AECOM

Town of Fenwick Island
Resiliency Plan
Revised Draft

March 14, 2023

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Acronym List

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.

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.

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.

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.

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.

SLRAC: Sea Level Rise Advisory Committee – Group convened by the DNREC Secretary consisting of various stakeholders including state agencies, business owners, local governments, citizen organizations, etc. to investigate the State of Delawares vulnerability to sea level rise and provide recommendations on how to best prepare for rising water levels.

SLR: Sea Level Rise – Increase in the level of the world's oceans because of global warming primarily caused by melting ice sheets and thermal expansion.

USACE: United States Army Corps of Engineers – mission statement reads: deliver vital engineering solutions, in collaboration with our partners, to secure our Nation, energize our economy, and reduce disaster risk.

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Executive Summary

The Town of Fenwick Island is particularly at risk to sea level rise (SLR) due to its geographical location of being bound by the Little Assawoman Bay to the west and the Atlantic Ocean to the east. Fenwick Island's proximity to both bodies of water make it highly susceptible to daily tidal inundation and tidal surges during inclement weather and storm events. Future SLR projections depict nearly 82% of existing buildings located to the west of Route 1 as being inundated twice daily and 43% of all roadways becoming inundated during high tide by the year 2080. The Town's low-lying topography, bayside canals, and need for stormwater infrastructure improvements further exacerbate the effects of SLR on the community. Without proper planning and an acknowledgement of SLR the community will struggle to adapt to these future challenges.

The Town in partnership with the Department of Natural Resources and Environmental Protection (DNREC) sought to develop a resiliency plan to mitigate against the potentially devastating effects of SLR on Fenwick Island and enhance the community's overall resiliency. The process looked to prioritize at risk areas of the Town, recommend action items that the Town can implement, engage residents and businesses, provide updated mapping and information to serve as the basis for well informed decisions, and articulate the Town's vision for adapting to SLR. This SLR Resiliency Plan is the result of these efforts.

Challenges in Quantifying Sea Level Rise

Quantifying SLR is exceptionally difficult due to the reliance by experts on historical data, current trends, and the everchanging climate that is affecting our environment. Professionals typically develop SLR scenarios at three levels: low, intermediate, and high. The unpredictable nature of SLR scenarios provides a substantial challenge to communities in being able to identify the potential impacts and when those impacts begin to have a negative effect. Proactive resiliency planning is the best way that any community can prepare for the impacts of SLR while using up-to-date models to make those informed decisions.

Project Background

The Town's Infrastructure Committee began discussing the need for an updated resiliency plan in Fall 2021, an update to their 2015 *Sea Level Rise Vulnerability Study*. AECOM was selected in Fall/Winter 2021 to assist the Town in completing a resiliency plan as well as produce updated SLR maps. The project team attended the Infrastructure Committee meeting in February of 2022 to discuss the initial SLR findings and mapping that had been completed. Engagement by members of the public and the committee led to next steps being outlined and a draft document beginning started. In October of 2022 the project team attended the Infrastructure Committee meeting to formerly present the completed SLR inundation maps and provide a status update of the working draft document. Discussions with the committee and members of the public during the October meeting permitted the team to move forward with developing adaptation and mitigation strategies.

Document Review

Eight individual documents were reviewed during the preparation of this SLR Resiliency Plan. The documents that were reviewed through this process include but are not limited to the *Town of Fenwick Islands Comprehensive Plan*, the *Sussex County All Hazard Mitigation Plan 2016 Update*, the *Recommendation of Sea-level Rise Planning Scenarios for Delaware: Technical Report 2017*, and the *SR1 Coastal Corridor Study*. Several of the documents are specific to Fenwick Island while others were produced as part of a coordinated effort by state, county, and local agencies. Common themes that emerge from each of these documents are the vital role that regulatory changes have in creating resiliency, the importance and benefits of public engagement and outreach, and the need for proactive planning.

Sea Level Rise Planning

SLR planning requires sufficient organization as conditions are consistently being updated. The SLR planning process consists of six separate areas that serve as the foundation for the following step. The six steps in the SLR planning process are as follows: 1. Identify appropriate SLR projections, 2. Identify potential impacts, 3. Risk assessment, 4. Development of adaptation measures, 5. Implementation, 6. Monitoring and revision.

Vulnerability Mapping

The project team performed an analysis of future SLR flood conditions to better understand where Fenwick Island would be most vulnerable by the effects of flooding and tidal inundation caused by SLR. A total of six scenarios at 10-year intervals were mapped by utilizing present-day tidal datum mean higher high water (MHHW) with projections of SLR to estimate what areas would be inundated by future MHHW conditions.

The SLR values for each of the six future scenarios were interpolated from the intermediate curve of the State of Delaware's 2017 SLR projection. Each map using the intermediate model and approach illustrates the extent of inundation and highlights buildings and roads affected by that inundation. It is important to note these maps reflect daily high tides that occur twice a day and do not consider storm surge. No impacts are seen on streets from 2030-2040, however the SLR map for 2050 depicts roadways becoming increasingly inundated.

Identification and Prioritization of Vulnerabilities

Assessment of various resources in Fenwick Island to identify and prioritize vulnerabilities was done by reviewing the prepared SLR inundation maps for the years 2030-2080 and examining three characteristics related to SLR. The three characteristics examined were SLR exposure, SLR sensitivity, and adaptive capacity to SLR. By taking into consideration these three characteristics vulnerable natural resources, populations, critical infrastructure and facilities, community assets, and evacuation routes were identified. Prioritization of vulnerable areas in Fenwick Island offers the Town the opportunity to address the most urgent concerns related to SLR.

Current Mitigation Measures

Efforts to address SLR are actively underway or have previously taken place in Fenwick Island. These actions and activities are important and show the commitment by the Town to protect their community from SLR inundation. Some of the important actions taken include participation in beach replenishment in coordination with the United States Army Corps of Engineers (USACE) and the development of a Stormwater Infrastructure Study in 2013 that assists in making improvements to stormwater infrastructure and reduces nuisance flooding.

Recommended Actions or Activities

Effective resiliency measures to alleviate the potential devastating impacts of SLR have been identified within this Plan. The Town will need to take immediate action in addition to plan for long-term projects to increase overall resiliency. Seventeen recommended actions and activities were recognized as being beneficial to the Town of Fenwick Island to implement. Recommended actions and activities were split into three categories the first being actions items to be started by 2030, future actions that require further engineering, design, and planning to begin by 2040, and long-term considerations (2070-2080).

1 INTRODUCTION

Sea level rise (SLR) is a pervasive threat on a global scale. Although climate change and SLR is often thought to be a recent occurrence, records indicate that since the late 1800's sea levels have continuously risen due to the burning of coal and other fossil fuels by humankind. For nearly 150 years the Center for Operational Oceanographic Products and Services has been measuring SLR by utilizing tide stations along all U.S. coasts. Tide stations can effectively account for sea levels rising by measuring the height of water referencing a set point on land where the elevation is known. Today, the global sea level is 5 to 8 inches higher on average than it was in the year 1900.

The first of two primary factors leading to rising sea levels is thermal expansion. Thermal expansion is the changing of space between particles of a substance. Due to the accumulation of heat absorbing greenhouse gases such as Carbon Dioxide within the Earth's atmosphere, 90% of this trapped heat is retained by our oceans and causes the warmer water to expand. The second of the two identified primary factors are the melting of large land-based formations such as glaciers and ice sheets. As these large frozen hydrological formations begin to melt due to warming atmospheric and water temperatures the resulting liquid flows into the Earth's oceans. However, there is a certain level of unpredictability with understanding the full effects of SLR, specifically, as it relates to the melting of ice caps and glaciers. Scientists and climatologists have wide ranging views on how these large formations will behave as temperatures become warmer over time. Currently, the Arctic is warming at a faster rate than the Antarctic is as the ice there is thinning at a faster rate. In addition to these changes to the worlds ocean's, certain geographical locations are faced with land subsidence. Land subsidence is the gradual settling or sinking of the Earth's surface due to the removal or displacement of subsurface materials. Principal causes of land subsidence include drainage of organic soils, natural compaction or collapse, underground mining, etc. Land subsidence can and will exacerbate the impacts of rising sea levels leading to further flooding and inundation. It is clear from the evolving science and research that SLR is a present and future threat to society that is projected to continue to increase. Although it is difficult to give a precise answer as to the exact amount of rise any one community will see, significant advances in technology and further modeling resources will be able to help vulnerable populations better prepare. It is important that communities at risk of SLR and flooding take a proactive approach to planning for a resilient future by laying out clear mitigation efforts to combat this threat.

Delaware is increasingly at risk due to SLR. The State has seen a greater rate of sea level change compared to that of the global rate. Although the entire State of Delaware is comprised of 381 miles of shoreline the topic of SLR is of greatest importance to Sussex County. Sussex County's shoreline runs along the Atlantic Ocean leaving it increasingly susceptible to rising waters and tidal flooding. The beautiful Atlantic beaches have drawn the attention of many people leading to increasing populations and development along the coast, a result of people moving to the area full time or as a vacation destination. Many of these communities are located within low lying areas and are prone to frequent flood inundation events. An increase in sea level is guaranteed to have a detrimental impact on these growing communities leading to substantial physical and monetary damages. Unless these issues are addressed by the introduction of shoreline protections and the elevation of at-risk areas these problems will continue to be incurred. Wholistic approaches are needed to address the growing reality of SLR to protect critical infrastructure, natural resources, and most importantly human life. Current practices have been limited to stormwater improvements and beach replenishment/restoration projects. Greater measures will need to be taken to effectively prepare for the long-term impacts that coastal communities throughout Delaware are faced with, including Fenwick Island.

Fenwick Island is left exposed to the detrimental effects of SLR from the east (Atlantic Ocean) and to the west (Little Assawoman Bay). Future impacts to the Town will be extensive including damage caused by heavy flooding events and storm surges to both residential and commercial properties. Long range planning efforts are not only warranted but needed to enable a more resilient Fenwick Island. Even though the totality of the effects of SLR on Fenwick Island cannot be predicted, the Town is hastened to act as it runs an extensive risk of encountering severe flooding impacts due to present and future sea level conditions.

2 CHALLENGES IN QUANTIFYING AND ADDRESSING THE IMPACTS OF SEA LEVEL RISE

There are many challenges in quantifying SLR and ultimately determining the extent of potential impacts. The primary challenge is the uncertainty in SLR models. Predictions are based on historical data and modeling of potential future climate impacts. These impacts are based on projections of greenhouse gas emissions as well as the impacts of those gasses on glaciers and ocean temperatures. Due to the uncertainty, the projections will often include low, intermediate, and high scenarios. The range in potential SLR leads to wide-ranging impacts making planning for the future more difficult. Another issue is lack of regulatory and design guidance. Without a framework in place, planning will become disorganized.

Another factor is the expense associated with addressing SLR impacts. There is no one solution that will combat the impacts of SLR, it will take a multi-strategy approach which equals money. Lastly, while it is certain that sea levels will continue to rise, the extreme impacts will not occur tomorrow. The good news is that there is time to plan. This means everyday operations must continue while simultaneously preparing for a future that considers potential SLR impacts. Proactive resiliency planning is the best strategy to be prepared for the future.

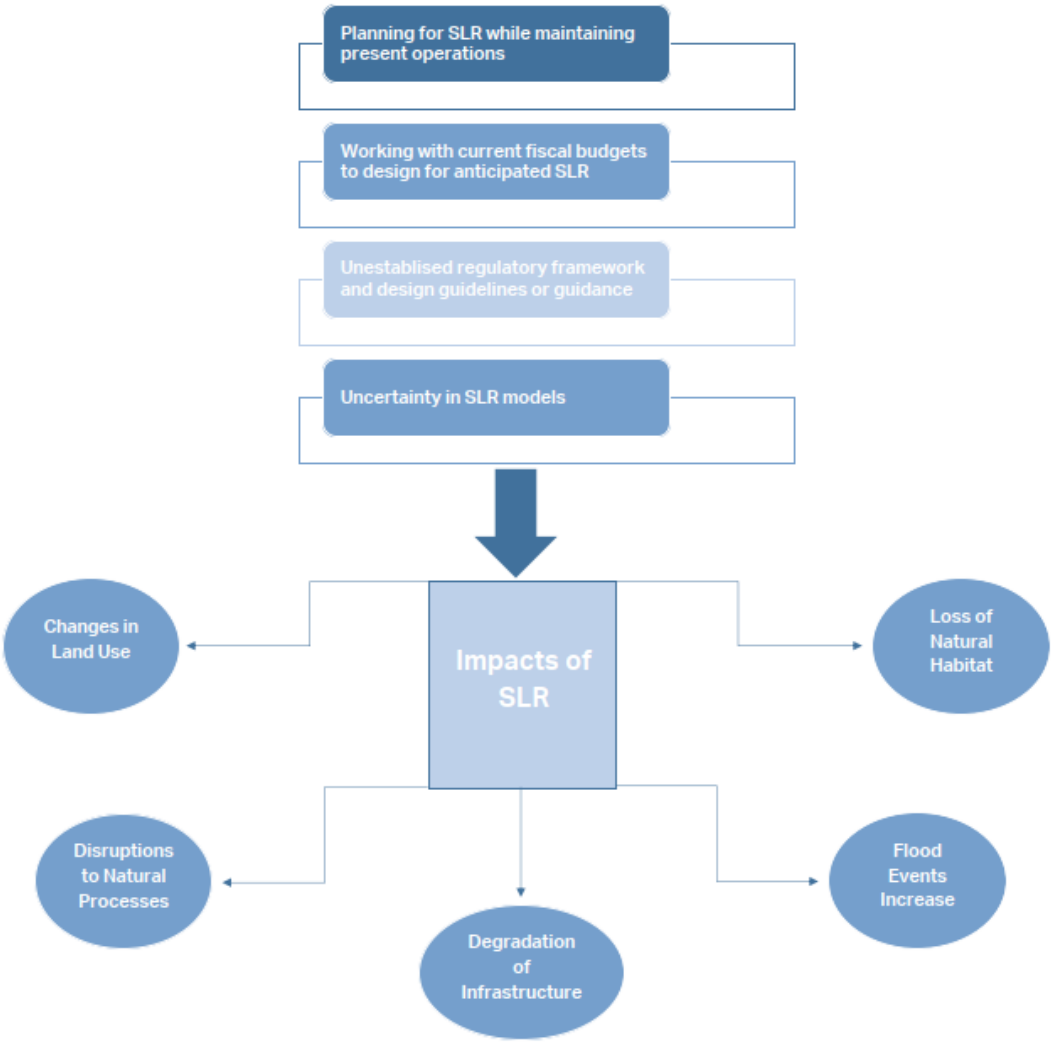


Figure 1 shows the challenges that could lead to numerous SLR impacts.

3 PROJECT BACKGROUND

In the Fall 2021, Fenwick Island's Infrastructure Committee began discussing the need for a resiliency plan and updated GIS mapping. The Town's most up-to-date resiliency plan and mapping was completed in 2015 and titled *Town of Fenwick Island Sea Level Rise Vulnerability Study*. Since that time, SLR science has continued to evolve and SLR projections have been updated to reflect the most current data and trends. To best prepare for the future, the Town recognized the importance of having the most current data and information in moving forward with resiliency planning.

AECOM was selected in Fall/Winter 2021 to assist the Town in completing a resiliency plan as well as produce updated SLR maps. Having completed the Town's previous *Sea Level Rise Vulnerability Study*, AECOM, formerly URS, was familiar with the SLR data as well as the potential impacts the Town faces due to climate change and SLR. For this Plan, the project team started with a review of existing planning and analysis efforts as outlined in Section 4 of this Plan. A series of SLR maps were drafted and used for analyzing the evolution of inundation and identifying priority areas as further discussed in Section 6. The information gathered through research and mapping analysis influenced the recommended actions and activities as detailed in Section 9.

The initial findings and draft SLR maps were presented to the Town of Fenwick Island Infrastructure Committee at their February 8, 2022, meeting. Two major issues were identified by the project team, the first being present-day high tide and secondly the future SLR projections. The maps projected by the year 2050 that the Town would begin to see significant impacts daily to bayside properties because of twice daily tidal inundation. The methodology of how the SLR maps were created was explained by the project team. The methodology and data analysis are further explained in Section 6 of this Plan. Committee members and residents expressed their concerns with the projections and were given the opportunity to ask questions in response to the newly developed maps. The project team and Infrastructure Committee concluded that the prioritization of specific areas in Town could begin to move forward.

AECOM's project team appeared before the Town of Fenwick Island Infrastructure Committee for a second time on October 11, 2022, to discuss the status of the draft resiliency plan. The scope of the town wide resiliency plan was outlined for the committee and members of the public in attendance. Individuals present both in person and virtually were given the opportunity to review prepared SLR inundation maps ranging from the years 2030-2080. The prepared inundation mapping depicted future scenarios that Fenwick Island would be faced with given the impacts of SLR and daily tidal flooding. Participants were able to provide input on the maps and express their concerns to the project team with regards to the present and future implications of coastal flooding.

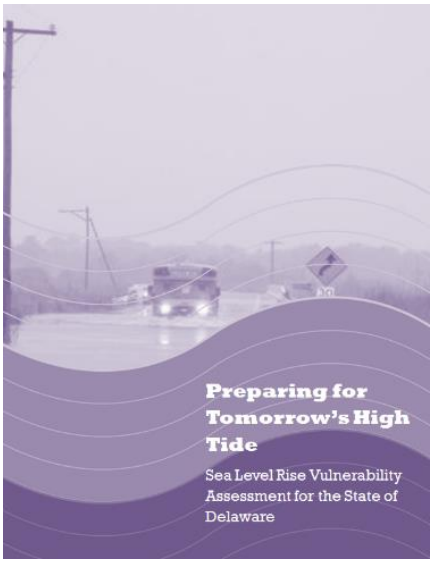
This meeting with the Infrastructure Committee provided the transition from discussing the issue of SLR and its future impacts to exploring possible mitigation measures. Bulkheads became the primary topic of discussion as citizens currently residing west of Route 1 and along the Little Assawoman Bay have deployed this methodology of shoreline hardening to decrease the impacts of tidal flooding. Unfortunately, due to rising sea levels and the frequency of large storm events increasing over the years, residents expressed that the existing bulkheads were being rendered ineffective. The cost of replacing or requiring bulkheads located on private property to be raised to a certain height led to various concerns. The meeting with the Infrastructure Committee allowed for the exchange of ideas and laid out next steps for the project. The project team provided the SLR Inundation maps to the Town of Fenwick Island along with PDF copies and a narrative describing them so they could be examined by the community.

4 DOCUMENT REVIEW

The following published documents were utilized by the AECOM project team to assist in the development of the Fenwick Island SLR Resiliency Plan.

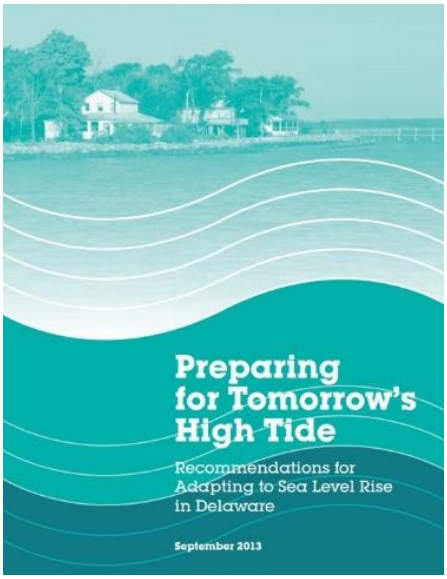
4.1 Preparing for Tomorrow's High Tide: Sea Level Rise Vulnerability Assessment, 2012

Delawares Sea Level Rise Advisory Committee (SLRAC) was established upon invitation by the former Secretary of the Department of Natural Resources and Environmental Control (DNREC), Collin O'Mara, to assist the State in planning for SLR. The *Sea Level Rise and Vulnerability Assessment for the State of Delaware* was completed in 2012. A second phase of this study, an adaptation planning phase, was completed in 2013 and is discussed in Section 4.2 below. Impacts of SLR throughout each of Delawares three counties were assessed to evaluate 79 statewide resources including but not limited to tourism, railways, and wetlands. Three working groups were comprised to carefully examine the impacts to Natural Resources, Society and the Economy, and Public Safety and Infrastructure. A Resource Risk Assessment was utilized to rank each of the identified resources as being of high concern, moderate concern, low concern, little concern, and no exposure. By investigating direct impacts to distinct resources, state agencies, local governments, and citizens can take proper steps to ensure the sustainability of their communities. Statewide methodologies concluded that between 8% and 11% of the State of Delaware's land could become inundated by just 0.5 meters to 1.5 meters of SLR including wetlands. This collaborative undertaking by DNREC and the SLRAC was the first of its kind in identifying the substantial risks associated with SLR inundation for the State of Delaware. The findings from this early report have and will continue to provide guidance for communities adopting and implementing adaptation strategies as they encounter the difficulties of SLR.



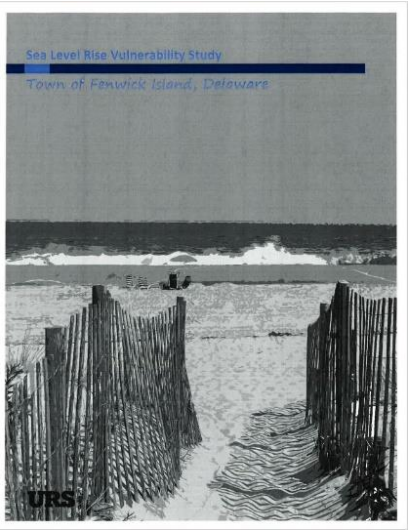
4.2 Preparing for Tomorrow's High Tide: Recommendations for Adapting to Sea Level Rise, 2013

The *Recommendations for Adapting to Sea Level Rise* was the second component of the SLRAC work. After concluding with the vulnerability assessment in 2012 the committee began working on developing recommendations based off their findings to address the challenges the State of Delaware faces with impending SLR. From their work, the SLRAC composed a list of 55 recommendations for adapting to SLR within the State. This report describes the recommendations fully and are aimed at building the adaptive capacity for communities. Proactive planning measures that are listed in this document lay out the roadmap in which local jurisdictions can follow to enhance their overall adaptive capacity in confronting SLR. Provided recommendations are applicable to State and local governments in addition to decisions that can be taken by personal property owners and businesses to become resilient. The report further serves as a caution that those entities that consciously choose not to act could be faced with substantially greater losses to infrastructure, habitat, and property resulting in unplanned retreat as a last resort.



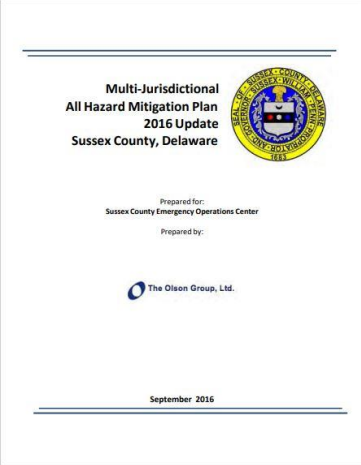
4.3 Town of Fenwick Island Sea Level Rise Vulnerability Study, 2015

In 2015 the Town completed a *Sea Level Rise Vulnerability Study* with the professional assistance of URS (now AECOM) in response to the impacts from Hurricane Sandy. The Town received funding through DNREC's Coastal Management Assistance grant program to complete the study. The goal of the study was to better understand potential impacts to the Town's streets and structures through an assessment of inundation maps, develop mitigation strategies to protect the built environments and Town residents, and complete public outreach to inform residents of the current and future vulnerabilities due to SLR. The maps demonstrated potential inundation resulting from 0.5-meter, 1 meter, and 1.5 meter of SLR above current high tide, providing a low, intermediate, and high scenarios. In the low scenario (slowest rate) most of the bayside is inundated and stops before encroaching on Route 1. In the high scenario (maximum inundation) all of Route 1 is inundated with no access to properties east of Route 1. Mitigation strategies ranged from enforcing the Flood Damage Reduction ordinance to raising streets and bulkheads.



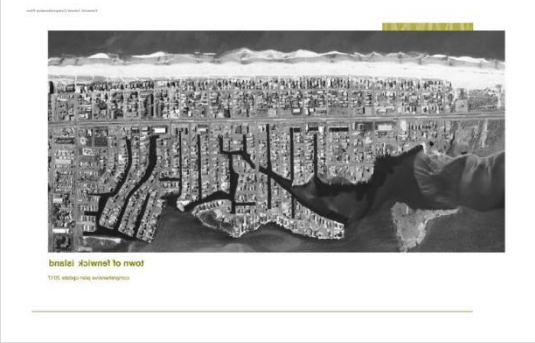
4.4 Multi-Jurisdictional All Hazard Mitigation Plan 2016 Update, Sussex County Emergency Operations Center, 2016

The *Hazard Mitigation Plan*, "identifies hazard mitigation goals, objectives and recommended actions and initiatives for County and municipal governments to reduce injury and damage from natural hazards." One of the potential hazards listed is coastal flooding which was ranked #1, making it the highest priority hazard of those that were identified. Coastal flooding is defined in the document as, "typically a result of storm surge, wind-driven waves, and heavy rainfall produced by hurricanes, tropical storms, nor'easters, and other large coastal storms." The Town of Fenwick Island was one of the 24 municipalities that participated in the plan update. Based on the risk and vulnerability assessment, Fenwick's primary losses would potentially come from flooding. Fenwick's estimated annualized losses from flooding are $2,258,541. The assessment also notes the Town has five state-owned critical facilities that could be vulnerable to flooding. The *Hazard Mitigation Plan* also includes a capability assessment which determines the ability of a municipality to identify opportunities to establish mitigation policies and/or implement a mitigation strategy. Fenwick Island was identified as having several programs in place at the time the plan was drafted, including a hazard mitigation plan, stormwater management plan, and flood damage prevention ordinance.



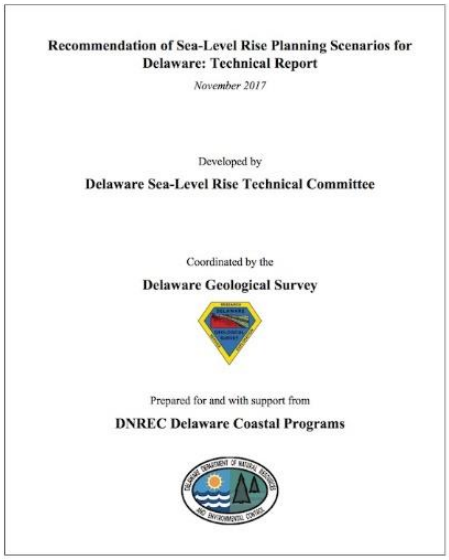
4.5 Town of Fenwick Island Comprehensive Plan, 2017

The Town's 2017 Comprehensive Plan addresses the importance of climate change and SLR in the Community Character – Natural Environment section. The plan discusses the impacts the Town has witnessed, and potentially faces, due to the increasing frequency of severe weather events including hurricanes and nor'easters. The plan does not include implementation items specific to addressing climate change and SLR. Delaware Office of State Planning Coordination updated their comprehensive plan guidelines in 2015 and strongly recommend municipalities include a section on climate change.



4.6 Recommendation of Sea-Level Rise Planning Scenarios for Delaware Technical Report, 2017

SLR planning scenarios were first published in 2009 for the State of Delaware. Three SLR scenarios were identified - 0.5, 1.0, and 1.5 meters - by the year 2100 to be used by the State in its planning activities. In 2016 the Delaware Geological Survey (DGS) joined with the DNREC Delaware Coastal Programs and others to form the SLR technical committee. The report summarizes peer-reviewed literature and international/national assessments published between 2009 and May 2017 regarding changes in sea level globally and within the Delaware region. Recommended scenarios regarding future SLR were developed using sound scientific methodologies and can be used by state, county, and local agencies to inform planning decisions and practices within their respective regulations. Updating SLR planning scenarios on a continuing basis is crucial in forecasting the impacts of future inundation and was a recommendation put forth by the SLR technical committee. Further monitoring and data collection will be imperative to provide accurate planning scenarios for communities globally and within Delaware to adapt their planning practices accordingly.


Recommendation of Sea-Level Rise Planning Scenarios for Delaware: Technical Report

November 2017

Developed by

Delaware Sea-Level Rise Technical Committee

Coordinated by the

Delaware Geological Survey

Prepared for and with support from

DNREC Delaware Coastal Programs

4.7 Resilient Community Partnership

In 2018 the Town of Fenwick Island partnered with the Delaware Coastal Programs (DCP) office and six other coastal municipalities, led by the City of Rehoboth Beach, to partake in an assessment of impervious surface coverage. The partnership consisted of the cities of Lewes and Rehoboth Beach, in addition to the towns of Bethany Beach, Dewey Beach, Henlopen Acres, Fenwick Island, and South Bethany. Project funding was provided by federal funds from the Delaware Coastal Programs and Office of Coastal Management (OCM), National Oceanic and Atmospheric Administration (NOAA), and the U.S. Department of Commerce. Community specific strategies were identified to decrease impervious surface coverage area and increase stormwater infiltration systems within their boundaries. Three deliverables were produced because of the partnership: 1) Coastal Delaware Best Management Practices (BMP) Guide completed by AECOM summarizing options for increasing stormwater infiltration and reducing the amount of impervious surface coverage, 2) a document provided by the University of Delaware's Geography Department consisted of a Delaware Coastal Communities Impervious Surface Coverage Report evaluating the status of impervious surface coverage within the boundaries of each participating community, and 3) KCI Technologies developed a third document, a Coastal Community toolkit highlighting the best practices for each individual community to control future development resulting in further impervious surface coverage. The collective goal of the partnership was to assist the participating communities with the necessary planning efforts required to enhance resiliency while combatting the challenges associated with SLR and coastal hazards.

4.8 SR 1 Coastal Corridor Resiliency Study, DelDOT, 2022/2023

The Delaware Department of Transportation (DelDOT) is currently examining impacts to the transportation infrastructure due to climate change and SLR. The area of focus is Route 1 (Coastal Highway) between Dewey Beach and the Maryland state line. This stretch of Route 1 is of particular concern due to the potential for oceanside and bayside impacts. The areas low-lying topography has led to frequent roadway flooding. The goal of the study is to develop solutions to protect this section of Route 1. The timeline for completion is a draft technical report by the end of 2022, a public workshop and final report by early 2023, and future studies and projects after 2024.

5 SEA LEVEL RISE PLANNING PROCESS

Effective SLR planning requires an organized process that allows for regular updates as community needs and scientific information changes. The first step is determining the most appropriate SLR projection. As mentioned previously, there is typically a range of projections – low, intermediate, and high. The preferred scenario will influence the mitigation strategies. Second and third steps include identifying potential impacts and assessing risks to development and resources. Both tasks require thinking of both current and future conditions. Mapping analysis is an important planning tool to use during these steps. The fourth step is developing mitigation strategies. Being able to prioritize recommendations is helpful when it comes to the fifth step which is implementation. The last step is monitoring and revising the SLR plan. It is important to remember the content of SLR planning will evolve as SLR science continues to advance.

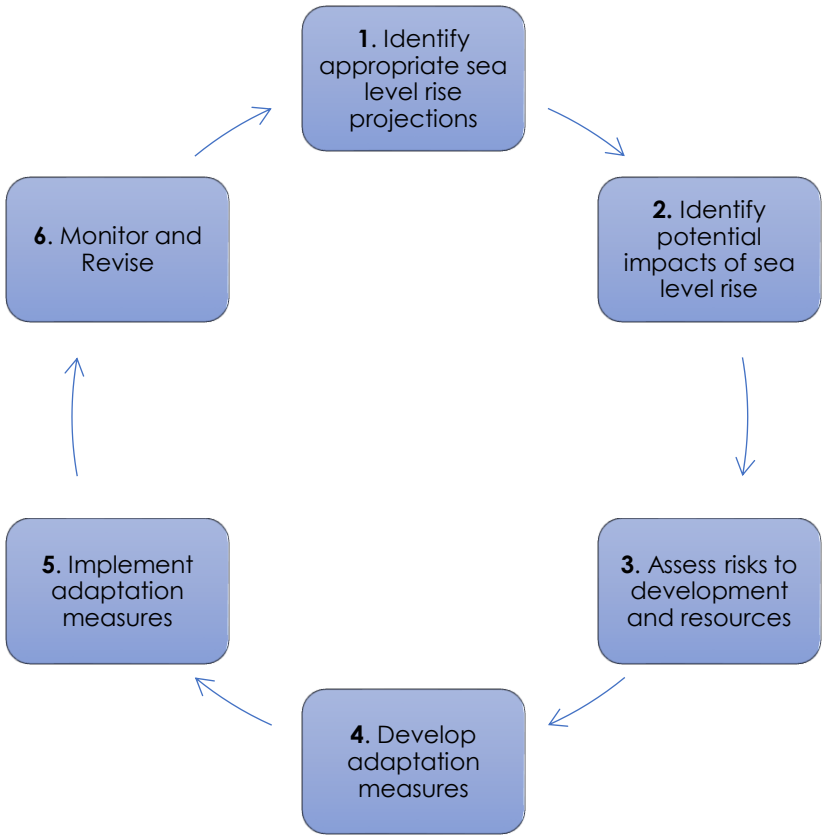


Figure 2 displays the order in which effective SLR planning should be carried out. It is important to note that Figure 2 is shaped as a circle with directional arrows showing the reinforcing nature behind each circumstantial step and the planning process is never static as climate conditions are continuously evolving.

6 VULNERABILITY MAPPING

6.1 Methodology

The SLR inundation maps for the Town of Fenwick Island were developed as part of this assessment by combing the present-day tidal datum mean higher high water (MHHW) with projections of SLR to estimate what areas would be inundated by future MHHW conditions. The method to determine the MHHW levels is discussed in Section 6.2 A total of six SLR scenarios were mapped using an intermediate curve representing the years 2030 through 2080 at 10-year intervals. More information on the SLR analysis is found in Section 6.3. Inundation extents were mapped using GIS software by comparing each future MHHW condition to a LiDAR-derived terrain.

6.2 Tide Analysis

Two present-day MHHW tidal datums were calculated: one for the Atlantic Ocean shoreline and a second for the Little Assawoman Bay shoreline. The Atlantic Ocean MHHW value of 0.46 feet NAVD88 was determined using NOAA's VDATUM software which supplies tidal datum information for most tidally influenced water bodies within the United States. The Little Assawoman MHHW value of 0.53 feet NAVD88 was derived from the water level time series recorded at the USGS tidal gage in Little Assawoman Bay, located at the end of Madison Avenue in Fenwick Island. The water level time series was imported into the Tidal Analysis and Prediction Module of the MIKE 21 Toolbox, a suite of tools to model and evaluate coastal processes. MIKE 21 computed tidal constituents from the water level record and generated a 19-year predicted tidal time series; a subset of the time series is pictured in Figure 3. The predicted tides were used to extract the higher of the two daily high tides and calculate MHHW for the Little Assawoman Bay at Fenwick Island.

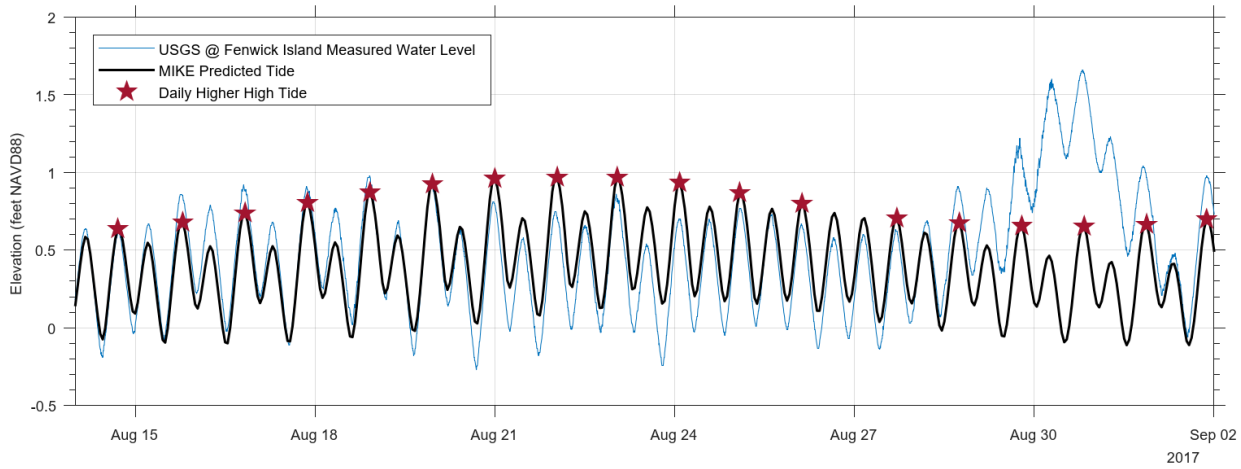


Figure 3 shows sample water level time series from USGS gage at Fenwick Island and predicted tides computed by MIKE software.

6.3 Data Analysis

The SLR values for each future scenario were interpolated from the intermediate curve of the State of Delaware's 2017 SLR projections, pictured in Figure 4. Each map (see Appendices A-F) using the intermediate model and approach illustrates the extent of inundation and highlights buildings and roads affected by that inundation. It is important to note these maps reflect high tides that occur twice a day and do not consider storm surge.

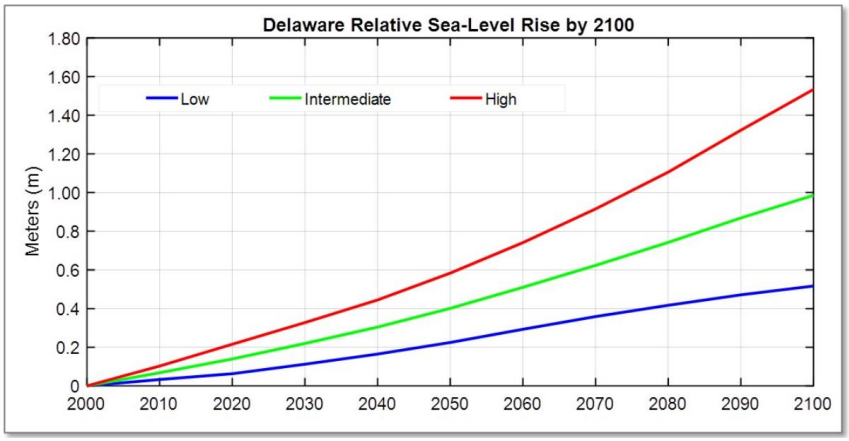


Figure 4 shows the 2017 Delaware SLR planning scenario curves to the year 2100.

Inundation is expected to primarily affect buildings and roads west of Route 1 which is characterized by flat, low-lying topography. The 2030, 2040, and 2050 scenarios affect approximately 10 buildings or less; however, flooding extents escalate in the later scenarios (2060-2080) affecting appreciably more buildings and roads. This is reflected in Table 1 summarizing the percent of buildings and roads inundated in each scenario. It should be noted this analysis did not include any effects SLR may have on long-term erosion of the ocean shoreline.

In reviewing the SLR maps, there are no inundation impacts to streets 2030 to 2040. Impacts to streets start to occur in 2050 and quickly expand by 2060. As indicated in the table below, by 2050 1.5% of Town roads will be inundated which increases to 12.5% by 2060. Those figures continue to drastically rise more than doubling by 2070 with 33% of the Town's roads flooded and about 43% by the year 2080. All the "wet roads," as they are labeled on the maps, are located on the west side of Route 1 with no impacts to streets east of Route 1.

Table 1. Summary of inundation impacts in Fenwick Island

Year	Percent of Buildings Inundated		Percent of Road Inundated
	Entire Town	West of SR1	Entire Town
2030	0.3%	0.4%	0.0%
2040	0.3%	0.4%	0.0%
2050	1.5%	2.2%	1.5%
2060	7.8%	11.2%	12.5%
2070	23.1%	32.9%	33.0%
2080	57.3%	81.7%	42.6%

With a dramatic rise in number of flooded streets over the course of 30 years and every road west of Route 1 being inundated by 2080, because of daily high tides occurring twice during the day, it is important to determine where mitigation efforts should begin. The series of SLR Inundation Maps (2030 - 2080) were used to analyze the evolution of flood prone areas from 2050 – 2080. These areas were prioritized into short-, mid-, and long-term timeframes to support mitigation efforts. Flood prone areas determined to be short-term mean these areas start to show signs of inundation by 2050, with a significant portion of the streets flooded by 2060. The mid-term timeframe includes the remainder of the streets showing signs of inundation starting in 2060. The streets included in long-term start to show significant impacts by 2070. Below is a further explanation of the Town streets included in each category.

6.3.1 Short-Term

The streets included in the short-term are areas that start to see inundation impacts by 2050 and greatly expand by 2060. One of the priority areas is North / South Schulz Road and its intersecting street - W. Dagsboro Street. By 2050, the area around that intersection is one of only two areas in Town that are projected to be flooded. The maps indicate by 2060 approximately 50% of North / South Schulz Road is inundated and W. Dagsboro Street is inundated to the intersection with McWilliams Street. Bora Bora Street does not show signs of potential flooding in 2050, but by 2060 majority of the street is inundated, primarily at the intersections with W. Houston and W. Georgetown Streets. West Essex is another street that shows drastic impacts between 2050 and 2060. In 2050 W. Essex Street does not indicate any flooding while in 2060 approximately 50% of the street is inundated. Madison Avenue and Glenn Avenue show a similar pattern to W. Essex Street. With no signs of inundation in 2050, by 2060 all of Madison Avenue is flooded with Glenn Avenue flooded at the end of the street. Lastly, W. James Street is one of two flood prone areas identified in the 2050 SLR Inundation Map. The end of W. James Street is inundated by 2050 and continues to gradually expand over time. North / South Schulz Road and W. Dagsboro Street should be a high priority for adaptation efforts due to the potential for major flooding in this area, and W. Dagsboro Street is the main corridor for residents accessing properties on North / South Schulz Road as well as Wright Street, McWilliams Street, Ebb Tide Cove, and Windward Way.

Short-term streets include:

- North and South Schulz Road
- W. Dagsboro Street
- McWilliams Street
- Bora Bora Street
- W. Houston Street
- W. Georgetown Street
- West Essex Street
- Madison Avenue
- Glenn Avenue
- W. James Street

6.3.2 Mid-Term

Included in the mid-term timeframe are streets that start to show signs of inundation in 2060. These streets include W. Indian Street, W. Farmington Street, W. Cannon Street, W. Bayard Street, W. Atlantic Street, and the intersection of W. South Carolina Avenue and Mermaid Street. Of the streets listed, W. Bayard and W. Atlantic shows the most flooding with approximately one-third of the street inundated. West Cannon, W. Indian and W. Farmington Streets are flooded at the ends of the streets. Similarly, W. South Carolina Avenue is also flooded at the end of the street, however, all of Mermaid Street is inundated.

Mid-term streets include:

- W. Indian Street
- W. Farmington Street
- W. Cannon Street
- W. Bayard Stret
- W. Atlantic Stret
- W. South Carolina Avenue
- Mermaid Street

A flooded roadway on the bayside of Fenwick Island caused by inundation from a storm event and high-water levels. Photo Courtesy of the Town of Fenwick Island

6.3.3 Long-Term

By 2070, approximately 90% of streets on the bayside are flooded. The streets included in the long-term timeframe show signs of significant flooding in 2070. While the area of W. Dagsboro and McWilliams Streets are included in the short-term priority, Wright Street does not see any flooding until much later. Bay Street shows no signs of inundation until 2070, however, by that time the entire street is flooded except for the intersection with W. James Street. Windward Way and Ebb Tide Cove are both inundated by 2070 despite their intersecting street, North / Schulz Roads, showing signs of inundation in 2050. Bayard Street Extension shows flooding at the end of the street as well as the intersection with W. Bayard Street. Other streets that show significant flooding starting in 2070 and 2080 include Bay Side Drive, Surf Avenue, and Oyster Bay Drive. The intersections of High Tide Lane, W. Maryland Avenue and Island Street are not completely inundated until 2080.

Long-term streets include:

- Wright Street
- Bay Street
- Winward Way
- Ebb Tide Cove
- Bayard Street Extension
- Bay Side Drive
- Surf Avenue
- Oyster Bay Drive
- High Tide Lane
- W. Maryland Avenue
- Island Street

7 IDENTIFICATION & PRIORITIZATION OF VULNERABILITIES

Assessing the vulnerability of various resources within the Town of Fenwick Island was based off three characteristics related to SLR and the impacts shown by the inundation maps from the year 2030-2080:

- Sea Level Rise Exposure: The hazard type, duration, and frequency at which resources within Town are subjected to.
- Sea Level Rise Sensitivity: The degree to which resources are impaired by rising sea levels.
- Adaptive Capacity to Sea Level Rise: The ability of each resource to adapt to evolving hazard conditions over the course of time.

Each of the three characteristics listed above were used in reviewing the SLR inundation mapping to determine those resources that are most vulnerable to SLR and the varying impacts. The vulnerability assessment first identifies five classifications including vulnerable populations, critical facilities and infrastructure, community assets, natural resources, and evacuation routes. After individual resources were identified each was analyzed by their exposure, sensitivity, and adaptive capacity characteristics in relation to incremental increases of SLR between 2030-2080. Resources exposed to coastal hazards related to SLR, highly sensitive to flooding and tidal inundation, and cannot be protected or easily accommodate the implications of SLR hazards over time are prioritized below as being highly vulnerable.

7.1 Vulnerable Populations

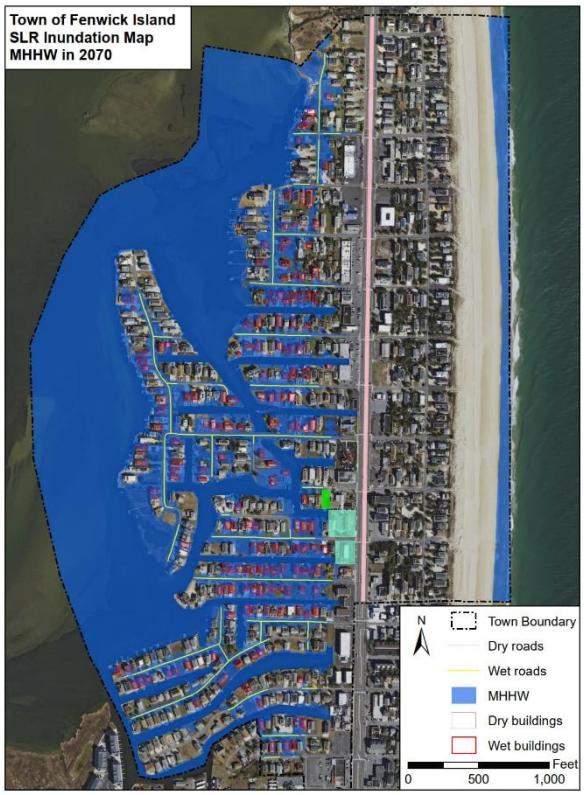
The average median age for the Town of Fenwick Island is 67.9 years. Senior citizens make up a substantial portion of full-time residents within Fenwick Island. Given the threat that pervasive flooding poses to the community and will only be exacerbated further by SLR, older generations will be heavily impacted. The Town of Fenwick Island SLR Inundation Map MHHW in 2080 shows most properties west of the Route 1 will be subjected to devasting flooding from the Little Assawoman Bay. These properties are primarily full-time residential homes that will be faced with the greatest levels of flood inundation with SLR as they are in flat low-lying topographical areas. Older populations will need to be prioritized as the most vulnerable demographic.

Fenwick Island is a coastal community that relies heavily on travel and tourism during the warmer summer months to stimulate its economy. The influx of tourists causes the seasonal population of Fenwick Island to increase significantly from 454 permanent residents, per the 2020 decennial census, to an estimated bed base of over 5,000 as indicated in the Town's 2017 Comprehensive Plan. Increased tourist populations reveal a potentially second vulnerable population. Individuals who are unfamiliar with the area and appropriate evacuation routes will be at a greater risk during events of heavy flooding. Extensive tidal flooding caused by SLR impact large portions of Fenwick Island, causing roadways and homes to become flooded and therefore leading to an increase civilian population attempting to retreat. Visitors who are unfamiliar with the region may pose another challenge for Fenwick Island to consider as they seek to enhance their overall resilience.

Flood inundation on the bayside of Fenwick Island with water levels exceeding half a foot. Photo Courtesy of WBOC

7.2 Critical Facilities and Infrastructure

SLR inundation will affect not only vulnerable populations but critical facilities and infrastructure as well. Fenwick Island is projected to see 57.3% of all buildings inundated with water by 2080 based on the SLR maps. The same projection shows that 81.7% of all buildings located westerly of the Route 1 will become inundated. Three of the buildings that comprise the 81.7% included the Town of Fenwick Island Police Department, Town Hall, and the Bethany Beach 2 Volunteer Fire Department. Each of these three critical facilities are at risk of SLR per the Town of Fenwick Island SLR Inundation Map MHHW in 2080. Emergency services are vital in assisting residents and providing aide to the community during disaster events such as flooding. The facilities and infrastructure identified within this section should be a top priority for the Town to protect.



Above: Figure 5 identifies critical facilities in turquoise, community assets in green, and their location in relation to the evacuation route shown in pink. Below: Cannon Street Park is located directly behind the Town's municipal buildings. Photo Courtesy of Paddling.com

7.3 Community Assets

Fenwick Island provides residents with several public amenities to for all ages to enjoy including Cannon Street Park located adjacent to the police department. Cannon Street Park is a communal area that offers residents the ability to enjoy the outdoors whether for a picnic or to utilize the ADA compliant canoe/kayak launch. Unfortunately, SLR maps project that this area could begin to be subjected to inundation as early as 2030. Specifically, the ADA watercraft launch and viewing deck would become inundated by rising water ultimately compromising these amenities. Further projections into 2080 depict most of the park becoming inundated because of SLR rendering the park unusable.

7.4 Natural Resources

The Town of Fenwick Island is home to several pristine beaches that stretch the entirety of the coastline from the northern boundary of Town limits to the southern limits of East Atlantic Street. The beach is a critical resource fronting on the Atlantic Ocean that serves full time residents and seasonal beachgoers and further provide natural protection that increases the Town's overall resilience to SLR. Sea level inundation projection maps from the years 2030 through 2080 show that the waters of the Atlantic Ocean will encroach further onto the beach due to rising sea levels. Inundation from SLR will further erode the sandy beaches, potentially causing flooding impacts to the eastern side of Town during storm surges as the natural barriers such as sand dunes will deteriorate over time. Beach restoration projects are provided to the majority of the Atlantic Ocean facing beaches in Fenwick Island by the United States Army Corps of Engineers. The beaches are an important natural resource to the Fenwick Island community, providing a plethora of recreational activities to residents and tourists alike and further serving as a catalyst for economic prosperity within the Town. SLR inundation will impact the overall area of the beach, leaving the dunes and beaches vulnerable to even greater impacts during storm events

including hurricanes and nor'easters. Longshore drift contributions from further north in the State of Delaware and from Ocean City to the south assist in providing sand further protecting the coastline. However, this will not be enough and future beach nourishment projects will need to be undertaken due to the impacts caused by SLR culminating in greater costs to the Town.

A 2018 beach restoration project being completed by the United States Army Corps of Engineers on Fenwick Island. Photo Courtesy of WMDT.

7.5 Evacuation Routes

Situated between the Little Assawoman Bay and the Atlantic Ocean, Fenwick Island is limited to one feasible option for evacuation during tidal inundation, flooding caused by storms, and other hazards related to SLR. Route 1 or more commonly referred to as the Coastal Highway, runs North / South and bisects the Town into the bayside west half and the oceanside east half. SLR inundation maps project that by 2080 nearly every roadway to the west of the Route 1 will be completely inundated due to rising sea levels at a minimum of twice a day. With minor arterials submerged, residents will be faced with the challenge of attempting to leave their homes during a storm event due to inundated side roads prior to accessing the evacuation route. Residents in the southern portion of Town will travel south on Route 1 and eventually head west on Route 54 towards Route 20. Those residing on the northern end of Fenwick Island will take Route 1 north towards South Bethany and eventually travel west on Route 26 west heading inland. SLR leaves an extensive portion of Fenwick Island's street network vulnerable to inundation, leaving residents at an impasse when seeking refuge.

Figure 6 shows the evacuation route for Fenwick Island – north on Route 1 towards Route 26 or south on Route 1 then west on Route 54.

8 CURRENT ADAPTATION AND RESILIENCY MEASURES

Fenwick Island has already undertaken adaptation initiatives to alleviate the impacts of climate change and SLR that include the following:

- The Town's Dredging Committee is currently moving forward with a canal and bay channel dredging plan. Fenwick Island has received grant funding for the dredging project. The current discussion is where to put the dredging spoils. One of the prime locations for spoils is Seal Island located just off the bayside of Fenwick Island. The Town has also been in communication with a few residential developments that would be interested in receiving the spoils.

- The Town continues to utilize the Stormwater Infrastructure Study, completed in 2013, to make stormwater improvements. Priority areas were identified during the Study and over the years the Town has applied for grant funding and made improvements. These projects have helped lessen nuisance flooding. The Town continues to make drainage improvements, including the inventorying of check valves and backflow preventors and replacing of aging valves throughout the drainage system.

- In January 2015 Town Council adopted Chapter 88 - Flood Damage Reduction which replaced the previous chapter adopted in the 1970s titled Flood Damage Prevention. Chapter 88 includes sections on administration, requirements for all special flood hazard areas as well as for specific flood zones, variance requirements, and enforcement. The Town continues to apply and enforce these regulations.

- The Town continues to participate in local planning efforts as it relates to effects of climate change and SLR. Fenwick Island has contributed to Sussex County's Hazard Mitigation Plan (2016) and more recently was one of the seven municipalities involved in the Resilient Community Partnership.

- The Town took part in a beach restoration project starting in July 2013 after the devastation of Hurricane Sandy in October of 2012. Approximately 389,000 cubic feet of sand was pumped along 6,500 feet of the Atlantic shoreline to replenish what had been lost during the major storm event. Providing maintenance to the beaches along the Atlantic coastline assist in protecting the eastern portion of Fenwick Island from flood inundation during storm events. In December of 2022 the USACE approved the next beach replenishment project for Fenwick Island to take place in 2023. Approximately 207,000 cubic feet of sand will be placed to replenish the significant amount of material lost during the early spring storms of 2022. Continued beach replenishment will prove beneficial over the long-term for the Town as SLR, causing daily tide cycles to encroach further onto existing dry land.

9 RECOMMENDED ACTIONS OR ACTIVITIES

Fenwick Island continues taking steps to better understand the potential threats of climate change and SLR and be proactive in their planning efforts. The Town's low-lying geography between the bay and ocean leaves the Town more vulnerable to impacts of flooding from both the ocean and the back bay. The Town needs to consider both immediate solutions and a long-term plan. The mitigation strategies below range from improving drainage to more complex projects such as raising streets. On the extreme end of the recommendations is the option of retreat, however, there are opportunities to make improvements in the short- and long-term to help preserve the Town. It is important to remember there is not one solution to solve every issue, it will take a combination of strategies.

The most important point to keep in mind, no matter the mitigation strategy, Fenwick Island will need to take a community-wide approach as they implement various strategies. A parcel-by-parcel approach will produce "quick fixes" to solve immediate problems but will be less effective in the long-term. Success will come from the Town and its property owners working together to implement a series of mitigation strategies at a larger scale.

9.1 SLR Resiliency Strategies Map

In an effort to visually represent several of the proposed mitigation strategies, the map below was created to show where these strategies would be most impactful in preserving properties on the ocean and bayside. The map includes location of proposed bulkheads, riprap with bulkheads, berms, and structural dunes. These action items are discussed in further detail in Sections 9.3 and 9.4. The map is also included as Appendix M for reference.

MAP 1. SLR RESILIENCE STRATEGIES
RESILIENCY PLAN 2023
TOWN OF FENWICK ISLAND

AECOM
March 2023

9.2 Action items to be started by 2030 and completed by 2040

9.2.1 Code Updates. For mitigation strategies to be successful, the Town should consider codifying requirements such as dwellings must be elevated, the use of permeable pavement, and ensuring properties drain to streets and not adjacent properties. Codifying requirements would ensure all property owners were following the same standards as part of the community-wide approach. If the Town decides to raise bulkheads (discussed further in Section 9.3.1), Town Code Chapter 81 Erosion Control should be updated. Section 81-1 requires shoreline properties install and maintain a permanent structure to control erosion. The Code references bulkheads or riprap as types of permanent structures to be installed which could be revised to specify bulkheads and include additional guidelines such as height of bulkhead, materials, and an approval process for property owners installing or improving a bulkhead. If the Town were to require bulkheads, it will also need to be determined if there are areas in Town where both bulkheads and riprap would be appropriate to strengthen shoreline protections. Also, Section 81-2 of the Code discusses the responsibility of the Town's Building Official to determine which properties have no erosion protection structure or structures that are no longer effective due to deterioration. Enforcement of this requirement will provide an opportunity for the Town to start surveying existing erosion protection structures.

9.2.2 Improve Drainage. The Town needs to continue evaluating and making improvements to their stormwater infrastructure. In 2013, the Town conducted a Stormwater Infrastructure Inventory which identified gaps in the existing system and needed improvements. Based on the inventory, the Town prioritized projects and have made several improvements. This would be the opportunity to again evaluate the Stormwater Infrastructure Inventory as an entire system and potentially reprioritize project areas. The Town should look at opportunities to increase the size of pipes for better efficiency as well as deficiencies based on age of stormwater pipes, which the original infrastructure study did not account for. The Town is currently working on drainage improvements by taking inventory of check valves and backflow preventors and replacing aging valves. Upgrading and replacing tidal backflow valves will become increasingly important to the Town as increasing flood events occur. Fenwick Island should also develop or update a maintenance plan to regularly keep stormwater pipes clean and in good working condition.

9.2.3 Participation in Future Studies. The Town of Fenwick Island is strongly encouraged to participate in the Delaware Inland Bay and Delaware Bay Coast Coastal Storm Risk Management Study. In June of 2022 it was announced that DNREC and the USACE were partnering to conduct a feasibility study investigating coastal storm risk management problems and solutions related to Delaware's inland bays and the Delaware Bay coast. The project is to be completed over the course of five phases. Phase 1 began in January 2023 and is focused on establishing a geographic scope, identifying possible risk management solutions, and to establish current and future environmental conditions. The State of Delaware is seeking input from communities that are affected by coastal flooding within the project area to assist with the study. This high level study is expected to yield community specific mitigation measures for each community within the study area. Fenwick Island is poised to provide an abundance of salient information to aid in the development of the study. Active participation could prove to be of great benefit to the Town as larger scale projects that would require greater levels of funding could be advocated for during the project.

9.2.4 Beach Replenishment. Beach restoration and replenishment projects in collaboration with the State of Delaware and the USACE will continue to be important to the long-term resiliency for the Town of Fenwick Island. This practice which has and continues to occur will assist in protecting the dunes that protect the oceanside of Town. The SLR inundation maps project that the water line will encroach further onto the beaches, bringing it closer to the dune line. Beach replenishment will protect the dune line, holding it during high tide cycles and storm events further protecting the eastern portion of Fenwick Island. Periodic review and evaluation of beach conditions will need to be conducted by officials to ensure their preservation.

9.2.5 Grant Funding. Being aware of what grants are available is a valuable tool in continuing resiliency planning. It is important to emphasize that working in close conjunction with the Delaware Coastal Program on resiliency projects, such as this plan, will open opportunities for future assistance from the State. The University of Delaware's Institute for Public Administration (IPA) program, along with the Delaware Coastal Program, has put together a searchable database of funding sources that support resiliency related projects. The website does note that the database, "prioritized financial assistance programs that support the implementation of high-cost activities such as infrastructure improvements, facility retrofitting, construction, and land acquisition." Many of these funding sources will be useful as the Town looks towards completing more in-depth resiliency planning and engineering projects. The funding database can be found at: https://www.bidenschool.udel.edu/ipa/resources/ddfrc.

9.2.6 Resiliency Funding. Resiliency planning is becoming a priority for many towns, and some communities are considering establishing a resiliency fund to help pay for future projects and grant funding geared towards adaptation projects. For example, the City of Lewes has discussed the merits of implementing a resiliency fund. The funding framework includes a goal amount of funding per year, time span of collecting funds, types of projects that are included and exempt from the funding, and guidelines for accessing funds. During their discussions, Lewes also established a proposed fee structure that includes a flat fee for residential properties and a fee based on impervious surface for non-residential properties. The Town could benefit from establishing a resiliency fund that could go towards future matching grants and SLR related projects.

9.2.7 Public Engagement. It will be important to keep property owners involved in conversations regarding climate change and SLR. This could include information sessions held at Town Hall, brochures mailed to property owners, and information posted on the Town's website. Topics should include general information about SLR, but more importantly, how climate change and SLR have already impacted Fenwick Island and will continue to do so in the future if not addressed.

9.3 Future tasks requiring additional engineering, planning, and surveying to begin by 2040 and completed by 2060:

9.3.1 Raising Bulkheads. Shoreline properties in Fenwick Island are required by Chapter 81 of Town Code to install and maintain permanent structures such as bulkheads and riprap as a method of erosion control. A bulkhead is a vertical shoreline stabilization structure that retains soil and provides protection from wave action or currents. Wooden bulkheads are mostly found throughout Fenwick Island, however, there are alternative materials such as steel, vinyl, and composite that are used. Bulkheads are used primarily as a shoreline stabilization technique providing protection against wave action and are not designed to withstand severe coastal flooding. However, vinyl bulkheads would provide a high level of protection, minimize seepage, are resistant to corrosion, and are are more cost effective for homeowners. Vinyl bulkheads also have a longer life span of up to 50 years. Composite and steel bulkheads are also effective in protecting properties from rising water levels but are more costly to the homeowner.

Example of newly installed bulkheading.

Many communities along the eastern seaboard of the United States have implemented minimum construction and design standards for bulkheads. Preliminary evaluation suggests bulkheads will need to be raised in Fenwick Island to a minimum of 4 feet NAVD88 by 2050 to attenuate SLR and nuisance flooding. The provided bulkhead elevation figure was calculated by using the intermediate curve from Figure 4 and maximum high tide recorded over the past 15 months (December 2022) by the Madison Avenue tidal gauge. Elevating bulkhead heights to 6 feet NAVD88 would attenuate SLR through 2080 and provide a robust protection from storm surge. The Town has approximately 6 miles of coastline on the bayside. Approximating improvements would cost at the higher end $1,200 per linear foot - the cost of upgrading bulkheads along the bayside would be between $9 and $38 million depending on material and costs at the time of construction. It will also need to be determined where the bulkhead would tie-in to form a seamless barrier. For the northern part of Town, it appears the tenable tie-in point would be along Route 1. It would be possible to construct a berm at the termination of Bay Street and following along the property line with the Fenwick Island State Park and Route 1. When looking at the southern portion of Town the bulkheads that are installed along High Tide Lane will need to tie-in with bulkheads located along adjacent properties outside of the Town boundary. The Town will need to coordinate closely with Sussex County on flood protection measures in the southern portion of Town. Similar strategies like elevating bulkheads will need to be implemented to protect properties along the southern canal system in unincorporated Sussex County between Fenwick Island and the Maryland state line. Refer to the map in Section 9.1 or Appendix M for proposed location of raised bulkheads.

Example of bulkhead with ramp to boat dock.

In requiring all bayside properties to be bulkheaded community assets important to this coastal community, such as boat ramps, will be impacted. It has been observed that the existing boat ramps are conduits for floodwater during high tide and storm events. Boat ramps will either need to be eliminated or an alternative type of boat ramp will need to be installed to accommodate the new shoreline design.

Bulkheading and boat ramp/access points will provide a greater level of protection and prevent inundation from occurring.

The effectiveness of raising bulkheads will rely on a town-wide approach with all property owners installing bulkheads and/or raising bulkheads to the same elevation. This would include properties that currently use riprap as shoreline protection. While all bayside properties should install bulkheads there may be opportunities for properties to utilize both bulkheads and riprap – this is discussed further in the following section. A survey should be conducted providing the following information at a minimum: location of bulkhead/riprap/etc., material, height, and current condition. The survey should be conducted in a manner that the data can be imported into GIS and used for mapping analysis. The Town should also develop a plan to reevaluate bulkhead standards to continue to account for changes due to SLR. It will also need to be determined whether cost of raising bulkheads would be at the expense of the Town, residents, or funded through grants.

9.3.2 Riprap and Bulkheads.

As mentioned above, all properties with existing riprap as their only shoreline protection will also need to add a bulkhead to ensure continuity among properties and prevent weak points for flooding along the bayside. Currently there are properties along the bayfront that have both a bulkhead system and riprap. DNREC does not permit the removal of riprap that is currently installed. After reviewing aerials of the Town there are several bayside properties that currently have both bulkheads and riprap installed, and there are opportunities for other direct bayfront properties to also utilize both. The combination of bulkheading and riprap will be beneficial to bayfront properties as added protection to reduce flooding and mitigate wave action.

Many bayfront properties, such as those along North/South Schulz Road, Bora Bora Street, and Bay Street, would benefit from using riprap to dissipate wave action with bulkheading installed behind to further protect the roadway from becoming inundated. Furthermore, the small cove and associated wetland area located along the southern end of Schulz Road will need to be fortified to prevent rising waters from easily flooding out the roadway and properties. This method would also add protection to street ends. Currently street ends only utilize riprap for protection, the addition of bulkheading in those areas would further protect and reduce flooding. Refer to the map in Section 9.1 or Appendix M for proposed locations of riprap and bulkheads.

Example of utilizing both bulkheading and riprap.

9.3.3 Berms. Individual property owners may wish to implement further protection by constructing a berm on their property. Berms are comprised of natural materials including clay and soils that are used to facilitate stormwater drainage and enhance fortification of an area. Berms would not be a beneficial adaptation technique to engage directly along the bayside as even small berms require an abundant amount of material to construct and occupy a large quantity of area. Fenwick residential lots are small, and berms would further reduce the area of enjoyment available for property owners. It is also important to note that berms are typically constructed using a specific slope. Individual lots that attempt to use a berm as a secondary source of protection may leave abutting properties at risk of water running off the sides leading to inadvertent flooding. Continuity among all properties fronting the bayside is incredibly important when determining the effective method to protect against SLR. Smaller sized berms may be an appropriate secondary level of protection to be installed behind existing bulkhead to prevent any seepage and wave overtopping from flooding out an individual property.

Properties located in the northern part of Town have the potential as a tie-in point for a seamless bulkhead utilizing a constructed earthen berm. The parcels in this section of Town are significantly larger than most residential parcels within Town limits and have a greater amount of area for an effective berm to be implemented. The area near the termination of Bay Street are best situated to use a large berm to protect against SLR but would also serve as the tie-in point with the neighboring properties bulkheads and Route 1. Refer to the map in Section 9.1 or Appendix M for proposed location of a berm.

9.3.4 Dredging. The Town is currently working on a canal and bay dredging plan. One option is to use the dredging spoils to rebuild Seal Island located off the bayside of Town. The restoration of Seal Island could help protect the Town during major weather events by reducing wave impact. However, the restoration of Sea Island will be limited in its capability of reducing flooding impacts to the bayside of Town. Wave attenuation would be the most significant benefit the Town would see from undertaking this endeavor. Furthermore, spoils from dredging efforts could also be used to elevate properties within Town. Recycling the spoils would lead to a reduction in the cost to the responsible party.

9.3.5 Elevating Dwellings. A systematic approach would be required for elevating dwellings. While many of the newer dwellings in Town are elevated, there are still many older houses that should be elevated. It is important to consider that elevating dwellings will protect personal property but will not keep the property from flooding. Homeowners should utilize the freeboard provision within the Fenwick Island Zoning Code to safeguard their homes and provide a greater level of assurance.

9.3.6 Raise Streets. This option is costly and would take major engineering and design. Adjacent coastal communities would also need to be involved for this strategy to be successful. Raising streets would need to be completed in conjunction with other scheduled DelDOT infrastructure improvement projects. Elevating inundated streets is extremely costly and can lead to unintended consequences with regards to stormwater runoff to adjacent properties causing further flooding and damage. The City of Miami Beach, Florida is presently in the midst of raising roadways that are subject to pervasive flooding, which in turn has led to legal challenges by homeowners whose properties have become flooded during storm events. Raising roadways would need to be done in concert with private properties being elevated with fill to eliminate potential negative impacts and alleviate the concerns of heavier flooding on lots fronting the right-of-way.

Schulz Road is the singular street that will experience significant flooding inundation daily due to the high tide cycle by 2050. If the Town were to move forward with elevating roadways, North / South Schulz Roads would be its top priority. However, by 2060 the number of roadways along the bayside of Town that will be subject to tidal inundation due to the heightened sea level increase dramatically to seven impacted roadways. Streets that would fall into the second tier of priority for evelvating include Madison Avenue, W. Dagsboro Street, W. Bayard Street, W.

Atlantic Avenue, W. Essex Street, W. Georgetown Street, and Bora Bora Street. The expense of elevating streets is currently estimated to be $3 million dollars for less than a mile of roadway. Significant costs to elevate streets would require an extensive amount of funding to properly address the SLR challenges Fenwick Island is confronted with.

9.3.7 Sea Level Rise Design Guidelines or Standards. Developing and adopting resilient design guidelines or standards would be an appropriate action for the Town to consider. Specific regulations tailored to address the impacts of SLR on both commercial and residential development would facilitate resiliency through adequate building and infrastructure design. Design measures to be considered for inclusion as part of the regulatory document could include elevation requirements, building materials, and landscaping requirements. By requiring all future development to meet design requirements and existing structures to be retrofitted, buildings will be able to withstand the harsh impacts and challenges brought forth by rising sea levels. Buildings and infrastructure that are designed in a manner consistent with a changing environment will enable residents and tourists alike to ensure their continued enjoyment of the Town.

9.4 Long-term Considerations for 2070 - 2080:

9.4.1 Structural Dune. Fenwick Island's oceanside dunes are healthy and have withstood severe storm conditions over time. Beach replenishment projects have continued to aide in the dune line holding. However, rising sea levels accompanied by major storm events could threaten the integrity of the existing dune-line. Although beach replenishment will continue to play an integral part in protecting the dunes, the construction of a structural dune would provide vital protection for those residing east of Route 1. The most used form of structural dune consists of a seawall typically constructed of steel and covered with sand to form a natural looking dune line. Structural dunes are often used synonymously with artificial dunes as they are built using sand transported to the project area from an external source and are not created from geological processes. The development of a structural dune along the ocean fronting properties would mitigate against SLR and tidal surges from severe weather events. Creation of a structural dune would be a very large undertaking and would need to a joint project between the Town, State and the USACE. Should a structural dune be installed, it should be done so in tandem with a scheduled beach replenishment project allowing time for the dune to stabilize from the planting of beach grasses. Refer to the map in Section 9.1 or Appendix M for location of structural dune.

9.4.2 Elevating Properties. To prevent residential properties from becoming inundated on the bayside, elevating using fill may be an action to consider. Elevating properties would need to be done uniformly to prevent unintended consequences and neighbor disputes. If properties are elevated, the streets on which they front will also need to be raised. Stormwater runoff from elevated properties could lead to nuisance flooding of the street, rendering them unusable by the community. FEMA does provide strict regulatory guidance on development within Special Flood Hazard Areas (SFHA) including how fill may be utilized. The use of fill is prohibited to be used for structural support of buildings in V zones.

The efficacy of elevating properties by several feet to the west of Route 1 would be a massive endeavor. Filling materials typically range from $5 to $15 per cubic yard and the amount of fill that would be required to achieve the Town's desired grade is expansive. Factoring in labor and trucking costs would further increase the total cost to property owners. One factor to consider when examining the cost of fill is the possibility of using dredging spoils from the canals. By using the spoils from potential dredging activities on the bayside could lead to a reduction in the cost of moving forward with this action. It is important to note that the materials that are usually contained within dredging spoils are typically high in organic materials that breakdown over time and therefore are not the most suitable to be used for filling.

9.4.3 Managed Retreat. There are many mitigation measures that can be implemented in combination to alleviate the impacts of SLR and preserve the Town. Managed retreat could be considered a last resort, but an idea that should be discussed by the Town in the long-term. Defined as, "the purposeful movement of people, buildings, and other assets from areas vulnerable to hazards," managed retreat is becoming a real option for those communities that find themselves with limited solutions to combating climate change and SLR.[1] To put the strategy into perspective it is noted that solutions, "like building flood walls and elevating threated structures, will involve small-scale retreat to make space for levees and drainage."[2] A type of managed retreat is buyouts which means an entity would buy properties that are most vulnerable to climate change and SLR impacts. These properties would be restored to natural open space, and in theory would help reduce flooding. Bowers Beach is a coastal community that has used buyouts. For Fenwick Island, potential buyouts might mean those properties identified as "wet buildings" (See Appendix C and D) on the SLR Inundation Maps starting in 2050 and 2060.

[1] *Coastal Cities of the Future.* June 17, 2021.
[2] *Coastal Cities of the Future.* June 17, 2021.

10 CONCLUSION

Failure to proactively plan for future SLR inundation will inevitably leave the Town of Fenwick Island defenseless. It is vitally important that the Town begins taking measures that enhance overall resiliency and allow for a greater level of adaptability in the face of future challenges. As sea levels continue to rise, as climate models show over the course of the next several decades, the current problems the Town has dealt with will only continue to worsen and thereby have widespread impacts. Natural Resources, populations, critical infrastructure and facilities, community assets, and evacuation routes will all be negatively affected by SLR. Fenwick Island is in a difficult predicament by way of its exact geographic location situated between the Little Assawoman Bay and the Atlantic Ocean. Properties and roadways located to the west of Route 1 will be subject to daily flood inundation due to the twice occurring high tide cycle. Storm events will only worsen the problem by continuing to diminish the beaches to the east of Route 1 and causing storm surges to potentially overtake natural barriers that protect residents due to sea levels being elevated.

There is a choice, however, that the Town can choose to make. Community-wide and inter-governmental collaboration efforts can assist in making Fenwick Island a more resilient community in the fight against SLR. Current SLR projections provide a 30-year window for the Town to begin implementing resilience measures before drastic negative effects begin to take effect. Multi-approach mitigation strategies including updating regulatory codes, requiring design specifications, and seeking grant opportunities to fund large-scale projects such as flood barriers and tidal gates will all contribute to this effort. Unfortunately, like so many coastal communities there is no one solution that Fenwick Island can use to eradicate all adverse impacts of SLR. Making the choice to consciously plan now will only be of benefit to the Town of Fenwick Island and allow for the creation of a greater level of resiliency to ensure it sustains into the future.

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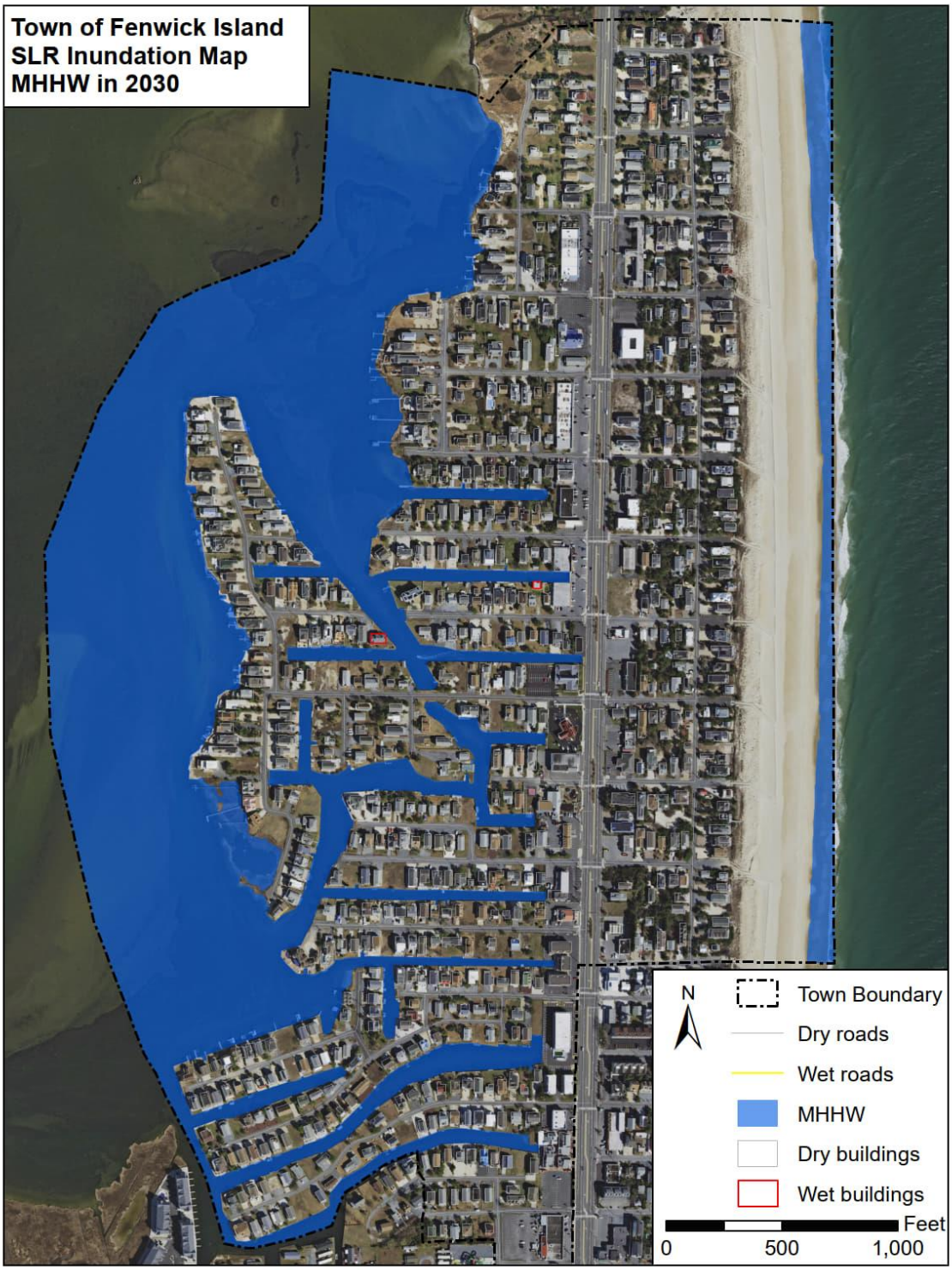
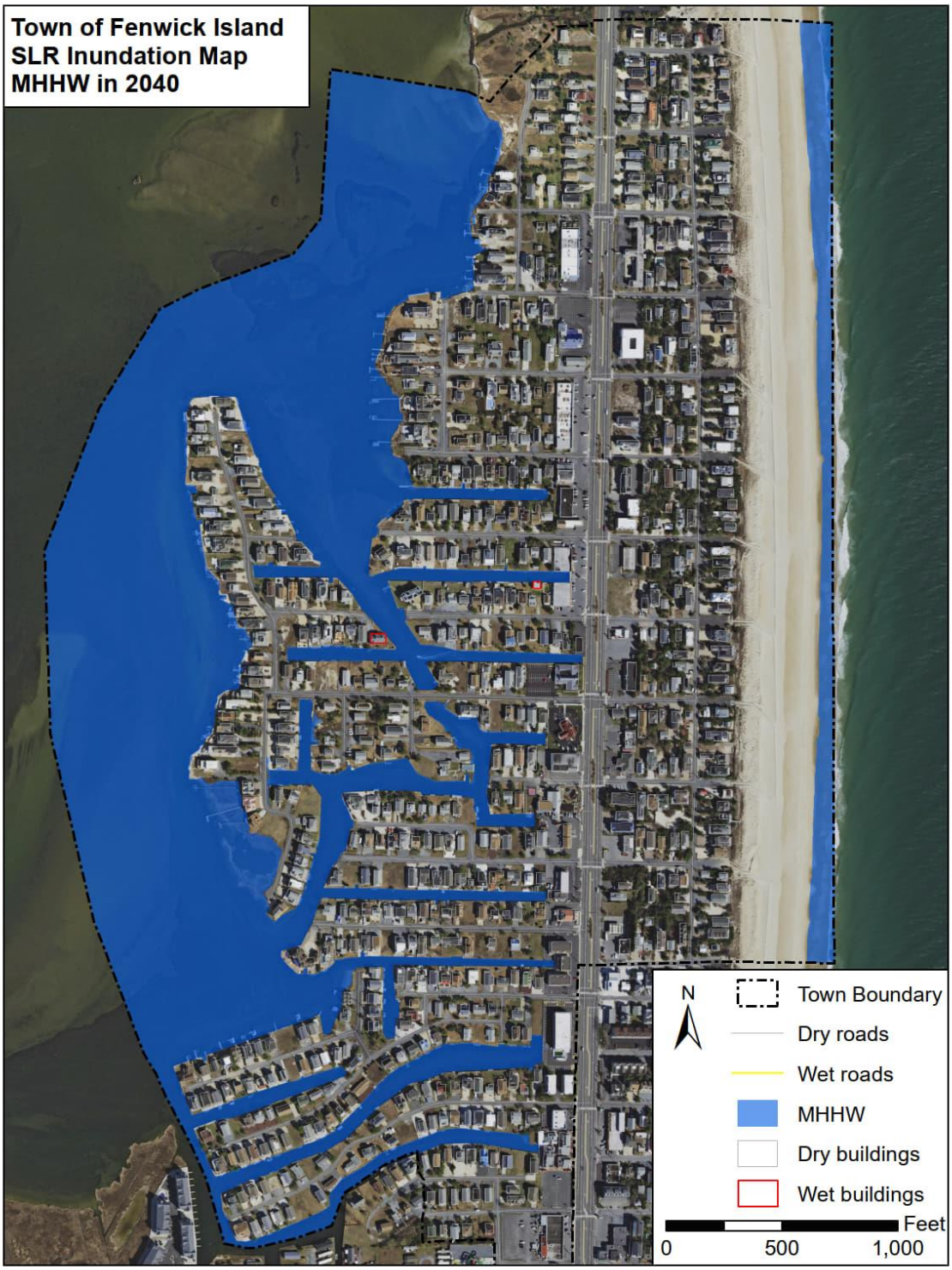
Appendices

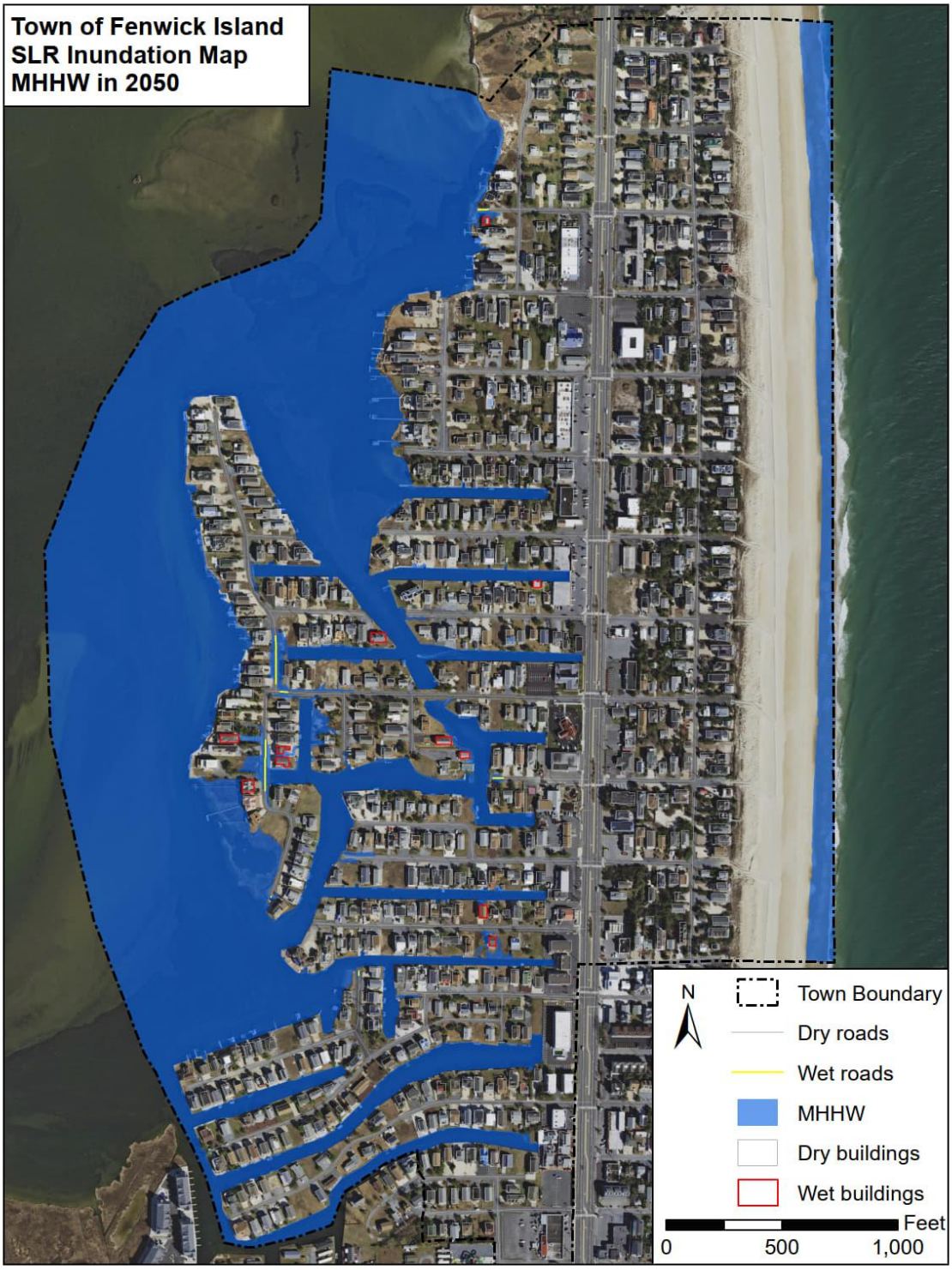
APPENDIX A


Town of Fenwick Island
SLR Inundation Map
MHHW in 2030
N
Town Boundary
Dry roads
Wet roads
MHHW
Dry buildings
Wet buildings
Feet
0
500
1,000

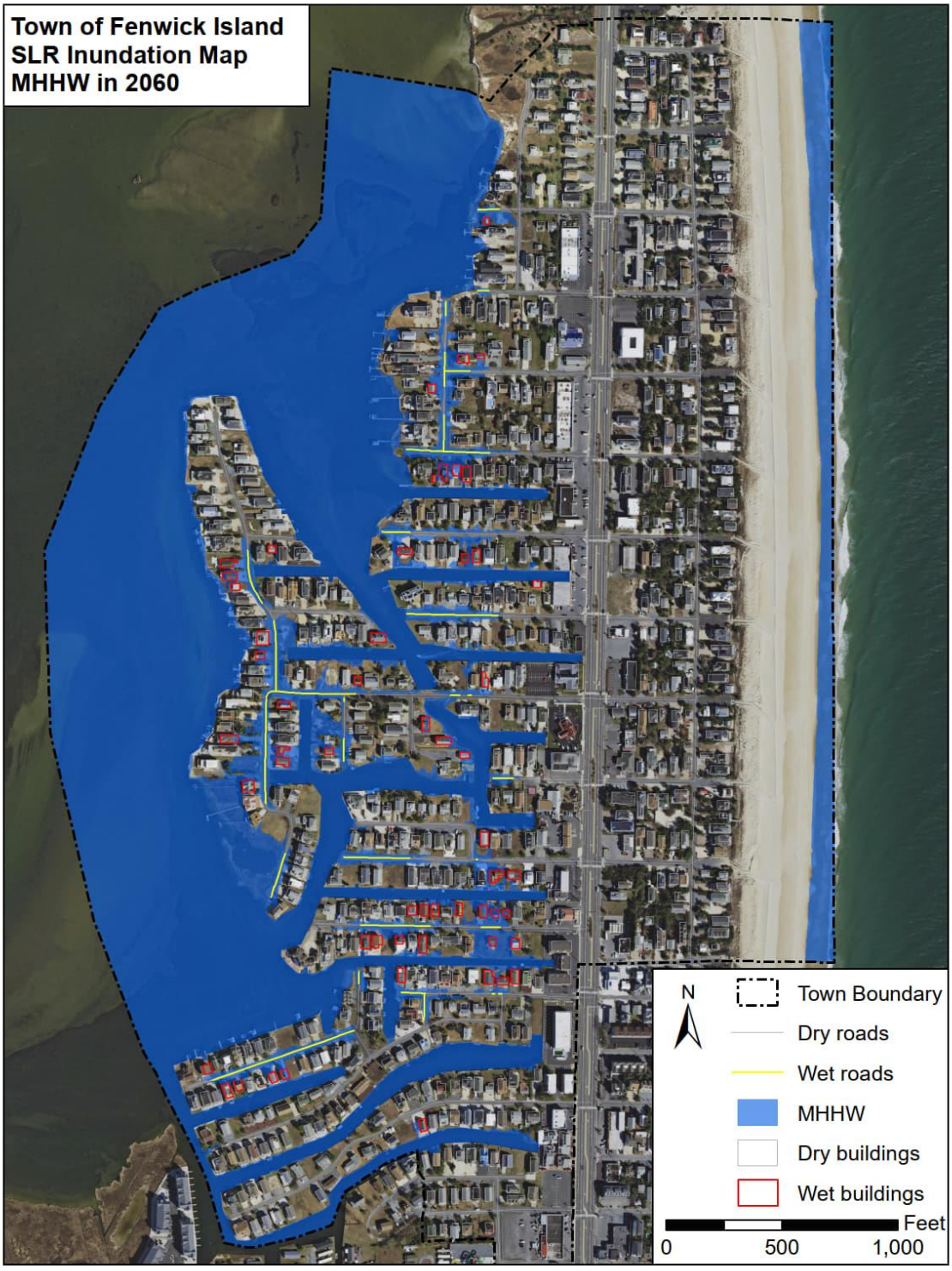
APPENDIX B


Town of Fenwick Island
SLR Inundation Map
MHHW in 2040
N
Town Boundary
Dry roads
Wet roads
MHHW
Dry buildings
Wet buildings
Feet
0
500
1,000

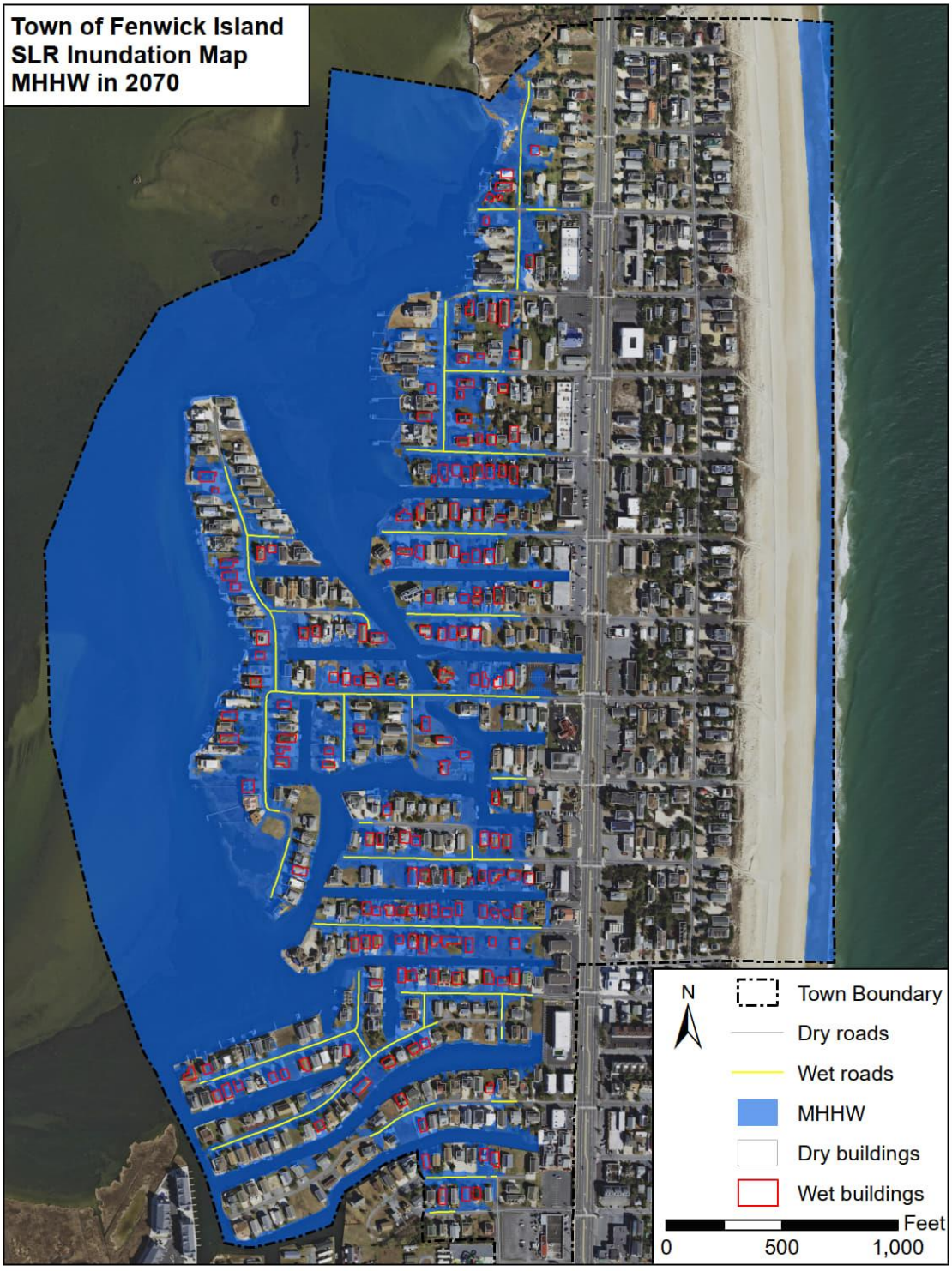
APPENDIX C


Town of Fenwick Island
SLR Inundation Map
MHHW in 2050
N
Town Boundary
Dry roads
Wet roads
MHHW
Dry buildings
Wet buildings
Feet
0
500
1,000

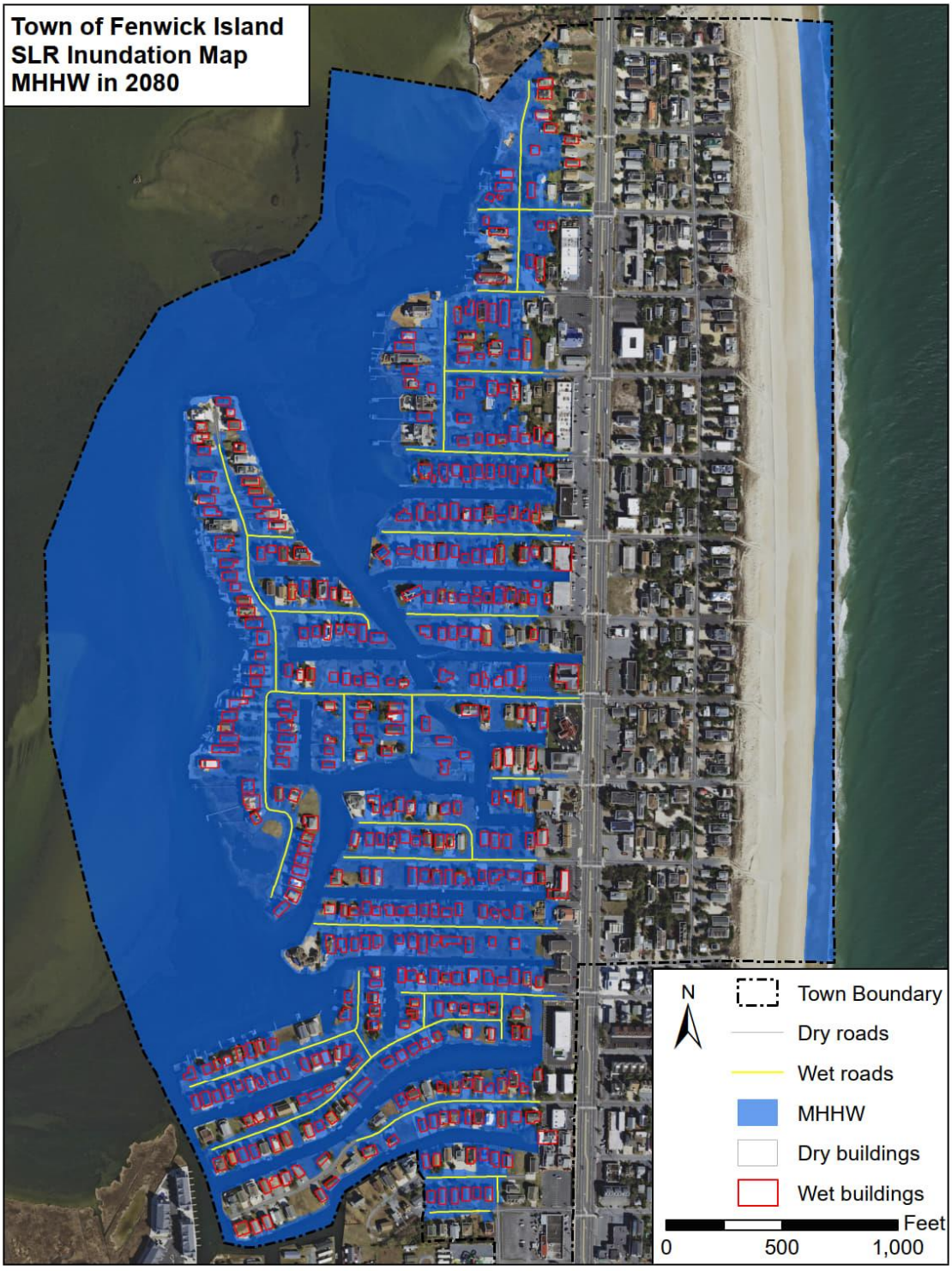
APPENDIX D


Town of Fenwick Island
SLR Inundation Map
MHHW in 2060
N
Town Boundary
Dry roads
Wet roads
MHHW
Dry buildings
Wet buildings
Feet
0
500
1,000

APPENDIX E


Town of Fenwick Island
SLR Inundation Map
MHHW in 2070
N
Town Boundary
Dry roads
Wet roads
MHHW
Dry buildings
Wet buildings
Feet
0
500
1,000

APPENDIX F


Town of Fenwick Island
SLR Inundation Map
MHHW in 2080
N
Town Boundary
Dry roads
Wet roads
MHHW
Dry buildings
Wet buildings
Feet
0
500
1,000

APPENDIX G


Town of Fenwick Island
SLR Inundation Map
MHHW in 2030
Town Boundary
Dry roads
Wet roads
Dry buildings
Wet buildings
Depth (feet)
< 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
N
0
500
1,000
Feet

APPENDIX H


Town of Fenwick Island
SLR Inundation Map
MHHW in 2040
Town Boundary
Dry roads
Wet roads
Dry buildings
Wet buildings
Depth (feet)
< 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
N
0
500
1,000
Feet

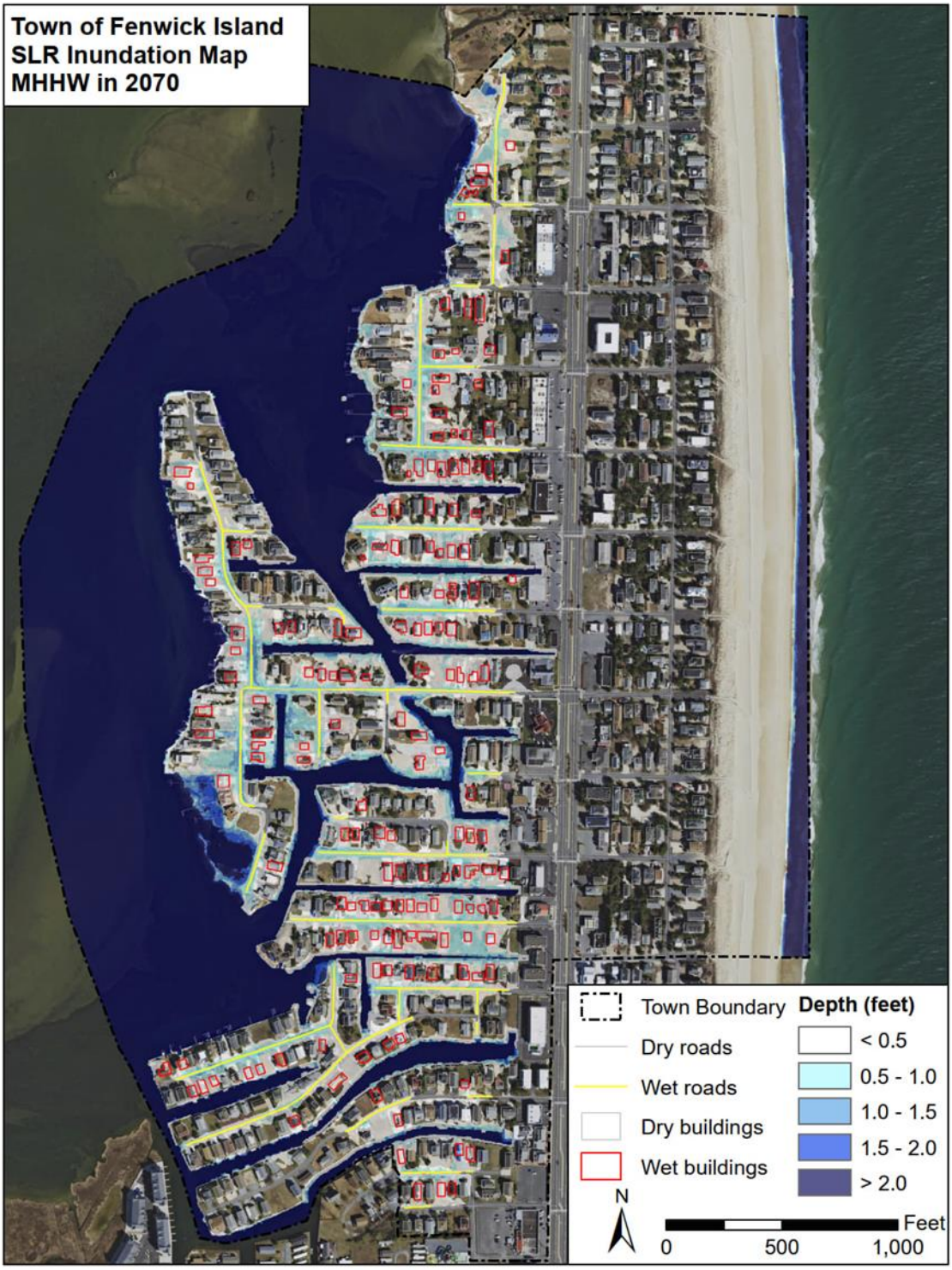
APPENDIX I


Town of Fenwick Island
SLR Inundation Map
MHHW in 2050
Town Boundary
Dry roads
Wet roads
Dry buildings
Wet buildings
Depth (feet)
< 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
N
0
500
1,000
Feet

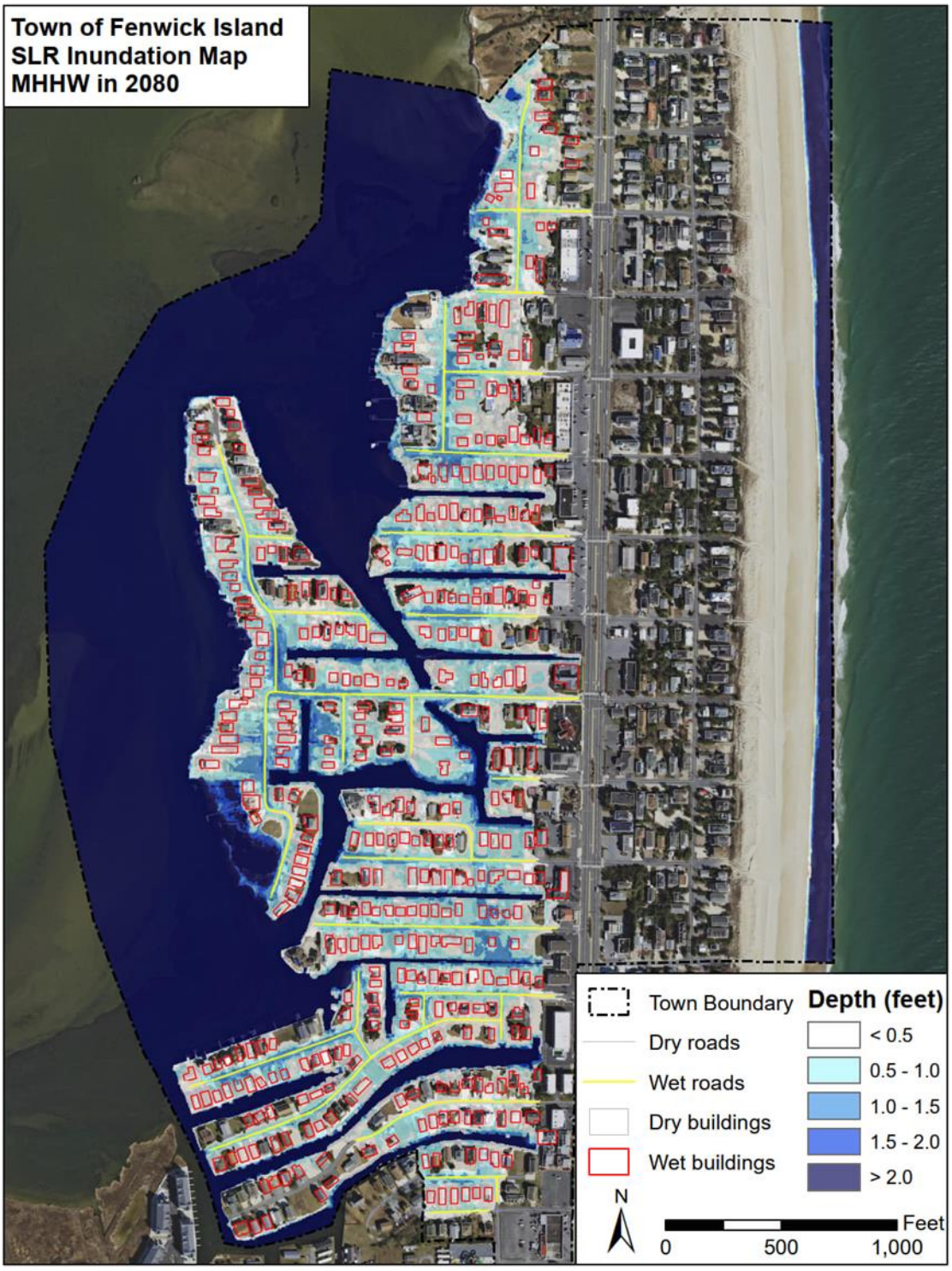
APPENDIX J


Town of Fenwick Island
SLR Inundation Map
MHHW in 2060
Town Boundary
Dry roads
Wet roads
Dry buildings
Wet buildings
Depth (feet)
< 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
N
0
500
1,000
Feet

APPENDIX K


Town of Fenwick Island
SLR Inundation Map
MHHW in 2070
Town Boundary
Dry roads
Wet roads
Dry buildings
Wet buildings
Depth (feet)
< 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
N
0
500
1,000
Feet

APPENDIX L


Town of Fenwick Island
SLR Inundation Map
MHHW in 2080
Town Boundary
Dry roads
Wet roads
Dry buildings
Wet buildings
Depth (feet)
< 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
N
0
500
1,000
Feet

APPENDIX M


LEGEND
Sussex County Raised Bulkheads
Structural Dune
Berm
Raised Bulkheads
Riprap w/Raised Bulkheads
Fenwick_Boundary
N
Coordination area with Sussex County
MAP 1. SLR RESILIENCE STRATEGIES
RESILIENCY PLAN 2023
TOWN OF FENWICK ISLAND
AECOM
March 2023