting of six existing stormwater management facilities to provide enhanced stormwater quality management, wetlands creation and enhancement as well as downstream clearing and construction of an outlet for the stormwater collection system at Washington Park along with wetlands creation (2009-2011).
- Assessment of the feasibility for a complete makeover of Delaware Street to not only provide safe travel by all types of users but to also make the street more sustainable or a "Green Street" (2016-2017).
- Routine cleaning of storm drain inlet grates in advance of major storm events (on-going).
- Regular communications with City residents and businesses through a monthly newsletter and website announcements (on-going).
- Attaining a classification of 8 in FEMA's Community Rating System (CRS). The CRS was developed to provide incentives in the form of premium discounts for communities to go beyond the minimum floodplain management requirements to develop extra measures to provide protection from flooding. The City's existing requirement for 18 inches of freeboard is a good example. Property owners in New Castle receive a 10% discount on flood insurance premiums due to the City's classification (on-going).
- Coordinating with two property owners during redevelopment for the provision of floodproofing measures. Both involve the installation of brackets across entryways for panels that can be placed in advance of flooding (~2010-2015).



Floodproofing example

Floodproofing gate brackets at small shopping center on Ferry Cutoff. Panels can be inserted into slots prior to flood event. Along with reinforced walls, such measures can protect structures from flood losses.

4.2 Vulnerability Matrix of Critical Structures

The spreadsheet of critical structures and flood depths was used to populate a Vulnerability Matrix based on the Delaware Sea Grant Tool Kit. The matrix is based on currently-available data and is being provided for demonstration purposes.

With vulnerability matrices, higher scores are assigned when the structures are highly sensitive to the sensitivity criteria. Conversely, higher scores are assigned when the structures have low adaptive capacity to the adaptive capacity criteria.

This spreadsheet assessed each structure for sensitivity and adaptive capacity.

Sensitivity is the degree to which a built, natural or human system is directly or indirectly affected by natural hazards and climate change. If a system is likely to be affected as a result of projected natural hazards or climate change, it should be considered sensitive to climate change.

Sensitivity was assessed for two criteria as follows:

- Inundation Depth: Structures surrounded by a water depth of 6 feet or greater (in the intermediate sea level rise planning scenario of 2 feet) scored high, 3 feet or greater scored medium, and all other depths scored low.
- Susceptibility to Waves: Structures within the AE flood zone and within the LiMWA line scored high, within the AE zone but not within the LiMWA scored medium, and all others scored low.

Adaptive capacity is the degree and ability of built, natural or human systems to accommodate or withstand changes in climate (including climate variability and climate extremes) or experience a natural disaster with minimal potential damage or cost.

Adaptive capacity was assessed for two criteria as follows:

- Material: Framed structures scored low, masonry structures scored medium, utility-related structures, which are assumed to have generally been constructed or retrofitted to withstand flooding scored high.
- Can be Floodproofed: Structures surrounded by a water depth of 5 feet or greater (in the intermediate sea level rise planning scenario of 2 feet) scored low, 3 feet or greater scored medium, and all other depths scored low.

The Project Team added a third category for assessment: criticalness of the structure (see Table 5), which was assessed for a single criterion as follows:

- Public Safety: Police, fire, and municipal operations scored high, utilities scored medium, and all other uses scored low.

The Critical Structures were categorized as follows:

	Utilities
	Schools, Other
	Public Safety
	Operations

Note that in some cases such as the electrical substations, multiple structures exist on the same parcel. Also, based on information provided by MSC, water wells are well above potential flood elevations and are thus not included.

The numbers under each of the criterion (cells that are not colored) represent weighting. That is to say that Inundation Depth, weighted as a 4, is scored twice as high as Susceptibility to Waves, weighted as a 2. In this matrix, Public Safety is considered most important and is thus weighted as a 5. These weights can be easily changed.

Using this scoring process, the MSC office on Chestnut Street and the Police Department building on Wilmington Road would be ranked as the most vulnerable critical structures in the City with Public Works Yard and MSC building and garage adjacent to the Police Department also ranked highly.

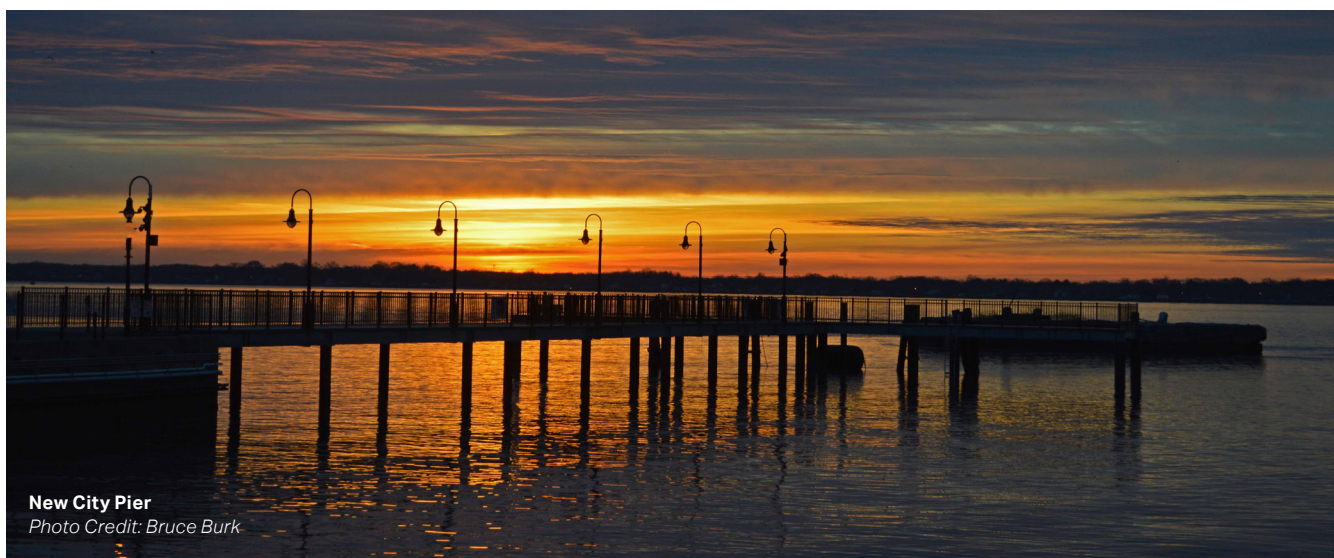
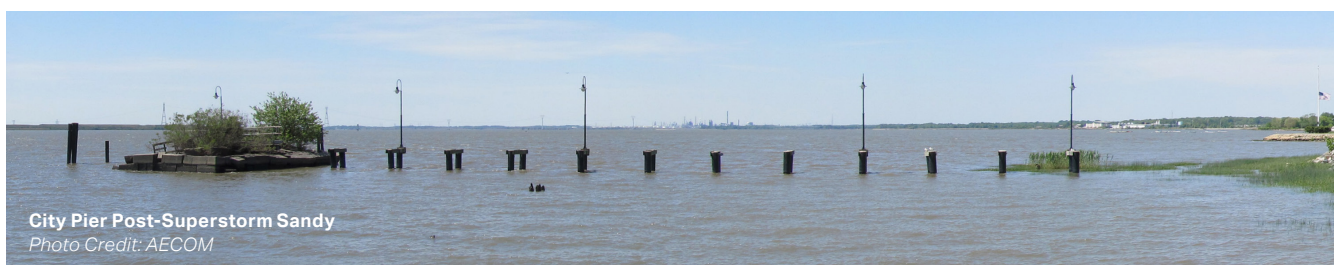
Additional investigative work as described in Section 6.0 would need to be performed before investments are made in these locations.

Sensitivity – the degree to which a built, natural or human system is directly or indirectly affected by natural hazards and climate change. If a system is likely to be affected as a result of projected natural hazards or climate change, it should be considered sensitive to climate change.

Adaptive Capacity – the degree and ability of built, natural or human systems to accommodate or withstand changes in climate (including climate variability and climate extremes) or experience a natural disaster with minimal potential damage or cost.

Table 5: New Castle Resilient Community Partnership example critical structures vulnerability matrix

Structure_ID	Type	Name	Sensitivity			Adaptive Capacity			Criticalness		Total
			Inundation Depth	Susceptibility to Waves	Subtotal	Material	Can be Floodproofed	Subtotal	Public Safety	Subtotal	
			4	2		3	3		5		
25	Well House	MSC Well House	Low	Low	6	High	N/A	3	Medium	10	19
99	School	New Castle Elementary School	Low	Low	6	Medium	N/A	6	Low	5	17
129	Town Hall	Town Hall	Low	Low	6	Low	N/A	9	High	15	30
134	Senior Center	Senior Center	Low	Low	6	Medium	Low	15	Low	5	26
136	Fire Station	Goodwill Fire Station	Low	Low	6	Medium	Low	15	High	15	36
139	MSC office	MSC office	Medium	Medium	12	Low	Low	18	High	15	45
148	MSC Building / Garage	MSC Building / Garage	Medium	Low	10	Medium	Low	15	High	15	40
151	Public Works Yard	Public Works Yard	Medium	Medium	12	Medium	Low	15	High	15	42
152	Police Department	Police Department	Medium	Medium	12	Low	Low	18	High	15	45
738	Water Tower	MSC Water Tower	Low	Low	6	High	N/A	3	Medium	10	19
1131	Electric Substation	Delmarva Electrical Substation	Low	Medium	8	Low	Low	18	Medium	10	36
1132	Electric Substation	Delmarva Electrical Substation	Low	Medium	8	Low	Low	18	Medium	10	36
1268	Pump Station	NCC Pump Station	Medium	Low	10	High	Low	12	Medium	10	32
1291	Pump Station	NCC Pump Station	Low	Low	6	High	N/A	3	Medium	10	19
1668	Electric Substation	MSC Electric Substation	High	Medium	16	High	Low	12	Medium	10	38
1669	Electric Substation	MSC Electric Substation	Low	Low	6	High	Low	12	Medium	10	28
1671	Electric Substation	MSC Electric Substation	Low	Low	6	High	Low	12	Medium	10	28
1673	Water Tower	MSC Water Tower	Low	Low	6	High	N/A	3	Medium	10	19
1683	School	Carrie Downie School	Low	Low	6	Medium	N/A	6	Low	5	17
2050	Pump Station	NCC Pump Station	High	Medium	16	High	Low	12	Medium	10	38
2253	Historic Register	Old Courthouse	Low	Low	6	Medium	N/A	6	Low	5	17
2254	Historic Register	Old Courthouse	Low	Low	6	Medium	N/A	6	Low	5	17
2278	City Hall	City Hall	Low	Low	6	Low	N/A	9	High	15	30
2333	Pump Station	NCC Pump Station	Low	Medium	8	High	Low	12	Medium	10	30
2335	Well House	MSC Well House	Low	Medium	8	High	Low	12	Medium	10	30



City Pier

The City Pier was destroyed by Superstorm Sandy in 2012. The newly built pier was reopened in 2017, and is a strong example of the City's resiliency.

5.0 Public Engagement

5.1 Community Outreach

Public participation and outreach was a priority of the project team. Not only is public input critical to understanding local perceptions of risk and impacts, but it also builds awareness and momentum that can lead to meaningful change. The City of New Castle has a diverse population and in order to reach as many residents as possible with project information and engagement opportunities, the team designed a multi-level outreach strategy that provided chances for all residents to participate in person (via public workshops) or through other forms of interaction (mailings, newspaper notices, websites/social media).

The team first began the general public outreach campaign with an announcement about the project to City Council at the Town Hall on May 9, 2017. Outreach continued over the summer with the release of a project overview one-pager and invitations to City residents and stakeholders to the first public workshop through a newspaper listing (City of New Castle Weekly), website and social media postings (DNREC Delaware Coastal Programs and the City of New Castle websites and facebook pages), and signage posted in several locations around the City.

5.2 Preparedness Task Force

For additional in-depth community engagement, the team formed the New Castle City Preparedness Task Force in September 2017. This group includes members who represent several City boroughs that currently experience flooding on a regular basis, as well as City stakeholders from sectors that will be involved in future flooding response and adaptation efforts.

New Castle City Preparedness Task Force Members

Gail Seitz	City Planning Commission
Drew Hayes	Foresight Associates Inc.
Tom Clayton	Good Will Fire Company
David Majewski Sr.	Good Will Fire Company
Ron Vukelich	The Strand
Jamie Rogers	City Police Department
Daniel Citron	New Castle Historical Society
Paula Stockton	Buttonwood
Jeffrey Bergstrom	City Building and Zoning

The City Preparedness Task Force met several times over the course of the project with the project team to vet findings and the vulnerability maps. The Task Force also held discussions on potential adaptation and mitigation recommendations, providing feedback on their feasibility, capacity to be implemented, and overall benefit to resiliency. See Appendix B for the Task Force meeting minutes. The City will continue to host meetings of the Task Force on a regular basis after the conclusion of this project in order to move forward with implementing the project's final adaptation recommendations.

5.3 Initial Public Workshop

The first public workshop was held on Thursday, September 7, 2017 at a local school within the City limits, the New Castle Elementary School, from 5:00 pm to 7:30 pm. to describe an assessment of the community's vulnerability to flooding caused by storms and sea level rise. The workshop was attended by 55 stakeholders and residents of the City of New Castle, including City



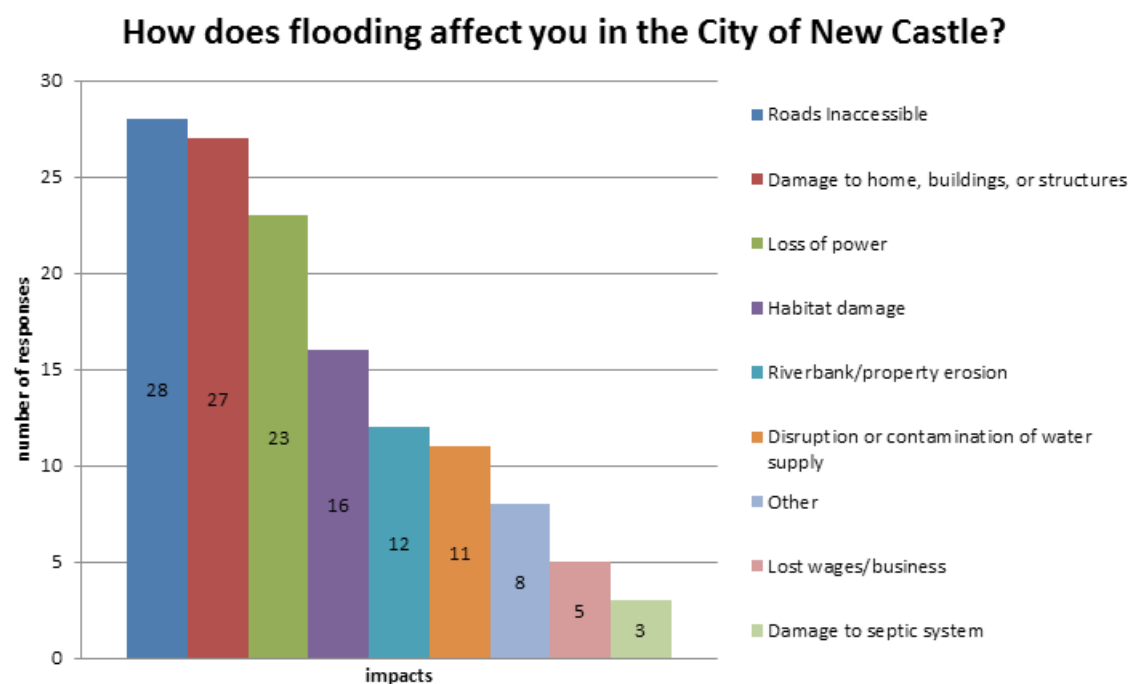
September 2017 Public Workshop
Photo Credit: DNREC

Council and Planning Commission officials. It also provided participants an opportunity to give input on which City sectors the City Preparedness Task Force should focus on first when addressing flooding risks. Members of the project team, the City Preparedness Task Force, as well as a representative from the DNREC Flood Mitigation Program Participants were also available to speak with attendees. At the end of the workshop, participants turned in a survey that asked them several questions about how concerned they are about flooding in the City, how they are personally affected by flooding, and about what they have done so far to adapt to flooding on their own personal property (see Figure 10). 96% of the attendees reported that they were concerned "a lot" or "somewhat" about flooding in the City of New Castle. A majority of attendees cited inaccessible roads and property damage among the greatest impacts that they experience with flooding. See Appendix C for detailed results of the surveys and sticky dot voting.

5.4 Resilient Community Day Public Workshop

A second public workshop to report the final findings of the project was held on Wednesday, March 14, 2018, from 4:30 pm to 7:00 pm, at a local school within the City limits, Carrie Downie Elementary School. This announcement of this event follows the same methods as the first workshop described above. This event was an opportunity to present the final results of the project and the adaptation and mitigation recommendations. This workshop also served as an informational session to promote a safe, more prepared community by connecting City residents with flood preparedness information, with tips for increase resiliency to flooding for personal property, and with subject matter experts from additional agencies and organizations outside the project team.

Figure 10: Survey results



September 2017 Public Workshop

Photo Credit: DNREC



6.0 Recommended Actions or Activities

Through input received from the residents at the two public hearing, comments from task force members at multiple task force meetings, review of documents including those referenced in Section 2.0, and numerous meetings of the project team, numerous actions or activities are being recommended. Please see Exhibit 1 (shown below) for a “snapshot” of these actions or activities as well as the following text for more detailed descriptions. In many ways, these actions or activities represent the City’s vision for resiliency for decades to come.

The actions or activities are categorized as follows:

- **Near-Term Standalone:** Planning, Community Engagement, Regulatory, and Economic actions or activities that can be initiated in the near future without need for any predecessor tasks and are generally independent of other actions or activities.
- **Near-Term Sequential:** Information Gathering tasks that could also be initiated in the near future without need for any predecessor tasks and would be needed before subsequent actions or activities are undertaken.
- **Mid-Term Sequential:** Modelling efforts that would build upon the obtained information.
- **Long-Term Sequential:** Capital Infrastructure, Capital Natural Resources, and Acquisitions, which are the culmination of predecessor actions or activities.

Detailed cost estimates are not provided herein as each of the actions or activities are fairly general and lacking specifics. Instead, a relative scale is being provided to gage orders of magnitude of costs for each as follows:

- **\$:** These tasks could generally be done with City staff or through limited contracting and therefore could be implemented for little cost.
- **\$\$:** Many of these tasks would necessitate the hiring of contractors and therefore more costly than those in the first category. \$0 to \$100,000.
- **\$\$\$:** Some of these tasks could involve complex computerized modelling while others involve restorative construction and could be costly. \$100,000 to \$250,000.
- **\$\$\$\$:** These generally involve construction and land acquisition, and many are therefore very costly. Potentially millions of dollars.

6.1 Near-Term Standalone Actions or Activities

6.1.1 Planning

PL1. Adopt land use policies and strategies that would guide growth away from high risk areas. Ensure technical expertise on team reviewing City’s Comprehensive Plan Update such that it can be the impetus to appropriate policies.

As part of the City’s Comprehensive Plan Update, adopt land use policies and strategies that would guide growth away from high risk areas:

- Sea level rise is expanding high tide inundation areas and increasing flood hazards in some locations that are currently designated as priority redevelopment areas in the Comprehensive Plan. Reevaluate these priority redevelopment areas and future land use and zoning designations for properties that are susceptible to future inundation and flooding.
- Delineate high risk areas where development/redevelopment should be limited.
- Evaluate requirements and/or incentives that guide development out of high risk hazard areas and promote low impact design and compact development in suitable areas.
- Evaluate ways to protect the high impact areas as open space and designate land for flood protection.
- In lower risk areas, and where development is unavoidable, implement additional safeguards to mitigate and minimize future hazards, such as the following:
- Build with additional flood hazard resistant construction methods.
- Minimize impervious areas and protecting and enhancing environmentally sensitive areas.
- Minimize contributing stormwater runoff to flood water receiving areas by requiring stormwater best management practices (BMPs) and porous materials where appropriate.

PL2. Update City’s Emergency Operations Plan.

As noted in Section 2.0, the existing Emergency Operations Plan is generic and lacking in specificity. Updates should include coordination with emergency planners from the

County and State and reiterate existing or identify new emergency evacuation routes. Vulnerable populations should be factored in.

PL3. Identify areas where cars could be parked in advance of likely flooding events.

Concerns were expressed at the first public workshop that residents, many of whom park on the street, would have nowhere to move their cars if a flooding event were to occur. Damaged cars could hinder rescue and/or recovery operations.

6.1.2 Community Engagement

CE1. Transition Flood Preparedness Task Force into standing committee with long-term role in advising City on future actions and further engaging residents and businesses.

The City of New Castle will continue to host meetings of the Taskforce on a regular basis after the conclusion of this project in order to move forward with implementing the project's final adaptation recommendations.

CE2. Continue to Refine Community Rating System (CRS) Status as an improved program translates to improved resilience and lower insurance premiums for residents.

Allocate resources (staff, equipment) to allow the CRS rating of the City to be reduced to the lowest practicable level.

CE3. Designate City staff persons to serve as community resiliency specialists. One focused on outreach and the other on more technical aspects. Make phone numbers readily available.

Self-explanatory. Staff training would be needed.

CE4. Identify specific approaches homeowners can take to mitigate flood risks that can lead to a reduction in flood insurance premiums.

Examples include incorporating mitigation tips and techniques as regular part of City activities where the public is present (like a safety moment) such as public meetings and other city sponsored events.

CE5. Sponsor a community-wide outreach event each year on emergency preparedness at the start of hurricane season.

Examples include exhibit booths about resiliency and emergency planning at City festivals or events. Demonstrate to the community that the City is "on top" of preparedness activities through ongoing communications.

CE6. Develop a resiliency checklist or webpage for all residents.

Examples include guidelines for preparing personal emergency plans, preparedness tips (such as raising HVAC equipment), and emergency contact numbers. Encourage residents to assist with City-wide efforts such as cleaning of storm drain grates. Provide links to webpages by others such as the University of Delaware in lieu of creating new content.

CE7. Provide access to interactive tools, and websites, in addition to trained staff for residents and businesses such that they can determine the extent of their vulnerability to sea level rise.

Self-explanatory. Would need to be provided in public place(s) for those without Internet access.

CE8. Encourage area schools to prepare lesson plans regarding sea level rise and resiliency planning (such as poster contests).

Self-explanatory.

6.1.3 Regulatory

RE1. Amend City Code by making adjustments to include sea level rise adaptation strategies, remove any barriers that would prohibit additional flood protection, and minimize future hazards.

As noted in Section 2.0, the Comprehensive Plan Update offers multiple recommendations to preserve the capacity of the floodplain to carry floodwaters and conserve environmentally sensitive areas by developing overlay zoning ordinances, environmental performance standards, and design criteria and/or mitigation requirements as well as amend the zoning code to prohibit development in wetlands and require a riparian buffer zone along wetlands and stream banks.

Specific amendments could include regulating areas above and beyond those identified by FEMA, more stringent floodplain management requirements, ensuring no net fill behind the dikes, standards for reconstruction in cases of damaged properties, and over-managing stormwater.

Building code updates could include building with additional flood hazard resistant construction methods, minimizing impervious areas, and minimizing contributing stormwater runoff to flood water receiving areas by requiring stormwater best management practices (BMPs) and porous materials where appropriate. The building code should be kept consistent with FEMA maps and requirements, particularly in mapped Coastal A Zone areas, New Castle County's code, and/or the latest edition of the IBC series.

6.1.4 Economic

EC1. Provide incentives to homeowners and businesses to implement flood management strategies that would lessen the City's costs for disaster mitigation.

The City should assess the advantages and disadvantages of providing grants or low interest loans to homeowners and businesses to raise and/or floodproof their properties.

6.2 Near-Term Sequential Actions or Activities

6.2.1 Information Gathering

IG1. Develop near and long-term funding strategies.

Research funding sources for grants and/or loans. Sources may include Federal and State government, foundation, and nonprofit agencies. Consider NOAA Coastal Resilience Grant. Seek partnerships. The Delaware Database for Funding Resilient Communities has a searchable database of funding sources.

IG2. Perform additional surveying to obtain first floor and adjacent ground elevations as well as determine the presence or absence of basements/crawlspaces for critical public structures likely to be impacted to fine-tune modeling.

As previously noted, the modelling described in Section 3.0 was not performed with the benefit of actual ground elevation adjacent to homes and other buildings nor did it include first floor elevations or whether or not basements/crawlspaces exist. These should be determined to adjust the vulnerability matrix described in Section 4.0 prior to initiation of significant restoration projects.

IG3. Perform additional surveying to obtain first floor and adjacent ground elevations as well as determine the presence or absence of basements/crawlspaces for private structures likely to be impacted to fine-tune modeling.

It is similar to IG2 but for private, not public structures. Performing the surveying described would help calibrate future modelling and could result in some structures being removed from the floodplain.

IG4. Perform additional surveying of tops and inverts of drainage inlets, sizes and materials of pipes, and inverts and configurations of outfalls as needed to complete inventory.

The City has a functioning database of drainage structures. Completing the inventory would allow for future modelling.

IG5. Perform study to determine the potential impacts to the City's ecosystems resulting from various sea level rise scenarios. Need partnership with DNREC.

Conduct a study to understand the marshlands ability to absorb flood waters and if the City and/or State should consider the feasibility of a wetland restoration program. A restoration program may include removing invasive vegetation and planting of native species to restore the marshlands to their natural and native state. Doing so could increase the City's overall sea level rise adaptive capacity, as well as, provide many other ecological, recreational, and educational benefits.

IG6. Perform economic analyses to maximize benefit/cost ratio of actions or alternatives that have both public and private costs and benefits.

For example, raising dikes would protect numerous homes and businesses and potentially remove them from flood insurance requirements. However, floodproofing measures at individual locations could allow maintaining dikes at current height. Quantify direct and indirect benefits and value private benefits resulting from public expenditures. Determine impacts such as loss of wages if businesses were closed for extended periods of time in various sea level rise scenarios. Identify increased costs of emergency response due to projected expansion of storm flooding to evaluate if additional funding should be allocated in City budget.

IG7. Install water surface elevation sensors/monitors/cameras to help predict roads or other areas likely to be inundated.

Need hardware and software/correlation to models and signage and other warning mechanisms. Would be done in partnership with DeIDOT.

6.3 Mid-Term Standalone Actions or Activities

6.3.1 Modelling

MO1. Perform dynamic modelling of coastal storms to more accurately model impacts from various sea level rise scenarios and waves.

Incorporate inputs from SLOSH models and latest DNREC sea level rise projections. Perform threshold analysis to maximize storage capacity behind dikes and determine at what point increased sea level would necessitate pumping out the dike system to alleviate high frequency flood events.

MO2. Perform dynamic modelling of storm drainage system to better determine incidents of localized flooding from drainage constraints (not coastal storms) and determine future capacity issues.

Modelling would identify areas lacking a sufficient number of inlets, undersized pipes, and system bottlenecks as well as assess potential impacts of sea level rise on outfalls.

MO3. Perform groundwater modelling to determine changes to elevations and extents of inward migration of saltwater resulting from various sea level rise scenarios.

Higher groundwater elevations could result in lessening capacity of stormwater conveyances, infiltration and inflow into sanitary sewers, and seepage into basements (private), and could impact MSC's wells.

6.4 Long-Term Standalone Actions or Activities

Capital Infrastructure, Capital Natural Resource Projects, and Acquisitions would only be undertaken or implemented if the results of Short-Term Sequential Actions or Activities and/or Mid-Term Sequential Actions or Activities support the technical feasibility and financial efficacy of doing so.

6.4.1 Capital Infrastructure

CI1. Further raise dikes and/or add additional dikes at Battery Park and The Strand to provide better protection for more storm events and sea level rise scenarios.

Develop an understanding of how many structures (public and private) would be affected by various raising or building scenarios. Need cost/benefit analysis (see Section 6.1.4). Also assess how raising or building additional dikes could necessitate pumping of water out behind the dikes.

CI2. Raise or otherwise protect select roads to secure emergency access routes.

Need to identify vulnerable roads and understand how many structures (public and private) would be affected by various raising scenarios. May also need right-of-way acquisition and partnership with DeIDOT.

CI3. Raise or floodproof select public structures to protect those essential to public safety and well-being.

Use the Vulnerability Matrix described in Section 4.0 to establish priorities.

CI4. Increase floodplain storage and existing storm sewer system capacities (depending on results of modelling).

Providing additional floodplain storage or additional capacity in storm sewers could decrease incidents of flooding.

6.4.2 Capital Natural Resource Projects

CN1. Anchor shorelines and/or install wave attenuation devices to protect from erosion from increased water surface elevations and/or wave action.

Need to identify preferred options (living shoreline versus hard anchoring) that may vary by location. Proposal at Battery Park could be used as model.

CN2. Implement wetland restoration program to enhance the City's adaptive capacity by embracing the beneficial effects of restored natural environments.

Restore marshes/wetlands and riparian buffers by removing invasive vegetation and planting of native species, which would increase its capacity to absorb flood waters and pollutants.

CN3. Increase use of green infrastructure throughout the City (e.g., Delaware Street redesign).

While green infrastructure is intended more to address stormwater quality impacts, its use could be an integral component to an overall resilient strategy.

6.4.3 Acquisitions and/or Demolitions

AC1. Lessen the risk and improve the resilience of properties clearly vulnerable to future inundation from sea level rise through land acquisitions and/or demolition of structures located on them to maximize community benefits, habitat connectivity, and resilience.

Potentially work with nonprofit organizations such as land trust to ensure that acquired lands become permanently-protected open space accessible by the public.

EXHIBIT 1

CITY OF NEW CASTLE RESILIENT COMMUNITY PARTNERSHIP ACTIONS OR ALTERNATIVES

	Action or Activity	Private Property	Public Safety	SWM Systems	Emergency Services	Shoreline Protection	Public Utilities	Historic Structures	Transportation	Public Services	Costs
NEAR-TERM STANDALONE ACTIONS OR ACTIVITIES											
Planning	PL1. Adopt land use policies and strategies that would guide growth away from high risk areas. Ensure technical expertise on team reviewing City's Comprehensive Plan Update such that it can be the impetus to appropriate policies.	✓						✓		✓	\$
	PL2. Update City's Emergency Operations Plan.		✓		✓		✓		✓	✓	\$
	PL3. Identify areas where cars could be parked in advance of likely flooding events.	✓	✓		✓				✓	✓	\$
Community Engagement	CE1. Transition Flood Preparedness Task Force into standing committee with long-term role in advising City on future actions and further engaging residents and businesses.	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$
	CE2. Continue to Refine Community Rating System (CRS) Status as an improved program translates to improved resilience and lower insurance premiums for residents.	✓						✓		✓	\$
	CE3. Designate City staff persons to serve as community resiliency specialists. One focused on outreach and the other on more technical aspects. Make phone numbers readily available.	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$
	CE4. Identify specific approaches homeowners can take to mitigate flood risks which can lead to a reduction in flood insurance premiums.	✓						✓		✓	\$
	CE5. Sponsor a community-wide outreach event each year on emergency preparedness at the start of hurricane season.		✓							✓	\$
Regulatory	CE6. Develop a resiliency checklist or webpage for all residents.	✓	✓							✓	\$
	CE7. Provide access to interactive tools, and websites, in addition to trained staff for residents and businesses such that they can determine the extent of their vulnerability to sea level rise.	✓						✓		✓	\$
	CE8. Encourage area schools to prepare lesson plans regarding sea level rise and resiliency planning (such as poster contests).		✓		✓					✓	\$
Economic	RE1. Amend City Code by making adjustments to include sea level rise adaptation strategies, remove any barriers that would prohibit additional flood protection, and minimize future hazards.	✓	✓					✓		✓	\$
	EC1. Provide incentives to homeowners and businesses to implement flood management strategies that would lessen the City's costs for disaster mitigation.	✓								✓	\$
NEAR-TERM SEQUENTIAL ACTIONS OR ACTIVITIES											
Information Gathering	IG1. Develop near and long-term funding strategies.	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$
	IG2. Perform additional surveying to obtain first floor and adjacent ground elevations as well as determine the presence or absence of basements / crawlspaces for critical public structures likely to be impacted to fine-tune modeling.		✓		✓		✓	✓		✓	\$
	IG3. Perform additional surveying to obtain first floor and adjacent ground elevations as well as determine the presence or absence of basements / crawlspaces for private structures likely to be impacted to fine-tune modeling.	✓								✓	\$
	IG4. Perform additional surveying of tops and inverts of drainage inlets, sizes and materials of pipes, and inverts and configurations of outfalls as needed to complete inventory.			✓			✓		✓	✓	\$
	IG5. Perform study to determine the potential impacts to the City's ecosystems resulting from various sea level rise scenarios. Need partnership with DNREC.			✓		✓				✓	\$

EXHIBIT 1 (Continued)
CITY OF NEW CASTLE RESILIENT COMMUNITY PARTNERSHIP
ACTIONS OR ALTERNATIVES

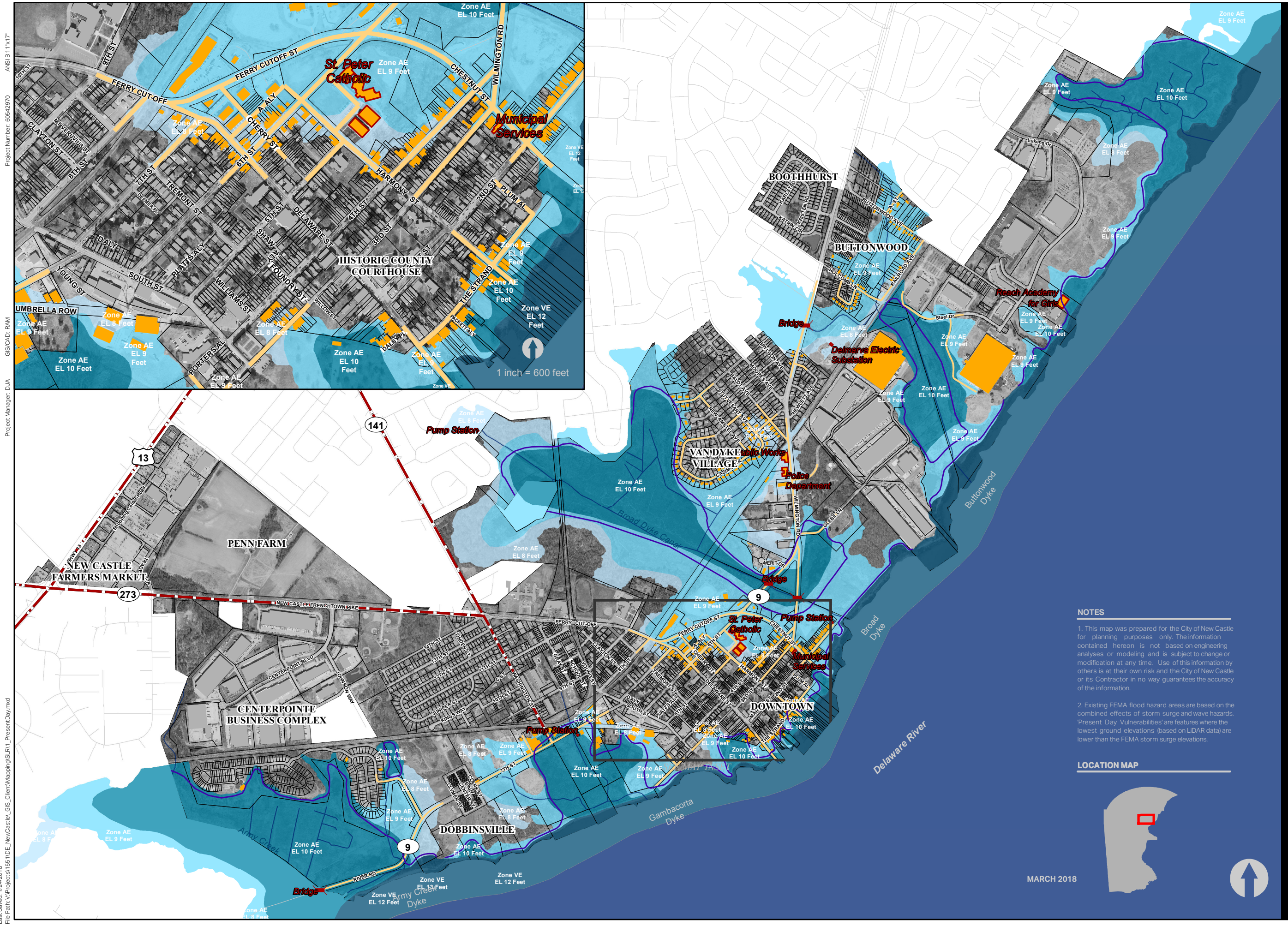
	Action or Activity	Private Property	Public Safety	SWM Systems	Emergency Services	Shoreline Protection	Public Utilities	Historic Structures	Transportation	Public Services	Costs
Information Gathering	IG6. Perform economic analyses to maximize benefit / cost ratio of actions or alternatives that have both public and private costs and benefits.	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$\$\$
	IG7. Install water surface elevation sensors / monitors / cameras to help predict roads or other areas likely to be inundated.		✓	✓	✓		✓		✓	✓	\$\$\$
MID-TERM SEQUENTIAL ACTIONS OR ACTIVITIES											
Modelling	MO1. Perform dynamic modelling of coastal storms to more accurately model impacts from various sea level rise scenarios and waves.	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$\$\$
	MO2. Perform dynamic modelling of storm drainage system to better determine incidents of localized flooding from drainage constraints (not coastal storms) and determine future capacity issues.	✓		✓	✓		✓		✓	✓	\$
	MO3. Perform groundwater modelling to determine changes to elevations and extents of inward migration of saltwater resulting from various sea level rise scenarios.			✓			✓			✓	\$
LONG-TERM SEQUENTIAL ACTIONS OR ACTIVITIES											
Capital Infrastructure, Capital Natural Resource Projects, and Acquisitions would only be undertaken or implemented if the results of Short-Term Sequential Actions or Activities and / or Mid-Term Sequential Actions or Activities support the technical feasibility and financial efficacy of doing so.											
Capital Infrastructure	CI1. Further raise dikes and / or add additional dikes at Battery Park and The Strand to provide better protection for more storm events and sea level rise scenarios.	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$\$\$\$
	CI2. Raise or otherwise protect select roads to secure emergency access routes.		✓	✓			✓		✓	✓	\$\$\$\$
	CI3. Raise or floodproof select public structures to protect those essential to public safety and wellbeing.		✓		✓		✓	✓		✓	\$\$\$
	CI4. Increase floodplain storage and existing storm sewer system capacities (depending on results of modelling).	✓	✓	✓	✓	✓	✓	✓	✓	✓	\$\$\$
Capital Natural Resource Projects	CN1. Anchor shorelines and / or install wave attenuation devices to protect from erosion from increased water surface elevations and / or wave action.			✓		✓				✓	\$\$\$
	CN2. Implement wetland restoration program to enhance the City's adaptive capacity by embracing the beneficial effects of restored natural environments.			✓		✓				✓	\$\$\$
	CN3. Increase use of green infrastructure throughout the City (e.g. Delaware Street redesign).			✓					✓	✓	\$
Acquisitions and / or Demolitions	AC1. Lessen the risk and improve the resilience of properties clearly vulnerable to future inundation from sea level rise through land acquisitions and / or demolition of structures located on them to maximize community benefits, habitat connectivity, and resilience.	✓	✓	✓	✓		✓	✓		✓	\$\$\$\$

7.0 References

- DGS, 2016. Delaware Sea-Level Rise Inundation Mapping Methodology, September 2016.
http://www.dgs.udel.edu/sites/default/files/projects-docs/Coastal_Inundation_Mapping_Methodology_2017.pdf
- DGS, 2017. Recommendation of Sea-Level Rise Planning Scenarios for Delaware: Technical Report, November 2017.
<http://www.dgs.udel.edu/sites/default/files/projects-docs/de%20slr%202017%20technical%20report%20final.pdf>
- FEMA, 2015. Flood Insurance Study for New Castle County, Delaware. February, 2015.
- NOAA, 2017. Delaware City, DE – Station ID: 8551762, <https://tidesandcurrents.noaa.gov/stationhome.html?id=8551762>

Appendix A

Maps



PROJECT

CITY OF NEW CASTLE
RESILIENT COMMUNITY
PARTNERSHIP
VULNERABILITY MAPS

MAP 1

1%-ANNUAL-CHANCE EVENT
WITH CURRENT SEA LEVEL

LEGEND

- Parcels
- Evacuation Route
- Bridge
- Streams

FEMA Flood Zone - Present Day

Flood Zone - Base Flood Elevation (Feet)

- AE 8
- AE 9
- AE 10
- VE 12
- VE 13
- Open Water
- Limit of Moderate Wave Action (LIMWA)

Present Day Vulnerabilities

- Critical Facility (8)
- Buildings in Zone AE (264)
- Roads in Zone AE (8 miles)

DATA SOURCES

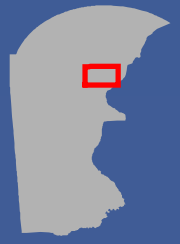
FEMA Flood Zone - 1% annual-chance-event, 2015
Aerial - USGS Orthoimagery, Delaware Environmental Monitoring & Analysis Center, 2012
Parcels - New Castle County, 2017
Buildings - New Castle County, 2017
Ground elevations - Delaware 2-foot Countours, USGS LiDAR data, 2009

NOTES

1. This map was prepared for the City of New Castle for planning purposes only. The information contained hereon is not based on engineering analyses or modeling and is subject to change or modification at any time. Use of this information by others is at their own risk and the City of New Castle or its Contractor in no way guarantees the accuracy of the information.

2. Existing FEMA flood hazard areas are based on the combined effects of storm surge and wave hazards. 'Present Day Vulnerabilities' are features where the lowest ground elevations (based on LiDAR data) are lower than the FEMA storm surge elevations.

LOCATION MAP



COMMUNITY PARTNERSHIP

City of New Castle, Delaware
DNREC - Delaware Coastal Programs (DCP)
DCP is a cooperative program between the State of Delaware and the National Oceanic and Atmospheric Administration (NOAA).



CONSULTANT

AECOM

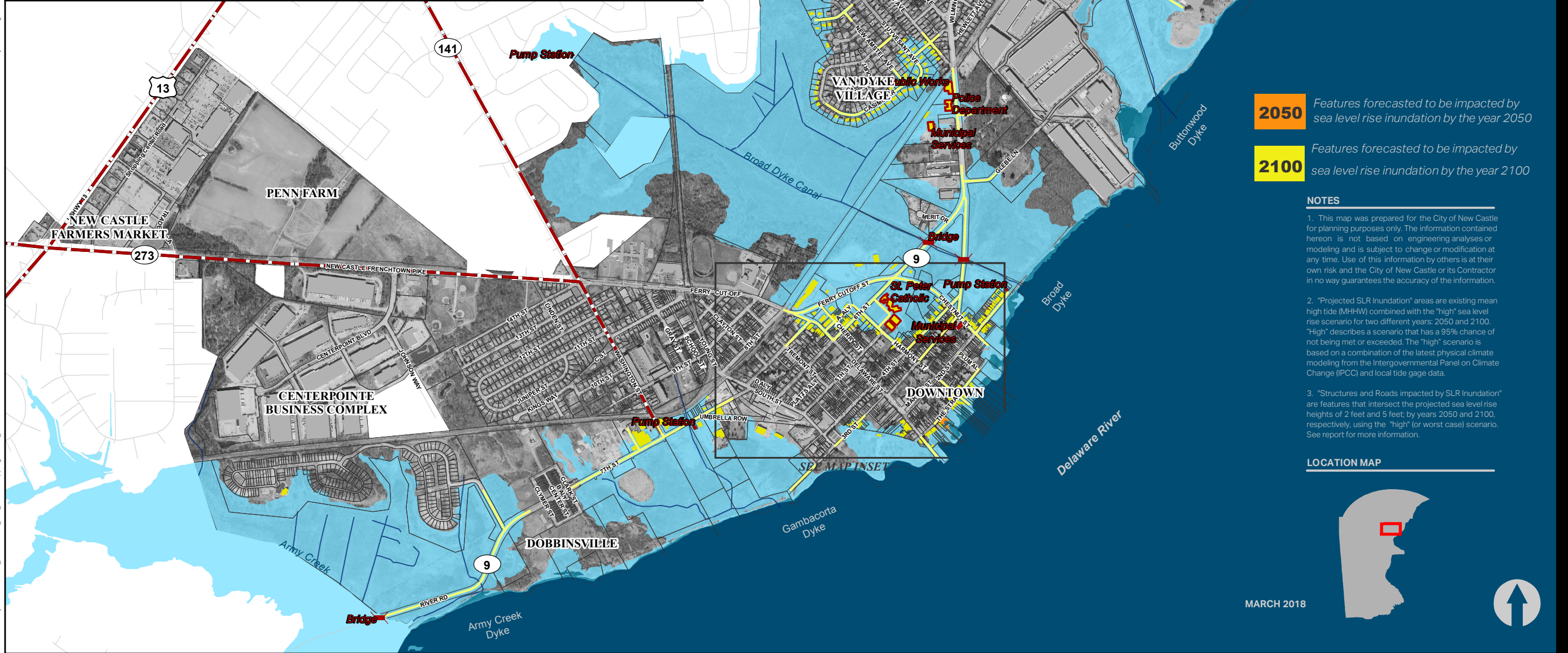
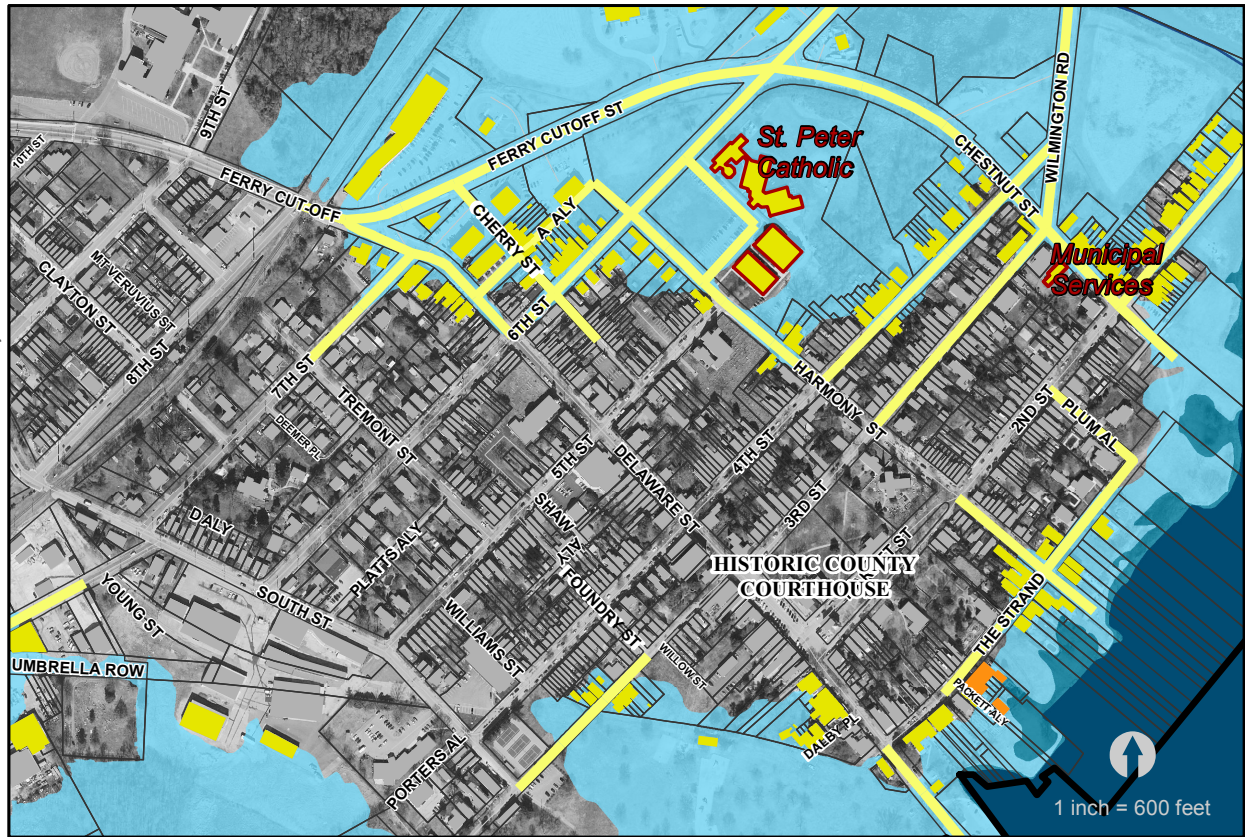
Sabre Building, Suite 300
4051 Ogletown Road
Newark, DE 19713
302.781.5900 tel 302.781.5901 fax
www.aecom.com

SHEET NUMBER

1 OF 7

Project Number: 60542970
GIS/CAD: RAM
Project Manager: DUA
Last Saved: 1/24/2018
File Path: V:\Projects\1551\DE - NewCastle\GIS Client\Mapping\SR1\1_PresentDay.mxd

Project Number: 60542970
GIS/CAD: RAM
Project Manager: DJA
Last Saved: 3/5/2018
File Path: V:\Projects\1551\DE_NewCastle\GIS_Client\Maping\SLR\2_SLR.mxd



PROJECT

CITY OF NEW CASTLE
RESILIENT COMMUNITY
PARTNERSHIP
VULNERABILITY MAPS

MAP 2

FUTURE SEA LEVELS IN
YEARS 2050 AND 2100

CRITICAL FACILITIES,
STRUCTURES AND ROADS

LEGEND

- Parcels
- Evacuation Route
- Bridge (4)
- Streams
- Present Day MHHW
- SLR Inundation (Projected MHHW)
 - SLR 2 FT, Year 2050
 - SLR 5 FT, Year 2100
- Structures Impacted by SLR Inundation
 - Critical Facility (2 FT- 0; 5 FT- 10)
 - SLR 2 FT - Structure (2)
 - SLR 5 FT - Structure (232)
- Roads Impacted by SLR Inundation
 - SLR 2FT - Road (0 miles)
 - SLR 5 FT - Road (7 miles)

DATA SOURCES

MHHW and SLR Scenarios - DE Coastal Inundation, DNREC and Delaware Geological Survey (DGS), FirstMap Data, 2016
Parcels - New Castle County, 2017
Buildings - New Castle County, 2017

SCALE



COMMUNITY PARTNERSHIP

City of New Castle, Delaware
DNREC - Delaware Coastal Programs (DCP)
DCP is a cooperative program between the State of Delaware and the National Oceanic and Atmospheric Administration (NOAA).



CONSULTANT

AECOM
Sabre Building, Suite 300
4051 Ogletown Road
Newark, DE 19713
302.781.5900 tel 302.781.5901 fax
www.aecom.com

SHEET NUMBER

2 OF 7

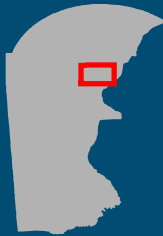
2050 Features forecasted to be impacted by sea level rise inundation by the year 2050

2100 Features forecasted to be impacted by sea level rise inundation by the year 2100

NOTES

- This map was prepared for the City of New Castle for planning purposes only. The information contained hereon is not based on engineering analyses or modeling and is subject to change or modification at any time. Use of this information by others is at their own risk and the City of New Castle or its Contractor in no way guarantees the accuracy of the information.
- "Projected SLR Inundation" areas are existing mean high tide (MHHW) combined with the "high" sea level rise scenario for two different years: 2050 and 2100. "High" describes a scenario that has a 95% chance of not being met or exceeded. The "high" scenario is based on a combination of the latest physical climate modeling from the Intergovernmental Panel on Climate Change (IPCC) and local tide gage data.
- "Structures and Roads impacted by SLR Inundation" are features that intersect the projected sea level rise heights of 2 feet and 5 feet; by years 2050 and 2100, respectively, using the "high" (or worst case) scenario. See report for more information.

LOCATION MAP



MARCH 2018

Project Number: 60542970
Project Manager: D.J.A.
Last Saved: 1/24/2018
File Path: V:\Projects\1551\DE_NewCastle\GIS_Client\Maping\SLR\SLR_Flood.mxd



PROJECT

**CITY OF NEW CASTLE
RESILIENT COMMUNITY
PARTNERSHIP
VULNERABILITY MAPS**

MAP 3

**1%-ANNUAL-CHANCE EVENT
WITH FUTURE SEA LEVEL RISE
IN YEARS 2050 AND 2100**

**CRITICAL FACILITIES,
STRUCTURES AND ROADS**

LEGEND

- Parcels
- Evacuation Route
- Bridge (4)
- Streams
- Present Day MHHW
- Future Flooding with SLR**
 - Year 2050
 - Year 2100
- Structures Impacted by Future Flooding**
 - Critical Facility (2 FT- 15; 5 FT- 20)
 - SLR 2 FT - Structure (474)
 - SLR 5 FT - Structure (747)
- Roads Impacted by Future Flooding >6" Depth**
 - SLR 2FT - Road (9.5 miles)
 - SLR 5 FT - Road (13.3 miles)

DATA SOURCES

SLR Scenarios- DE Coastal Inundation, DNREC and Delaware Geological Survey (DGS), FirstMap Data, 2016
FEMA Flood Zone - 1% annual-chance-event, 2015
Floodplain plus SLR - See Note #2.
Parcels - New Castle County, 2017
Buildings - New Castle County, 2017
Ground elevations - Delaware 2-foot Countours, USGS LIDAR data, 2009



COMMUNITY PARTNERSHIP

City of New Castle, Delaware
DNREC - Delaware Coastal Programs (DCP)
DCP is a cooperative program between the State of Delaware and the National Oceanic and Atmospheric Administration (NOAA).



CONSULTANT

AECOM

Sabre Building, Suite 300
4051 Ogletown Road
Newark, DE 19713
302.781.5900 tel 302.781.5901 fax
www.aecom.com

SHEET NUMBER

3 OF 7

NOTES

1. This map was prepared for the City of New Castle for planning purposes only. The information contained hereon is not based on engineering analyses or modeling and is subject to change or modification at any time. Use of this information by others is at their own risk and the City of New Castle or its Contractor in no way guarantees the accuracy of the information.

2. "Future flooding with SLR" areas are the existing FEMA flood hazard areas combined with the "high" sea level rise scenario for two different years: 2050 and 2100. "High" describes a scenario that has a 95% chance of not being met or exceeded. The "high" scenario is based on a combination of the latest physical climate modeling from the Intergovernmental Panel on Climate Change (IPCC) and local tide gage data. Existing FEMA flood hazard areas are based on the combined effects of storm surge and wave hazards.

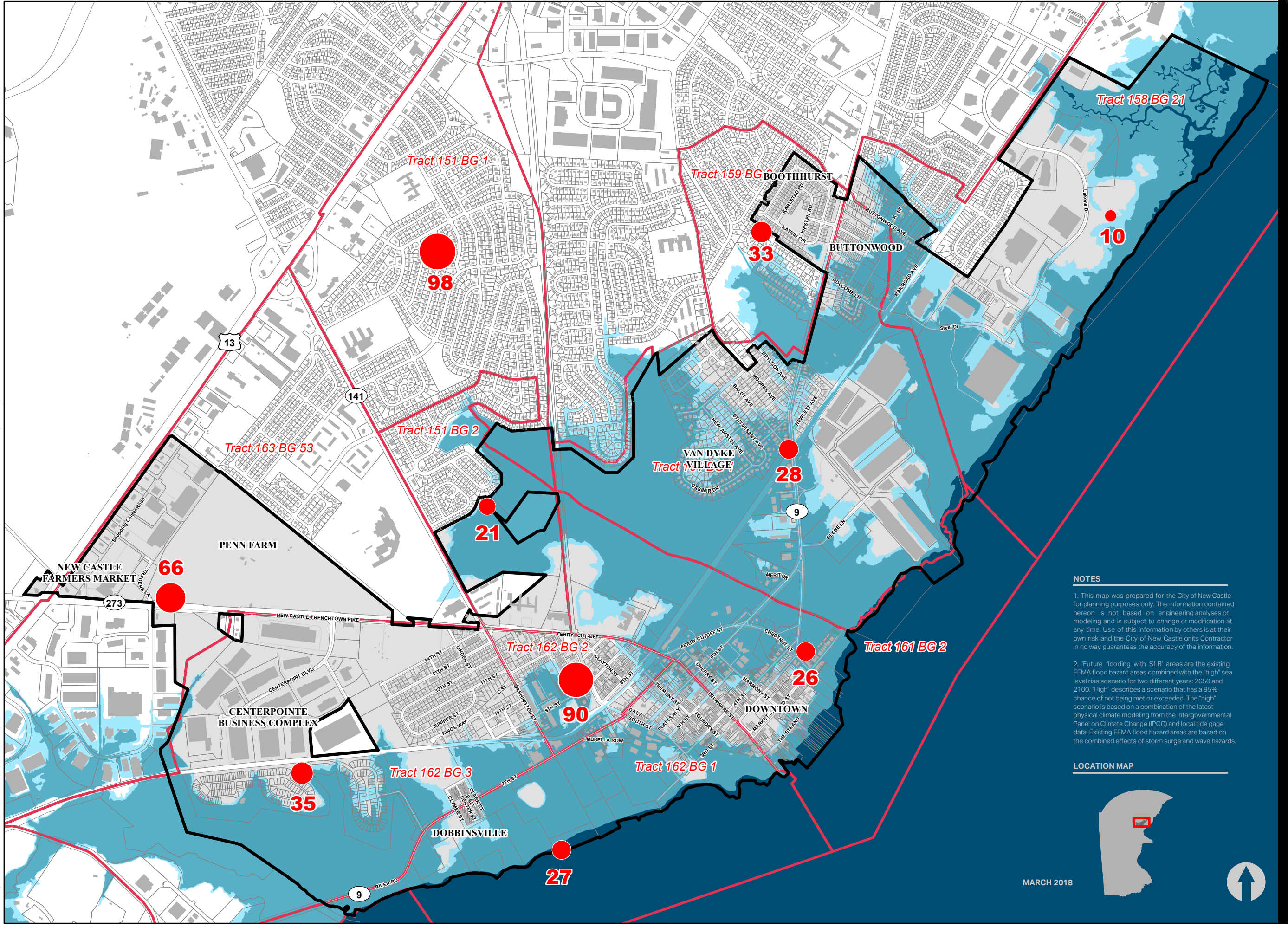
3. "Structures and Roads impacted by Future Flooding" are features where the lowest ground elevations (based on LIDAR data) are lower than the FEMA storm surge elevations plus the sea level rise heights of 2 feet and 5 feet, by years 2050 and 2100, respectively, using the "high" (or worst case) scenario. See report for more information.

LOCATION MAP



MARCH 2018

Project Number: 60542970
ANSI B 11x17"
GIS/CAD: RAM
Project Manager: DJA
Last Saved: 2/1/2018
File Path: V:\Projects\1551\DE_NewCastle\GIS_Client\Maping\SLR\4_PovertyRate.mxd



NOTES

1. This map was prepared for the City of New Castle for planning purposes only. The information contained hereon is not based on engineering analyses or modeling and is subject to change or modification at any time. Use of this information by others is at their own risk and the City of New Castle or its Contractor in no way guarantees the accuracy of the information.

2. "Future flooding with SLR" areas are the existing FEMA flood hazard areas combined with the "high" sea level rise scenario for two different years: 2050 and 2100. "High" describes a scenario that has a 95% chance of not being met or exceeded. The "high" scenario is based on a combination of the latest physical climate modeling from the Intergovernmental Panel on Climate Change (IPCC) and local tide gage data. Existing FEMA flood hazard areas are based on the combined effects of storm surge and wave hazards.

LOCATION MAP



MARCH 2018

PROJECT

**CITY OF NEW CASTLE
RESILIENT COMMUNITY
PARTNERSHIP
VULNERABILITY MAPS**

MAP 4

**1%-ANNUAL-CHANCE EVENT
WITH FUTURE SEA LEVEL RISE
IN YEARS 2050 AND 2100**

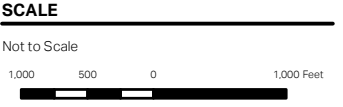
**HOUSEHOLDS BELOW
POVERTY LEVEL**

LEGEND

- City Boundary
- Parcel
- MHHW
- Future Flooding with SLR
 - Year 2050
 - Year 2100
- Households Below Poverty Level
 - 10
 - 50
 - 100

DATA SOURCES

SLR Scenarios- DE Coastal Inundation, DNREC and Delaware Geological Survey (DGS), FirstMap Data, 2016
Floodplain plus SLR- See Note #2.
Parcels - New Castle County, 2017
Buildings - New Castle County, 2017
Census Block Group Boundaries and Households below Poverty Level - US Census, ACS 2015



COMMUNITY PARTNERSHIP

City of New Castle, Delaware
DNREC - Delaware Coastal Programs (DCP)
DCP is a cooperative program between the State of Delaware and the National Oceanic and Atmospheric Administration (NOAA).



CONSULTANT

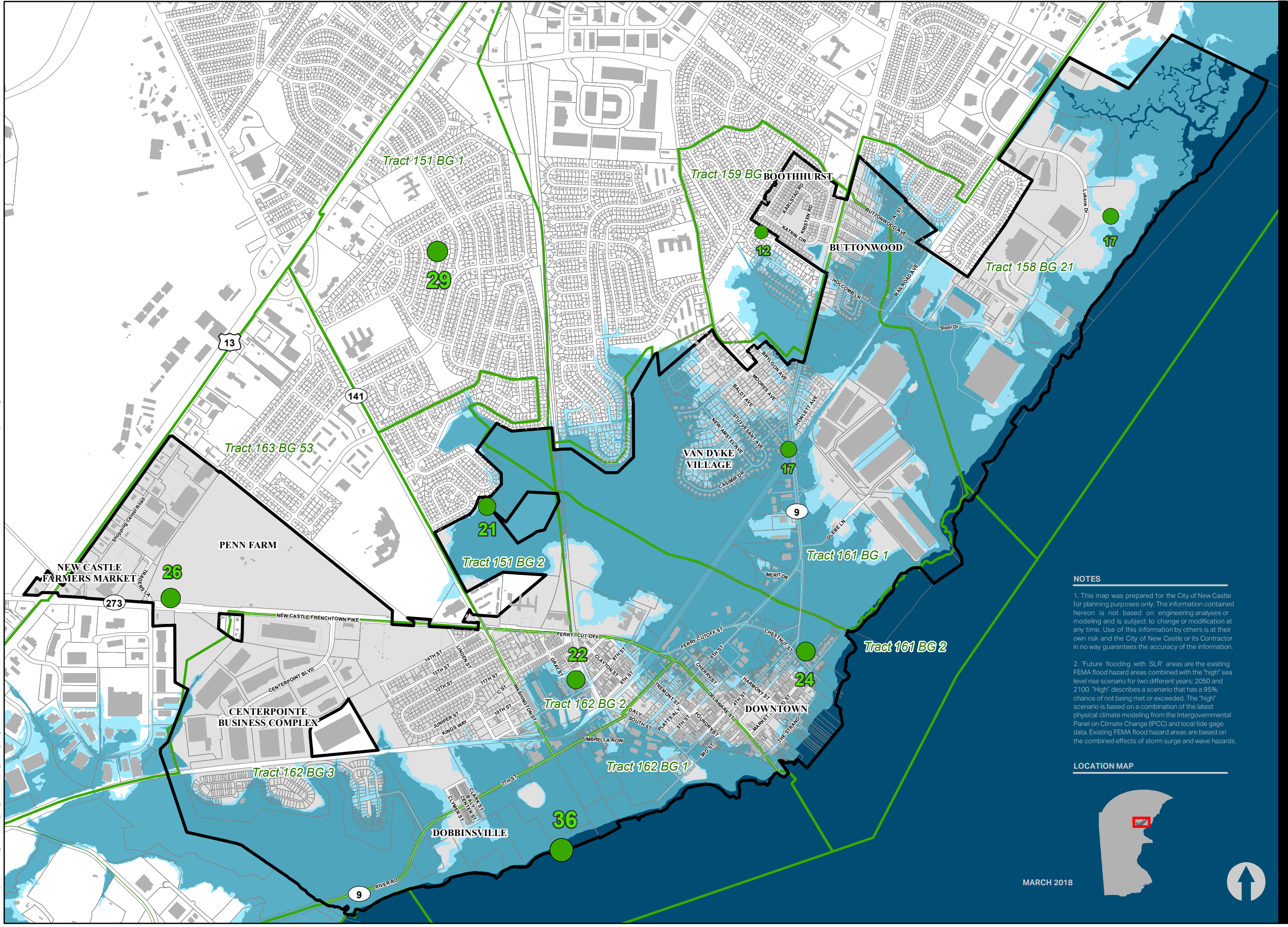
AECOM

Sabre Building, Suite 300
4051 Ogletown Road
Newark, DE 19713
302.781.5900 tel 302.781.5901 fax
www.aecom.com

SHEET NUMBER

4 OF 7

Project Number: 60542970
ANSI B 11x17"
GIS/CAD: RAM
Project Manager: DJA
Last Saved: 1/24/2018
File Path: V:\Projects\11551\DE_NewCastle\GIS_Client\Mapings\SLR\5_HHS_NvVehicle.mxd



PROJECT

**CITY OF NEW CASTLE
RESILIENT COMMUNITY
PARTNERSHIP
VULNERABILITY MAPS**

MAP 5

1%-ANNUAL-CHANCE EVENT
WITH FUTURE SEA LEVEL RISE
IN YEARS 2050 AND 2100

HOUSEHOLDS WITH
ZERO VEHICLES

LEGEND

- City Boundary
- Parcel
- MHHW
- Future Flooding with SLR**
 - Year 2050
 - Year 2100
- Households with Zero Vehicles**
 - 20

DATA SOURCES

SLR Scenarios- DE Coastal Inundation,
DNREC and Delaware Geological Survey (DGS),
FirstMap Data, 2016
Floodplain plus SLR- See Note #2.
Parcels - New Castle County, 2017
Buildings - New Castle County, 2017
Census Block Group Boundaries and Households
without a Vehicle - US Census, ACS 2015

SCALE



COMMUNITY PARTNERSHIP

City of New Castle, Delaware
DNREC - Delaware Coastal Programs (DCP)
DCP is a cooperative program between the
State of Delaware and the National Oceanic
and Atmospheric Administration (NOAA).



CONSULTANT

AECOM
Sabre Building, Suite 300
4051 Ogletown Road
Newark, DE 19713
302.781.5900 tel 302.781.5901 fax
www.aecom.com

SHEET NUMBER

5 OF 7

NOTES

1. This map was prepared for the City of New Castle for planning purposes only. The information contained hereon is not based on engineering analyses or modeling and is subject to change or modification at any time. Use of this information by others is at their own risk and the City of New Castle or its Contractor in no way guarantees the accuracy of the information.

2. "Future flooding with SLR" areas are the existing FEMA flood hazard areas combined with the "high" sea level rise scenario for two different years: 2050 and 2100. "High" describes a scenario that has a 95% chance of not being met or exceeded. The "high" scenario is based on a combination of the latest physical climate modeling from the Intergovernmental Panel on Climate Change (IPCC) and local tide gage data. Existing FEMA flood hazard areas are based on the combined effects of storm surge and wave hazards.

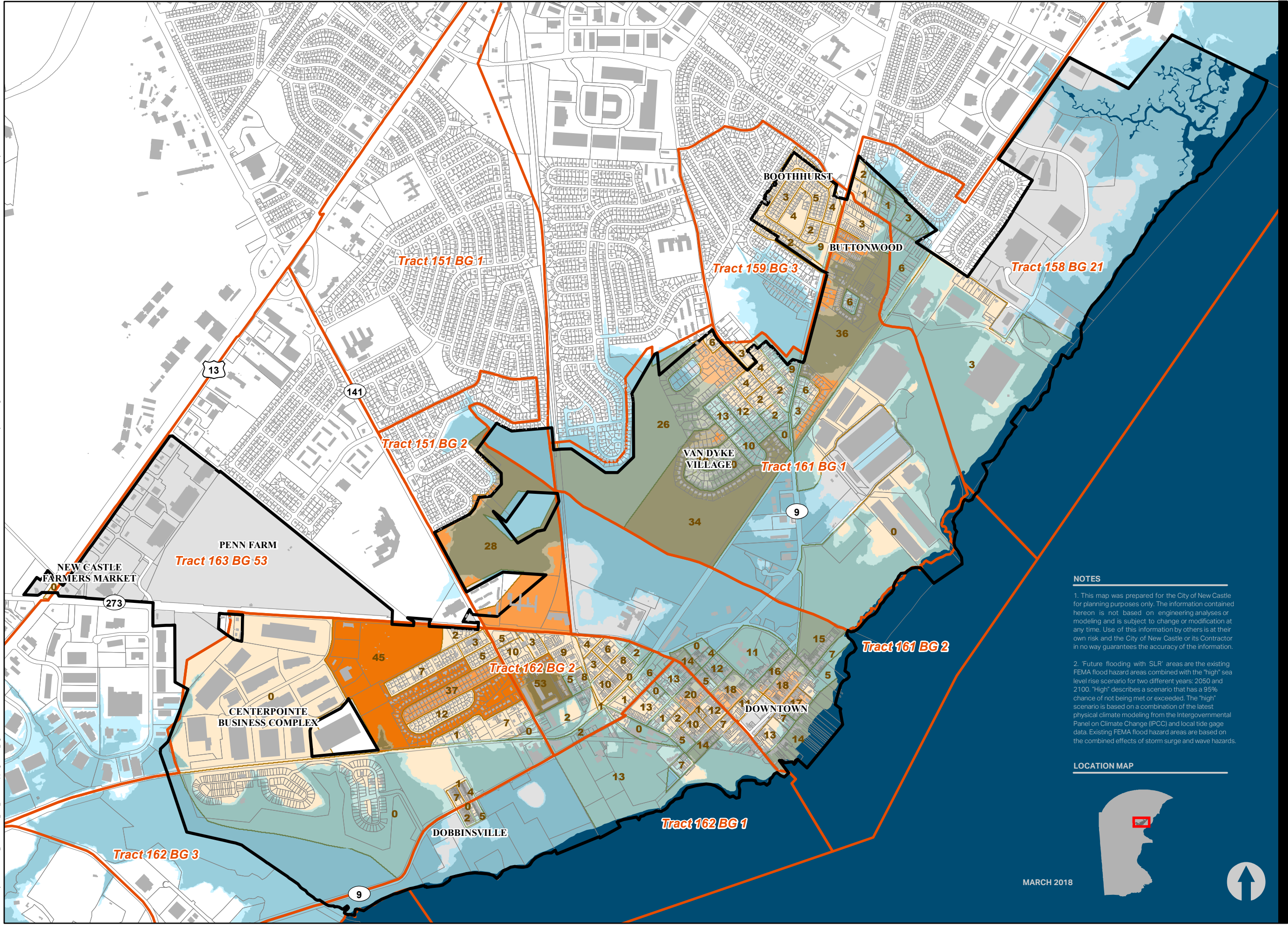
LOCATION MAP



MARCH 2018



Project Number: 60542970
Project Manager: DJA
GIS/CAD: RAM
Last Saved: 1/24/2018
File Path: V:\Projects\1551\DE_NewCastle\GIS_Client\Mapings\SLR6_Age65andOlder.mxd



PROJECT
CITY OF NEW CASTLE
RESILIENT COMMUNITY
PARTNERSHIP
VULNERABILITY MAPS

MAP 6

1%-ANNUAL-CHANCE EVENT
WITH FUTURE SEA LEVEL RISE
IN YEARS 2050 AND 2100
POPULATION 65 YEARS
AND OLDER

LEGEND

- City Boundary
- Parcel
- MHHW
- Future Flooding with SLR
 - Year 2050
 - Year 2100
- Number of Persons Age 65 and Over
 - 0 - 13
 - 14 - 26
 - 27 - 39
 - 40 - 53

DATA SOURCES

SLR Scenarios- DE Coastal Inundation,
DNREC and Delaware Geological Survey (DGS),
FirstMap Data, 2016
Floodplain plus SLR- See Note #2.
Parcels - New Castle County, 2017
Buildings - New Castle County, 2017
Census Block Boundaries and Persons 65 Years
and Older - US Census, 2010

SCALE

Not to Scale
1,000 500 0 1,000 Feet

COMMUNITY PARTNERSHIP

City of New Castle, Delaware
DNREC - Delaware Coastal Programs (DCP)
DCP is a cooperative program between the
State of Delaware and the National Oceanic
and Atmospheric Administration (NOAA).



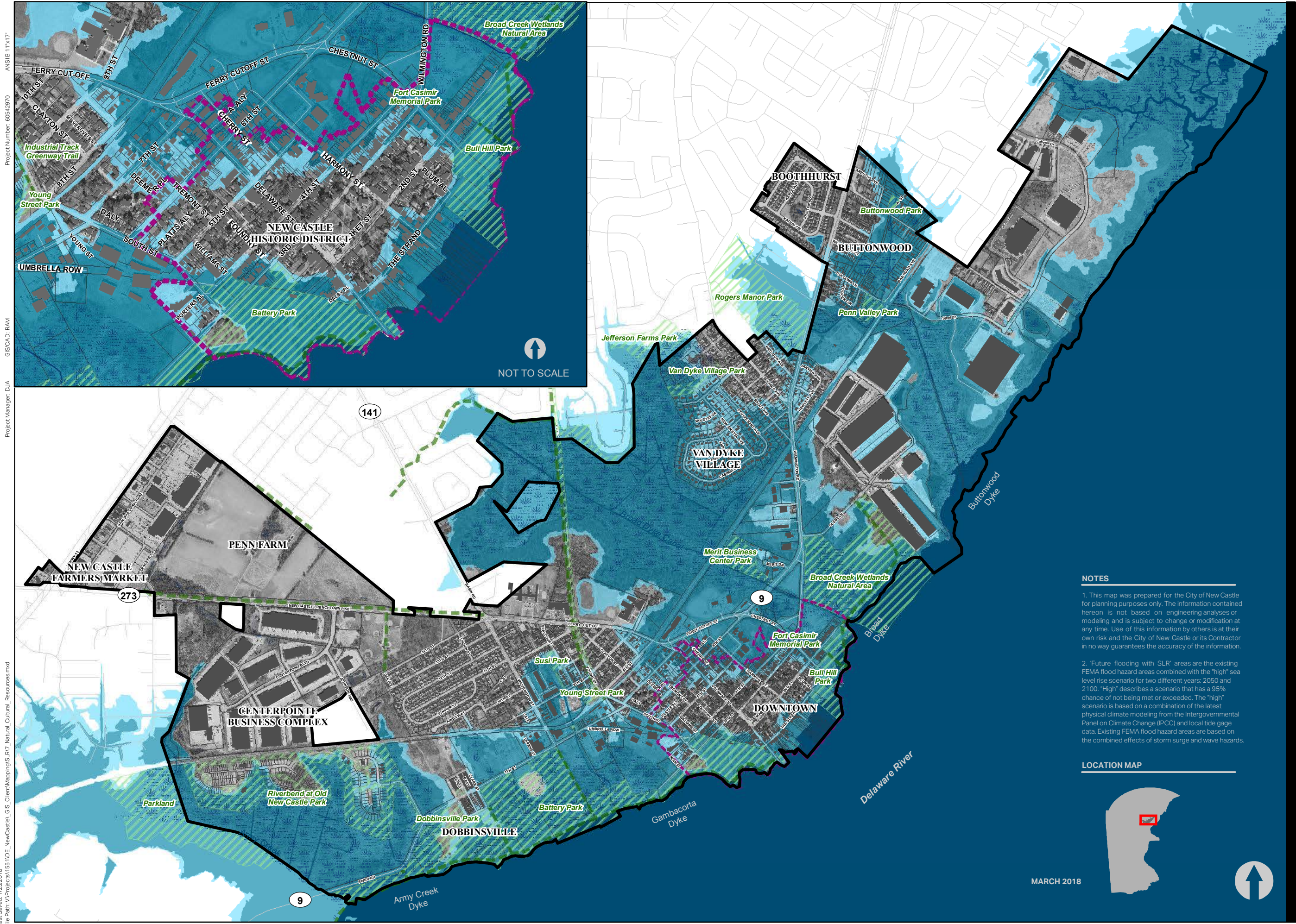
CONSULTANT

AECOM

Sabre Building, Suite 300
4051 Ogletown Road
Newark, DE 19713
302.781.5900 tel 302.781.5901 fax
www.aecom.com

SHEET NUMBER

6 OF 7



PROJECT

**CITY OF NEW CASTLE
RESILIENT COMMUNITY
PARTNERSHIP
VULNERABILITY MAPS**

MAP 7

**1%-ANNUAL-CHANCE EVENT
WITH FUTURE SEA LEVEL RISE
IN YEARS 2050 AND 2100**

**NATURAL AND CULTURAL
RESOURCES**

LEGEND

- City Boundary
- Parcels
- Historic District
- Parks, Greens, and Natural Areas
- Trails
- Streams
- Wetlands
- MHHW
- SLR Scenario with 100 Year Flood-95% Curve
 - 100 Year plus 2 FT (Year 2050)
 - 100 Year plus 5 FT (Year 2100)

DATA SOURCES

SLR Scenarios- DE Coastal Inundation, DNREC and Delaware Geological Survey (DGS), FirstMap Data, 2016
Floodplain plus SLR - See Note #2.
Parcels - New Castle County, 2017
Buildings - New Castle County, 2017
Wetlands - DE SWMP, DNREC, USFWS's NWI, 2007
Open Space, Trails - FirstMap WMS Feature Service
Historic District - City of New Castle



COMMUNITY PARTNERSHIP

City of New Castle, Delaware
DNREC - Delaware Coastal Programs (DCP)
DCP is a cooperative program between the State of Delaware and the National Oceanic and Atmospheric Administration (NOAA).



CONSULTANT

AECOM

Sabre Building, Suite 300
4051 Ogletown Road
Newark, DE 19713
302.781.5900 tel 302.781.5901 fax
www.aecom.com

SHEET NUMBER

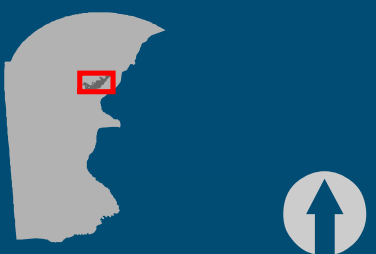
7 OF 7

NOTES

1. This map was prepared for the City of New Castle for planning purposes only. The information contained hereon is not based on engineering analyses or modeling and is subject to change or modification at any time. Use of this information by others is at their own risk and the City of New Castle or its Contractor in no way guarantees the accuracy of the information.

2. Future flooding with SLR areas are the existing FEMA flood hazard areas combined with the "high" sea level rise scenario for two different years: 2050 and 2100. "High" describes a scenario that has a 95% chance of not being met or exceeded. The "high" scenario is based on a combination of the latest physical climate modeling from the Intergovernmental Panel on Climate Change (IPCC) and local tide gage data. Existing FEMA flood hazard areas are based on the combined effects of storm surge and wave hazards.

LOCATION MAP



MARCH 2018

Appendix B

Meeting Minutes

New Castle Resilient Community Partnership Preparedness Taskforce Meeting Notes

October 18, 2017 Police Department Community Room

Recap of September Public Workshop and Feedback Discussion

- Only one presentation needed at future workshops. Or could start them earlier in the evening since residents tend to come out early than later in the day.
- Attendees are very interested in how their homes in particular, and went to the maps to see how they fared with the sea level rise scenarios. Will need to direct them to the bigger picture of planning for the City as a whole.
- Need to increase education and outreach to City residents about how drainage systems work, and who is responsible for maintaining them (is it the City or the property owner?) in order to prevent flooding.

Status of Public Inundation Maps

- Label additional structures on maps to help with orientation (only critical facilities were labeled) perhaps this can be done in a different text color/font
 - Label same structures on each iteration of the maps
- Make titles clearer on each map – place at the top of the page?
- All maps need context/explanation with them, especially if posted publicly
 - Need interpretation to say that inundation areas can differ based on different storm tracks or precipitation conditions
 - Say that inundation maps are only part of the bigger picture of vulnerabilities to the city
 - Explanations need to say some tangible action steps that can be taken to reduce risk so people know that there is a positive to them
- Maps will not be posted publicly online until the final report can be placed with them (or they will be contained in the final report)
- Adaptation already in place to note: Subway and the liquor store have slots that allow flood gates to be put in place in case of high water situations

Vulnerability Matrix

- Matrix needs to include location information of each critical facility/structure/road segment
- Rank the MSC Building and the Electric substation structures as high importance
- Discussion on do we add publically funded, but not City-run facilities to the list?
 - Examples:
 - Courthouse complex, sheriff's house, arsenal, George Read house
 - Could help them make a good case to apply for grant funding to do adaptation implementation work

- Decision: Yes, we will include publically funding facilities (schools, City Hall, etc), but not private property or land
- Do we add a column on whether or not a facility can be relocated?
 - No, would need to determine the building's lifespan, and when it could be moved. Too many details beyond scope of this project
- Need to educate residents on:
 - Emergency evacuation routes and instructions on what to do/where to go in emergencies
 - How to maintain drainage systems and how they work
- Need to identify critical routes for emergency services, fire, and police in addition to state designated evacuation routes.
 - Ask taskforce members to assist with this
- If levees are raised it would decrease the area of the City in the floodplain and would immediately lower the costs of residents' flood insurance because they would only pay a rate that covers them for the small chance of dike failure instead of the larger, more expensive rate they paid currently for living in the floodplain (that is not protected enough by the dikes)
 - This is a quality of life issue because if people pay too much for insurance rates they will be priced out of being able to afford to live in the City and then will move away, and then the City will have a reduce population and reduced tax base to fund the City.
 - The CRS rating lowering could help alievate the expense they pay for flood insurance
 - Currently the City is at an 8, could work towards a 7, but would take a lot to get to a 6, and don't have much more they can do after that point to get any lower.

Adaptation Option Discussion – on Flip Chart Responses

- Barriers to adaptation options include costs and reasonableness of building adaptations (are they even feasible?)
- Some recommendations are to do things that the City is already doing, but to increase their frequency or to do them better (like cleaning drainage systems)
- Some of the options are difficult to achieve and may take 50 years, but we have the time to do it if we start now (we have 80+ years before 2100 impacts happen)
 - There needs to be a standing Dike or Preparedness Task Force that can direct the activities that need to take place in order to get this done over the years. It will take our generation and the next generation to work on this.
- Almost every option will require partnerships in order to get them done. We need to start working on better partnerships
 - Example: Building up/elevating roads. DelDot has a list of all of the City's roads and when they are slated for repair. Some will not be done for another 20 years. We need to work with them to get things done faster.
 - Politicians could be better involved
 - Continue outreach/education to residents through the project and afterwards

Project Next Steps

- Homework for the Task Force: Bring to the next meetings ideas for adaptation options that are thought out more.
- DCP will send out a Doodle poll to schedule the next meeting in November.



Public Services

Schools, senior living, public housing

Dikes Family Foundations

Escape route defined

Improve drainage on properties

Identify vulnerable populations

INFORMATION CLEARING HOUSE (CENTRAL SOURCE)

Historic Buildings & Structures

Explore ideas of walls & gates

Raise HVAC compressors

Improve drainage

- GREEN OR GREY ASSESSMENTS
SUMP PUMPS

Transportation

roads, evacuation routes, bridges, rail, bus

Identify critical routes - Define

Availability of evac vehicles

Raise roadways

HIGH WATER VEHICLES

Public Utilities

Sewers, wells, wastewater treatment
electric

Water Filtration System
Keep sewers clean/maint.

* MAINTAIN ~~DT~~RES - (CLEANING
AND MAJOR ID'D RUN-OFFS

Emergency Services police, fire, rescue

move operations

IMPROVE INTER AGENCY COORDINATION

FLOODPROOF CRITICAL FACILITIES

IMPROVE COMMUNICATION W/ PUBLIC

Explore storage of additional supplies & equipment
in secondary areas

Buy hovercraft

* COORDINATE W/ CRODA (ICI)
EMERGENCY BROADCAST SYSTEM

Shoreline Protection

dikes, erosion, living shorelines

RAISE DIKES / ADD DIKES DOWN → think about pumps
REPLACE FAILING BULKHEADS W/ LIVING SHORELINES

Dredge around dikes

Stormwater Management Systems

drains, retention ponds, wetlands, bioswales, tide gates, etc.

IMPROVE THE CONDITION OF EXISTING STORM DRAINS

INCREASE STORAGE ABOVE AT RISK AREAS (UPSTREAM OF)

REPLACE/ADD CHECK VALVES TO STORM DRAINS

IMPROVE ROUTINE DRAINAGE MAINTENANCE (MIG REQUIREMENTS)

- HOME OWNER RESP.
(clean up oil spills) - Leaking Vehicle Fluids
- ENCOURAGE RESIDENTS TO REPORT UNUSUAL FLOW PATTERNS...

DNREC - City of New Castle Resilient Community Partnership Flood Preparedness Task Force Meeting Notes

Wednesday, December 6, 2017 *City of New Castle Police Department Community Room*

Attendees:

DNREC- Lara, Kelly, Danielle, Bob, Drew; Task Force- Linda, Jamie, Bill, Gayle, Drew; AECOM- Ryan, David

2:00 pm **Welcome, update on project status, and introduction of meeting objectives - Danielle Swallow**

2:10 **Overview of Adaptation Option Matrix - David Athey**

- Planning
 - Update policies to guide growth
 - City updating comp plan currently
 - EOP
 - Parking locations during flooding
- Community Engagement
 - Task force transition to standing committee
 - CRS for lower insurance premiums
 - Staff resiliency specialist
 - Homeowner mitigation options
 - Yearly outreach event
 - Can be an implementation
 - Checklist
 - Interactive tools to use
 - Possible combine with 4,6
- Regulatory
 - Amend codes in line with FEMA
 - Flood Plane Protection and Zoning Ordinance for sea level rise?
 - BMP safeguards
- Economic
 - Incentives to implement strategies
 - Econ analysis for flooding impacts
 - Econ analysis of emergency response
- Ecosystem Protection
 - Living Shoreline
 - Green Infrastructure
- Information Gathering
 - Funding strategies
 - Survey actions (first floor, ground, public and private structures, drainage systems)
 - Majority of drainage is mapped
 - Check for new additions to map

- Sea level rise ecosystem impacts
- CBA of mitigation actions
 - Measure public and private expenditures
- Water sensors
- Modelling
 - Dynamic modelling (wave actions)
 - Storm drainage modelling for undersized pipes
 - Ground water modelling
- Capital Infrastructure
 - Raising or adding dikes
 - Right of way problems
 - \$\$\$
 - Emergency access routes to be raised
 - Raise or flood proof public structures
 - Increase capacity of storm drainage system
- Ecosystem Projects
 - Shoreline anchoring
 - Wetland restoration
- Acquisitions
 - Vulnerable property buyouts?

2:30 Discussion of Selected Adaptation Options from the Action Item Matrix - All

Next steps to refine the list:

- RE1
- Where should city start? What has been discussed in past?
- Changes that can put the City ahead of the curve...
 - Bill- Not aware of any discussion for changing codes so difficulty is that we are starting from scratch. How do you start with incremental steps to not shock system
 - Linda- we do have regulations that require flood protection for new building but not to this extent
 - Already have freeboard requirement
 - Figure out where they codes stand right now
 - Paula- Are there FEMA reps? Many questions fall back to insurance problems. Have residents be aware of local area and drains that could cause a problem.
 - Danielle- we can incorporate this into the homeowner options
 - Kelly- also can do educational events at preparedness day and bring in DEMA
 - Gayle- gateway regulations
 - Business and residential mixed use buildings
 - Danielle- land use plans to discourage development or fill areas which could be put in the comp plan
 - Also incorporate resiliency like Milford
 - Linda- resiliency does cross many chapters of comp plan

- Drew- Code could build on increasing flood storage. Selling yourself short by losing that storage capacity
 - Kelly – Wetland creation possibilities
 - Danielle- thoughts for comp plan- do no harm- from building activities
 - Drew- Lesson plans for the school kids
 - Bob- Is there a maintenance number to call for maintenance?
 - Can educate public to know what to do in the situation
- Comp Plan
 - Danielle- Can you recruit resiliency people to participate in comp plan? Put in as a strategy?
 - Bob- maybe just include flooding expertise on committee
 - Gayle- We do plan on using insights from this project
- Setbacks
 - Linda- you would lose a lot of the build-able lots downtown
- Rebuild Standards
 - Paula- if you look at past storm events high standards did better
 - Kelly- want to think about standards in comp plan and how they could change community in future
- Drew- Somehow encourage wave attenuation for people along the river for additional flood protection
- Wetlands
 - Danielle- Is there capacity in town to encourage wetland creation
 - Open space has been turned to meadows in many areas
 - Look into the returning them to wetlands
 - Linda- may be several issues because of what it took to become meadows
 - Bob- studies to determine storage capacity behind dikes
 - Drew- could be used to discourage flood plain filling
 - Bill- Could show how beneficial that it would be to be wetlands
 - Danielle- are there other benefit like CRS that could be used to show benefits
 - Bill- Can that be used to predict level how much it could help flooding along rt 9?
 - Bob- Studies can show how much more water they could hold before there would be flooding
 - Bill- Unless we could have real results there would be no reason to do the project
- EOP
 - Kelly- if you know where the flooding is a problem how can it be incorporated
 - Jamie- Plan case by case there isn't a catch all storm plan
 - Danielle- Might want to think of contingency plans
 - Jamie- small size restricts us and must rely on the state for support
 - Danielle- can you incorporate NC into state agency plans?
 - Knox Boxes
 - Homeowner Plan
 - Event could cover this issue and bring it to light

- Paula- contractor that could come and evaluate property for flood risk
- City Staff Resiliency Person
 - Bill- was a result of recommendation of city hiring a staff
 - Who would be able to train whoever would do it
 - Split the technical expertise and outreach expertise
- Dikes
 - Who and what would have to be at the table to get process started to raise dikes
 - Are we saying that this is really the only long term solution that will actually work?
 - Need economic study to show what the benefits to raising would be and where would the money be best spent
 - City would need to contract out grant work and studies
 - Prioritize which studies should be done first
 - Bill- when dike committee was started years ago there was a cost analysis done if the dikes were to fail
 - Where does community support for the work stand?
 - Gayle- thinks homeowners are willing but need the coordination with the govt
 - Linda- individual can do the most for the nuisance flooding
 - Would need to be a government project to affect FEMA maps

3:30 Other adaptation options, anything that we missed?

- Drew- incorporate goals into the action and the report
- Show that it will take a combo of efforts instead of just focusing on the dikes

4:00 Wrap up and next steps

- Next meeting of the Task Force will be on February 15, 2018 at the New Castle Police Dept. Community Room

DNREC - City of New Castle Resilient Community Partnership Flood Preparedness Task Force Meeting Notes

2:00 – 4:00 pm Thursday, February 15, 2018

City of New Castle Police Department Community Room

Notes

Welcome, update on project status, and introduction of meeting objectives

- Kelly reviewed the Task Force's actions at the last meeting in December, which included:
 - Provided feedback to AECOM on the Adaptation Options Matrix
 - Discuss selected adaptation options and assessed things like:
 - Would the community support (this adaptation option)?
 - What would be the constraints to implementing (this adaptation option)?
 - Discussed adaptation options including: Amending city codes, provisions on resiliency in the City's Comprehensive Plan update, the FEMA Community Ratings System, community engagement on preparedness planning, raising/extending the dike system along the Strand/Battery Park.

Overview of Recommended Actions/Activities in Final Report

- David reviewed the recommended actions and activities included in the RCP's final report that the City can take to increase its resiliency to flooding in the report.
 - The City asked for the report to include a description of the steps they have already taken to mitigate flooding impacts
 - When was flood proofing installed on 2nd street? 5-10 years ago

Discussion of Comments on the Final Report Recommendations -

- Kelly asked everyone to please send any final comments on the report in by Friday, Feb. 23
- Kelly will send the FEMA chart that shows a 30% chance of flooding in the 100 year storm floodplain to AECOM for inclusion as graphic in the final report beside the explanation regarding the risk of flooding throughout the lifetime of a 30 year mortgage.
- Do not include recommendations that the City reduces greenhouse gas emissions that contribute to climate change in the report. This recommendation is better located in the City's Comprehensive Plan update.
- Do not make specific recommendations on freeboard requirements in the report. It is already set at 18" above the base flood elevation. As FEMA maps are redrawn and updated, they are mapped to the current water line, so the basis for this 18" measurement will change with rising sea levels.
- David will add the listings of complementary adaptations actions to the matrix.
- The City has footing to declare eminent domain, however this reference should be removed from the report.

- What would people looking at buying real estate within the City think if they saw references to “inundation” and “eminent domain” next to each other in the report?
- Could change the recommendation to “Acquire properties that reduce risk of flooding and increase resiliency”
- If the City doesn’t start pumping in the future, flooding will accumulate in the marsh behind 4th and 5th street as well as 6th and 7th.
- What does New Castle County say about fill? What does it allow to save a house?
- The City could have an ordinance that no net fill is allowed behind the dike system so as to not reduce flood storage capacity.
 - But dikes are below base flood elevation and lawyers would not be able to legally define this area.

Plans for the final Public Workshop/Community Resiliency Day (Weds. March 14 at 4:30 p.m.) and roles for the Task Force members at the event - Kelly

Wrap up and Next Steps

- Next meeting of the Task Force: March 28 from 2:00 – 4:00 pm at the Police Department Community Room

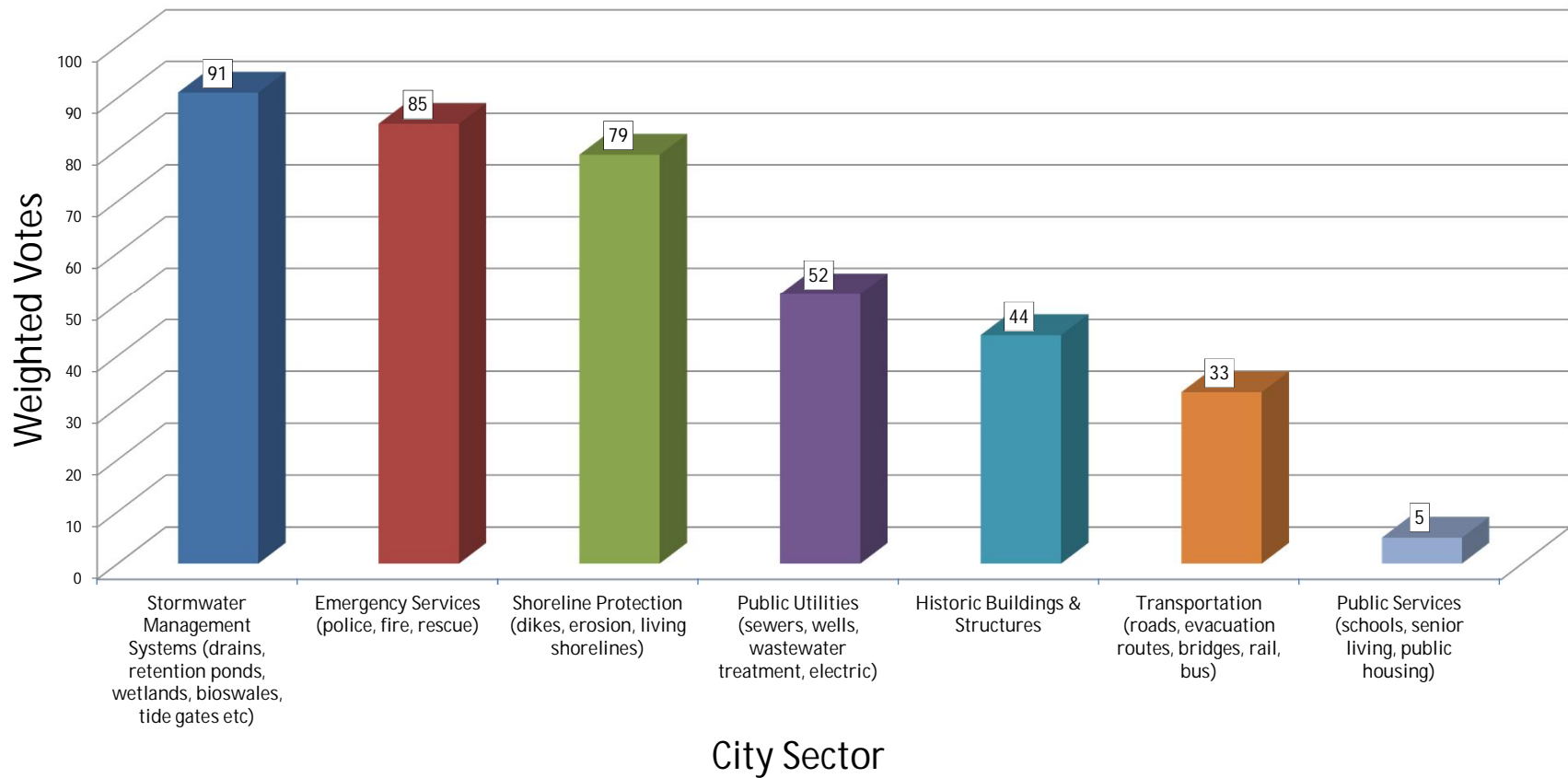
Appendix C

**Analyses of Surveys and
Sticky Dot Voting**

Sticky Dot Voting Results Public Workshop #1 for City of New Castle RCP Project

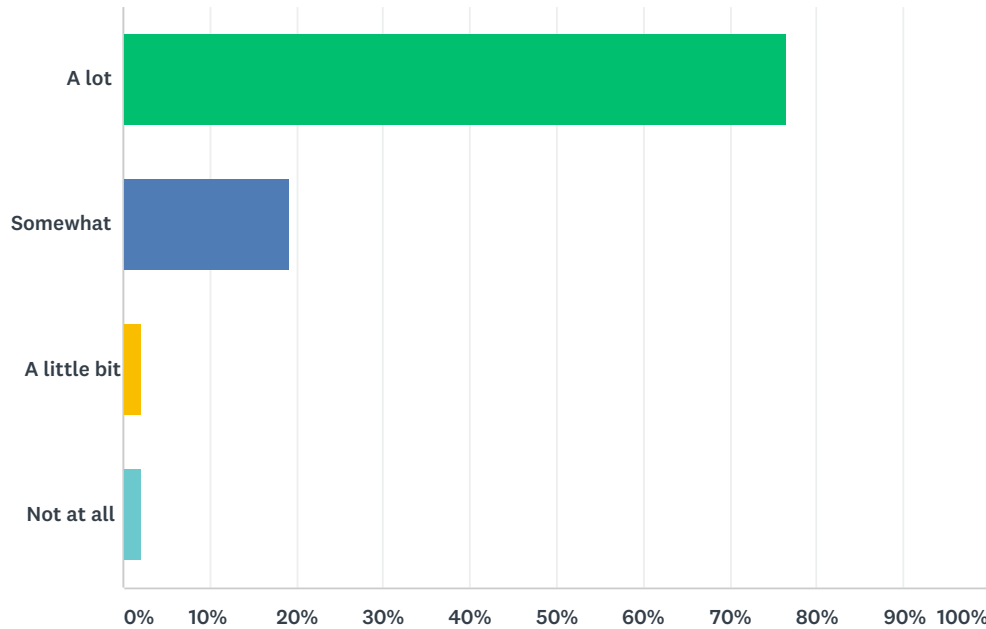
"Which Category of *public* services and infrastructure should receive priority attention by the City for resiliency planning?"

Red = Priority 1; Green = Priority 2; Yellow = Prio



Q6 How concerned are you about flooding in the City (within the City Limits of New Castle)?

Answered: 47 Skipped: 1



ANSWER CHOICES	RESPONSES	
A lot	76.60%	36
Somewhat	19.15%	9
A little bit	2.13%	1
Not at all	2.13%	1
TOTAL		47

#	COMMENTS	DATE
1	A Lot - Long term, Somewhat - Short term	9/11/2017 4:05 PM

Q7 What neighborhood or area of town (or streets/area directly around your home) do you live in?

Answered: 46 Skipped: 2

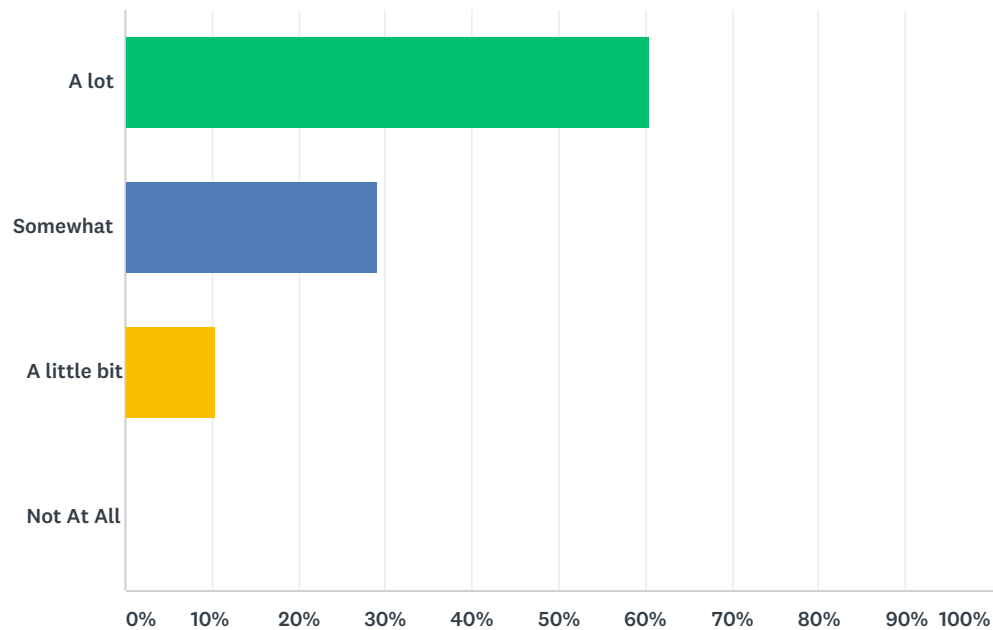
#	RESPONSES	DATE
1	South	9/12/2017 10:32 AM
2	South	9/12/2017 10:31 AM
3	East 6th Street	9/12/2017 10:30 AM
4	Delaware St.	9/12/2017 10:29 AM
5	Historic district	9/12/2017 10:28 AM
6	The Strand	9/12/2017 10:26 AM
7	West Fourth	9/12/2017 10:25 AM
8	Washington Park	9/12/2017 10:23 AM
9	42 W. 4th Street, New Castle DE 19720	9/12/2017 10:23 AM
10	E. 6th Street	9/12/2017 10:21 AM
11	Shawtown	9/12/2017 10:20 AM
12	Downtown	9/12/2017 10:20 AM
13	West 3rd (back to Battery Park)	9/12/2017 10:17 AM
14	The Strand between Harmony and Delaware Street	9/12/2017 10:13 AM
15	4th Street - Old New Castle	9/12/2017 10:11 AM
16	Historic area - The Strand	9/12/2017 10:08 AM
17	Washington Square	9/12/2017 10:06 AM
18	Historic	9/12/2017 10:05 AM
19	The Strand	9/12/2017 10:05 AM
20	Dalby Alley	9/12/2017 10:04 AM
21	Buttonwood Ave. (N.E. New Castle City)	9/12/2017 10:02 AM
22	The Strand	9/12/2017 10:00 AM
23	The Strand	9/12/2017 9:59 AM
24	East Third Street - Academy & Immanuel across the street	9/12/2017 9:59 AM
25	Old New Castle - Second St.	9/12/2017 9:57 AM
26	6th and Delaware	9/12/2017 9:56 AM
27	Center of town	9/12/2017 9:55 AM
28	Chestnut and Third	9/12/2017 9:54 AM
29	E. 4th Street	9/12/2017 9:51 AM
30	2nd & Harmony	9/11/2017 4:34 PM
31	West 4th Street	9/11/2017 4:34 PM
32	Downtown historic on Harmony Street	9/11/2017 4:33 PM
33	27 The Strand	9/11/2017 4:32 PM
34	The Strand	9/11/2017 4:29 PM

New Castle Resilient Community Partnership Workshop Comment Form

35	End of Dalby Alley - on Battery Park #1	9/11/2017 4:28 PM
36	South Street	9/11/2017 4:23 PM
37	Van Dyke Village	9/11/2017 4:22 PM
38	Downtown - W. 3rd	9/11/2017 4:21 PM
39	The Strand	9/11/2017 4:05 PM
40	The Green	9/11/2017 4:03 PM
41	New Castle Manor - Janvier Ave.	9/11/2017 3:58 PM
42	Historic district - The Strand	9/11/2017 3:45 PM
43	Rogers Manor (not in City limits)	9/11/2017 3:41 PM
44	n/a not a resident	9/11/2017 3:39 PM
45	The Strand	9/11/2017 3:38 PM
46	The Strand	9/11/2017 3:13 PM

Q8 How concerned are you about flooding specifically in your neighborhood or area of town (or streets/area directly around your home)?

Answered: 48 Skipped: 0

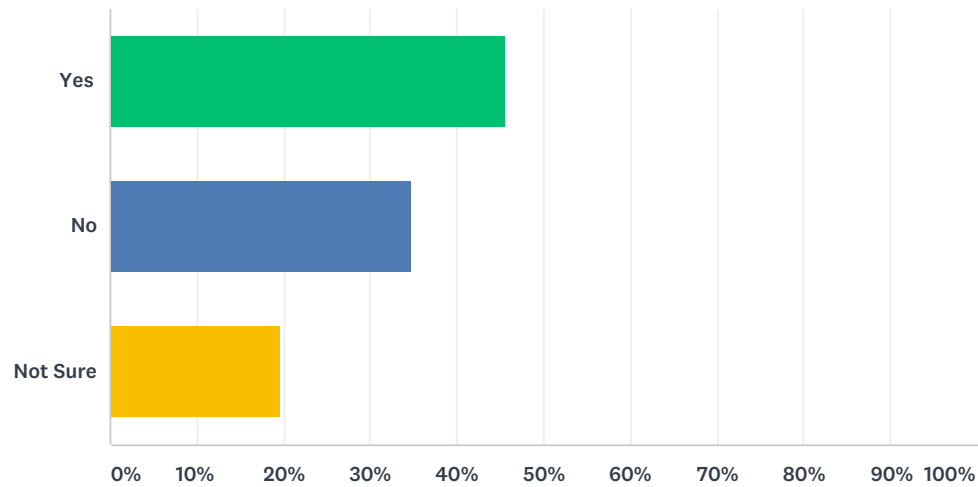


ANSWER CHOICES		RESPONSES	
A lot		60.42%	29
Somewhat		29.17%	14
A little bit		10.42%	5
Not At All		0.00%	0
TOTAL			48

#	COMMENTS	DATE
	There are no responses.	

Q9 Is your neighborhood or area of town already prone to recurring flooding? (check one)

Answered: 46 Skipped: 2



ANSWER CHOICES		RESPONSES	
Yes		45.65%	21
No		34.78%	16
Not Sure		19.57%	9
TOTAL			46

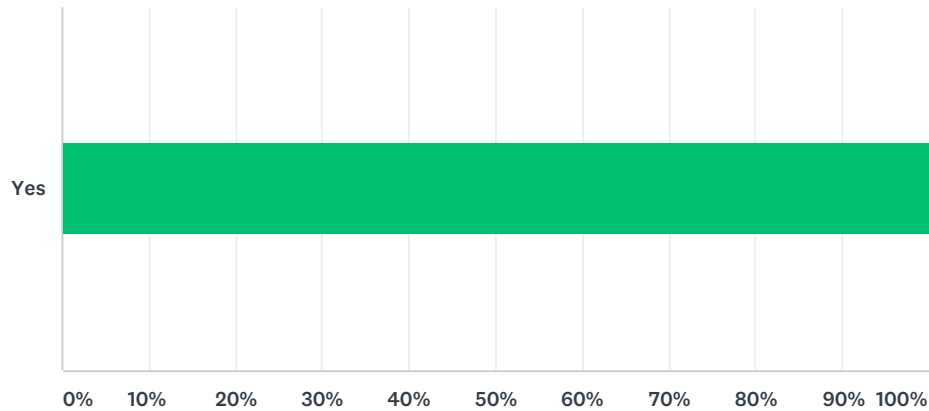
Q10 If yes or not sure, how often does flooding occur, how long does it last, and under what conditions?

Answered: 16 Skipped: 32

#	RESPONSES	DATE
1	a lot of rain, comes from corner of Rt. 9 & Ferry cut off	9/12/2017 10:30 AM
2	Sandy forced water near to my residence.	9/12/2017 10:26 AM
3	Not really flooding but water in the basement	9/12/2017 10:21 AM
4	We flooded badly in Sandy, losing utilities and all possessions in basement. Water within 1" of back door. No dike protection in our area.	9/12/2017 10:17 AM
5	basement took water during Sandy	9/12/2017 10:13 AM
6	My house (#15) is dry so far. Others on the street flood.	9/12/2017 10:08 AM
7	In our home, once since 2011 - during Hurricane Sandy	9/12/2017 10:05 AM
8	-Intense rain events - snow fall over 6" - Normally takes 2-3 hours until drainage system catches up.	9/12/2017 10:02 AM
9	Major storms Several Days	9/11/2017 4:29 PM
10	1981 - 17 inches on park. Several years ago 4-5" 40 inches	9/11/2017 4:28 PM
11	Street can handle heavy rain, moves to sewers but they don't handle volume of water.	9/11/2017 4:23 PM
12	The streets flood in heavy rain. Water comes up over the curbs onto the sidewalk against house. Goes away quickly when rain stops	9/11/2017 4:21 PM
13	~ 5 years	9/11/2017 4:05 PM
14	Basements "flood" regularly with any storms >1.5" - 2"	9/11/2017 3:58 PM
15	Yard floods every few years due to nor'easter or hurricane. Recedes as soon as tide goes down (low tide).	9/11/2017 3:45 PM
16	Storm surge; tidal flooding Avg. 1x/year	9/11/2017 3:13 PM

Q11 Damage to homes, buildings, or structures

Answered: 27 Skipped: 21

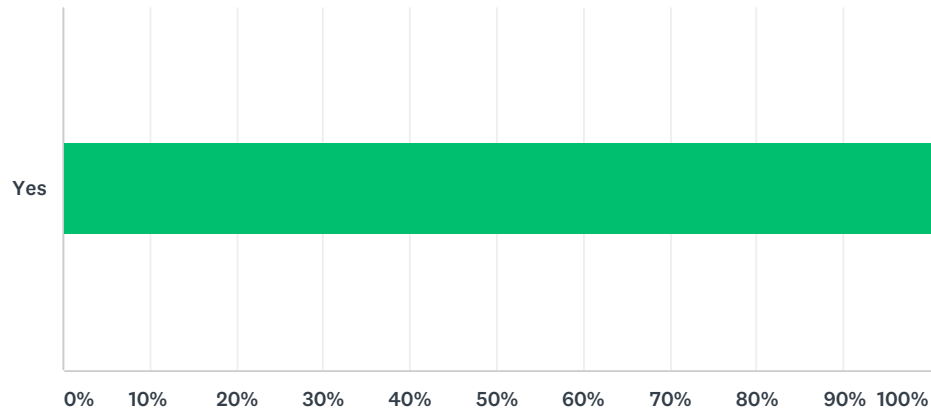


ANSWER CHOICES	RESPONSES
Yes	100.00% 27
Total Respondents: 27	

#	COMMENTS:	DATE
1	Basement flooding	9/12/2017 10:26 AM
2	flooding of basements - HVAC, furniture, etc.	9/12/2017 10:13 AM
3	Water in our basement - not substandard	9/12/2017 10:05 AM
4	Slight water in basement	9/12/2017 9:57 AM
5	so far, minimal yard damage	9/11/2017 3:45 PM

Q12 Riverbank/property erosion

Answered: 12 Skipped: 36

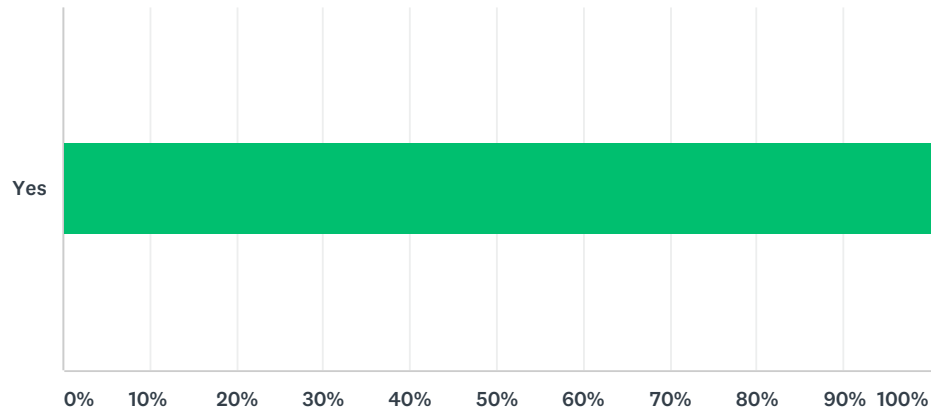


ANSWER CHOICES	RESPONSES
Yes	100.00%12
Total Respondents: 12	

#	COMMENTS:	DATE
1	potential for major loss of soil	9/12/2017 10:13 AM
2	we have been fortunate, however feel badly for others who experience flooding in N.C.	9/12/2017 9:59 AM

Q13 Loss of power

Answered: 23 Skipped: 25

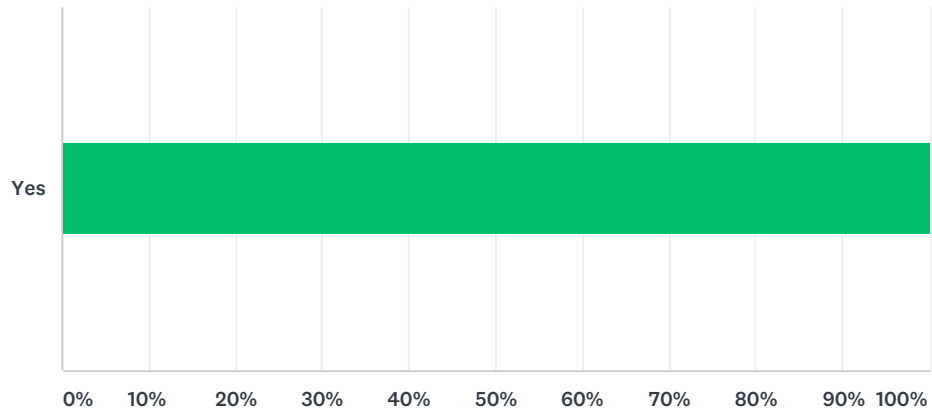


ANSWER CHOICES	RESPONSES
Yes	100.00% 23
Total Respondents: 23	

#	COMMENTS:	DATE
1	hurricane preparation, water, batteries, etc.	9/12/2017 10:26 AM
2	rarely, but sump pump is ESSENTIAL	9/11/2017 3:45 PM

Q14 Disruption or contamination of water supply

Answered: 11 Skipped: 37

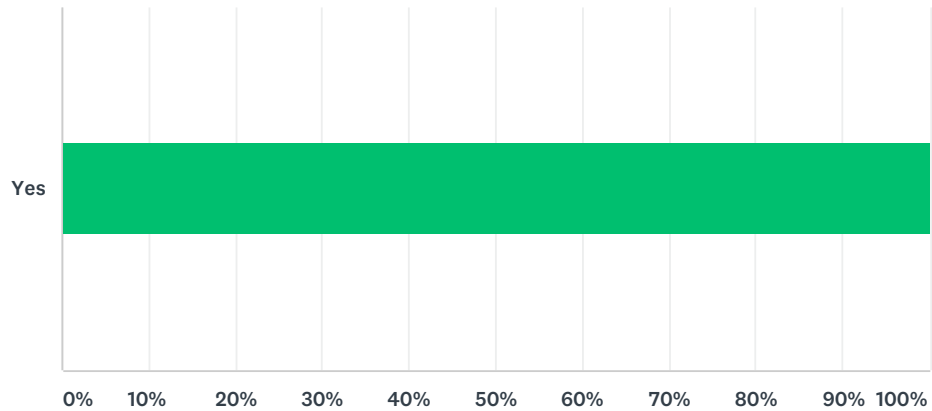


ANSWER CHOICES		RESPONSES
Yes		100.00%
Total Respondents: 11		11

#	COMMENTS:	DATE
	There are no responses.	

Q15 Damage to septic system

Answered: 3 Skipped: 45

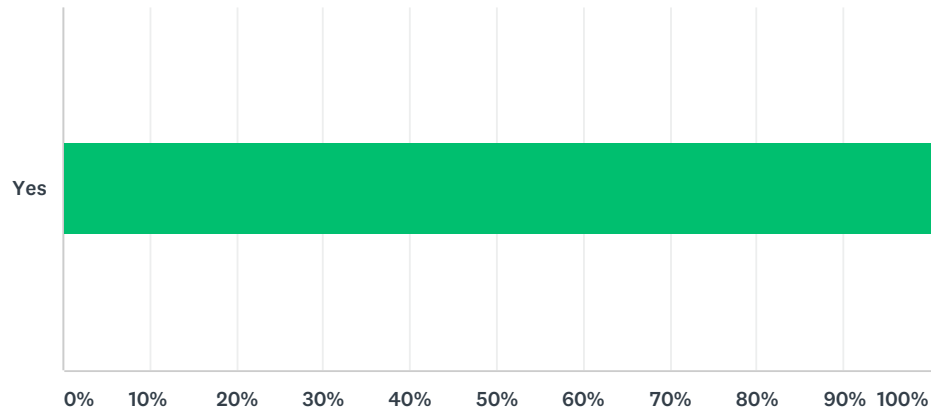


ANSWER CHOICES		RESPONSES	
Yes		100.00%	3
Total Respondents: 3			

#	COMMENTS:	DATE
	There are no responses.	

Q16 Lost wages/business

Answered: 5 Skipped: 43

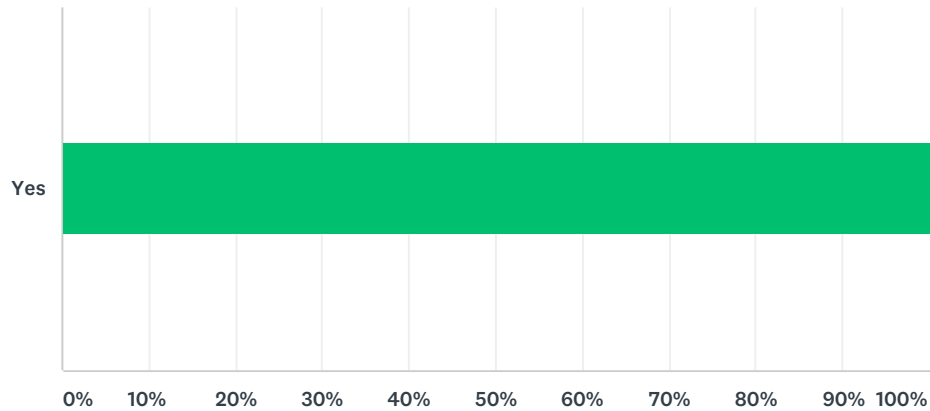


ANSWER CHOICES		RESPONSES
Yes		100.00%
Total Respondents: 5		5

#	COMMENTS:	DATE
1	Cleanup	9/12/2017 10:17 AM

Q17 Habitat damage

Answered: 16 Skipped: 32

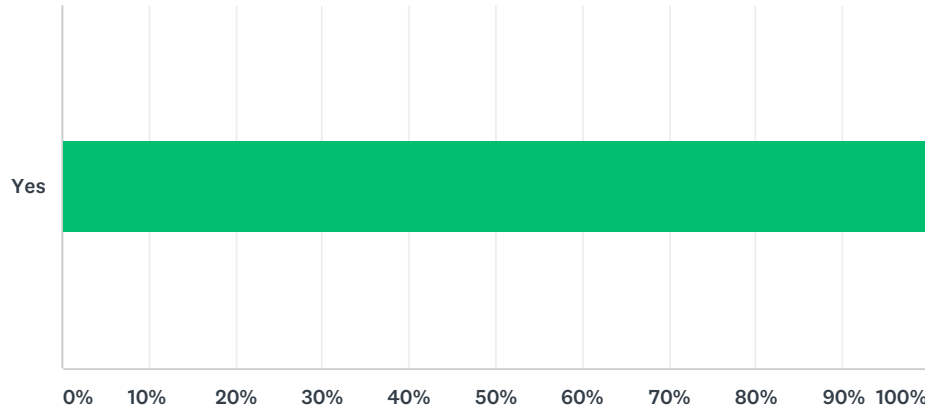


ANSWER CHOICES	RESPONSES
Yes	100.00%16
Total Respondents: 16	

#	COMMENTS:	DATE
1	soil toxic from river - flotsom destroyed yard	9/12/2017 10:17 AM
2	flooding of lawns and meadows destroys natural sites	9/12/2017 10:13 AM

Q18 Roads inaccessible

Answered: 28 Skipped: 20

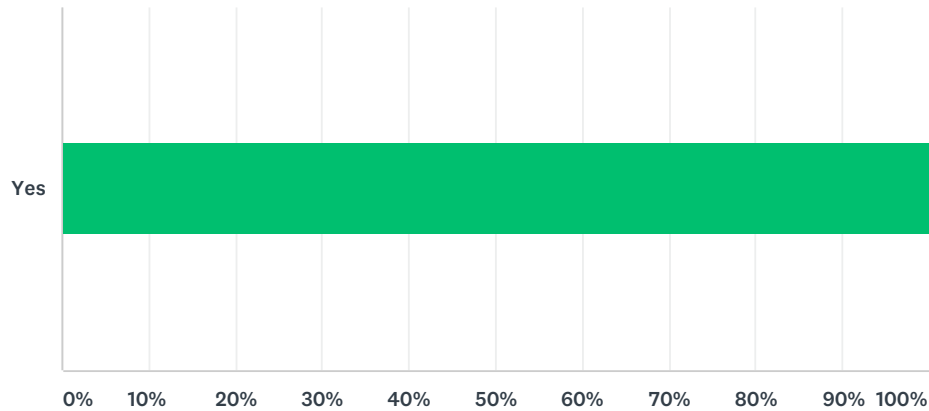


ANSWER CHOICES	RESPONSES
Yes	100.00% 28
Total Respondents: 28	

#	COMMENTS:	DATE
1	possible street flooding relocated for Sandy	9/12/2017 10:26 AM
2	3rd St. floods - wake hits historic homes	9/12/2017 10:17 AM
3	exits from town are low-lying	9/12/2017 10:13 AM
4	Rt. 9 south of town becomes unuseable	9/11/2017 3:45 PM

Q19 Other Impacts (please explain)

Answered: 8 Skipped: 40

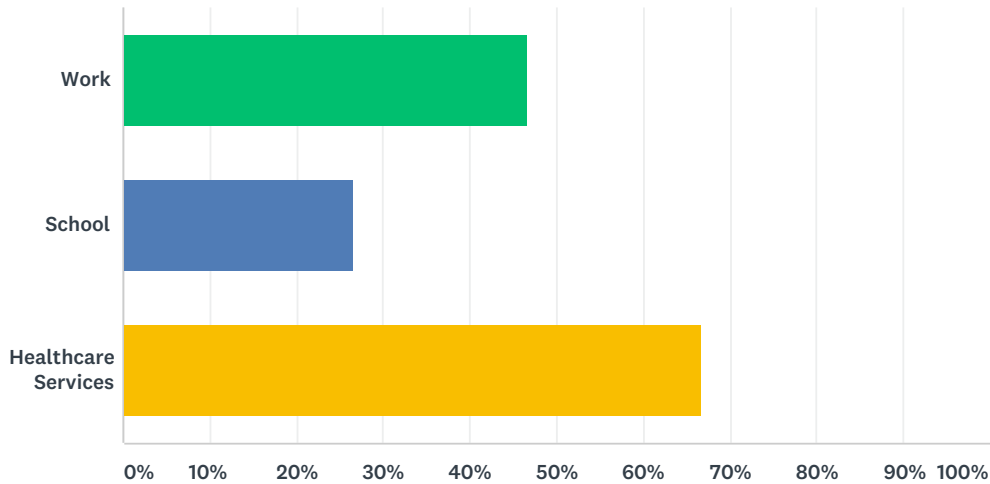


ANSWER CHOICES	RESPONSES
Yes	100.00% 8
Total Respondents: 8	

#	COMMENTS	DATE
1	could not take Rt. 9 to Wilmington	9/12/2017 10:30 AM
2	none have happened to us so far. We are not in the flood zone!	9/12/2017 10:28 AM
3	Toxins from water enter house	9/12/2017 10:17 AM
4	Value of home	9/12/2017 10:05 AM
5	Have not lived here during flooding	9/12/2017 10:04 AM
6	Water seepage into properties	9/12/2017 10:02 AM
7	Although our house site hasn't flooded we care greatly about everyone who calls New Castle home.	9/12/2017 9:59 AM
8	water in basement	9/12/2017 9:56 AM
9	access to supplies	9/11/2017 4:29 PM
10	not yet	9/11/2017 4:21 PM
11	Cost of flood insurance	9/11/2017 3:41 PM

Q20 If roads are inaccessible, do you have difficulty accessing:

Answered: 15 Skipped: 33

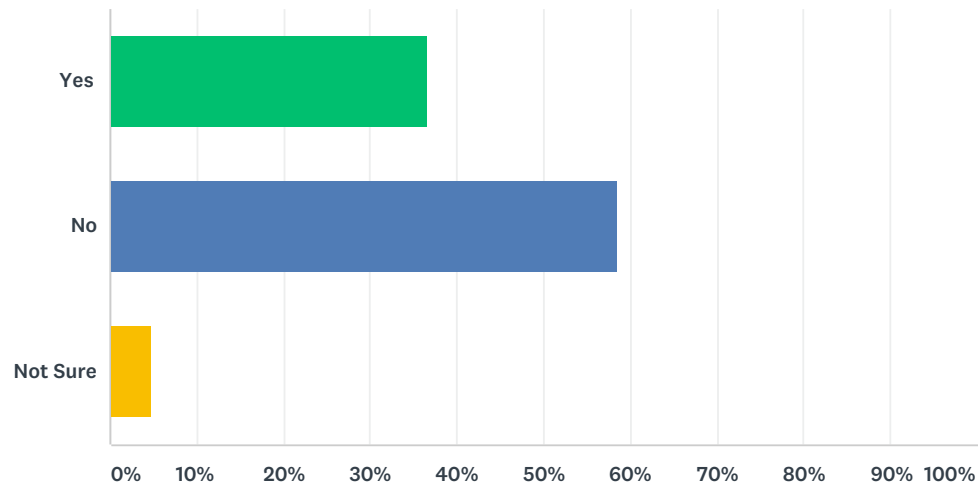


ANSWER CHOICES	RESPONSES
Work	46.67% 7
School	26.67% 4
Healthcare Services	66.67% 10
Total Respondents: 15	

#	COMMENTS	DATE
1	leaving	9/12/2017 10:26 AM
2	Dr. Appt Meds	9/12/2017 10:23 AM
3	If can't drive - can't get there	9/12/2017 9:52 AM
4	any needed emergency services	9/11/2017 4:34 PM
5	I am almost 84	9/11/2017 4:28 PM
6	7th & Washington, part of South can't handle heavy rain, drains back up with convey drains	9/11/2017 4:25 PM
7	I did & would	9/11/2017 3:58 PM
8	need to help take care of grandkids	9/11/2017 3:46 PM

Q21 Have you made changes to your own property to prepare for or respond to flooding?

Answered: 41 Skipped: 7

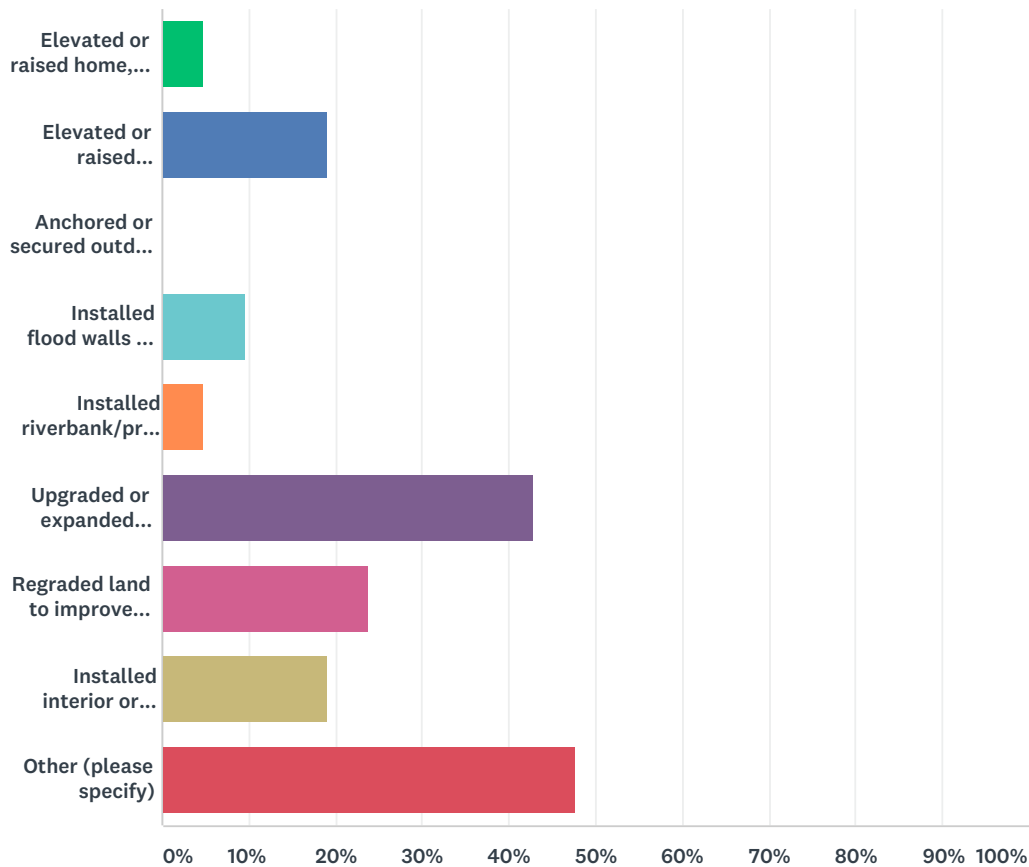


ANSWER CHOICES		RESPONSES	
Yes		36.59%	15
No		58.54%	24
Not Sure		4.88%	2
Total Respondents: 41			

#	COMMENTS	DATE
	There are no responses.	

Q22 If Yes or Not Sure, have you taken any of these measures at your own property to prepare for flooding?

Answered: 21 Skipped: 27



ANSWER CHOICES		RESPONSES	
Elevated or raised home, buildings, or structures		4.76%	1
Elevated or raised utilities (such as air conditioners)		19.05%	4
Anchored or secured outdoor propane tanks or other "loose" utilities		0.00%	0
Installed flood walls or gates around property or utilities		9.52%	2
Installed riverbank/property erosion controls (such as rip-rap, hardened shoreline, or vegetation)		4.76%	1
Upgraded or expanded drainage systems (gutters/french drain system)		42.86%	9
Regraded land to improve drainage or runoff		23.81%	5
Installed interior or exterior backflow valve		19.05%	4
Other (please specify)		47.62%	10
Total Respondents: 21			

#	OTHER (PLEASE SPECIFY)	DATE
1	sealed basement windows, stored sandbags on property	9/12/2017 10:28 AM

New Castle Resilient Community Partnership Workshop Comment Form

2	Swale, battery back up for sump pump	9/12/2017 10:21 AM
3	removed basement window, but duplex, and neighbors still have theirs	9/12/2017 10:19 AM
4	concrete floor in basement	9/12/2017 9:56 AM
5	have flood insurance	9/12/2017 9:53 AM
6	Have flood insurance	9/11/2017 4:35 PM
7	sump pump and french drain	9/11/2017 4:21 PM
8	Window sealing at basement level	9/11/2017 4:05 PM
9	extended rain gutters to reach outflow 10 feet from house	9/11/2017 3:59 PM
10	Installed back-up sump pump that works on water pressure rather than electric.	9/11/2017 3:23 PM

Q23 Please leave any additional comments or concerns that you have for the City of New Castle Resilient Community Partnership team about flooding, or coastal and climate hazards in general:

Answered: 18 Skipped: 30

#	RESPONSES	DATE
1	I am just generally concerned about floods in the future	9/12/2017 10:30 AM
2	The berm along the east side of the Strand (built by property owners) needs to be extended from the Battery to Bull Hill to protect the city and historic nature of the city. Regardless of ownership considerations!	9/12/2017 10:28 AM
3	If water level occurs and rises, will the city take steps to divert the water such as bulkheads?	9/12/2017 10:24 AM
4	Cost of the annual increase to FEMA Flood ins. min 11% annually.	9/12/2017 10:22 AM
5	Commercial district & Battery Park not protected by dikes. Have been suggesting for many years to raise river walk to tie into existing bluff and also act as a dike. Other cities use this very effectively. Thank you for your help, Deb Shane/Bryan Shelton 302-325-4484	9/12/2017 10:19 AM
6	Flood protection is important but also needs to consider mandatory historic character of Old New Castle; in particular 1 access to riverfront. Consider building levee offshore, so that current homeowners do not lose property. This may actually be less expensive, s.... access from the river may be easier than trucking in equipment and earth.	9/12/2017 10:15 AM
7	We need a levee on the Strand. (yes I know it blocks my views). Do not assume that building a levee situated 10-20' off shore is more expensive than building it on what is currently dry ground. A levee is not always a pile of dirt. There are other types of structures/walls that work. I think only 2 houses (#13 & #15) own riparian rights to the riverbed. The other owners cannot stop progress since such a levee will not be on their land. (I will type up something more legible when I am not writing on my lap!)	9/12/2017 10:10 AM
8	Had hoped to see mapping of streams. (River -> marsh -> streams) High water table in our City. Good explanation of maps. Thanks!	9/12/2017 10:07 AM
9	-Drainage systems need improvement - Regular sewer maintenance programs -Stop over developing and cutting down trees in the process - Encourage residents to know their flow (sewer drain habits and observations)	9/12/2017 10:03 AM
10	more drainage is needed on Harmony St. - Fourth St. courses around the corner and down Harmony St. also - joining the downhill flow.	9/12/2017 9:55 AM
11	concerns because of changing weather patterns.	9/12/2017 9:54 AM
12	Please suggest to our council and council president that they think twice before paving any more of our green space. And before allowing more housing and roads in the St. Rt. 9 area.	9/12/2017 9:53 AM
13	Assisting residents to evacuate hazard areas - too much traffic on preferred roads out of town.	9/11/2017 4:35 PM
14	Great concern regarding passage of resolution #510, paving over ground is unwise	9/11/2017 4:30 PM
15	More concerned about historic area - it must be protected. :)	9/11/2017 3:59 PM
16	- Drainage is becoming an issue. Recently storm drains on Delaware St. (between 5th and 7th) were overflowing after a very strong downpour. - Any new dike changes must include better mechanisms for water to escape when the storm subsides.	9/11/2017 3:47 PM
17	While I do not live in the city, I am in the 19720 zip code. At some point while we had a mortgage, our lean holder forced us to buy flood insurance, not sure how many years we paid this ins., but it was expensive. Then at some point we were not in flood zone and stopped paying the flood ins. Now my neighbor is trying to sell her home and she has a small portion of her house in the flood plain and no one wants to buy the house with the flood insurance attached - FRUSTRATING!	9/11/2017 3:43 PM

New Castle Resilient Community Partnership Workshop Comment Form

18	We already have water in our basement when we have moderate to heavy rain. We have been told that the main sewer drain pipe on W. 4th St. sags and it occasionally causes backups in our house. If there was heavy flooding from the river in a major storm this could be a significant problem. Repair of our aging sewer lines needs to be part of this planning.	9/11/2017 3:23 PM
----	---	-------------------

This report was prepared by AECOM using Federal funds under awards NA16NOS4190168 from the Delaware Coastal Programs and the Office for Coastal Management (OCM), National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the OCM NOAA or the U.S. Department of Commerce.

