The City of Lewes
Hazard Mitigation and Climate Adaptation Action Plan

June 2011

The City of Lewes
Hazard Mitigation and Climate Adaptation Action Plan

A community guide developed to improve public safety, minimize losses and create greater city-wide resilience.

Presented to the City of Lewes by

Delaware Sea Grant College Program
ICLEI-Local Governments for Sustainability
University of Delaware Sustainable Coastal Communities Program

Prepared in conjunction with

The City of Lewes Mitigation Planning Team – Pilot Project Subcommittee
City of Lewes Pilot Project Workshop Participants

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The City of Lewes

The City of Lewes, a thriving bay front community, offers both visitors and residents a unique opportunity to experience intimate walkable commercial and historic districts along with beautiful open spaces, including sandy beaches and healthy wetlands. Lewes' proximity to water and well understood threats from coastal storms and flooding has made the city a leader in the field of hazard mitigation. With a strong Mitigation Planning Team, the City works diligently to provide its citizens and visitors with a safe place to both live and play. Recognizing the threat climate change poses to its hazard mitigation efforts, the City has worked on a pilot project that integrates climate change adaptation into hazard mitigation planning.

This report summarizes the process and results from this pilot project – a project that has helped the City of Lewes enhance local understanding of climate change and natural hazards impacts and begin devising strategies to build resilience towards these impacts. This project engaged key local stakeholders – City staff, City Board / Commission members, and Regional / State partners – as well as the public and resulted in this summary report and six initial recommendations for the City to begin implementing.

As both a citizen of Lewes and a member of the Mitigation Planning Team, I am proud to have been involved throughout this pilot project. I am now honored to endorse this document as the City's unified **Hazard Mitigation and Climate Adaptation Action Plan**. Finally, I look forward to working with local Boards and Commissions to implement the plan and create a more resilient and safe Lewes today and tomorrow, for our residents, visitors, and businesses.

James L. Ford, III, Mayor
City of Lewes

Table of Contents

List of Figures

List of Tables

Executive Summary

Lewes, Delaware, with its strong history of hazard mitigation planning and preparedness is perfectly poised to take advantage of an increasing understanding of climate change impacts. It is already known that temperatures are rising, glaciers are retreating, snowpack is disappearing, spring is arriving earlier, and seas are rising. These changes will exacerbate hazards that are known to threaten Lewes today. While these changes cannot be prevented, the effects of these events are dependent upon the choices and actions that Lewes makes today.

Given the increasing future threats that Lewes faces, the overall goal of the Hazard Mitigation and Climate Adaptation pilot project has been to further the City's hazard mitigation work by incorporating climate adaptation. The project has developed this unified plan that aims to improve community sustainability and resilience. Local officials and residents have been engaged through four workshops to determine the City's greatest existing and future vulnerabilities and to chart a course of action to reduce these vulnerabilities.

The subsequent sections provide further details on the project, the methods used and the outcomes of the effort. Section 1 focuses on providing a context for this effort and details the methods used. Section 2 provides a case for engaging in both hazard mitigation and climate adaptation. Section 3 details the natural hazards assessed. Section 4 is focused on the climate change knowledge and impacts to natural hazards that were presented to workshop participants. Section 5 outlines the vulnerability self-assessments that were conducted during the workshops. These assessments resulted in the identification of two key vulnerabilities. The first is Lewes' water system and the combined threats of saltwater intrusion into the aquifer and destruction of water conveyance systems that it faces from sea level rise. The second vulnerability is the destructive impacts on homes and City infrastructure from increased flooding.

Based upon these two key vulnerabilities, Section 6 describes the action selection process. Through this process, the following six actions were identified as recommendations that the City begin implementing. Finally, Section 7 provides implementation guidance for these identified actions.

- Incorporate climate change concerns into the comprehensive plan and into future reviews of the building and zoning codes. Recommended actions and implementation guidance are included on page 53.

- Improve outreach and education particularly focused on successful behavior changes related to home building and retrofits. Recommended actions and implementation guidance are included on page 59.

- Ensure that aquifer information is integrated into all planning efforts. Recommended actions and implementation guidance are included on page 63.

- Use elevation data to determine road levels and evacuation risk. Recommended actions and implementation guidance are included on page 65.

- Evaluate the City and the Board of Public Works (BPW) infrastructure's flood vulnerability from direct flood impacts as well as from indirect flood impacts to access routes. Recommended actions and implementation guidance are included on page 67.

- Improve the City's level of participation in the community rating system (CRS). Recommended actions and implementation guidance are included on page 69.

Section 1: Introduction

1.1 General Overview of the City of Lewes

1.1.1 History, Geography, and Core Values

The City of Lewes, founded in 1631 and incorporated in 1818, is the oldest town in Delaware. Lewes was the site of Delaware's first European settlement, and is often referred to as "the First Town in the First State." The first permanent Dutch colony, named "Zwaanendael," or Valley of the Swans, was established in 1631. Zwaanendael was decimated in an attack by natives in 1632, but by 1659 the Dutch had resettled the area. Following nearly a century of British control, the area was first incorporated as the town of Lewes in 1818. Lewes became a critical focal point for the region, not only for commercial trade but also for national defense, especially during the War of 1812 when the town successfully defended the Delaware Bay from a British blockade (Lewes Comprehensive Plan, 2005, p. 5).

Situated on the bayside of Cape Henlopen, a natural spit of sand that serves as a divide between the Atlantic Ocean and the mouth of Delaware Bay, the community is bordered by tidal wetlands, tidal creeks and tributaries, sandy beaches and agricultural land. The City is also transected by a man-made waterway - the Lewes and Rehoboth Canal which is connected to Delaware Bay via Roosevelt Inlet. Map A- 1 in Appendix A, an aerial photograph of the Lewes vicinity, shows the City of Lewes municipal boundaries and the surrounding area.

Lewes has a total area of 4.2 square miles and is comprised of residential neighborhoods, a central business district, a beachfront area that extends five miles along the Delaware Bay shoreline, and an active canalfront/ harbor area in the center of town. The City's topography is generally flat, ranging from sea level along the shores of Delaware Bay to approximately 20+ feet above sea level at some of the highest points in the City center area.

The town is probably best characterized by the core values identified as part of the 1992 Lewes Long Range Plan and updated by the Lewes Planning Commission in 2001. The following core values have been developed to help guide decision-making in the community:

- Lewes has a special and historic relationship with the sea.
- Lewes is a community of diversity.
- Lewes values its human town scale and sense of face-to-face intimacy that is characteristic of its quality of life.
- Lewes is a town of busy days and quiet nights.
- Lewes recognizes and maintains its internal communities.
- Lewes has unique historical origins and strives to highlight its heritage through building design and architectural preservation.

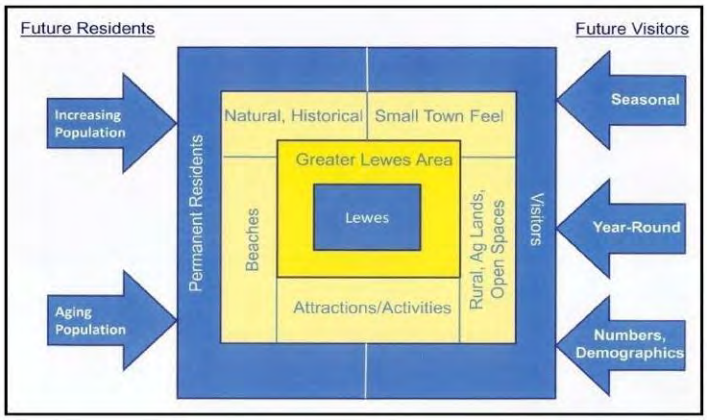

Figure 1.1: A conceptual model of Lewes and its attraction to residents and visitors (Lewes FutureScan, 2008, p. 4).

Lewes FutureScan, a 2008 report prepared by Delaware Sea Grant for the Greater Lewes Foundation, provides an overview of Lewes and the surrounding region with regard to core values, general characteristics, growth, development and changing demographics. As generated by the FutureScan project, Figure 1.1 is a visual

representation of those features of Lewes that make it so attractive, as well as some of the pressures that are facing the City today that will shape its future (FutureScan, 2008, p. 4)[1].

1.1.2 Demographics

United States census data from 1930 to 2010 indicate that the population of Lewes has fluctuated over time, increasing from 1,923 residents in 1930 to an early peak of approximately 3,025 in the 1950s and 1960s. After a slight decline through the 1980s, the population increased steadily through 2005 (Lewes Comprehensive Plan, 2005, p. 6) to 3,116, which reflects a 36 percent increase in population from 1990-2005 (2005 U.S. Census data). However, from 2005 to 2010, Lewes experienced a 12% decline in population to a total of 2,747 residents (2010 U.S. Census data). Map A-2 in Appendix A shows the City of Lewes 2010 population distribution by block group (2010 U.S. Census data). The Delaware Population Consortium (DPC) estimates that the City of Lewes' population is projected to grow to over 3,500 residents by 2020, and this estimate could be greater with potential annexation of a planned development adjacent to the City (FutureScan, 2008, p. 7).

It should be noted that population estimates provided by the U.S. Census reflect a count of people at their place of residence on April 1 of the census year – therefore, this 2,747 resident population number does not include all seasonal residents. It is estimated that the number of seasonal residents almost doubles the population of Lewes during summer months to 6,235. When summer employees and day visitors to Lewes Beach, the Cape May – Lewes Ferry, Cape Henlopen State Park, and other local attractions are considered, an additional 10,000 people could be added to the City's population on any given summer day (Lewes Comprehensive Plan, 2005, p. 10).

Figure 1.2: Lewes Harbor as viewed from Savannah Road Bridge.

[1] A general synopsis of FutureScan project findings is included here, but the reader is referred to the Lewes FutureScan (2008) report and the City of Lewes Comprehensive Plan (2005) for additional details and information.

Lewes is generally characterized by an older population, with a median age of 62.6 years. Forty-four (44) percent of Lewes residents are age 65 or older (2010 U.S. Census data). In 2000, 13.6 percent of Lewes residents were children (ages 0-17) (2000 U.S. Census data), and by 2010, only 9 percent of Lewes residents are reported to be between the ages of 0-17 (2010 U.S. Census data). The 2000 U.S. Census also reports that 42.5 percent of Lewes residents have at least an undergraduate college degree, and a median household income of $41,707 (which is higher than the U.S. average). Moreover, 6.6 percent of Lewes households reported incomes exceeding $150,000 (FutureScan, 2008). U.S. Census results also show that as of 2010, Lewes is somewhat less diverse than either Sussex County or the State of Delaware, and is becoming less diverse over time. The 2010 Census reports the following distribution of race percentages for the City of Lewes: 90 percent white residents, 8 percent black residents, and 2 percent people of other races (2010 U.S. Census data). The measurable portion of Lewes' minority population experienced a decrease of 2.7 percent over the past ten years. When 1990 and 2010 data are compared, the measureable portion of Lewes' minority population experienced a decrease of 5.6 percent over that 20 year period.

1.1.3 Economic Development, Land Use, and Zoning

As identified by the Lewes Comprehensive Plan in 2005 and confirmed by the City of Lewes in 2008 (FutureScan, 2008) and during the 2010 workshops that were part of this project, tourism is currently the primary focus of the Lewes economy. Hotel rooms, seasonal homes, bed-and-breakfast businesses, and a variety of conference facilities can provide accommodations for approximately 3,400 overnight visitors at any given time.

The town's economy is dominated by the retail sector, the center of which is the pedestrian-focused downtown area with shops, restaurants, and historic structures, but many maritime-related businesses are also major economic contributors (FutureScan, 2008, p. 10). The recreational fishing industry, including charter and head boats, service and storage of recreational vessels, and support services and launching of trailered boats are also important to the Lewes job sector. The professional service industry (e.g. doctors and lawyers) comprises 43 percent of the local work force, with many doctors and medical personnel drawn to the area by Beebe Medical Center (FutureScan, 2008, p. 10). Approximately 30 percent of the workforce is in the retail field, 10 percent in construction, 4 percent in public administration (City, County, State or Federal), 3 percent in providing services for other businesses, 3 percent in manufacturing, 3 percent providing personal services, 2 percent in finance, insurance and real estate, and 2 percent in transportation, communications, and public utilities. With the exception of SPI Pharma, there is very little industrial activity in Lewes (FutureScan, 2008, p. 10).

Land use planning has become an important topic in Lewes and surrounding areas. In 2008, the Lewes FutureScan project evaluated land use in and around the City of Lewes. Planning issues for land, natural resources, and basic infrastructure needs are wide ranging, and span from planning for increasing uses in the adjacent Cape Henlopen State Park to dealing with increasing daily visitor traffic in central Lewes (Figure 1.3). During public meetings with stakeholders and local residents convened by the Lewes FutureScan project, there was an overwhelming feeling that in order for Lewes to be properly managed for the future, communication among residents, development interests, and various state and local agencies is imperative (FutureScan, 2008, p. 12). Regional land use planning coordination efforts are

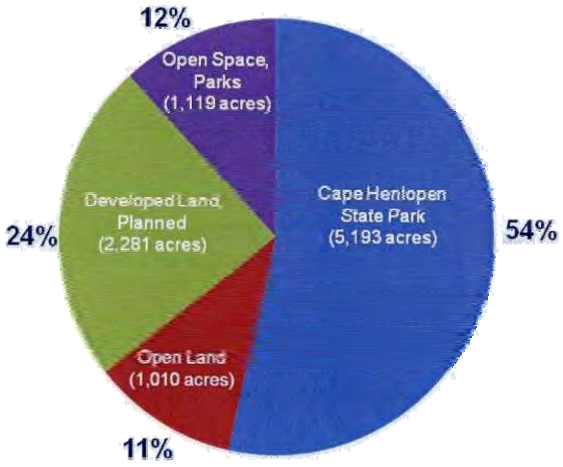

Figure 1.3: 2008 land use in and around the City of Lewes (Lewes FutureScan, 2008, p. 12).

presently underway. Map A-3 in Appendix A is the base map used for the Planning for Prosperity in the Cape Sub-Region project, including participating municipalities and the extent of land area included in the current regional planning effort.

The Lewes Comprehensive Plan (2005) provides an overview and summary of 2003 existing land uses in Lewes (Map A-4). As shown in Figure 1.4, Open Space represents the single largest area of land use in Lewes (37.3 percent of total acreage). The Open Space land use category includes lands that are undeveloped and are likely to remain undeveloped such as the canal and bordering wetlands, Canary Creek, the Great Marsh and portions of Cape Henlopen State Park. With more than 159 acres of Lewes dedicated to parklands, land use designated as Parks comprises another 6.2 percent of City space. Residential (16 percent) and Vacant Land (15 percent) together represent approximately another third of the total acreage in Lewes and the Institutional land use category (government and community services) comprises approximately 10 percent of Lewes' acreage. Commercial land use includes property that is used for conducting business involving retail sales and services. Approximately 2.6 percent of Lewes land area (104 properties) is in commercial use, primarily located on Second Street and along Savannah Road. Concentrated along Freeman Highway, Industrial use areas comprise only 1.9 percent of total acreage in Lewes. Roads (8.8 percent) and Utilities (1.7 percent) comprise the remaining acreage of land area (Lewes Comprehensive Plan, 2005, p. 19).

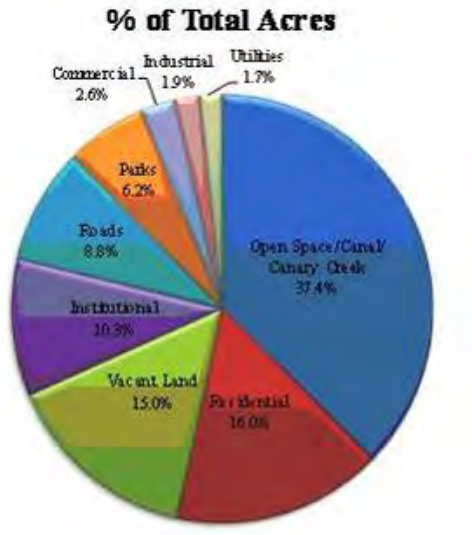

Figure 1.4: Current Lewes land use based on 2005 Lewes Comprehensive Plan data.

As shown in Map A-5, existing zoning designations in the City of Lewes include: Open Space, Old Town, Lewes Beach Residential, Old Town Development District, Commercial Core, Commercial / Business, Commercial / Residential (on Lewes Beach and on Savannah Road), University or College, Community Facilities, and Industrial. The City is presently evaluating and considering proposed amendments to the City Zoning Code (Chapter 197) and zoning map as prepared by the Lewes Planning Commission in October 2010 (additional information regarding proposed amendments to the City of Lewes Zoning Code is currently available through the City of Lewes website: www.ci.lewes.de.us).

1.1.4 Hazard Mitigation Projects and Programs

The City of Lewes presents a unique opportunity to develop and implement an integrated coastal hazards mitigation and climate change adaptation plan. Lewes is an interested and active community that has already engaged in hazard mitigation projects and collaborative community planning efforts. There are two existing groups within Lewes – the Lewes Mitigation Planning Team and the Lewes Planning Commission – that have done excellent work to move the City forward from a hazard mitigation and community cohesiveness perspective.

The Lewes Mitigation Planning Team was appointed by former Mayor George H. P. Smith and City Council on March 18, 2002 in order to establish an ongoing hazard mitigation program for the City. The purpose of the Team is to carry on the pre-disaster mitigation initiatives that began in 1998 with the City's designation by the Federal Emergency Management Agency (FEMA) as a "Project Impact" Community. The members of the Mitigation Planning Team (MPT) work in partnership with Local, State and Federal representatives and agencies to make the community more resistant to disasters by implementing actions to reduce the City's

vulnerability. The Lewes Mitigation Planning Team work products and plans (listed below) provide a strong foundation for continued hazard mitigation efforts and climate change integration:

1. Participant in the National Flood Insurance Program (NFIP) (1977-present): The City of Lewes participates in the NFIP by adopting and enforcing floodplain management ordinances and construction standards to reduce future flood damage. In exchange, the NFIP makes federally-backed flood insurance available to homeowners, renters, and business owners in the community. Flood insurance is designed to provide an alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods. Buildings constructed in compliance with NFIP building standards suffer approximately 80 percent less damage annually than those not built in compliance. The NFIP also provides Flood Insurance Rate Maps (FIRMs) for the City that depict the location of flood hazard zones, provide data needed for floodplain management programs, and provide a basis to actuarially rate new construction for flood insurance.

2. FEMA's Project Impact Initiative (1998-2001): The purpose of the Project Impact Disaster Resistant Community Initiative was to reduce the risk of natural hazard losses within the City of Lewes. The City addressed risks and vulnerabilities related to natural hazards, primarily flooding and wind damage from coastal storms (hurricanes and northeasters) and reduced risk through strengthening the City's geographic information system (GIS), conducting a comprehensive analysis of the City's infrastructure and hazard vulnerability, developing a flood mitigation plan, promoting awareness about Project Impact, including education about hazards that may impact the City, and upgrading emergency communication and warning systems within the City. In addition, Lewes developed a Multi-Hazard Loss Reduction Plan to address structural retrofitting and mitigation actions identified by the Hazard Vulnerability Analysis. The initiative actively established partnerships that included the City of Lewes, County and State governmental entities, private companies, voluntary and professional associations, academic institutions, community organizations and interested members of the public.

3. Flood Mitigation Plan (1999): Funded and supported by the Lewes/FEMA Project Impact Initiative, this plan establishes a comprehensive strategy for implementing technically feasible flood mitigation activities for Lewes.

4. Hazard Vulnerability Study (2000): Also funded and supported by the Lewes/FEMA Project Impact Initiative, this study identifies and provides goals for mitigating natural hazards that have the potential to cause serious damage to Lewes.

5. The City of Lewes Hazard Mitigation Strategy (2004-2009; updated 2009-2013): This hazard mitigation plan is part of the Sussex County Multi-Jurisdictional Hazard Mitigation Plan, and it establishes a broad community plan for reducing hazard risks by proposing specific actions to eliminate or reduce identified vulnerabilities.

Additionally, Lewes has an active Planning Commission and a solid comprehensive plan that could be enhanced and/or amended to include climate adaptation strategies and best-practice recommendations. The City's current comprehensive plan, adopted and certified in October 2005, identifies several critical issues that should be addressed to maintain current community character and quality of life, many of which are pertinent to hazards/climate change adaptation, including:

1. Drinking water and irrigation: The Board of Public Works expressed concern that a large quantity of drinking water was being used for irrigation during the summer of 2002. This seems excessive, particularly since the State was under drought conditions and had imposed water restrictions.

2. Drinking water: Saltwater intrusion into the aquifer is a major concern of Lewes. In the 1940s, the City relocated its wells inland to their present location as a result of saltwater intrusion into earlier wells. The current well field is located as far from the Bay as possible and is not currently within municipal limits. While the aquifer is considered safe for now, it may only be a matter of time until these wells are contaminated by saltwater.

3. Total maximum daily load: The location of the wastewater treatment facility is identified as a concern, along with discharge into Lewes/Rehoboth Canal.

4. Stormwater management: Lewes is generally characterized by flat topographic conditions which can cause difficult situations for stormwater management. In addition, many areas of Lewes are vulnerable to inundation from storm surge/tides and higher than normal lunar (spring) tides.

5. Flooding: Although a significant portion of Lewes is within the FEMA flood zone, there are still many older homes within the 500-year-flood zone that do not qualify for FEMA assistance.

The Comprehensive Plan includes several recommendations related to natural hazards and climate change. These recommendations are varied and range from developing/adopting a wellhead-recharge-protection ordinance to seeking opportunities to upgrade the City's drainage system and preventing flooding during storm events to encouraging the City to explore alternative sources of energy.

The City of Lewes has been and will continue to be directly impacted by natural hazards including storms, flooding/inundation and high winds. Additionally, like other coastal cities, climate change will impact Lewes directly through continuous sea-level rise, increased coastal erosion, changes to wet/dry seasons that can cause both severe drought and higher volume precipitation and associated floods that impact both natural systems and the built environment. Lewes' government and citizens will also be impacted by increasing strains upon and costs of maintaining infrastructure, as well as costs associated with properties at risk with uncertain actuarial futures (e.g., costs of flood insurance).

1.2 General Overview of the Project

The overall goal of the Hazard Mitigation and Climate Adaptation project is to provide assistance and guidance to the City of Lewes in the development of a unified plan for natural hazard mitigation and climate change adaptation that will improve community sustainability and resilience. Local officials and residents have been engaged throughout this process to determine the City's greatest existing and future vulnerabilities and to chart a course of action to reduce these vulnerabilities. With this goal in mind, the following objectives were the focus of this project:

- Increase overall awareness of the threats from natural hazards and climate change and create outreach materials for City officials to keep citizens and others informed.
- Design a methodology that integrates climate change adaptation into hazard mitigation planning which will enable the City, in the future, to engage in a combined hazard mitigation and climate adaptation planning effort.
- Enhance the understanding of Lewes' vulnerability to climate change and natural hazards and identify data gaps related to natural hazards, climate change and associated threats.
- Utilize a prioritization system to select 2 – 4 climate adaptation/hazard mitigation initiatives from national best adaptation/preparedness strategies for coastal communities.
- Create a final action plan that the City can use to implement the chosen initiatives.

1.3 General Overview of the Methodology

The methodology used in the planning process was based on an effort to unite two different processes – ICLEI's Climate Resilient Communities™ Five Milestones for Climate Adaptation planning framework (Figure 1.5) and natural hazard mitigation planning frameworks from the Federal Emergency Management Agency (FEMA) and the National Oceanographic and Atmospheric Administration (NOAA).

ICLEI's planning process is a performance-based framework that includes the following Five Milestones:

- **Milestone 1:** Conduct a Climate Vulnerability Assessment
- **Milestone 2:** Set Preparedness Goals
- **Milestone 3:** Develop a Preparedness Plan
- **Milestone 4:** Implement Preparedness Plan
- **Milestone 5:** Measure Progress and Re-evaluate

Figure 1.5: ICLEI's Climate Resilient Communities™ Five Milestones for Climate Adaptation.

FEMA's process has the following steps and associated subtasks outlined below for all multi-hazard mitigation planning:

- **Step 1:** Conduct a Risk Assessment
  - Identifying Hazards
  - Profiling Hazards
  - Assessing Vulnerability
- **Step 2:** Create Hazard Mitigation Strategy
  - Local Hazard Mitigation Goals
  - Identification and Analysis of Mitigation Actions
  - Implementation of Mitigation Actions
- **Step 3:** Plan Maintenance
  - Monitoring, Evaluating and Updating the Plan
  - Incorporation into Existing Planning Mechanisms
  - Continued Public Involvement

NOAA's guidance focuses on conducting a self-assessment of hazards and vulnerabilities as further detailed in Section 5.3.

Using the ICLEI, FEMA, and NOAA frameworks as guides, the research team created five general steps to administer this project. However, to be successful, the research team recognized that local stakeholder input would be necessary at each step. This input was gathered primarily through four workshops and several meetings held in Lewes between July 2010 and January 2011. The first workshop, held by invitation included key local stakeholders – City staff, City Board/Commission members, and Regional/State partners; however, all subsequent meetings were open to the public[2]. The five steps created for this project include:

- **Step 1: Identify existing hazards and associated vulnerabilities**
  - Information was gathered from prior analyses in order to document the historic trends of natural hazards in Lewes where possible and in Sussex County in general.

[2] The presentations and notes from these workshops can be found at http://www.icleiusa.org/lewesmeeting.

- A workshop was held in July of 2010 (Workshop 1) where participants were divided into four groups – 1) Critical Facilities, 2) Society, 3) Economy, and 4) Environmental Resources – and asked to identify resources in their sector that would be or already are impacted by the 100-year storm event according to FEMA's flood insurance study (January 6, 2005) and Flood Insurance Rate Maps (FIRMs).

- **Step 2: Identify climate change impacts on existing hazards and associated vulnerabilities**
  - Regional climate change assessments were used to better understand the range of potential changing climate conditions in Lewes. Specifically, reports for Maryland, Delaware, New Jersey and the Northeast were consulted on potential temperature and precipitation changes, while additional state level analyses were used to create a range of potential future sea level rise scenarios.
  - Potential natural hazard impacts were derived by the researchers from these reports as well as a basic understanding of natural hazard processes.
  - These vulnerabilities were presented at a second workshop (October 21, 2010) and workshop participants were asked to revise, comment or add additional areas of concern.
- **Step 3: Identify two key vulnerabilities for which to plan**
  - During the second workshop held in October of 2010, workshop participants listed their top three specific concerns and the climate change impact that was the cause of those concerns. For a complete list of concerns see Appendix D. These concerns were then aggregated into themes, focusing on the primary system that was likely to be impacted. The systems identified through this process were beaches, critical facilities, economy, emergency services, environment, food/agriculture, health, homes, infrastructure, social, transportation, water, and wastewater.
  - Participants then voted (each participant had three votes) on the system that was of greatest concern to them. The water system and its vulnerability to changing precipitation patterns and homes (to which land use was added) and their vulnerability to flooding received the most votes.
- **Step 4: Select hazard mitigation/climate adaptation actions**
  - During Workshop 2 in October 2010, participants were divided into two groups – water and homes/land use – associated with the key vulnerabilities identified above. Participants then proposed several actions that could be used to lessen these vulnerabilities.
  - Best practices for home flooding risks, City infrastructure flooding risks and water resource risks were presented by ICLEI, DEMA, DNREC and FEMA during Workshop 3 in December 2010.
  - Workshop 3 participants worked in groups to narrow a complete list of possible hazard mitigation/climate change adaptation actions (see Appendix E) down to the 5 top actions for each of the three categories (homes, City infrastructure and water resources).
  - During workshop 4, participants were broken into 5 groups and asked to rank proposed actions with a score of 1 – 5 for the action's social, technical, administrative, political, economic and environmental feasibility/benefit. See Appendix F for further ranking materials.
  - Averaging across the groups (see Appendix F for collective scores) the 6 highest ranked actions were selected to recommend that the City work towards implementing.
- **Step 5: Create implementation plans**
  - Lead contacts for each of the 6 actions selected were identified by representatives of the hazard mitigation planning team, City council and City staff.
  - Working directly with these leads through phone conversations, one-on-one meetings, and written feedback, implementation plans were drafted and revised identifying how each of the 6 actions could move forward and be brought to fruition.

Section 2: Why Plan to Mitigate Natural Hazards and Adapt to Climate Change

Lewes, Delaware, is highly vulnerable to many natural hazards including coastal storms, flooding and high winds. With the climate changing and thus increasing the threats from natural hazards, the City is becoming increasingly vulnerable. To that end, a study by Greenhorne and O'Mara (2000) concluded that 1/3 of all parcels in the City are within the FEMA 100-year (1 percent chance) floodplain and that such an event could cause $23.8 million in flood damages. Additionally, Lewes has multiple main roads serving as primary evacuation routes for the City that are within the current FEMA 100-year floodplain, which, if flooded, could result in extremely limited access to critical facilities during major flood events. This same study found that all properties and many critical facilities within the City are at risk of damage from high wind events.

Current and past human actions are known to be causing alterations in the earth's atmosphere that have and will continue to result in changes in climate. There are many indications that these changes are already underway: temperatures are rising, glaciers are retreating, snowpack is disappearing, spring is arriving earlier, and seas are rising. These changes will exacerbate hazards in Lewes in a number of ways. Temperature increases will lead to more heat waves, while shifting precipitation patterns and rising seas will result in increased flooding. Some of the most extreme impacts associated with a changing climate might still be avoidable by taking actions to reduce greenhouse gas (GHG); however, even if greenhouse gas emissions are cut to zero, Lewes will continue to experience changes for decades to come due to the inertia in the climate systems. While these changes cannot be prevented, the effects of these events are dependent upon the choices and actions that Lewes makes today.

Given these known natural hazard risks and the ever-increasing certainty of climate change impacts, there are a number of reasons for municipalities in general and Lewes in particular to proactively mitigate natural hazards and adapt to climate change. First, today's choices will shape tomorrow's communities and determine how vulnerable or resilient a community will be. Therefore, since a role of local governments is to provide a safe and sustainable home for its citizens, it is imperative that communities take action today to mitigate natural hazards and adapt to climate change as this will help provide a strong and resilient community in the future. Additionally, due to the fact that significant time is required to motivate, develop adaptive capacity, and to implement changes, acting now will allow for the time needed to achieve these long-term goals.

Another major reason to begin enhancing Lewes' hazard mitigation efforts with climate change adaptation is that proactive planning is often more effective and less costly than reactive planning, and can provide immediate benefits. Moreover, significant cost savings can be seen through hazard mitigation efforts. According to the National Institute of Building Sciences, on average, every dollar spent by FEMA on natural hazard mitigation resulted in $4 of future benefits (National Institute of Building Science, 2005). Climate change adaptation being a much broader concept cannot be assessed in such specific cost terms; however, it is generally thought that climate change adaptation planning will lead to actions that are cost-effective and will save municipal budgets in the future.

Finally, climate change impacts are projected to get worse in the coming years; therefore, acting today will help prepare Lewes for these worsening impacts. By gathering further knowledge about the City's vulnerability, creating an engaged and committed community and by taking proactive steps to reduce the City's vulnerability, Lewes will set itself up to be ready for the increased threats that climate change poses to its natural hazard risks.

Section 3: Overview of Current Natural Hazards

3.1 Identification and Profile of Current Natural Hazards in Lewes, Delaware

Natural hazards identified as potential threats for the City of Lewes include, in order of significance to the City, coastal storms, flooding, severe thunderstorms, wind, winter storms, drought, extreme heat, wildfire, erosion, tornadoes and tsunamis. Amongst these hazards, some are a specific event that has multiple other listed hazards associated with it, while others are the focused impact that could be caused by different natural events. For example, a coastal storm could cause wind, flooding, and coastal erosion. Flooding on the other hand is an impact that can be caused by many of the listed storm events.

The following self-assessment of these hazards includes an overview of the specific hazard and examples of the hazard occurring in Lewes. This information has been compiled from a review of recent reports prepared for Sussex County (2010) and the City of Lewes (Greenhorne & O'Mara, 1999 and 2000), as well as recent discussions with the Lewes Mitigation Planning Team and results from break-out sessions conducted during the Lewes project workshop held on July 14, 2010. Additionally, for several of the identified hazards such as floods and tornadoes, maps are provided that identify risk areas that are likely to be affected by the hazards. For example, risk areas for flooding were mapped using output from FEMA's Flood Insurance Rate Maps (FIRMs). The FIRMS are developed from the output of hydrologic models, identifying areas with a high potential for flooding. The Sussex County (2010) report includes detailed tables and charts related to county-wide natural hazards and vulnerabilities; the data that are specifically relevant to the City of Lewes and vicinity are included in Appendix B.

3.1.1 Coastal Storms - Tropical Systems and Northeasters

Coastal storms are primary and significant hazards in Delaware and they play a major role in shaping the shoreline. Lewes can be affected by two types of coastal storm systems: tropical systems and extratropical systems (often called northeasters). Tropical systems, which include tropical depressions, tropical storms, and hurricanes, have strong winds circulating around a well-defined center. They generally originate in the warm waters of the Atlantic Ocean, Caribbean Sea, or Gulf of Mexico. Extratropical systems develop outside of the tropics and typically result from development of one or more low pressure systems, with winds blowing from the northeast as the storm passes by the coast. While the season for tropical systems runs from June 1 through November 30th, northeasters are a year-round threat to coastal Delaware and the City of Lewes.

Tropical Systems: Tropical storms are a type of tropical system characterized by sustained winds averaging from 39 to 74 miles per hour (mph). When sustained winds intensify to speeds greater than 74 mph, the resulting tropical system is called a hurricane. Since records have been collected, the State of Delaware has never experienced a direct hit by a hurricane, but tropical systems (including tropical depressions, tropical storms, and/or hurricanes) have passed over and near Delaware annually, usually accompanied by high waves, high tides, and heavy rainfall.

Northeasters or Extratropical Systems: While not as powerful in terms of wind speeds as hurricanes, northeasters occur more frequently in Delaware. Because they cover a larger area and are typically slow moving storms, northeasters usually affect a large portion of the coast and exert significant impacts on beaches, dunes, buildings and roads over several successive tides. Northeasters are most damaging when they stall off the coast, as is evidenced by the coastal storm of record in Delaware – the March 1962 storm.

Figure 3.1: Flooded roadway (New Road) during 2008 northeaster.

Coastal storm impacts: Although the origins of these storms differ, tropical systems and northeasters share many characteristics, and their impacts on the coast can be similar. Both types of storms are characterized by strong winds, high waves and storm surges causing higher storm tides. High winds can blow shingles off roofs, and knock down trees and power lines. Large objects can be lifted and blown through the air, thus becoming hurling projectiles and causing additional destruction. The effect of torrential rainfall that accompanies these storms often includes overtopping of creeks, streams and rivers, as well as flooding of roadways and homes. High waves, tides and storm surge result in extensive flooding of low-lying coastal areas (Figure 3.1). Structural debris that ends up in the turbulent water can act as battering rams, increasing the amount of damage done to buildings, particularly foundations.

Coastal storms can cause extensive beach and dune erosion, which results in the destruction of dunes, narrowing of the beach or overwash of the beach and dune system. Sand and water may wash over or break through the dunes and rush over property and streets behind the dune. When overwash occurs, breaking waves and high velocity currents can cause extensive damage to properties located behind the breached dune system.

History of coastal storms in the Lewes area: Historical data indicate that both tropical systems and northeasters have caused significant damage to the Delaware Coast. However, both coastal Delaware and the City of Lewes are most susceptible to flooding caused by extratropical coastal storms known as northeasters. Historically, northeasters have resulted in the heaviest rainfalls, highest tides, and most significant damage to the coast. These slow-moving storms allow ocean tides and storm surge to cause water levels to rise in Delaware Bay and the Lewes/Rehoboth Canal. Rising water levels in the Lewes/Rehoboth canal results in flooding of low-lying areas and could potentially cause significant damage to the City of Lewes.


Figure 3.2: Flooding in Lewes during the 1962 Ash Wednesday Storm.

The most damaging coastal storm to impact Lewes is a northeaster that occurred in March 1962 (Figure 3.2). The March (Ash Wednesday) 1962 storm was extremely severe because it stalled off the Delaware coast through five successive high tides. The extreme storm surge combined with strong northeast winds and wind-driven waves, produced a

record high tide of 9.5 feet above mean lower low water (mllw) registered at the Lewes Breakwater Harbor tide gauge (maximum stillwater elevation of +8.1 feet NGVD). The Lewes/Rehoboth Canal overflowed, resulting in flood damage to many homes along Lewes Beach as well as damage to many canal-side structures. High water marks reported by Lewes residents put flood levels at the intersection of Savannah Road and Cape Henlopen Drive at +8.61 ft NGVD 29. Similarly, flood levels at the corner of New Hampshire and Cedar Avenues were reported to be +8.92 ft NGVD 29 (Greenhorne & O'Mara, 1999, p. 9).

Figure 3.3: Lewes Beach roadway flooding during 1998 northeaster.

More recently, back-to-back northeasters in January and February 1998 produced heavy rains, high winds, waves, and extreme tides. The high tide during the January storm was 9 feet (4.3 feet above normal) above mean lower low water (mllw). Wind gusts exceeded hurricane strength (> 80 mph) in the vicinity of Indian River Inlet, and gusts reached 70 mph at the Lewes Pilot Tower. Eight to ten foot seas were reported at the breakwater on Delaware Bay. The Lewes/Rehoboth Canal flooded into adjacent low-lying areas of Lewes Beach. Flooding was described as "deep" and "unheard of" in Lewes, as flooding reached Bay Avenue and Cedar Street (Figure 3.3). Several streets were barricaded because of the flooding and numerous cars were damaged. About 10,000 homes and businesses in the state lost power, primarily in Sussex County, although no serious injuries were reported. Damage estimates were approximately $1.3 million for the January storm and $1.7 million for the February storm (Greenhorne & O'Mara, 1999).

A review of historical tracks of tropical storm systems within 100 nautical miles of Delaware indicates that Lewes has been affected by such storms 73 times from 1842 – 2008. Twenty-three of these were tropical depressions, tropical storms, or extratropical storms. An additional eighteen were Category 1 hurricanes before they were downgraded to tropical storm status (Figure 3.4). A few of the recent Category 1 hurricanes passing near Lewes include Barbara (1953), Alma (1962), Charley (1986), Bonnie (1998), and Floyd (1999). There have been twenty-five Category 2 hurricanes passing near Lewes from 1858 to present, including Carol (1954), Donna (1960), Belle (1976), and Gloria (1985). Of the eight Category 3 hurricanes to pass within 100 nautical miles of Lewes, residents will most

Figure 3.4: Historical tracks of Category 1 hurricanes (74-95 mph) passing within 150 nautical miles of Lewes from 1851 to 2008 (image courtesy NOAA Coastal Services Center).

likely recall threats imposed by Bob (1991) and Emily (1993). There are no records of Category 4 or 5 hurricanes passing within 100 nautical miles of Lewes (NOAA CSC).

Over the past century, notable hurricane damage occurred in Lewes in 1933, 1944, and 1956. The 1933 hurricane passed approximately 100 miles west of Delaware, causing higher than normal tide levels in many Delaware communities. Street flooding and flood-related damage to structures was widespread. The 1944 hurricane passed within 50 miles of the Delaware coast. Lewes experienced flooding that warranted evacuating residents from homes along the beach. In 1956, Hurricane Flossy caused severe flooding along the entire Delaware coast. Greenhorne & O'Mara (1999) reported that road crews in Lewes used 500 tons of broken concrete, gravel and boulders in an attempt to prevent storm surge flooding. However, combined winds and high tides caused serious damage to the community (Greenhorne & O'Mara, 1999, p. 9).

Statistically speaking, a tropical system (hurricane, tropical storm, or tropical depression) passes over or near the Delaware/Maryland coast an average of once every two years, and a hurricane passes within 150 miles of the mid-Atlantic once every five years (Greenhorne & O'Mara, 2000). The last Category 3 hurricane (110-130 mph winds) to pass within 150 miles of the Delaware/Maryland coast was Hurricane Bob in 1991. From 2000 – 2009, twelve tropical systems have passed within 100 miles of Lewes (Figure 3.5). The Sussex County (2010) All Hazard Mitigation Plan includes a list of coastal storm events accompanied by significant coastal flooding that have impacted people, property and the environment (see Table 3.1).

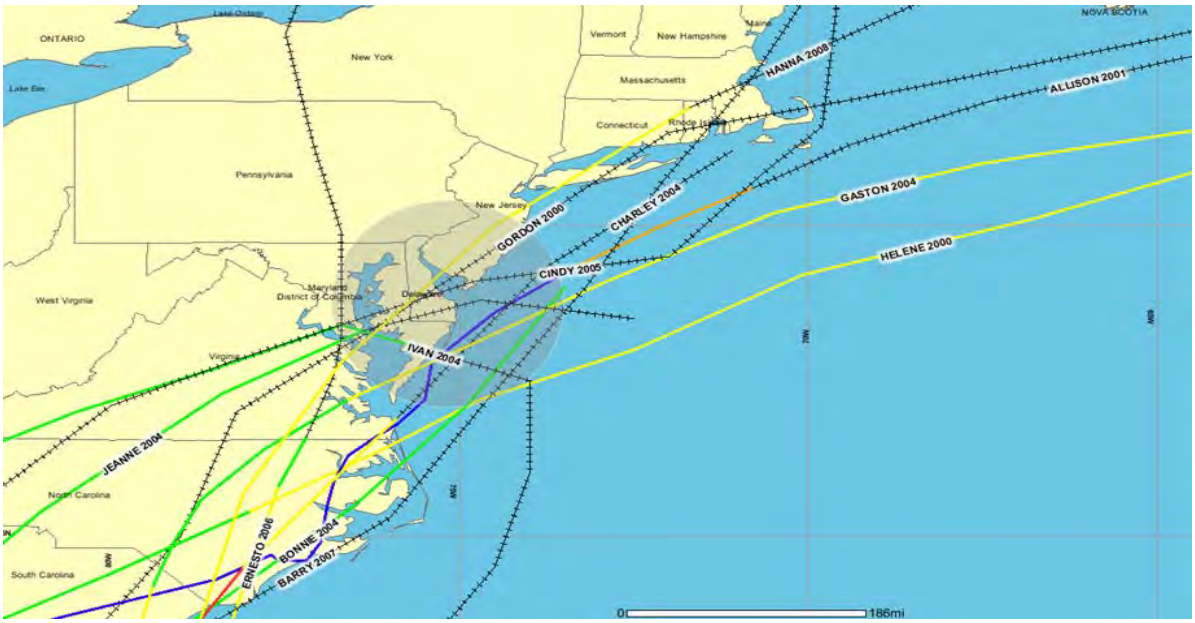

Figure 3.5: Tracks of tropical systems passing within 100 nautical miles of Lewes from 2000 to 2009 (image courtesy of NOAA Coastal Services Center).

Table 3.1 Coastal storm and flood events that have impacted Sussex County from 1992-2009. Note that property damage estimates are county-wide and not specific to Lewes (Sussex County, 2010).

Storm Type	Date	General Impacts	Tide Height	Wind Speed	Property Damage $$
Northeaster	3/13/1992	Minor coastal flooding; beach erosion; street flooding in Dewey and Rt. 1	n/a	n/a	$50,000 reported
Northeaster	12/20/1995	Minor tidal flooding	n/a	n/a	n/a
Tropical Storm	Bertha; 7/13/1996	Wind damage; minor tidal flooding; minor beach erosion; heavy rain; flooding related to poor drainage			
Northeaster	6/2/1997	Minor tidal flooding; heavy surf; beach erosion	+2' above normal	48 mph gust	n/a
Northeaster	11/7/1997	Widespread but minor tidal flooding; beach erosion	+3.5' above normal; Lewes tide +7.1' mlw	n/a	n/a
Northeaster	11/14/1997	Moderate tidal flooding; beach erosion	+2' above normal; Lewes tide +7.5' mlw	n/a	n/a
Northeaster	12/29/1997	Minor tidal flooding	+2.5' above normal; Lewes tide +6.1' mlw	n/a	n/a
Northeaster	1/28/1998	Severe coastal flooding; beach erosion; strong winds; heavy rain	+4.3' above normal; Lewes tide +9.0' mllw	65, 70, and >80 mph gusts;	$1.3 million
Northeaster	2/4/1998	Severe coastal flooding; extensive beach erosion; damaging winds; heavy rain	+4.5' above normal; Lewes tide +8.6' mlw		$1.7 million
Northeaster	5/11/1998	Minor to moderate coastal flooding; beach erosion	Lewes tide +6.7' mlw		
Hurricane	Floyd; 9/16/1999	Torrential rains (10.58" in Sussex County); damaging winds; widespread flash flooding;			$8 million
Northeaster	9/5/2000	Minor tidal flooding	+2.3' above normal; Lewes tide +7.1' mlw		
Northeaster	9/29/2000	Minor to locally moderate tidal flooding; beach erosion	Lewes tide +6.7' mlw		
Tropical Storm Henri(remnants)	2003				
Hurricane Isabel	2003				
Northeaster &remnants of TS Ernesto	9/1/2006	Heavy rain; flooding; damaging winds; tidal flooding; high waves; beach erosion			
Northeaster	10/6/2006	Tidal flooding; heavy rain; strong winds; beach erosion;	Lewes tide +7.4' mllw	50 mph gusts	
Northeaster	5/12/2008	Minor to moderate tidal flooding; heavy rain; street flooding; high waves; beach erosion			
Tropical Storm Hannah	2008				
Northeaster	10/16/2009	Minor to moderate tidal flooding; heavy surf; high waves; beach erosion; flooded roadways			
Northeaster	11/12/2009	Moderate tidal flooding; heavy rain; severe beach erosion; street flooding and closures;	+4.5' above normal; Lewes tide +7.88' mllw	60 mph gusts	$45 million

3.1.2 Floods

Flooding, which refers to the circumstance of normally dry land being covered by water for a limited period of time, differs from inundation, which is when land that was once dry becomes permanently wet. Flooding in Lewes can be coastal or inland in nature. Coastal flooding is caused by high tides and storm surge from several different storm events – coastal storms (described above), thunderstorms and winter storms (described below). Inland flooding is related to excessive precipitation, run-off and infiltration factors that are affected by general topographic drainage features and elevation of infrastructure relative to the floodplain throughout

Lewes. Both coastal and inland flooding are not only threats to human life, but can also cause extensive damage to property.

At first glance, the link between inland flooding and coastal storms may not be obvious; however, torrential rainfall (6 inches or more of precipitation) typically accompanies tropical storm systems and can produce deadly and destructive flooding. Both tropical systems and northeasters can bring rain in large volumes and long duration, which may cause extensive flooding in both coastal and non-coastal areas. Typically, greater rainfall amounts and flooding are associated with tropical systems that have a slow forward speed or stall over an area. This is a major threat to inland areas in Delaware and all residents should be aware that the impact of coastal storms is not limited to shorelines but can be widespread throughout the region.

Inland flooding: In general, there are two types of inland flooding – riverine flooding and flash flooding. Riverine flooding occurs from heavy rains and excessive run-off volumes within the watershed of a stream or river. In extreme cases, riverine floods can last a week or more. Flash flooding occurs in creeks, streams, and urban areas within a few minutes or hours of excessive rainfall. The type of heavy rainfall that causes flash flood conditions can result from slow-moving thunderstorms or heavy precipitation associated with tropical systems. Rapidly rising water can reach heights of 10 feet or more and flood waters move at very high speeds. Flash flooding occurs in natural waterways but is also common in urbanized areas with impervious surfaces. Urban flooding causes problems when storm drains become overwhelmed or clogged by debris and may be exacerbated in areas where development has impacted or restricted stream flow and increased impermeable surfaces.

Flooding in the Lewes area: Much of the following flood hazard information has been gathered from two reports completed in 1999 and 2000 by Greenhorne & O'Mara for the City of Lewes - *A Flood Mitigation Plan for the City of Lewes* and *The Hazard Vulnerability Study for the City of Lewes* – as well as the *Sussex County 2010 Multi-Jurisdictional All Hazard Mitigation Plan Update.* These studies identify flood hazards based on 1) large-scale design events which are predicated on a 100-year probabilistic storm event, or an event that has a 1 percent chance of occurring in any given year, and 2) events that have actually occurred in the past.

1) Design Events – the 100-Year Storm: FEMA's Flood Insurance Rate Maps (FIRMs) can be used to determine areas within Lewes that fall within the designated floodplain, considered on these maps to be the areas that can be impacted by a 100-year design event according to a FEMA study from January 6, 2005 (Map A-6). FIRMs distinguish the extent and magnitude of flooding by dividing the 100-year floodplain in Lewes into two primary flood hazard zones (e.g. VE and AE). Zone VE (velocity zone) designates areas where wind and wave action will increase the water surface elevation and cause further damages such as erosion, high velocity flows, and debris impacts due to the movement of the water. Zone AE designated areas are locations that can expect stillwater flooding from the 100-year storm.

The predicted flood elevation on the FIRMs is the expected height of flooding above the North Atlantic Vertical Datum of 1988 (NAVD 88). This value is used to subdivide both VE and AE zones (Map A-7). Areas that are not mapped as flood zones are expected to experience less than a foot of flooding during a 100-year flood event or could experience no flooding during such an event. Therefore, an area designated as AE 9 is a stillwater flooding area with an expected flood elevation of 9 feet above the designated datum elevation.

As depicted in Map A-8 in Appendix A (FEMA flood hazard map), more than one-third of all structures (898 out of 2210) in Lewes fall within 100-year floodplain boundaries and could consequently be impacted by floods. The majority of these structures are situated along Lewes Beach, the Lewes/Rehoboth Canal, and Roosevelt Inlet. Structures in Zone AE include homes south of Bay Avenue from Roosevelt Inlet to Route 9. The 1999 Greenhorne & O'Mara report identifies two high-risk areas in this zone, including Cedar Avenue from Iowa Avenue to Illinois Avenue, and the Market Street vicinity. Most of the structures in the AE Zone are residential, but commercial businesses and the City's Wastewater Treatment Plant are also located in this

Figure 3.6: Flooding in commercial/residential area (Savannah Road), Lewes Beach.

flood area (Figure 3.6). At the western end of Pilottown Road, portions of the University of Delaware campus are partially located in the 100-year floodplain as are the U.S. Coast Guard Station, Delaware DNREC's Lewes Field Facility, and several private businesses.

Several of the newer homes constructed in Lewes along Cape Henlopen Drive are located in Zone AE, including Pilot Point Townhomes and the Cape Shores Development. However, these structures are assumed to be at lower risk since post-FIRM construction requires main living floor levels to be above the 100-year storm elevation (Greenhorne & O'Mara, 1999, p. 14). The Greenhorne & O'Mara (1999) study also reports that many of the older residential homes in Zone AE have been elevated by their owners. The City of Lewes has worked with FEMA under the Hazard Mitigation Grant Program to elevate eight residential structures in this vicinity.

2) Historical Flash Flooding in Sussex County: Extreme precipitation events can cause flash floods, further contributing to stormwater management problems. A list of flash flooding events that have significantly impacted people, property and the environment over the past several decades is included in the Sussex County (2010) report. Those impacting the general Lewes vicinity (including northeast and eastern Sussex County locations) include:

- Hurricane Floyd (September 16, 1999) – Hurricane Floyd battered the State of Delaware with damaging winds and torrential rains that caused widespread flash flooding. On average, approximately 9 inches fell within a 12-hour period. The worst damage in Sussex County occurred inland.

- Severe Thunderstorm (July 15, 2000) – Thunderstorms with torrential downpours and frequent lightning caused flash flooding in northeast sections of Sussex County. The heaviest rain fell in the Cedar Creek and Broadkill Hundreds, with 12 inches of rain measured at the Rookery Golf Course. In Rehoboth Beach, 4.5 inches of rain fell in 90 minutes. Major roadways were flooded and dozens of vehicles became stranded in high water.

- Severe Thunderstorm (September 2, 2000) – Thunderstorms with torrential rain caused flash flooding in Broad Creek and Broadkill Hundreds, with 4 to 5 inches falling in those areas. Flash flooding spread across roadways and caused several major closures.

Stormwater Management: Stormwater management practices attempt to control surface and subsurface water and are especially important in areas of Lewes where tidal flood waters and/or excess runoff from precipitation events are not absorbed into the soil or conveyed into adjacent waterways (e.g., creeks, canals, Delaware Bay).

During periods of extreme tidal flooding and/or excessive precipitation, the volume of runoff can exceed a region's infiltration or drainage component, resulting in flooding. Human activities and increased development in Lewes, including less pervious area, changes in vegetation and other hydrologic factors may all contribute to reducing the process of infiltration.

The 2000 Greenhorne & O'Mara study reports that there are several issues that affect stormwater management in Lewes, including general topographic conditions, the age of some stormwater control system components, and maintenance issues in some areas (Greenhorne & O'Mara, 2000, p. 26). The study also concludes that while "the Lewes storm drain system appears to function effectively….many areas in Lewes use open channels to convey stormwater runoff. The age and failures of older stormwater conveyance structures, combined with lack of maintenance, compound these effects" (Greenhorne & O'Mara 2000, p. 26).

Over the past several years, the City of Lewes has addressed several stormwater drainage issues and localized flooding problems, including the following general areas: Washington Avenue, Brownson Court, Harborview Road, Ocean View Boulevard, and sections of Fourth Street Extended. Currently, the locations with chronic flooding problems related to coastal storms include Savannah Road between Anglers Road and Massachusetts Avenue, Cedar Avenue generally from Washington Street to Nebraska Avenue, and under heavy storm/tide conditions at the Canary Creek crossing on New Road. Occasionally, after extreme precipitation events, some flooding may occur on Cape Henlopen Drive, and there are occasional complaints from property owners in Drake Knoll, Pilottown Village, and the residents on the south side of DeVries Circle regarding flooding in the stream that runs behind their home towards the culverts under Savannah Road. (Charles O'Donnell, Henry Baynum, and Gilbert Holt, personal communication, 2011).

3.1.3 Severe Thunderstorms

Though thunderstorms typically impact a small area, they can be extremely dangerous due to their capability of generating tornadoes, hailstorms, strong winds, flash flooding, and damaging lightning. Thunderstorms are caused when air masses of varying temperatures meet, with rapidly rising warm moist air that quickly cools and condenses, serving as the energy driver of thunderstorm convection cells. These storms can move through an area very quickly or linger for several hours, with longer duration resulting in the possibility of excessive precipitation and increased likelihood of flash floods (Sussex County, 2010, Section 4.1, p. 8-9).

Lightning occurs as the result of the discharge of electrical energy within a thunderstorm. The actual lightning bolt can reach temperatures of 50,000 degrees Fahrenheit. Thunder is caused when the high temperature air surrounding the bolt is rapidly cooled by adjacent air. Lightning strikes can kill, and they can result in fire hazards to properties, trees, and natural areas (Sussex County, 2010, Section 4.1, p. 8-9).

Based on information provided by the 2010 Sussex County report and the National Climatic Data Center (NCDC), Sussex County experienced 286 thunderstorm high-wind events from January 1950 through October 2009. These countywide events resulted in two deaths, 10 injuries, and approximately $8.6 million in property damage. According to the Sussex County Report there were 9 thunderstorms in Lewes from 1997 to 2009; however, there were no thunderstorm-related deaths, injuries or property damage specifically reported for Lewes.

Analyses conducted by Sussex County (2010) reveal that there is a negligible potential normalized, annualized loss from severe thunderstorms for the City of Lewes. A total value of $14,471 is the estimated potential

normalized, annualized loss from severe thunderstorms for the greater Lewes vicinity (Minor Civil Divisions (MCD)) (summary Table 3.2).

Jurisdiction	Flood	Tropical Storm Wind	Thunder-storm	Tornado	Drought	Winter Storm
Lewes	$700,624	$7,481	Negligible	Negligible	$65,458	Negligible
MCD Lewes	$19,357,870	$367,759	$14,471	Negligible	$1,261,154	$29,303

Table 3.2: Summary table of potential normalized annualized losses from natural hazards for the City of Lewes and Lewes Minor Civil Divisions (MCD Lewes) (Sussex County, 2010).

3.1.4 Wind

Wind hazards in Lewes are generally caused by storm events such as coastal storms, thunderstorms or tornadoes. Lewes is currently included in a hurricane-susceptible region of Wind Zone II (160 mph) (Sussex County, 2010, Section 4.1, p. 13). National Weather Service (NWS) records show that during a hurricane that occurred in 1950, wind speeds exceeded 120 mph (Greenhorne & O'Mara, 2000). Eyewitness reports from Lewes during the March 1962 northeaster suggest that sustained winds were 35-45 mph, with gusts up to 70-80 mph.

Historical records show that Lewes is vulnerable to hurricane and tropical storm-force winds. Tropical systems and northeasters can produce damaging winds and tornadoes that can impact utilities, structures, and produce damaging debris. Older structures which were built before the adoption of modern wind-resistant structural techniques could be vulnerable to wind hazards. Extreme wind events can also cause significant damage to trees, which can result in permanent loss of trees, and associated secondary impacts that include damage to structures, utility lines, and blockage of roads and drainage systems.

Results from the Greenhorne & O'Mara (2000) wind analysis study reveal that while high winds could potentially impact all properties in Lewes, additional factors such as cover, trees, and quality of construction could reduce the wind damage potential for structures in Lewes. Two wind model scenarios for northeaster-type winds of 57 mph and tropical storm wind speeds of 72 mph would cause approximately $200,000 and $1.68 million of damage in Lewes, respectively. The hurricane wind model scenario resulted in damages exceeding $10 million (Greenhorne & O'Mara, 2000, p. 58). While all structures are considered vulnerable to extreme wind events of all types, manufactured homes in Lewes were the most vulnerable to wind damage.

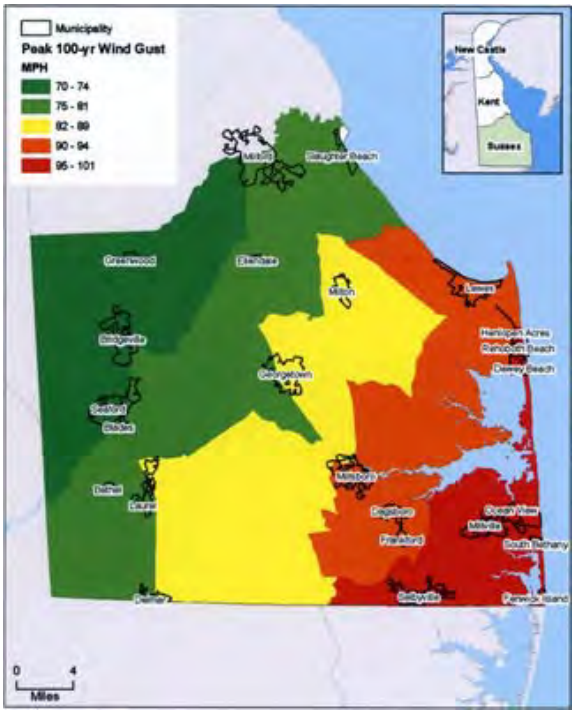

Figure 3.7: Potential for tropical system winds that could affect Sussex County for a 100-year wind event (Sussex County, 2010).

Sussex County (2010) includes an analysis conducted using Hazards U.S. Multi-Hazard (HAZUS-MH), a nationally applicable standardized methodology that estimates potential losses, for wind data. Figure 3.7 shows the result of that analysis, and the potential for tropical storm winds that could affect the area for a 100-year wind event. The City of Lewes is in the designated area for peak 100-year wind gusts of 90-94 mph. Additionally, excerpted from the 2010 Sussex County report, Tables 3.2 and 3.3 show Lewes' total annualized expected losses from tropical storm wind events, and the potential damage to Lewes' critical facilities from tropical storm wind events, respectively.

Jurisdiction	Total Number of Critical Facilities	100-year Wind			500-year Wind			
		Moderate Damage	Slight Damage	Negligible Damage	Extensive	Moderate Damage	Slight Damage	Negligible Damage
Lewes	40	30	10	0	15	8	17	0
MCD* Lewes	175	136	36	3	127	31	14	3

Table 3.3: Potential damage to critical facilities from tropical storm wind events[1] (Sussex County, 2010).

[1] Negligible: less than 1 percent damage; Slight: 1 to 5 percent damage; Moderate: 5 to 30 percent damage; Extensive (where applicable): 30 to 60 percent damage.

3.1.5 Winter Storms

Lewes may also be impacted by winter storms that bring snow and ice to the area. Recent historic records indicated that Lewes has experienced storms that have deposited more than 20 inches of snow. Many winter storms are accompanied by low temperatures, high winds, and heavy and/or blowing snow which can create snowdrifts (Figure 3.8).

Figure 3.8: Car caught in snowdrift on Second Street, Lewes, DE.

Winter storm events in coastal areas such as Lewes are likely to produce not only snow, but other forms of winter precipitation, including sleet, ice pellets and freezing rain. Sleet, or rain that freezes into ice pellets before reaching the ground, can accumulate like snow to cause hazardous road conditions. Freezing rain is rain that falls onto a frozen surface (i.e., below 32 degrees Fahrenheit), forming a coating of ice. Even minor accumulations of ice can cause significant hazards to roadways, power lines, and trees.

Statistics from the National Weather Service show that from 1948 to 1999, the average snowfall in Lewes was 2 inches (306 events). Roughly a third (97 events) of these storms had snowfall greater than 2 inches. During the same period there were 10 snowstorms with six or more inches of snowfall (9.8 inch average) (Greenhorne & O'Mara, 2000, p. 22).

Ice and snow events in Lewes can cause a variety of problems including electrical/utility system disruptions, transportation disruptions and secondary hazards to businesses and homeowners. Direct and indirect effects of winter storms on Lewes utilities include breaking of power lines by the weight of ice or snow and higher electrical demands by customers. Potential loss of electrical power can also impact operation of pumping stations associated with sanitary and storm sewer discharges (Greenhorne & O'Mara, 2000, p. 28).

National Climatic Data Center information collected by Sussex County (2010) shows that the geographic area of Sussex County experienced 55 distinct winter storm (snow and ice) events from January 1, 1993 through November 2009. In recent history, several of the most powerful and costly storms to affect Sussex County

include the Blizzard of January 1996, a storm over President's Day Weekend 2003 and the blizzards that occurred in January and February 2010.

Historic evidence shows that Lewes is quite vulnerable to winter storms, with several occurring each year. In the Sussex County (2010) vulnerability assessment, the annualized expected losses for the City of Lewes from winter storm events is negligible, while the annualized expected losses from winter storms in the MCD Lewes region is $29,303 (Sussex County, 2010; see summary Table 3.2).

3.1.6 Drought/Extreme Heat

Drought conditions are the result of extended periods of limited precipitation. Human activities, high temperatures, high winds and low humidity can exacerbate drought conditions and may also make areas more susceptible to wildfire (see 3.1.7 below). Periods of drought can have significant negative impacts on agriculture (e.g., crop development), water reservoir levels, surface and groundwater supplies and any water-dependent resources or products. This hazard could affect Lewes' water supply when decreased aquifer recharge is coupled with increasing consumptive demand, resulting in the possibility of drought-related potable water shortages (Greenhorne & O'Mara, 2000).

An extreme heat condition is commonly identified when prolonged temperatures are greater than or equal to 10 degrees above the average high temperature for a region. Periods of extreme heat in Delaware are also often accompanied by high humidity. Extreme heat can cause medical problems and pose significant risks to humans, especially the elderly, young children and to persons with respiratory difficulties. Studies have shown that a significant rise in heat-related illness occurs when excessive heat persists for more than two days (Sussex County, 2010, Section 4.1, p. 15). Livestock, pets and vegetation are also vulnerable to heat effects. The Greenhorne & O'Mara (2000) study reports that Lewes lies within a region with a very high heat index (115 to 120 degrees Fahrenheit for the 5 percent annual chance event). Few areas in the United States have higher heat indices (Greenhorne & O'Mara, 2000, p. 29).

It is possible that Lewes could experience both drought and extreme heat conditions, including associated impacts to water supply and human health. Lewes is especially susceptible to extreme summer weather as a result of very high temperatures and humidity.

Sussex County (2010) reports that according to the National Climatic Data Center, the State of Delaware has experienced 49 reported droughts and/or periods of unseasonably dry weather from 1950 through July 2009, most of which affected all three counties in Delaware. All crop damage reported for this period ($29.1 million) is tied to a single event—the drought that gripped the Middle Atlantic States throughout much of the growing season of 1999. This drought ended with the arrival of the record-breaking rain associated with Hurricane Floyd on September 16, which produced as much as 10.5 inches of rain across Delaware.

For the City of Lewes, annualized expected losses from drought events are estimated at $65,458 (Sussex County, 2010). For the Lewes MCD region, which includes larger areas of farms and crop land, expected losses are estimated to be much higher at $1,261,154 (Sussex County, 2010; see summary Table 3.2 above).

Sussex County (2010) collected data from the National Climatic Data Center, showing that Sussex County has experienced 78 reported cases of spring/summer extreme heat from 1995 through 2009. These spring/summer heat waves have caused 7 deaths and 41 injuries (Table 3.4).

Storm Location	Date	Time	Type	Death	Injuries	Property Damage
Countywide	07/23/1995	0000	Unseasonably Warm	1	0	0
Countywide	08/16/1997	0900	Excessive Heat	0	3	0
Countywide	07/20/1998	0900	Excessive Heat	0	8	0
Countywide	06/07/1999	0900	Excessive Heat	0	5	0
Countywide	07/04/1999	0800	Excessive Heat	4	10	0
Countywide	07/23/1999	0900	Excessive Heat	0	10	0
Countywide	08/01/2006	0900	Excessive Heat	2	5	0
			TOTALS:	**7**	**41**	**0**

Table 3.4: Extreme summer heat dates causing injury or death for Sussex County, 1995-2009 (Sussex County, 2010).

3.1.7 Wildfire

Wildfires, or any naturally occurring fire in a grassland, brush or forested area, are especially dangerous hazards during periods of drought. The most common cause of wildfires is negligent human behavior (causing 80 percent of forest fires). Lightning strikes are the second most common cause and typically occur during summer months. Fire probability depends on local weather conditions, human activity and implementation of community fire prevention measures. Areas with large amounts of dry fuel, such as vegetation, debris, or trees, are particularly susceptible to wildfires caused by lightning strikes (Greenhorne & O'Mara, 2000, p. 27).

Over the past several decades, wildfires have occurred in Lewes, primarily in the dredge material disposal areas north of the Lewes/Rehoboth Canal. Recently organized fire prevention activities (Figure 3.9) have managed the fuel source in these areas (primarily *Phragmites*) and Lewes has recently implemented measures to continue proper management and control of areas with a high threat of wildfire.

Figure 3.9: Control-burn of a *Phragmites* area in Lewes, Delaware.

According to the Delaware Fire Service, the greatest wildfire danger is in the marshes along the Delaware Bay that contain large amounts of *Phragmites* (Sussex County, 2010). Located just north of Lewes, the 1,400 acre fire that occurred in Prime Hook in 2002 is an example of the significant fire hazard posed by *Phragmites*. The Delaware Forest Service explains that the climate, forest types and terrain generally found in Sussex County do not promote large wildfires (Sussex County, 2010, Section 4.2, p. 24).

In Lewes, specific geographic regions of fire concern include *Phragmites* areas adjacent to Lewes Beach (especially from Cedar Avenue to Anglers Road) and along the Lewes/Rehoboth Canal, and *Phragmites* stands located near and adjacent to Savannah Road and Freeman Highway.

3.1.8 Coastal Hazards – Erosion, Waves, and High-Velocity Flow

Erosion – Coastal erosion hazards can be short-term and dramatic when generated by storm events, or long-term and less recognizable when changes occur over a period of decades. Areas of Lewes susceptible to coastal erosion hazards include the entire Delaware Bay shoreline as well as the marsh edges along the Broadkill River, Canary Creek and the Lewes/Rehoboth Canal.

Coastal erosion is generally categorized as either episodic (e.g., storm-induced) erosion or long-term erosion. Short-term or episodic erosion is the rapid recession of the coast in response to higher than normal wave, tide and along-shore current impacts that usually occur during coastal storm events (Figure 3.10). Storm-generated erosion ranges over periods of hours to several days and the impact of short-term erosion to private and public property can be severe. Dunes and other natural protective features of the coast can be breached and destroyed, exposing structures behind them to further damage from subsequent storms. However, sand transported offshore during an episodic event may eventually be restored as post-storm wave and current

Figure 3.10: Erosion along the Delaware Bay shoreline, Lewes Beach.

conditions transport sediment back to the beach area. Scour, which is highly localized erosion, is generated by the acceleration of water flow around an object. As water moves past a fixed structure such as a piling, it accelerates, creating turbulence just above the surface. Erodible material such as sand is suspended by the turbulence and transported away, resulting in localized erosion.

Long-term erosion occurs over a period of several years and is the result of cumulative impacts of storms, sea-level rise, man-made impacts, sediment supply and everyday coastal processes such as waves and currents. Sediment removed via long-term erosion is usually considered to be permanently lost from the beach system. Long-term erosion increases the vulnerability of coastal structures to damage by exposing them to increased risk over the lifespan of the structure.

According to the U.S. Army Corps of Engineers Feasibility Study for the Roosevelt Inlet-Lewes Beach, DE project, studies show that over a time period from 1892 to 1990, the long-term erosion rate for Beach Plum Island and Lewes Beach has varied from 0.5 feet/year to 10.7 feet/year. The higher loss rates were found for Beach Plum Island. Erosion rates for the vicinity of Roosevelt Inlet are approximated to be less than 4.0 feet/year. Most of the studies suggest that the western to central portion of the shoreline has experienced greater rates of erosion than the eastern portion (Greenhorne & O'Mara, 1999, p. 12).

Periodic beach nourishment has been used as a management strategy to mitigate effects of long-term and storm-induced erosion along Lewes Beach. Since 1953, both beachfill and channel maintenance material have been used to nourish Lewes beaches. Materials dredged from Roosevelt Inlet are routinely placed onto the adjacent beach in Lewes (Greenhorne & O'Mara, 1999, p. 12).

FEMA's velocity zone (VE zone) is an area susceptible to the effects of moving water including erosion, scour, and wave impacts. Velocity areas in Lewes are identified by FEMA's Flood Insurance Rate Maps (FIRM) and include structures on the bayward side of Bay Avenue. This zone extends eastward to include buildings in Pilot Point and Cape Shores. Most of the structures located in this zone are residential.

Waves – Wave hazards can affect coastal areas of Lewes in a number of ways, from daily impacts of waves breaking on the beach to more extreme wave impacts that occur during storm events. The size and intensity of storm-generated waves depend on the magnitude and duration of the storm as well as the sustained wind speeds. During calm weather, large waves usually break offshore, away from the shoreline. During storm conditions, however, elevated water levels generated by storm surge allow waves to break much closer to the shoreline, exposing coastal structures directly to wave attack, wave run-up and wave-induced scour and erosion.

Breaking wave attack – The most extreme wave hazard to the built environment, occurs when a wave breaks on a structure. Peak pressures from a 5-foot high breaking wave can exceed 2,000 pounds per square foot. Post storm damage inspections have shown that breaking waves are capable of destroying all wood-frame or unreinforced masonry walls (Greenhorne & O'Mara, 2000).

Non-breaking waves – A wave can also impact a structure before and after breaking. If a wave strikes a solid structure prior to breaking, the wave energy is reflected back toward the ocean. Associated with wave energy reflection is increased erosion and scour at the base of the structure, potentially leading to undermining and collapse. If a wave passes under an open foundation, such as the pilings below a fishing pier, the structure may experience vertical uplift forces and associated damage – for example, decking may be lifted from the pilings and beams.

Wave run-up – Wave run-up is the distance a wave will travel up a sloped surface or vertical wall, and is considered a hazard because it can drive large volumes of water and debris against coastal structures. Strong currents associated with run-up can result in localized erosion and scour and uplift forces can destroy decks, flooring and porches.

High-Velocity Flow – Floodwaters moving at high velocities can result in destructive force impacts on structures located in the flood area. High-velocity flows can be created by storm surge and wave run-up flowing landward through breaks in dunes or low-lying areas and by wave-generated currents flowing along

the shoreline. When floodwaters exceed a velocity of 10 feet per second, tremendous force is applied to structures in its path. High-velocity flows are also capable of moving large quantities of sediment (sand) and debris.

Waterborne debris carried by floodwater generates short duration impacts when they strike stationary objects. Waterborne debris typically includes any floating object that is not secure: decking, stairs, breakaway wall panels, pilings, fences, propane and oil tanks, boats, portions of buildings and sometimes entire houses. Such objects are capable of destroying other structures on impact.

Sea-Level Rise - Because Delaware's coastal environments have evolved and responded to increases in sea level over thousands of years, the impact of sea-level rise is considered to be a long-term or chronic coastal hazard. Tide gauge records at Breakwater Harbor in Lewes show that sea level has been rising at a rate of approximately one foot per century since the 1920s (Figure 3.11). There is considerable agreement among scientists that the rate of sea-level rise will increase in the next 100 years. An increasing sea level may result in more significant erosion, inundation and flooding issues in coastal areas.

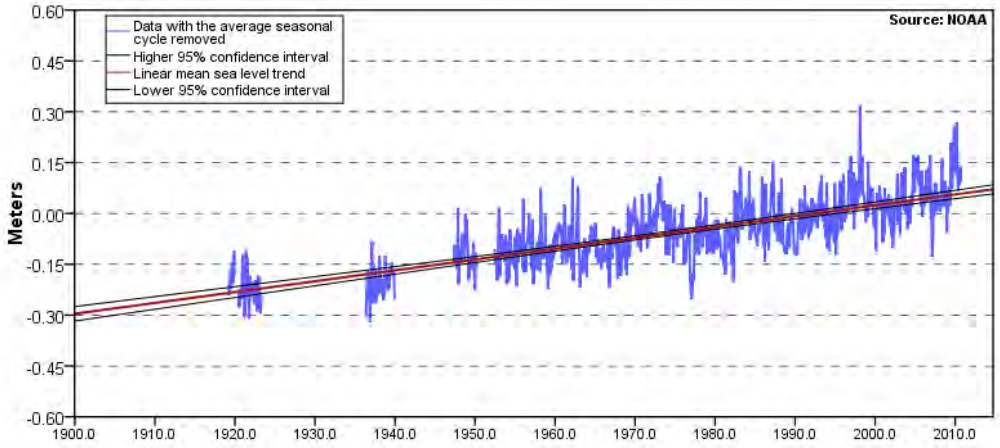

Figure 3.11: Historic relative sea-level observations for Lewes, Delaware and trend lines.

3.1.9 Tornadoes

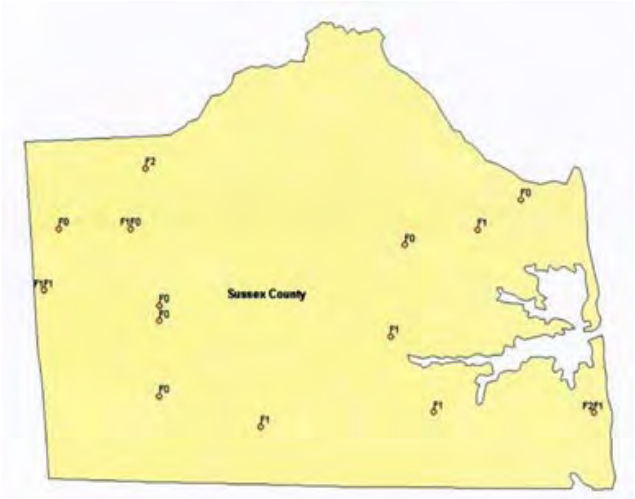

Figure 3.12: Historic tornado occurrences in Sussex County, DE (1950-2009) (Sussex County, 2010).

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground (Sussex County, 2010). Tornadoes most often result from the intersection and interaction of cool dry air as it overrides warm moist air, causing the warm air to rise rapidly. These conditions are also associated with severe thunderstorm activity, so it follows that tornadoes are most often generated by thunderstorms (including those associated with tropical systems such as hurricanes). Tornado wind speeds can range anywhere from 40 to more than 300 mph, resulting in catastrophic failures of structures and facilities, as well as the potential for injury and death. The most violent tornadoes have caused extreme destruction over areas that can be a mile wide and several miles long. Because tornado-generated winds exceed standard building code design values, few buildings are prepared to resist tornado effects. Ancillary damages may result

from debris projected at high speed through the air with enough force and velocity to penetrate masonry and concrete walls (Greenhorne & O'Mara, 2000 p. 22).

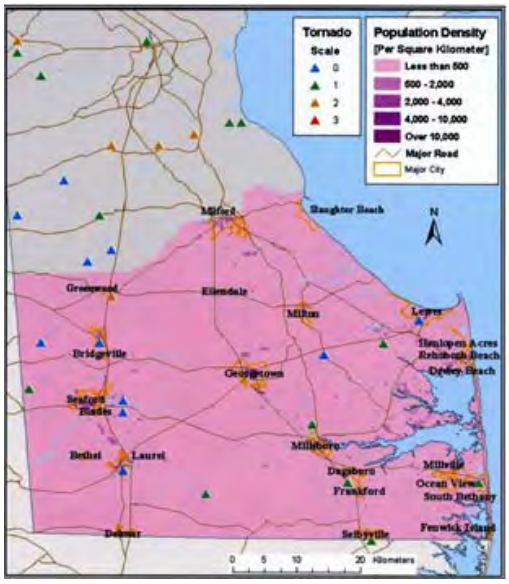

Figure 3.13: Tornado occurrence relative to population density in Sussex County, DE (Sussex County, 2010).

When compared to national records and statistics, the Lewes area is not considered to be an area of high tornado activity. However, a tornado event in the vicinity of Lewes has an average chance of occurring once every three years (Greenhorne & O'Mara, 2000 p. 22).

The 2010 Sussex County document reports that an assessment conducted by the NCDC indicates that the State of Delaware experienced 58 tornado events from January 1, 1950 through July 31, 2009. Tornadoes during this time period are responsible for 11 injuries and $596,000 in property damage. Figure 3.12 graphically illustrates the location of historic tornado occurrences in Sussex County.

Figure 3.13 shows the location and magnitude of past tornado events in relation to population density in Sussex County (Sussex County, 2010). While historic evidence indicates that Sussex County is vulnerable to tornado activity, it is difficult to predict where a tornado will touch down. Therefore, for the county as a whole, all buildings and facilities are considered to be exposed to this hazard, making it difficult to estimate the number of residential and commercial facilities that may experience losses. Analyses conducted by Sussex County (2010) reveal that there is a negligible potential normalized annualized loss from tornadoes for the City of Lewes (summary Table 3.2).

3.1.10 Tsunamis

While tsunamis are not considered to be a high risk hazard, it is possible that a tsunami could impact the Delaware coast. Any disturbance that displaces a large water mass including earthquakes, landslides, volcanic eruptions, explosions and meteorite impacts can generate a tsunami. From the origination area, which can be thousands of miles away from any coast, tsunami waves will travel outward in all directions. Areas at greatest risk to tsunami impacts are generally regions of low elevation (< 50' above sea level) located within one mile of the shoreline.

Tsunamis in the Atlantic Basin are most commonly generated by earthquakes and landslides. Primary sources of tsunami-producing earthquakes in the Atlantic are located near Puerto Rico, Portugal and the Canary Islands. Tsunamis in the Atlantic Ocean may also be caused by underwater landslides, usually occurring near the continental shelf and slope.

Historic records show that tsunamis have impacted the east coast of the United States, including Delaware. Since 1600, forty tsunamis and tsunami-type waves have been documented in the eastern United States (Sussex County, 2010). In 1929, an earthquake off the Grand Banks produced a tsunami that caused death and destruction, primarily in Newfoundland. This tsunami is also known to have impacted the shoreline of Maine. East coast tide gauges can detect even small tsunami waves caused by distant earthquakes. For example, in 1918 and 1946, gauges recorded waves just a few inches high generated by earthquakes in Puerto Rico and the Dominican Republic, respectively. More recently, Atlantic basin gauges recorded 5-10 inch waves generated by the December 2004 Indian Ocean tsunami. Despite this evidence of past east coast tsunami waves, there is a relatively low probability of a tsunami significantly impacting the State of Delaware.

Section 4: Overview Regional Climate Change Impacts

4.1 Global Climate Change

Over the past century there have been numerous documented changes in climate globally. To-date, the world has seen increases in annual average temperatures, altered precipitation patterns and sea level rise (SLR), as well as other trends, such as increases in weather extremes, changes in the onset of seasons and the melting of glaciers. Globally, temperatures have increased 1.3°F over the past century resulting in less snow accumulation in winters and an earlier arrival of spring. In regards to precipitation, from 1900 to 2005 the world experienced changes in precipitation patterns over large areas, including an increase in eastern North America. Sea level rise, another documented impact of global climate change, has been rising globally at a rate of 0.8 inches per decade or 0.67 feet over the century. These current global climate change trends – including increasing temperatures, altered precipitation patterns and rising sea levels – are expected to continue into the future; however, the rate of many of these changes are expected to increase (IPCC, 2007, p. 30 & 33).

Moving from documentation of past climate characteristics to prediction of future situations, one must rely on models to determine global and regional climate projections. These models are based on different greenhouse gas (GHG) emissions scenarios, such as those used by the Intergovernmental Panel on Climate Change (IPCC). The emission scenarios factor in different variables, including population growth, energy use and other societal choices. Many analyses of climate changes and their associated impacts, including those referenced here, use one high – often A1FI – and one low – often B1 – GHG emissions scenario (Figure 4.1) (IPCC, 2007, p. 44).

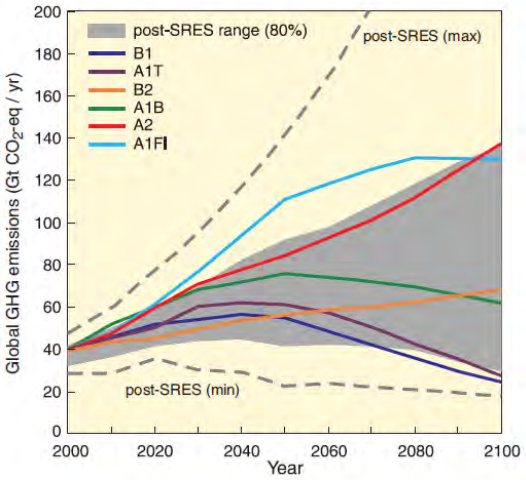

Figure 4.1: Emissions Scenarios used by the Inter-governmental Panel on Climate Change (IPCC, 2007, p.44).

It is important to recognize that although efforts to curb GHG emissions (mitigation) are important to reduce the impacts of climate change, there is a certain amount of climate change that will be experienced in the coming decades regardless of global GHG emissions reductions. As Figure 4.2 illustrates, temperature changes for the Northeast between now and approximately 2040 follow a similar path for both the low and high emissions scenarios. Thus, Northeast communities should start planning now for existing and future changes in climate, regardless of the GHG emissions scenario (NECIA, 2006, p. 10).

4.2 Regional Climate Change

To date, the vast majority of climate science and future scenario building has been accomplished using global climate models. In order to make these coarse resolution projections relevant at the regional scale, one must use a process called downscaling. There are two main types of downscaling – statistical and dynamical. In both types of downscaling some uncertainty is added to the existing uncertainty associated with modeling an unknown future. Regardless of this uncertainty, global and regionally

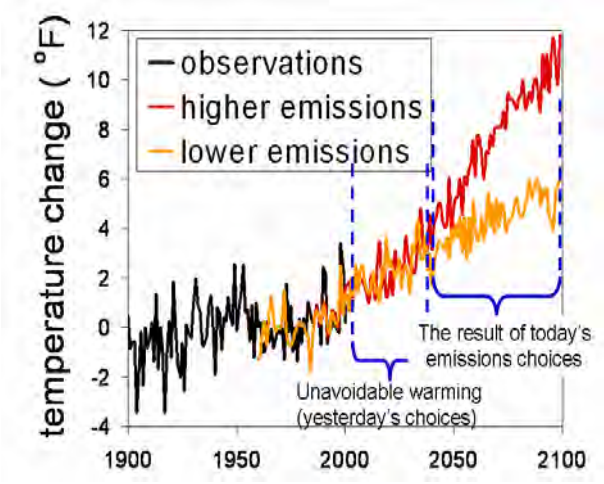

Figure 4.2: Temperature trends for the North East under the low and high emissions scenarios (NECIA, 2006, p.10).

downscaled climate models provide highly accurate information that managers can utilize to make informed decisions about future action.

For the Mid-Atlantic region, most scientists agree that by the end of the 21st century, warming temperatures and rising sea levels are extremely likely (>95 percent). Also by the end of the century, changes in precipitation patterns and their effects are considered to be likely (>66 percent) with the exception of higher winter and spring time precipitation, which is thought to be very likely (>90 percent) (Table 4.1) (Najjar, 2010, p. 16).

Projected Mid-Atlantic Climate Change

Projected change	Likelihood
Warming	Extremely likely
Higher sea levels	Extremely likely
Higher winter and spring precipitation	Very likely
Higher annual precipitation	Likely
Higher winter & spring streamflow	Likely
Greater hydrological extremes	Likely

Table 4.1: Likelihood of occurrence for the major projected climate change conditions in the Mid-Atlantic (Najjar, 2010).

To provide information for the City of Lewes, four major reports were used to compile regionally and locally relevant climate projections. The analysis and results from the *Climate Change and Delaware Estuary* report (Kreeger, 2010) were used to provide Delaware specific information. This information was supplemented by the *Comprehensive Assessment of Climate Change Impacts in Maryland* report (CACCIM, 2008), the *Economic Impacts of Climate Change on New Jersey* report (CIER, 2008) and the *Preparing for a Changing Climate: the Potential Consequences of Climate Variability and Change* (MARA, 2000) report. The following paragraphs provide details on temperature, precipitation and sea level changes that the City can expect in the future.

Temperature. In terms of temperature changes over the past century, the Mid-Atlantic Region has seen an increase of approximately 1°F (MARA, 2000, p. 17). Going forward, the average of 14 models downscaled for Delaware show that temperatures by the end of the century are expected to increase by 3.6 – 7.2°F above the recent past (1980 – 1999). In both the high and low emissions scenarios, the summer months are expected to see greater warming than the winter months, which includes an increase in extreme heat days (above 80°F) (Kreeger, 2010, p. 24). In Maryland, the mean of seventeen models shows an increase of 2°F by 2025, an increase that can be expected regardless of which emissions scenario is followed. By the end of the century, summer temperature increases are expected to be 4.8°F under the low emissions scenario and 9°F under the high emissions scenario. Winter increases are expected to be 4°F and 7°F under the low and high emissions scenarios, respectively. Although there is recognized variability across the state's diverse geographic and climatic zones, these temperature changes are above the recent past averages and are expected to apply to all areas of the State of Maryland. Also in Maryland, by 2100 the number of days with temperatures above 90°F is projected to double or triple under the low and high emissions scenarios, respectively (CACCIM, 2008, p. 16).

New Jersey is also expecting future temperature increases between 2 – 8°F for annual average temperature and a significant increase in extreme heat days (CIER, 2008, p. 17). These regional temperature changes are summarized in Table 4.2.

Climate Condition		Delaware	Maryland	New Jersey
Temperature	Annual Average (°F)	3.6 – 7.2	4.0 - 9.8	2.0 - 8.0
	Extreme Heat Days	significant increase	double - triple	significant increase

Table 4.2: Shows downscaled temperature predictions for 2100 under high and low emissions scenarios.

Precipitation. Generally it is thought that average precipitation will increase in most regions of the world due to higher rates of evaporation; however, as noted above, there is more uncertainty surrounding this climate variable than temperature and sea level rise (Najjar, 2010, p. 16). According to the average of 14 models, the annual mean precipitation rate for the State of Delaware is expected to increase 7 – 9 percent. These models

show greater increases in precipitation in winter months than in summer months. Furthermore, three-quarters of the models predict that there will be substantial increases in the frequency of extreme precipitation events, meaning that there will likely be more heavy downpours followed by consecutive dry days (Kreeger, 2010, p. 25). Research for Maryland shows that there will be an increase in winter precipitation, meaning that much of what is experienced now as snowfall will become rain in the future (CACCIM, 2008, p. 20). New Jersey is expecting precipitation changes as well with a range of 10 – 20 percent more average annual rainfall by the end of the century (CIER, 2008, p. 17). These regional precipitation changes are summarized in Table 4.3.

Climate Condition		Delaware	Maryland		New Jersey
		2100	2050	2100	2100
Precipitation	Annual Average (% increase)	7 - 9			10 - 20
	Winter Precipitation (% increase)		6.6 - 6.8	10.4 - 12.6	
	Winter Snow Volume (% decrease)		25	50	

Table 4.3: Shows downscaled precipitation data for high and low emissions scenarios.

Sea Level Rise. Sea level rise is expected to progress at an accelerated rate over the coming century. Global or eustatic sea level rise is based on the rising waters due to the thermal expansion of water and the melting of land-based ice commonly called glaciers. The IPCC estimated that global sea level rise will increase from 0.59 ft to 1.9 ft based solely on thermal expansion of water (IPCC, 2007, p. 45). However, many scientists consider these estimates to be low due in part to the fact that they do not include glacial melt. More recent estimates that incorporate additional components of sea level rise, including land-based ice melt, suggest that eustatic sea level rise could be as high as 4.6 ft (Rahmstorf, 2009). The range of estimates and the global historic trend can be seen in Figure 4.3.

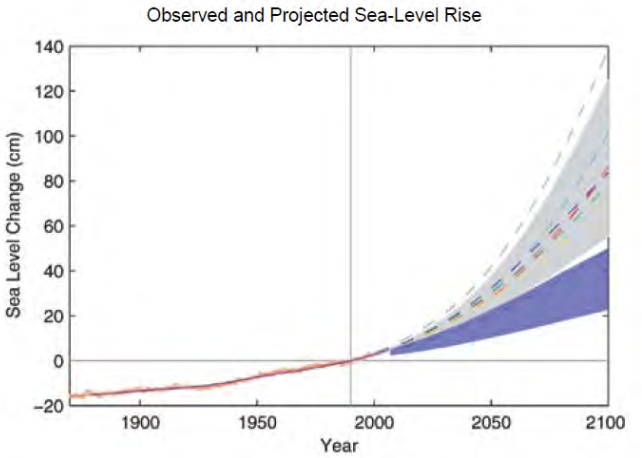

Figure 4.3: Historic global sea-level observations (red) and future projections (dashed lines). The shaded areas represent future sea-level rise projection (CCSP, 2009, p. 20).

Several additional factors, including circulation patterns and land elevations changes, are known to impact local or relative sea level rise. The historic sea level rise observations and trend for Lewes, shown in Figure 3.11, indicates that Lewes has seen about 1 foot (0.32m) of sea level rise over the past century. Were this trend to continue, the City could, at a minimum, expect another foot this coming century. However, as noted earlier, scientists are expecting sea level rise rates to increase in the coming century. Many regional reports have taken this expected increase and incorporated it with specific local data to create ranges of relative sea level rise predictions for the coming century. All of these reports take additional localized factors into account; however, it should be noted that not all reports take exactly the same factors into account. These regional relative sea level rise changes are summarized in Table 4.4. Furthermore, it is important to note that based on this information, the State of Delaware's Department of Natural Resources and Environmental Control is currently working with the range of future sea level rise between 1.6 ft and 4.9 ft for planning purposes.

Report Name	Location	Low SLR (Ft)	High SLR (Ft)
Department of Natural Resources & Environmental Control Administrative Policies and Provisions	Delaware	1.6	4.9
Climate Change and the Delaware Estuary Three Case Studies in Vulnerability Assessment and Adaptation Planning	Delaware Estuary	2.6	5.6
Future Sea Level Rise and the New Jersey Coast	New Jersey Coast	2.1	3.9
Maryland Commission on Climate Change – Climate Action Plan	Maryland	2.7	3.4
Climate Change and Chesapeake Bay State-of-the Science Review and Recommendations	Chesapeake Bay	2.3	5.3
Governor's Commission on Climate Change – Final Report: A Climate Change Action Plan	Virginia	2.3	5.2
North Carolina Sea-Level Rise Assessment Report	North Carolina	1.3	4.6

Table 4.4: Relative sea level rise estimates for 2100 under a low and high emissions scenarios.

4.3 Regional Impacts of Climate Change

The changing climactic conditions, though important in and of themselves, are also indicators of a broader set of impacts that the region can expect in the coming century. One way to look at these future changes is through a heat index, which is a measure of how hot it feels based on temperature and humidity. For southern coastal New Jersey, by 2100, the area's summers will feel like Northern North Carolina under a low GHG emissions scenario and like Southern Georgia under a high emissions scenario (Figure 4.4). A similar shift should be expected in Delaware. Imagining this change can be hard, but a focused look at some of the direct impacts can help put it into perspective. One direct effect for Delaware of the changing climate is a significant increase in the number of extreme heat days. This increase will lead to more people at risk of experiencing heat stress, heat exhaustion and life threatening heat stroke. This increase will in turn lead to a greater stress on medical facilities and on the systems in place to provide people with help during heat waves (NECIA, 2007, p. 95).

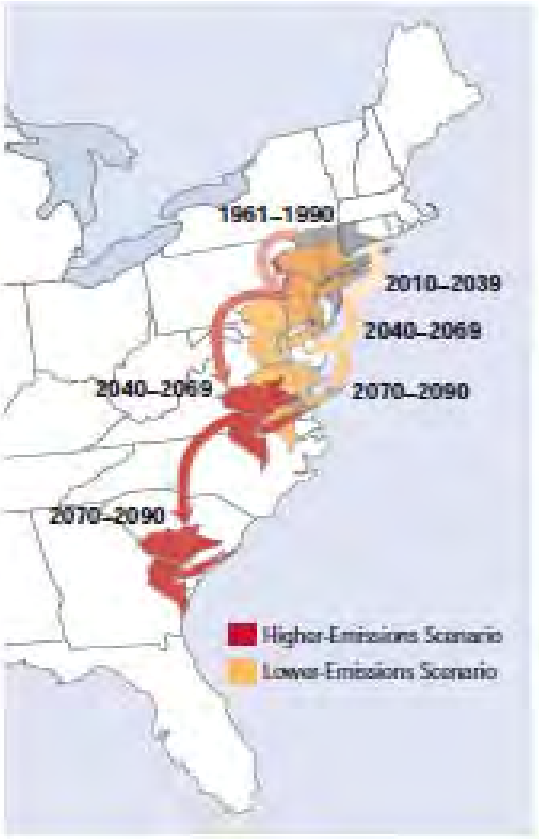

Figure 4.4: Heat index, a measure of the weather experience that is a combination of temperature and humidity, for the NYC Tri-State Area (NECIA, 2007, p. 7).

Spring is often a welcome relief from wintertime blues, and under the current changes in climate it has been arriving earlier. As one example, the bloom date for lilacs has shifted four days earlier since the 1960s (NECIA, 2007, p. 11). The impacts from these changes are likely to be felt in the plant communities that make up the area and in the agricultural sector. In fact, the number of growing days in

Maryland is expected to increase by the end of the century from 239 days a year to either 259 or 278 days a year (Figure 4.5) depending on the GHG emissions scenario. This increase will place an additional strain on regional water resources (CACCIM, 2008, p. 21). Moreover, these changing climactic conditions will likely require a change in crops being used. This could be a source of opportunity to those farmers with the resources to change what they grow, but could also be a challenge for those who cannot adapt (NECIA, 2007, p. 12). Additionally, the area's woods and non-wetland green spaces will likely shift to more southern pines and oaks and away from Northern hardwood trees such as beech and maple – a shift to more southern pines

Figure 4.5: A depiction of the changes in growing season in Maryland (CACCIM, 2008 p. 21).

could be preceded by an outbreak of pests and diseases. These green spaces may also succumb to drought more frequently (US EPA, 1998).

Though the interactions of temperature and precipitation changes can be extremely complex, it is these interactions that may contribute to some of the region's greatest impacts. Increased temperatures combined with increases in the intensity of rainfall are likely to result in increases in the intensity of extreme weather events, meaning that the area's storm events – including tropical and extratropical systems – will become more severe. These storm impacts will likely be felt along the coast with increased erosion related damages and increased flooding. Moreover, there will be greater flooding from rain events, resulting in flooded rivers. These intense rainfall events will lead to additional runoff and pollution in the area's streams (NECIA, 2007, p. 26 & 65).

Ecosystem changes and agricultural changes will also be affected by changing precipitation patterns. As opposed to extreme wet weather events, these interactions may also lead to extreme periods of dry conditions. Warmer conditions require more water use; however, with less water falling in the summer, this increased need will be difficult to meet. These interactions could result in increases in long- and short-term droughts. In fact, it is thought that short-term droughts – those that last one to three months – could occur as frequently as once per year in the Mid-Atlantic (NECIA, 2007, p. 63).

Increasing water temperatures and ocean acidification are two other results of the interactions amongst changing climate conditions that could affect the Lewes community. Warmer air temperatures in many locations are leading to warmer water temperatures. These shifts, which will affect weather patterns as noted above, will also change the marine environment. There will be impacts on the quality of coastal and marine waters such as coral bleaching, hypoxia, pathogens and disease, harmful algal blooms, and invasive species. Certain species will also be affected by the decreases in pH, which results from a buildup of carbon dioxide in the atmosphere. These changes make it harder for shellfish and other sea life to build their shells and skeletons. These associated impacts will ultimately lead to major consequences including the loss or degradation of coastal and marine ecosystems, the potential decrease in the goods and services these ecosystems provide and the economic losses associated with decreased services (NOAA, 2010, p. 14).

Finally, **sea level rise** is known to have impacts on the land as well as on the marine and estuarine environments. On the estuarine side, the Delaware Bay can expect increases in submerged wetlands, salinity variability, harmful algae and hypoxia. The Bay will also see a reduction in eelgrass and altered interactions amongst tropic levels (Najjar, 2010, p. 18). These impacts, as well as an increase in invasive species may have

further cascading effects and could result in the loss of key estuarine species in the area (Kreeger, 2010, p. 28). On the landward side, a known impact of sea level rise is inundation, which is the change in the mean higher high tide line resulting in areas that were once dry becoming permanently wet. A second result of sea level rise is an increase in coastal flooding frequency. Researchers have found that in Atlantic City, the present 1 percent chance storm (100-year storm) could be seen as frequently as once every 4 years by 2050 and once every 2 years by the end of the century under either GHG emissions scenario (Kirshen, 2008). A second landward impact of sea level rise is that the 1 percent chance storm could reach farther landward, affecting a greater overall area. Both of these sea level rise impacts will result in increased flooding impacts to Lewes' built environment – including commercial, residential and industrial buildings, its sewage and septic systems, as well as transportation infrastructure. In addition to changes in flooding patterns, sea level rise will also cause increased erosion on non-hardened shorelines and the landward migration of natural environments (Titus, 2009). One last impact from sea level rise in many places is increased salt water intrusion into local and regional aquifers. In the next section of this report we look more carefully at the impacts of climate change on natural hazards in the City of Lewes.

4.4 Climate Change Impact to Natural Hazards in Lewes, Delaware

Although detailed engineering based hazard profiles could not be conducted for this project, the above climate change information can be used to inform and enhance our current understanding of natural hazard profiles in and around the City of Lewes. The following sections provide information on how changing climate conditions – temperature increases, altered precipitation patterns and sea level rise – are projected to impact the natural hazards profiled in Section 3. Additionally, given the particularly high threat from sea level rise to coastal communities, a special section detailing those impacts has been created at the end of this chapter.

4.4.1 Coastal Storms

Coastal storms (tropical and extratropical), which can lead to flooding (4.1.2), wind (4.1.5), and erosion (4.1.10) impacts, will be affected by climate change in several different ways. First, there is growing evidence that warming sea surfaces have resulted in the increased destructive potential of Atlantic tropical storms since 1970 (CACCIM, 2008, p. 9). The increasing intensity of tropical storms is likely to continue in the coming century as ocean waters continue to warm. Additionally, it is thought that rainfall intensity of storms is likely to increase thus causing more inland flooding at both the large watershed level (riverine flooding) and smaller creek level (flash flooding) (CACCIM, 2008, p. 30). Rising sea levels will also exacerbate the negative effects of coastal storms including erosion and flooding. Although the exact destructive potential of both tropical and extratropical storms depends on a given storm's track, which cannot be predicted today, it can be said that the threat Lewes faces of future flooding, erosion, and wind impacts is greater than it is today. Further information regarding these impacts is provided in each of the appropriate sections below.

4.4.2 Floods

All three types of flooding – coastal, inland riverine and inland flash floods – will likely increase due to climate change (inundation, a permanent flooding effect is further described in section 4.4.8). Coastal flooding will most directly increase due to sea level rise, although inland flooding occurring at the same time as coastal flooding may further exacerbate a particular future flooding event. Inland flooding will increase due to the changing precipitation patterns (i.e., increased intensity of rainfall events) that are expected for the region. This flooding could also be directly effected by land use decisions, as the amount of permeable surfaces affects rainfall's infiltration potential.

Looking at specific coastal storm data, researchers have found that there will be an increased frequency of current design storms (i.e., the 100-year storm) across the Northeast and Mid-Atlantic. In Atlantic City the present 1 percent chance storm (100-year storm) could be seen as frequently as once every 4 years by 2050

and once every 2 years by the end of the century under both a high and low GHG emissions scenario (Kirshen, 2008). Moreover, sea level rise will cause the 1 percent chance storm to reach farther landward affecting a greater overall area of Lewes.

4.4.3 Severe Thunderstorms

The research to date on climate change and storms is for major tropical and extratropical storms and not for isolated severe thunderstorms; however, some thunderstorms are associated with these bigger storm systems and in these cases their intensity may increase. Additionally, as with other storm events, higher seas and more intense rainfall could lead to greater inland and coastal flooding and greater erosion during these storm events.

4.4.4 Wind

With the increased intensity of tropical storms caused by climate change comes an increase in future wind speeds threatening the buildings, ecosystems and human health in the Mid-Atlantic region. Although there is a projected increase, the exact amount is not yet fully understood. This projected increased threat may be tempered by the fact that there is some evidence that this increased intensity will coincide with a decreased frequency of these intense storm events (CACCIM, 2008, p. 55). It should be noted that the strength of winds associated with future extratropical storms, thunderstorms, or tornadoes is not yet known. Given this mix of semi-contradictory information, Lewes should remain aware of wind risks; however, they are not likely its greatest future threat.

4.4.5 Winter Storms

Currently there are two climate change impacts that are likely to affect winter storms in Lewes. First, it is believed that precipitation in the winter will become more episodic with it falling in more extreme events (CACCIM, 2008, p.14). These extremes could exacerbate current winter storms making the overall effects of the storms worse. Additionally, the increase in average temperature will likely cause a reduction in the amount of precipitation falling as snow or ice as that precipitation will likely fall as rain instead (NECIA, 2007, p. 9). When snow and ice are reduced and the increased episodic precipitation is rain, Lewes could see an increase in inland flooding during winter storm events (see 4.4.2 above).

4.4.6 Drought/Extreme Heat

Climate change is expected to increase the number and intensity of both drought and extreme heat events. Drought, the result of a reduced amount of water in both the natural and human systems, can be caused by both a reduction of precipitation that penetrates the system as well as by heat that causes increases in evaporation. Current climate change predictions for the region indicate that precipitation may become more irregular, thus reducing the amount of precipitation that penetrates the groundwater system. Additionally, higher temperatures in the region will cause increases in evaporation. These interactions will likely increase the number of short-term droughts – those that last one to three months – making them occur as frequently as once per year (NECIA, 2007, p. 63). Moreover, there is some chance that sea level rise will cause salt water intrusion in the local aquifer. Were this to occur, drought conditions would be exacerbated.

Additionally, the number of extreme heat days across the Mid-Atlantic is expected to increase. Though there is no specific data for Lewes, the data for Philadelphia shows that by 2100 the number of days over 100°F could be as high as 28 while today there are on average 2 days above 100°F (NECIA, 2007, p. 93). Lewes has coastal breezes and a limited heat island effect that will help it as the number of extreme heat days increases; however, the City will become increasingly vulnerable to these impacts in the coming century.

4.4.7 Wildfire

Wildfires could become a greater threat to Lewes with changing climate conditions. Areas with large amounts of dry fuel are particularly susceptible to wildfires and in Lewes these areas are primarily *Phragmites* stands. As climate change impacts the species in the area's wetlands, it may bring in more *Phragmites* stands thereby increasing the region's wildfire risk. Dry hot summer days – particularly extreme heat days – will exacerbate these wildfire risks, leaving more plants dry and potentially even reducing the amount of water in the system to treat such a threat.

4.4.8 Coastal Hazards – Erosion, Waves and High-Velocity Flow

As noted in the coastal storms section, short-term erosion will be greater in the future due to rising sea levels and greater intensity of storm events. Long-term erosion will also increase as sea levels continue to rise. This is particularly true in locations that cannot be naturally maintained at the current rate of sea level rise. Figure 4.6 shows that Lewes is likely to experience a combination of bluff/upland erosion and overwash/erosion/island breaching under both 7 inch and 27 inch sea level rise scenarios. In addition to erosion impacts, sea level rise and the increased intensity of storms could lead to higher velocity water flow and to more intense waves including breaking waves, non-breaking waves and wave run-up during storm events.

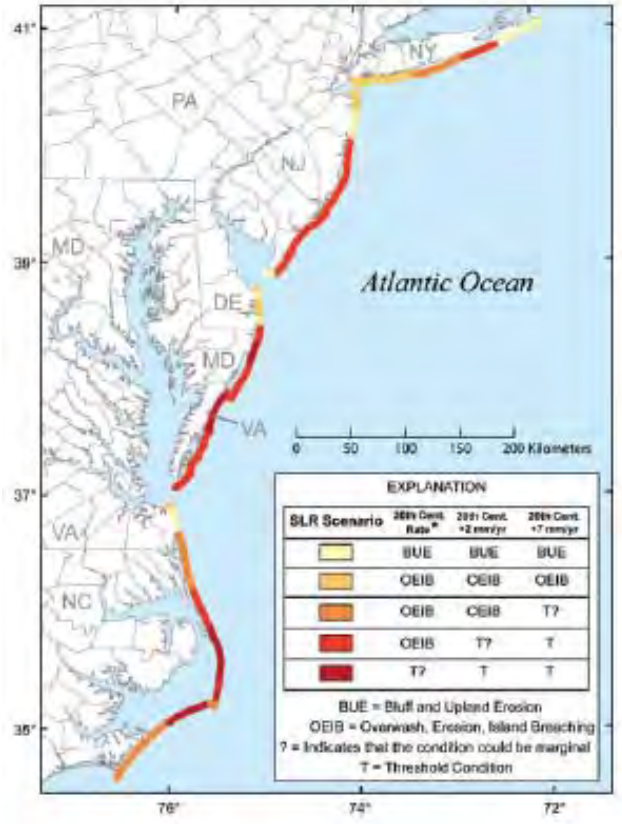

Figure 4.6: Coastal erosion risks along the Mid-Atlantic coast (CCSP, 2009, p. 3).

Another coastal hazard impacted by sea level rise is the changing location of the mean higher high water line. This line will likely shift landward, causing the inundation of certain dry areas. Figure 4.7 (located at end of Section 4) shows the current mean higher high water line in the City of Lewes as well as possible future inundation scenarios that are based upon different amounts of sea level rise. These inundation maps were developed in the Department of Natural Resources and Environmental Control (DNREC) inundation map viewer.[1]

4.4.9 Tornadoes

There is not significant research into the relationship between climate change and tornadoes; however, the research that is available does indicate that there is no meaningful relationship between these two. Given the lack of data/knowledge, this current assessment will operate on the understanding that the Lewes area is not considered to be an area of high tornado activity.

[1] DNREC's viewer can be found at http://www.dnrec.delaware.gov/Pages/SLRMaps.aspx

4.4.10 Tsunamis

Tsunamis are not caused by conditions that the changing climate is currently affecting; however, sea level rise could exacerbate the impacts of a tsunami. Higher seas in the future would mean that a tsunami wave would push farther inland causing greater wave and flooding damage.

4.4.11 Sea Level Rise

Due to the fact that the many and varied threats to Lewes from sea level rise are great, this section is a summary of all the threats that were called out in the previous sections. First, sea level rise will change flood patterns in the City of Lewes – causing current design flood events to occur more frequently. Additionally, sea level rise will cause coastal flooding to reach farther landward, thus covering greater areas of land in the City of Lewes. These flood pattern changes can be applied to the many different hazardous events – coastal storms, severe thunderstorms, winter storms and tsunamis – that can cause flooding. Sea level rise will also cause certain dry areas in Lewes to become inundated, meaning that they will become permanently wet (Figure 4.7). A third effect of sea level rise in Lewes is on erosion, which will also be greater as sea levels rise. This effect applies to both chronic erosion and storm-induced erosion. Sea level rise is known to cause saltwater intrusion into coastal aquifers. This impact could exacerbate future drought threats in Lewes. Finally, in addition to the effects that sea level rise will have on natural hazards, it was noted in section 4.3 that sea level rise will alter local habitats and natural systems.

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Figure 4.7: Future sea-level rise inundation scenarios for Lewes, Delaware (images captured from Delaware DNREC's inundation map viewer: www.dnrec.delaware.gov/Pages/SLRMaps.aspx).

Section 5: Assessing the City of Lewes' Current and Future Vulnerability

This next section addresses Lewes' current and future vulnerability to natural hazards based upon self-assessments. The current vulnerability self-assessment described fully in sections 5.1 and 5.2 was based primarily on a natural hazards approach and focused on identifying exposures to flooding. The future vulnerability self-assessment was based on a vote conducted of workshop participants following an introduction to the three elements of climate change vulnerability assessments – exposure, sensitivity and adaptive capacity. Using these methods, two key vulnerabilities were identified. The first is Lewes' water system and the combined threats of saltwater intrusion into the aquifer and destruction of water conveyance systems that it faces from sea level rise. The second vulnerability is the destructive impacts on homes and City infrastructure from increased flooding.

5.1 Risk and Vulnerability – Self-Assessment Tools and Methodology

While this community pilot project did not include an engineering-based hazard vulnerability and risk assessment for the City of Lewes, a community self-assessment was conducted following the methodology provided by NOAA's Coastal Services Center (CSC) Risk and Vulnerability Assessment Tool (RVAT) and Community Vulnerability Assessment Tool (CVAT). These tools are intended to be used to guide communities through the process of identifying people, property and resources that are exposed to and threatened by injury, damage or loss from natural hazard events. This information is important to help determine and prioritize the precautionary measures that can make a community more disaster-resistant. The process includes a hazard identification analysis, which was covered in sections 3 and 4. The vulnerability assessment component as determined primarily by exposure to flooding includes a critical facilities, societal, economic and environmental assessment. A brief overview of the CVAT analysis rationale and methodology is included below.

Hazard Identification and Analysis – A hazards analysis provides a community with maps that indicate which areas are most susceptible to hazards. A first step in this part of the self-assessment is to consider all hazards that could impact the community. Hazard maps can then be created to assist in determining which areas are susceptible to individual hazards, multiple hazards or possibly all hazards that have been identified. The appropriate decision-makers can then use maps that depict individual hazards or a combination of hazards to make informed decisions about potential actions to reduce hazards.

Critical Facilities Analysis – The critical facilities analysis focuses on determining the exposure of key individual facilities, roadways, transportation corridors or resources within the community to the natural hazard. Because these facilities play a central role in disaster response and recovery, it is important to protect critical facilities to ensure that service interruption is reduced or eliminated.

Societal Analysis – Societal analysis helps communities identify potential sub-populations with special needs or considerations and the locations of these populations. Such groups often include higher concentrations of aging populations or low-to-moderate income households that would most likely require public assistance and services to recover from disaster impacts. Another potential societal concern would be areas with a high concentration of non-English-speaking residents or individuals who lack social connections.

Economic Analysis – The purpose of this analysis is to identify economic vulnerabilities to hazard impacts. Some of the most devastating disaster impacts to a community include the loss of income associated with business interruption and the loss of jobs as a result of business closures. This analysis focuses on determining the flood exposure of centers of economic activity, and the largest employers within the community.

Environmental Analysis – The environmental analysis identifies 1) key environmental resources and environmentally sensitive areas, and 2) those areas that may be impacted by secondary hazards. Environmental resources may be impacted when a primary hazard (coastal storm, wildfire, flood) triggers additional hazards such as toxic releases or hazardous spills. The proximity of significant environmental resources to sites where hazardous or toxic materials exist enables a community to determine overall threats from these facilities. It is then possible to evaluate, prioritize, and target vulnerable locations (key resources and secondary sites) for hazard mitigation activities.

5.2 Risk and Vulnerability Self-Assessment

5.2.1. Critical Facilities

The City of Lewes fully recognizes that before, during, and after a hazard event it is imperative that critical facilities remain operational and accessible. Therefore, as part of this process, Lewes identified critical facility structures within City limits (see Appendix A, Map A-9). During the Lewes vulnerability self-assessment discussion, it was also noted that major roads should be given consideration as critical facilities, especially evacuation routes and those roads that provide access to Beebe Medical Center. Another suggestion was that Fire Station Number 2, although located outside of Lewes municipal boundaries, should be considered a critical facility as it can be used as a shelter and alternate operations center. The complete list of critical facilities identified by the City of Lewes Hazard Mitigation Planning Team is below:

Critical Facilities

- Army Reserve Center
- Beebe Medical Center
- Beebe Medical Center James Monihan Central Utility Building (CUB)
- Cape Henlopen High School
- City of Lewes – City Hall and Government Offices
- City of Lewes Police Department
- Delaware Bay and River Authority – Cape May / Lewes Ferry
- DNREC Lewes Field Facility
- Delaware River and Bay Pilots Association
- Delaware River and Bay Pilots Association Communication Tower
- Harbor Healthcare Nursing and Convalescent Center
- Lewes Board of Public Works Offices (BPW)
- Lewes BPW – 31 Lift Stations
- Lewes BPW Metering Station
- Lewes BPW Substation & Equipment Facility
- Lewes BPW Wastewater Treatment Facility
- Lewes BPW Water Production Plant
- Lewes BPW Well Field
- Lewes Fire Station Number 82, Station 1
- Lewes Fire Station Number 82, Station 2
- Lewes Post Office – Main Facility
- Lewes Post Office Annex
- Radio Transmitter Tower (Lewes)
- Richard Shields Elementary School
- SPI Pharma
- Sussex Consortium
- The Lewes School
- University of Delaware – Cannon Building
- University of Delaware – Marine Operations Building (MOB)
- University of Delaware – Pollution Ecology Lab (PEL)
- University of Delaware – Smith Building
- U.S. Coast Guard Station (Roosevelt Inlet)
- WR-196 (Delmarva Power – Tarpon Drive)
- WR-210 (Delmarva Power – Wescoats Rd.)

Critical Roadways

- Cape Henlopen Drive
- Cedar Avenue
- Gills Neck Road
- Kings Highway
- New Road
- Savannah Road
- Theodore C. Freeman Highway

To help prioritize potential hazard mitigation measures for Lewes' critical facilities, it is important to identify the intersection of critical facilities locations with hazard threat areas. Structures located in high-risk areas should be targeted as priority facilities for conducting future detailed structural and operational vulnerability analyses. Map A-10 in Appendix A is a map of Lewes' critical facilities and their locations relative to the 100-year floodplain.

Critical Facility	Within Floodprone Zone?	Lowest floor elevation (ft NAVD 88)	FEMA 100-year Flood Elevation
Army Reserve Center	N	15.45	--------
Beebe Medical Center	N	11.94	--------
Cape Henlopen High School	N	21.40	--------
City Hall - Main Building	N	8.96	--------
City Hall - Police Annex	N	8.96	--------
City of Lewes Water Production Plant	N	7.06	--------
Delaware Bay and River Authority - Cape May / Lewes Ferry	Y	8.66	VE 10
DNREC Lewes Field Facility	Y	--------	AE 10
Fire Station No. 82	N	9.93	--------
Harbor Healthcare Nursing and Convalescent Center	N	12.25	--------
Lewes Wastewater Treatment Facility	Y	--------	AE 9
Pilot Station / Communication Tower	N	2.22	--------
Post Office Main Building	N	6.77	--------
Post Office Annex	Y	6.24	AE 9
Shields Elementary School	N	4.61	--------
SPI Pharma	Y	6.56	AE 9
Sussex Consortium	N	13.09	--------
The Lewes School	N	6.62	--------
University of Delaware - Cannon Building	Y	12.17	AE 10
University of Delaware – Marine Operations Building	Y	8.10	VE 10
University of Delaware – Pollution Ecology Lab	Y	8.75	AE 10
University of Delaware - Smith Building	N	15.27	--------
U. S. Coast Guard Station	Y	9.90	AE 10

Table 5.1: Lewes' critical facilities located within areas vulnerable to flooding (elevation data updated to NAVD 88 datum based on elevation surveys from Greenhorne & O'Mara, 2000; 100-year flood elevation data based on FEMA FIRMs, January 6, 2005).

As part of its hazard vulnerability study, Greenhorne & O'Mara (2000) examined the relationship between Lewes' critical facilities and flood-prone zones, including surveys of lowest floor elevations at each critical facility. Table 5.1 provides summary information from this report on Lewes' critical facilities located within areas vulnerable to flooding (Greenhorne & O'Mara, 2000, p. 49). Lewes' critical facilities located within flood-prone zones include: SPI Pharma [Barcroft Chemical Plant in 2000], U. S. Coast Guard Station, DRBA – Cape May/Lewes Ferry, DNREC Lewes Field Facility [Doxsee in 2000], Lewes Wastewater Treatment Facility, Post Office Annex, and University of Delaware Hugh R. Sharp campus buildings – Cannon Laboratory, Marine Operations Building (MOB), and the Pollution Ecology Lab (PEL).

Access to and from critical facilities and residences can be seriously limited during major flood events if roadways are flooded. Several of Lewes' main roads lie within FEMA's 100-year floodplain, including Cedar Avenue and Cape Henlopen Drive, and most of the other streets north of the Lewes/Rehoboth Canal. A major flood would minimize or eliminate access to and from Lewes Beach residences and several critical facilities including SPI Pharma, the Delaware River and Bay Authority Cape May/Lewes Ferry, the Post Office Annex, the Pilot Station/Communication Tower and the Lewes Wastewater Treatment Plant. Access to points in Lewes south of the canal would also be limited, with possible flood impacts to portions of Savannah Road, Pilottown Road and New Road. The Greenhorne & O'Mara Hazard Vulnerability Study (2000) includes bridge elevation survey data for 4 bridges in Lewes, 3 of which are in the floodplain (Table 5.2). Each of the bridges is located along a major roadway and each roadway provides access to 1 or more critical facilities.

Table 5.2: Bridge and floodplain elevations, Lewes, Delaware (elevation data updated to NAVD 88 datum based on elevation surveys from Greenhorne & O'Mara, 2000; 100-year flood elevation data based on FEMA FIRMs, January 6, 2005).

Bridge	Surveyed Elevation (ft NAVD 88)	Hazard Zone and Floodplain Elevation (FEMA 2005)	Difference in Elevation	Surrounding Roadway Segments in the Floodplain
Pilot Town Road over Canary Creek	4.11	AE 10	5.89 ft	1050 ft (to DNREC Lewes Field Facility)
New Road over Canary Creek	3.0	AE 9	6.0 ft	600 ft
Savannah Road over the Lewes and Rehoboth Canal	16.85	AE 9[1]	-------	-------
Freeman Highway Bridge	8.67	AE 9	0.33 ft	3500 ft (to SPI Pharma)

[1]The Savannah Road Bridge is located outside of the 100-year floodplain, but is adjacent to an AE 9 zone.

As described in the Greenhorne & O'Mara Flood Mitigation Plan (1999, p. 15-16), a general overview of Lewes' critical facilities and their flood hazard vulnerability is included below:

> The Beebe Medical Center was evaluated in a 1996 Hazard Mitigation Assessment completed by Greenhorne & O'Mara, Inc. This study found that the Beebe Medical Center is protected from flood waters because it is located on high ground along Savannah Avenue. However, flooding along Canary Creek and the Ebenezer Branch could block vehicular access along Savannah Avenue to the Beebe Medical Center. The study noted that an interruption in service at the City's wastewater treatment plant would

probably cause a disruption in hospital functions. Interruptions in service from the electrical distribution center could also affect the medical center.

"Harbor Health Care is a long-term care facility located in Pilottown Village. The majority of the village lies within Zone X and thus would likely not incur flooding during a 100-year event. However, access to and from the facility would be restricted. Vehicles must travel along Pilottown Road, which is located partially within Flood Zone AE 10 [based on 2005 FIRM; AE 9 Zone in 2000 report], to access the facility. Several residents have reported flooding along Pilottown Road during major storm events that could prevent vehicles from traveling along the roadway."

"City Hall is located west of the canal and lies outside of both the 100- and 500-year floodplains. The portion of Freeman Highway connecting City Hall to more inland areas is located just outside of the 100-year floodplain at its intersection with Monroe Avenue. This flooding is associated with the canal. As mentioned above, sections of Savannah Road that connect downtown Lewes to inland areas are shown on FIRMs to be inundated during the 100-year event by flooding from Canary Creek and Ebenezer Branch. Therefore, Freeman Highway offers the best passage between inland areas and the downtown area, but is in close proximity to the 100-year floodplain."

"The Fire Station is located on Savannah Road southwest of the Lewes/Rehoboth Canal within Flood Zone X. Flooding from Ebenezer Branch and Canary Creek could restrict vehicular traffic along Savannah Road. More detailed information about the risk to the facility and possible hindrances to emergency services could be obtained through a hazard vulnerability assessment of the facility. A second fire station also serves Lewes that is located off of Ocean Highway near Nassau Road. This facility is not within the corporate boundaries of the City of Lewes."

"The Lewes Wastewater Treatment Facility [Sewage Treatment Facility in Lewes in 2000] is located in the Canal Flooding Zone and within FEMA's AE 9 Zone [based on 2005 FIRM; AE 10 Zone in 2000 report]. Potential damage to this facility poses a serious risk to the community. Access to this structure would likely be cut-off during a 100-year event. Damage to the facility could cause a break in service, which would affect all residents and shelters as well as emergency operations [services] at the Beebe Medical Center. Furthermore, flood damage could result in a failure at the plant that might lead to an overflow of the plants' contents, resulting in a serious health risk to the community. Further analysis of the plant facilities and its hazard vulnerability would provide more information about the facility's susceptibility to flood damages and what preventative measures can be taken."

"The City's Water Production Plant and BPW Substation and Equipment Facility [Electrical Distribution Center in 2000] is located on Schley Avenue in Flood Zone X. Kings Highway and Savannah Road provide access to the plant [center] from inland areas. According to the City's FIRMs, Savannah Road would experience some flooding during a 100-year event, but Kings Highway would not. Therefore, it is likely that access to the plant [center] would be restricted by floodwaters, but possible via Kings Highway."

"The Cape May/Lewes Ferry Terminal Facility in eastern Lewes is run by the Delaware River and Bay Authority and is located along the Delaware Bay within FEMA's VE 10 zone [based on 2005 FIRM; VE14 and AE9 flood zones in 2000 report]. Access to the terminal would be severely restricted during a 100-year event as the entire area surrounding the facility is within the 100-year floodplain. Cape Henlopen Drive is shown being entirely submerged by the 100-year event on the community's FIRMs, and is the only roadway that provides access to the facility."

"The USCG Station and University of Delaware's facilities near Roosevelt Inlet might experience restricted access due to street flooding during a major flood event. The Delaware River and Bay Cooperative operates from the University's facilities and is responsible for tracking all oil carriers within the Bay in case of a spill. Access to the facilities is provided via Pilottown Road, which flooded during the 1962 and 1998 storms (Figure 5.1)."

Figure 5.1: Flooding on Pilottown Road during 1998 storm.

"Cape Henlopen High School and The Lewes School [Lewes Middle School in 2000] are two facilities that might be used as shelters during a storm event. Shields Elementary School does not serve as a shelter, but is considered a critical facility. Cape Henlopen High School is located outside of the City of Lewes' corporate boundary in Zone X. Access to the school via Route 9 does not appear to be hindered by the 100-year flood according to the FIRM. The elementary and the Lewes schools [middle school in 2000] are located near the intersection of Savannah Road and Sussex Drive outside of the 100- and 500-year floodplains. Access to and from inland areas along Savannah would be difficult during the 100-year storm event as the road is shown as being inundated by floodwaters from Canary Creek and Ebenezer Branch on the FIRM."

"The Lewes Sussex Consortium School is located on Dupont Avenue. The school is not a storm shelter facility, but is a learning facility for disabled children. The school is located in Flood Zone X, but due to street flooding during a 100-year event along Pilottown Road and Savannah Road, vehicular access to the facility could be difficult." (Excerpts from Greenhorne & O'Mara, 1999, p. 15-16, with updated facility names and FEMA flood zones included.)

5.2.2. Societal Analysis – Vulnerability Self-Assessment

A societal vulnerability assessment examines the vulnerability of people of different ages, income levels, ethnicity, capabilities and experiences to a hazard or group of hazards. Special consideration areas are those where personal resources or characteristics are such that their ability to deal with hazards is limited. For

example, in low-income households, structures may be more likely to be underinsured for hazard damages, and persons may have limited financial resources for pursuing individual hazard mitigation options. There may also be areas where other considerations such as age, mobility or language can significantly impact individual response to a disaster, as well as disaster-recovery efforts.

During the July 14, 2010 workshop, the societal analysis breakout group focused on a discussion of how the current population of Lewes can be characterized. In general, Lewes is comprised of both year-round and seasonal residents. Currently, many of the year-round residents are retirees representing a societal mix. During summer months, seasonal residents, renters, and visitors add to the mix of Lewes' population. It was noted that within town boundaries, many of the neighborhoods in Lewes have become gentrified over the past several decades. The population has also become more aged, with a greater number of persons over age 60, and a smaller influx of children and young adults.

In the absence of more detailed, accurate data collected at the local level, publicly available census data at the block and block group level can be used for this analysis. Demographic characteristics can be used to identify special consideration areas. For the City of Lewes, two categories were selected from currently available 2000 U.S. Census and 2005-2009 American Community Survey data to help illustrate community sectors with high needs: percent of persons 21-64 years with a disability (Map A-11, Appendix A), and owner-occupied housing with no vehicle available (Map A-12, Appendix A).

5.2.3. Economic Analysis – Vulnerability Self- Assessment

The Lewes economic analysis includes a general overview of the local economy, including identification of primary regions of economic activity and Lewes' largest employers. To evaluate the vulnerability of the Lewes economy to impacts of flood hazards, the location of commercially zoned economic activity centers is mapped with an overlay of the floodplain (Maps A-13 & A-14 in Appendix A). Based on proximity to high-flood risk areas, it is then possible to educate vulnerable businesses and industries about their risks and vulnerabilities, and encourage them to conduct additional evaluations and detailed analyses. By identifying high-risk business areas, communities can work with local businesses to identify hazard mitigation measures that help reduce their structural and operational vulnerabilities and create a more sustainable economy.

During the July 14, 2010 workshop, the economic analysis breakout group identified revenue generators and revenue catalysts for the City of Lewes. Tourism and Beebe Medical Center were highlighted as primary catalysts of revenue. The list of revenue generators included the many small businesses in Lewes (especially those located on Second Street), rental properties (especially those located in the Lewes Beach area), the University of Delaware campus, many of the special functions coordinated by the Chamber of Commerce, seasonal activities such as the Lewes Farmer's Market, and the boating/fishing/tourism industry in general. It was also noted that Lewes history and the Lewes Historical Society are important economic generators, especially related to tourism and visitors attracted to architectural heritage, special activities, tours, and museums. Maps A-15 and A-16 depict the location of historic resources in Lewes and their location relative to the 100-year floodplain. A few of the primary employers mentioned during discussions include Beebe Medical Center, the Cape Henlopen School District, University of Delaware, various local banks and SPI Pharma. Additionally, it was noted that many of the employees of local businesses are not residents of Lewes, but rather drive in from adjacent outlying areas.

5.2.4. Environmental Analysis – Vulnerability Self- Assessment

Key Environmental Resources – Several areas were identified by Lewes workshop participants as key environmental resources, including bay waters and bay bottom, beaches, dunes, wetlands, tidal creeks, freshwater streams, freshwater ponds, wellheads and recharge areas, forests, all wildlife and

endangered/threatened species (e.g., horseshoe crabs, plovers, red knots, fish, etc.). Special notice was given to salt marsh and beach-protected areas and wildlife refuge/preserve sites (e.g. Beach Plum Island). Additional environmental resources that should be considered in the vulnerability analysis include all recreational areas, as well as cultural, historical and archeological sites in the Lewes vicinity.

Areas of special interest and value include tidal wetlands, especially the marshes located along the Lewes / Rehoboth Canal, the Great Marsh of Lewes and Lewes Creek Marsh. These areas are not only valuable natural resources areas that provide habitat, nesting and resting areas for many animals, but they also provide important flood protection to adjacent structures and infrastructure. When tidal flooding occurs, the wetland areas serve as buffers by storing floodwaters during severe storm events.

Of special note is the 30-35 acre tract of undeveloped wetlands that lies northeast of the canal between Savannah Road and Freeman Highway. The Lewes Sewage Treatment Plant is located within this wetland area, and although it is vulnerable to flooding, the salt marsh provides added protection from flooding. Other critically important tracts of wetlands include the marsh areas that extend approximately 200-800 feet northeast along the canal from the Savannah Road Bridge to Roosevelt Inlet. Additionally, it is important to note that Lewes' western and eastern borders are wetlands – The Great Marsh to the west, and Lewes Creek Marsh to the east.

An outdoor resource inventory map is shown in Appendix A, Map A-17. The location of these outdoor resources relative to the 100-year floodplain is shown in Map A-18.

Secondary Risk Sites – The location of potentially hazardous facilities relative to primary hazard zones (e.g. flood zones) is critical to identification of secondary risk sites. Hazardous facilities or secondary risk sites may pose threats not only to environmental resources but also to human health and properties. For example, a sewage treatment plant located in a flood zone may be damaged during an extreme event, thus releasing untreated sewage into a nearby water system. This could not only harm the local ecosystem, but could also contaminate adjacent waterways and flooded properties. By identifying and prioritizing hazardous facilities that intersect with environmental resources, mitigation strategies to protect both can be developed.

During workshop discussions (July 14, 2010), the following types of hazardous facilities (secondary risk sites) were identified for Lewes: oil and gas storage facilities, underground storage tanks, solid waste facilities, marinas/ports for their fuels and oils, the UD wind turbine and chemical storage at certain businesses (e.g. SPI Pharma, University of Delaware, Beebe Medical Center, Lewes BPW, etc.). Additional consideration should be made for secondary risk sites outside City limits, as discharge from hazardous facilities can be transported into Lewes via runoff, streamflow, etc.

A map showing various hazardous facilities in the Lewes vicinity and the location of these hazardous facilities relative to the 100-year floodplain is shown in Map A-19.

5.3 Future Vulnerability Self-Assessment - Exposures

Using the information about existing natural hazards (Section 3) and climate change (Section 4), combined with the critical systems information discussed above (Section 5), a preliminary self-assessment of future exposure was conducted. From this analysis, it is believed that coastal storms, floods, wind, drought/extreme heat and coastal hazards, such as erosion, are the primary natural hazards that will be affected by climate change. Severe thunderstorms, wildfire and winter storms may also be experienced at a greater frequency or a greater intensity in the future due to climate impacts, but the extent of this change is unclear.

In the case of flooding, some additional specific data was used to create a better understanding of the City's future flood vulnerability. First, as the maps developed through the Department of Natural Resources and

Environmental Control (DNREC) inundation map viewer (Figure 4.7 in Section 4) reveal, the future areas of the City likely to be inundated will be greater. Additionally, Maps A-20, A-21 and A-22 in Appendix A, which were developed by Mike Powell (Delaware DNREC) and Mark Nardi (U. S. Geological Survey) for Workshop Three, show that the future 100-year storm event could cover more land in the New Road area. This is an indication that future 100-year flooding across Lewes would be greater. In addition to conceptualizing future flooding in terms of it physically covering more ground, one should recognize that future flood heights will be higher in any one location than they will be today. Moreover, scientific analyses have shown that flood frequencies will be greater in the future. In other words, the 100-year storm of today could become the 10-year or even 5-year storm event. Specifically in Atlantic City, researchers found that the present 1 percent chance storm (100-year storm) could be seen as frequently as once every 4 years by 2050 and once every 2 years by the end of the century (Kirshen, 2008).

From a self-assessment perspective, the following additional vulnerabilities were identified during a workshop in Lewes held on October 21, 2010:

Societal Impacts

- Evacuation route closes from flooding leading to isolation of citizens
- Cape shores beach erosion
- Increased public health risks including air quality and skin cancer
- Physical loss of homes due to flooding
- Small population of low-income people who will suffer more
- Historical structures and cemeteries in the community could be destroyed or damaged

Economic Impacts

- Loss of homeowner and business insurance from future flooding
- Loss of tourism from the loss of beaches
- Strain caused by food supply threats

Environmental Impacts

- Loss of beaches from erosion
- Loss of critical habitat and species

Critical Facilities

- The wastewater treatment plant could be lost or damaged from both flooding and erosion
- Several concerns regarding water resources and the supply, in particular, were cited including saltwater intrusion into the groundwater and seasonal increases in drought.

Finally, the flooding potential of specific roads – New Road, Cedar Street and Savannah Road – under current and future design storms was analyzed by Mike Powell (Delaware DNREC) and Mark Nardi (U.S. Geological Survey). In this analysis, the road elevations were compared with the flood heights in order to determine the location of current and future flooding. As Map A-23 (Appendix A) shows, in the case of New Road, a one-foot rise in water level would lead to two additional road locations being flooded during the 100-year storm event and only one additional location being flooded during the 10-year storm event.

5.4 Selecting Key Vulnerabilities

Climate change vulnerability is determined by exposure as well as sensitivity and adaptive capacity. Sensitivity is the degree to which a system would be impaired by the impacts of climate change if the system were to hypothetically experience those impacts. Systems that are greatly impaired by small changes in climate have a high sensitivity, while systems that are minimally impaired by the same small changes in climate have a low sensitivity. Adaptive capacity is the ability of a specific system to make adjustments or changes in order to maintain its primary functions even with the impacts of climate change. In cases where exposure is identified, sensitivity and adaptive capacity levels are typically combined upon the general relationship displayed in Figure 5.2.

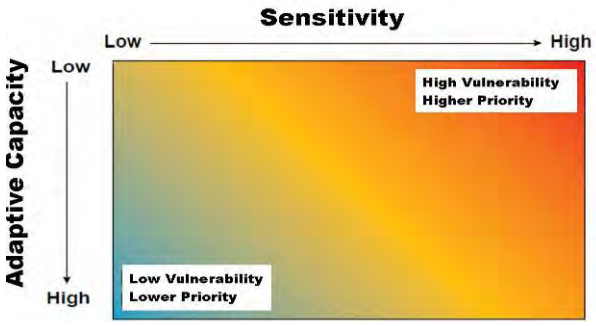

Figure 5.2: Vulnerability level based on sensitivity and adaptive capacity.

Key vulnerabilities are those that are of greatest concern to a community. In the case of these self-assessments, these key vulnerabilities were determined by introducing the participants in the October 2010 workshop to the above-described concepts of vulnerability. Participants were then asked to list the impacts of climate change and natural hazards that were of greatest concern to them (the complete list of concerns is shown in Appendix C). These concerns were aggregated into the collective system they represented – in total, 12 systems were identified. Systems and their associated vulnerabilities were voted upon by participants. Specifically, each participant was given three votes to identify what they believed to be a key vulnerability. Two systems received an overwhelming majority of votes: the **water system** and its vulnerability to changing precipitation patterns as well as possible recharge area contamination; and **homes** and **City infrastructure's** vulnerability to flooding.

Section 6: Strategies for Addressing Vulnerabilities to Hazards and Climate Change

This section provides information on ways for the City to move forward with improving its resilience towards natural hazards and climate change. Included in this chapter is information on work that Lewes has already done in the area of natural hazard mitigation as well as the work that the City has proposed in the most recent County Hazard Mitigation Plan. Additionally, this section covers best practices presented to workshop participants, the strategy prioritization exercise used and the final actions that workshop participants identified for implementation by the City.

6.1 Current Hazard Mitigation Actions

The City of Lewes has a long tradition of being a leader in the area of natural hazard mitigation. The City was one of only 200 US cities to participate in Project Impact, a FEMA effort to enable municipalities and businesses across the country to become more resilient to natural hazards. Additionally, the City established a Mitigation Planning Team in 2002, thus making the City more effective and proactive in addressing its hazard vulnerabilities. The efforts of the Mitigation Planning Team have led to many successful projects in Lewes. The team has coordinated table top exercises and improved emergency preparedness procedures. Additionally, the planning team has created a controlled burn program, making the City significantly less vulnerable to the threat of wildfires.

Also, through the efforts of the Mitigation Planning Team (MPT), Lewes has updated its hazard mitigation strategy, part of the County's multi-hazard mitigation plan, which has been approved by both the Delaware Emergency Management Agency (DEMA) and FEMA. During this recent update to the hazard mitigation strategy, the City identified a suite of actions as their primary goals for the coming five years. These actions are also listed in further detail on the City's website[1]. As noted with an asterisk in the list below, several of the strategies recommended through the Lewes Hazard Mitigation and Climate Adaptation project are the same as or will enhance the actions identified by the MPT:

1. Review and update evacuation and notification procedures for the City.*
2. Improve stormwater capabilities throughout the City.
3. Increase participation in the NFIP.*
4. Minimize damages from high wind events.
5. Implement a community outreach program.*
6. Reduce vulnerability to wildfires.
7. Continue data acquisition and enhancement to the City's GIS.*
8. Enlist the services of City service organizations in implementing a disaster preparedness outreach program.
9. Facilitate the coordination of response procedures related to events.
10. Develop response plans related to specific needs population and pets. Also, include a "Refuge of Last Resort" plan and a plan to transport City residents to County designated shelters.

6.2 Potential Hazard Mitigation and Climate Change Adaptation Strategies

Though there are many strategies that can be used to address both flooding and water resource concerns, this section focuses on a few types of strategies likely to be of relevance for Lewes. A complete list of all the strategies suggested during this process from ICLEI, Delaware Sea Grant, DEMA, DNREC and FEMA can be found in Appendix D. Strategies for any system can be broken down into 7 different types – listed below along with examples for flooding and water resource systems.

[1] http://www.ci.lewes.de.us/index.cfm?fuseaction=plansprojects.hazardmitigationstrategy

1. Planning Tools
    - Integrate climate change and natural hazards into Local Comprehensive Plans
    - Consider water resources in all planning efforts
2. Information Gathering Tools
    - Survey of vulnerable homes based upon home heights
    - Increase understanding of aquifer dynamics and amount of influence of recharge zones
3. Regulatory Tools
    - Zoning and floodplain overlays
    - Setbacks
    - Water conservation requirements
4. Spending Tools
    - Capital improvements
    - Acquisitions of vulnerable lands
5. Tax and Market-Based Tools
    - Additional financial incentives for building above the building code
    - Stormwater utilities
    - Beach nourishment tax district
6. Community Engagement Tools
    - Improve outreach and education focused on successful behavior changes related to home building and retrofits
    - Create water monitoring or storm monitoring programs that utilize citizens while also providing useful data to the City
7. Ecosystem-Based Tools
    - Create buffer zones for inland migration of natural resources
    - Restore the health of natural water purification systems

6.3 Strategy Prioritization

Recognizing that the City could not implement all the actions identified through the workshop process, two workshops were dedicated to prioritizing the actions in order to identify a limited number to recommend that the City implement. During Workshop 3, participants, in groups of 7 – 10, voted on the most important of the actions listed in each of the three categories – homes, City infrastructure and water resources. Based upon these votes, the list was narrowed down to the top 5 for each of these categories. Then during Workshop 4, participants, again in groups, gave each action a score of 1 – 5 for the action's social, technical, administrative, political, economic and environmental feasibility/benefit. Thus, for example, the action of elevating certain roads might get a score of 3 for technical feasibility, but only a score of 1 for economic feasibility. Scores were totaled for each action and then submitted to be compared with other actions. The average score from all 6 groups was taken and used as the final means of ranking the proposed strategies. Ranking exercise materials and scores can be found in Appendix E.

6.4 Primary Hazard Mitigation and Climate Change Adaptation Actions

Based upon the results from the ranking exercise, as well as some additional input from relevant City boards and departments, the following are the six actions recommended that the City begin implementing. The actions are listed in order of the scores that they received with the highest ranked action at the top. Many of these actions (starred below) were listed by the Mitigation Planning Team in the current hazard mitigation strategy as part of the County's Multi-Hazard Mitigation Plan.

1. Incorporate climate change concerns into the comprehensive plan and into future reviews of the building and zoning codes.
2. Improve outreach and education particularly focused on successful behavior changes related to home building and retrofits.*
3. Ensure that aquifer information is integrated into all planning efforts.
4. Use elevation data to determine road levels and evacuation risk.*
5. Evaluate the City and the Board of Public Works (BPW) infrastructure's flood vulnerability from direct flood impacts, as well as from indirect flood impacts to access routes.*
6. Improve the City's level of participation in the community rating system (CRS).*

It is important to note that many of these actions could help create a foundation towards other actions that were highly regarded by participants but that did not make the top of the list. For example, evaluating City infrastructure's flood vulnerability could help the City to incorporate climate change and natural hazard impacts into design, construction, operations and maintenance of these facilities. Two links can also be made between improving outreach materials (ranked second and a selected action) and developing improved maps (ranked seventh). First, these improved maps could be created to help enhance the outreach materials. Furthermore, as the outreach materials succeed in moving public knowledge and opinions, the improved maps could possibly be adopted into City policy.

The remainder of this document focuses on the specific actions identified by workshop participants and recommendations for how the City can implement these measures.

Section 7: Moving Forward – Monitoring and Implementation Guidance

In order to help ensure that this project is successful, it is proposed that the Mitigation Planning Team work to monitor the implementation of these proposed actions. During every other quarterly meeting, the Hazard Mitigation and Climate Adaptation Action Plan should be addressed. The team should check in both with each other and outside departments on progress with implementation. As progress is made, additional actions that did rank as highly should be considered. When implementation is not progressing, the team should work to determine what barriers are holding up implementation and work to devise solutions for overcoming those barriers. By determining the road block, the team can determine if there is a way to remove that particular deterrent or if the action should be put on hold for an extended period of time.

In addition to monitoring the plan, the following guidance on implementing the 6 proposed climate change adaptation and hazard mitigation strategies are intended to assist City staff and boards with achieving these goals. For each strategy, a lead contact is identified as the primary person responsible for overseeing the complete strategy; however, key additional staff and resources are also identified in order to provide the lead with the assistance necessary to complete specific tasks. Going forward, the lead will initiate specific strategy steps and determine the timeline while the other people, departments or outside resources identified may complete the majority of the specific work.

Also included in the guidance below are key steps in the process, general information on possible timelines, as well as some points regarding the budget for each strategy. Additionally, the strategies each highlight their relevance for the City in terms of the City's comprehensive plan and Mitigation Planning Team goals.

Guidance for Implementation:
Proposed Inclusion into Planning and Zoning Strategy for the City of Lewes

Specific action: Incorporate climate change and natural hazard concerns into the comprehensive plan and the zoning code.

A. Alignment with Existing Priorities & Co-Benefits

- Lewes' meaningful relationship with the sea, a core community value, would be greatly enhanced by recognizing in advance that that relationship will change as sea levels rise. Integrating climate change and natural hazards into planning and zoning codes will help Lewes to maintain its meaningful relationship with the sea.
- The Lewes Comprehensive Plan includes the following actions that would be enhanced by this action:
  - Create and adopt a conservation-design ordinance and regulations including wetlands, wellhead and recharge protections, open-space preservation, open-space and wetlands buffers and clustering to encourage environmentally sensitive development.
  - Research, write and adopt ordinances to protect wetlands, wellhead and water-recharge areas, including riparian buffer zones.
  - Research and adopt methods to permanently protect existing and future open space, including buffer zones.
- Depending on the exact zoning code changes that are made, these actions could help to improve Lewes' Community Rating System (CRS) scores.

B. Administration and Staffing

- Led by the Planning Commission with the chairperson as the primary point of contact.
- The Mitigation Planning Team would provide assistance as needed.

C. Implementation Steps – General

Step 1. Create regular communications between the Planning Commission and the Mitigation Planning Team either in the form of post-meeting email updates or in the actual attendance of key meetings by representative members of the groups.

D. Implementation Steps – Comprehensive Plan

Step 2. During the current update[1] of the comprehensive plan add the following suggested revisions or similar revisions in order to help ensure that the future update to the plan has climate change and hazard mitigation concerns fully integrated.

- Add a specific recommendation that states: **"High—Study further and integrate climate change and natural hazards into the next update of the comprehensive plan."**
- Following the mention of either the *Hazard Vulnerability Study or the Flood Mitigation Plan for the City of Lewes* add the following language: **"Documented data has shown that sea level has increased in Lewes by one foot over the past century. Conclusions from scientists around the world are that the rate of sea level rise will increase over the next century. These changes in sea level will cause increased inundation, shoreline erosion, and flooding from severe weather events in Lewes. It may additionally cause accelerated saltwater contamination of ground water and surface water supplies, and expedited loss of critical habitats. According to Delaware Department of Natural**

[1] The current update of the comprehensive plan is a quick revision occurring in the coming months.

Resources & Environmental Control (DNREC), development in Delaware's coastal zone that does not account for increasing inundation levels puts homes, businesses and infrastructure at risk resulting in human hardship and higher cost to government for response and recovery. Given that Lewes is already vulnerable to storms and flooding events, these increased threats from climate change are of even greater concern to our community."

Step 3. During the future rewrite[2] of the plan, work to fully integrate climate change and natural hazards language into the plan through some or all of the following options:

- During the planning process including maps of potential future flood risks.
- Creation of a core value around the general safety of citizens and the community with a need to plan for future threats.
- The inclusion of climate change and natural hazards data in the background information – specifically be sure to call out the impacts the community has experienced as well as the **future flood threat** to the community.
- Include the above provided language following the mention of either the *Hazard Vulnerability Study or the Flood Mitigation Plan for the City of Lewes.*
- Have a highest priority recommendation be that the City enhance its zoning code to foster citizen safety through some of the revisions listed in Section E below.

Step 4. During the future rewrite of the plan work to fully integrate climate change and natural hazards into the plan by using the following sample language:

- General language about Lewes as a hazard mitigation leader and preparing for future climate change impacts:
  "Over the last decade, Lewes has worked to address natural hazard threats through the creation of a Mitigation Planning Team, controlled burns and internal assessments. Lewes can and will continue to be a leader in this area by preparing and planning for the expected impacts of a changing climate."
- Lewes' climate change threat:
  "Lewes, Delaware, already considered highly vulnerable to many natural hazards including coastal storms, flooding and high winds, will become increasingly vulnerable to these threats as the climate changes. The greatest threats to the community come from rising seas, which have been documented locally to be one foot per century since the 1920s. Looking forward, scientists have confirmed the seas will rise at an accelerated rate this coming century. In Lewes, this rise will very likely cause flooding to cover more land and reach high elevations on already designated flood zones. It is also expected to cause an increased frequency of current design flood events and increase erosion rates. Finally, sea level rise could cause saltwater intrusion in the local coastal aquifer thus threatening Lewes' sole water source."
- Specific actions items to recommend:
  "Highest – review the zoning code to ensure that flood regulations are strengthened and buffers around wetlands are increased"
  "High – enhance wellhead-recharge protection efforts"
  "High – improve City-wide stormwater management program"
  "Medium – create an educational program for citizens centered on flood hazards, coastal construction practices and evacuation procedures"

Step 5. Review national best practices for integrating climate change into comprehensive planning and adopt several of these practices locally.

[2] The future rewrite of the comprehensive plan will be a full scale edit to the current plan intended to be completed in 2015.

E. Implementation Steps – Zoning Code

Step 6. Review, and when appropriate, adopt the following specific suggestion for regulations that exceed the National Flood Insurance Program (NFIP) minimums.

a. Create a freeboard standard for homes in the floodplain.
   - This is an additional height requirement above the current base flood elevation (BFE) that provides a margin of safety and saves people money on their flood insurance.

b. Create stricter flood regulations for critical facilities (hospitals, fire stations, hazardous materials storage sites, etc.).

c. Create specific development prohibition in floodplain areas. Examples include:
   - The prohibition of new sheds in the floodplain.
   - Prohibiting the expansion of the footprint of existing homes.

d. Create a floodplain setback – requiring that homes be built a minimum distance from the floodplain, river channels or shorelines.

e. Protection of flood storage capacity – using land development criteria and low density zoning to reduce the damage potential within the floodplain and help maintain flood storage and conveyance capacity.

f. Updating flood maps to include future flood risks.

Step 7. Review the zoning code for additional changes with a focus on improving public safety and property protection.

a. Determine framework by which to review the zoning code. Some suggestions would be to consider the number of homes, properties and citizens affected, the potential risk that the revisions would eliminate and the local acceptance of these zoning code changes.

b. Review the follow sections using framework:
   i. Floodplains (§197-72)
   ii. Drainage (§197-76)
   iii. Permanent stormwater management (§197-77)
   iv. Erosion and sediment control (§197-78)

c. Create proposals to strengthen the code in order to better protect citizens and create a more resilient community.

Step 8. Finalize zoning code changes.

F. Timeline Information

- Step 2 should be started immediately so as to ensure that it is addressed fully in time for the comprehensive plan update that will be occurring in the next few months.
- Step 1, which would be an ongoing action with no specific end date, can also be started immediately as it could greatly benefit both the Mitigation Planning Team and the Planning Commission and does not require a significant amount of time to complete.
- Steps 3, 4, and 5 could be considered ongoing as they will be a part of a longer-term strategy for the 2015 comprehensive plan update.
- Zoning code regulation changes should be explored as soon as possible to determine if any can be easily added to the current code update. If the recommendations cannot be easily added, a separate time frame for zoning code changes would need to be created.

G. Financing and Budget

- This work can vary greatly in cost; however, the initial review and changes to lay the groundwork for future updates could be done for limited costs.
- Costs are likely to increase if a contract with professional services or consulting firm are required, and/or if review by an attorney is required.

H. Monitoring

- An indicator of partial success of this strategy would be a reference to climate change in the current comprehensive plan update.
- An indicator of complete success of the comprehensive plan update portion would be many references to climate change in the future comprehensive plan and an inclusion of at least 2 of the suggested changes.
- An indicator of complete success of the zoning code portion would be the inclusion of several standards that go beyond the NFIP minimums and improved CRS scores.

Addendum to Implementation Guidance – Preparing for Future Flood Risk: Recommended Planning, Regulatory, and Management Options

The following recommendations and options for managing future flood risk were presented by Mike Powell, Flood Mitigation Program manager for Delaware Department of Natural Resources and Environmental Control:

A range of options for preparing for future risk – all are needed

- Educate the public and decision makers about future flood risk.
- Make land use decisions based on future increased risk, not on past decreased risk.
- Building Codes for current/future construction should reflect the increased risk that buildings will experience not on past decreased risk.
- Public safety planning should reflect changing conditions.

Planning and Regulations – recommended changes

- The 100-year flood standard for setting floor elevations is neither adequate not is it sustainable.
- Adopt higher standards and regulatory floodplain area to address uncertainty.
- All new construction and substantial improvements have lowest floor elevated at least 1-2 feet of freeboard above FEMA's 100-year flood elevation (but what about height restriction?)
- New lots should not be created in the floodplain.
- Limit new development in the floodplain – no new subdividing, infilling existing lots allowed but to higher standards.
- New structures should be set back adequately from eroding shorelines to allow for dune and beach preservation over the lifetime of the structure, taking into account expected erosion rates.
- Regulate development to future risk level, not past.
- Adopt a No Adverse Impact approach to regulation to reduce or eliminate practices which increase flood risk to adjacent properties.

Risk Management and Flood Mapping –recommended changes

- Utilize best available technology to map risk and plan development accordingly.
- Use new technologies to more easily visualize risk.
- Manage flood risk to future levels, not current or past. Stop using floodplain maps which depict current or past risk to design future construction.
- Consider flood mapping that projects future levels of risk.
- Use GIS-based data and planning approaches rather than paper maps.
- Evacuation and street flooding should be incorporated into subdivision design.
- Roads servicing new development should be located on grade above the base flood elevation.
- Incorporate hazard mitigation into community functions - for example:
  - City of Lewes Mitigation Planning Team.
  - Provide grant assistance to property owners where possible – form partnerships.
  - Training of staff in flood hazard reduction.
  - Greater utilization of existing resources.

Guidance for Implementation:
Proposed Education and Outreach Strategy for the City of Lewes

Specific action: Improve outreach and education particularly focused on successful behavior changes related to home building and retrofits.

Education and outreach about natural hazards, climate change, potential community impacts, and what can be done to prepare for and mitigate impacts can have multiple benefits. Public education can foster public support for preparedness planning at the government level and influence changes in behaviors to decrease vulnerability and risk to natural hazards and climate change.

Outreach materials related to hazard mitigation and climate change adaptation in the City of Lewes are included in Appendix F, including fact sheets, presentations and talking points, and a case study summary of the City of Lewes pilot project.

A. Alignment with Existing Priorities & Co-Benefits

- This adaptation strategy meets and aligns with existing community priorities and practices as identified by the City of Lewes Mitigation Planning Team.
- It specifically aligns with one of the eight mitigation actions submitted as part of the 2010 Sussex County Multi-Jurisdictional Hazard Mitigation Plan: Implement a Community Outreach Program.
- Education and outreach activities are also in alignment with the City's Project Impact initiative and the high priority that Lewes has placed on taking steps to strengthen homes and buildings to withstand high winds and floods, as well as public education and awareness through workshops and seminars.
- Annual reminders of the flood threat, safety precautions, warning signals, etc., have been shown to be helpful in keeping up awareness of the hazard and what individuals should do.
- The following co-benefits can be achieved by implementing this measure:
  - Coordination with and enhancement of Mitigation Planning Team (MPT) outreach publications and brochures.
  - Coordination with and enhancement of information with BPW mailings and City tax bills.
  - Coordination with and enhancement of CRS education/outreach activities that may ultimately result in improvement of the City of Lewes' CRS rating.

B. Administration and Staffing

- This effort would be led by the Mitigation Planning Team (MPT), with the Mayor and/or MPT chairperson as a primary point of contact. Additional members of the Mitigation Planning Team will provide assistance as needed, especially related to specific hazards and areas of expertise.
- For example, the Lewes Building Official will be the primary point of contact on topics related to construction retrofits; the Lewes Fire Department will be the primary point of contact on fire-related hazards.
- In addition, Delaware Sea Grant College Program will provide assistance with education and outreach efforts.

C. Implementation Steps

Step 1. Compile a list of existing hazard mitigation materials that are currently utilized by the City for education and outreach purposes. These materials would include newsletters, fact sheets, utility inserts and brochures that have been developed for the Mitigation Planning Team activities and/or NFIP and CRS program activities.

Step 2. Identify areas for expanding outreach opportunities. Determine which education/outreach materials should be updated to include additional natural hazard, climate change and mitigation activity information.

Step 3. Develop a coordinated education/outreach plan that meets multiple needs and purposes. For example, enhancement of separate MPT and CRS activities and products could likely be combined to serve emergency management, hazard mitigation, flood mitigation program and public safety purposes.

Step 4. Review current information, identify gaps/needs and update information available on the City's website related to natural hazards, climate change, mitigation and adaptation. Information posted on the City website can be easily accessed across the community and can be revised and updated as necessary.

Step 5. Review and update print hazard mitigation/climate adaptation reference material and resources provided by the City to the Lewes Public Library.

Step 6. Continue the practice of providing fact sheets, references and other relevant resources in Lewes City Hall.

Step 7. Develop a schedule for public meetings and educational workshops related to natural hazards, climate change mitigation and adaptation. A sub-committee of the Mitigation Planning Team could develop a list of possible topics and speakers and work with partners to schedule events and presentations. Public meetings and educational workshops can be scheduled around particular events, such as decisions about major infrastructure investments or specific weather/climate-related events such as drought, severe coastal storms, etc.

Step 8. Continue work on planning, hosting, and/or attending professional development training sessions for City officials, MPT members, and others.

Step 9. Continue the practice of issuing press releases, public statements and special announcements related to specific natural hazards (e.g., Hurricane Awareness Week). Enhance existing practice by expanding public statements to include climate change and various mitigation/adaptation strategies. Press releases can be distributed to draw the public's attention to specific activities that the City is pursuing to continue managing the process of natural hazards/climate change preparedness.

Step 10. Develop a communication and outreach program with groups such as local Homeowner's Associations. Events aimed at specific groups can be used not only for awareness purposes, but also to obtain targeted feedback about preparedness actions and options from property owners and residents.

D. Timing Information

- All education/outreach activities can and should begin immediately.
- Outreach should be considered an ongoing activity rather than a one-time event.
- Activities can be implemented at any time – timing is not critical, but information sharing and public events can be tied to external events (hurricane season, '62 storm anniversary).
- In general, most education and outreach activities could and should be coordinated to enhance objectives of various programs and committees within Lewes. For example, there are many opportunities for collaboration between Mitigation Planning Team education activities and Lewes NFIP/CRS outreach programs.

E. Financing and Budget

- While education and outreach activities are presently included as part of the Mitigation Planning Team efforts, additional activities and goals may go beyond basic expectations of current staff.
- Additional funds may be needed for print publications and web-based materials.
- At this time it is not known if additional funding sources are available, but the Mitigation Planning Team can explore funding opportunities via DEMA, FEMA, DNREC, Delaware Sea Grant, and other agencies.
- At this time it is not known how much additional funding may be required.

F. Monitoring

- Indicators to gauge success would include: a list of print and web-based educational materials created and delivered to City stakeholders, residents, and property owners; an inventory list of outside agency publications made available to residents and property owners; a list of training courses, workshops and seminars presented to residents, property owners, and City officials, etc.
- An additional indicator of success would be the number of CRS credits achieved through education and outreach activities.

Guidance for Implementation:
Proposed Aquifer Information Integration Strategy for the City of Lewes

Specific action: Ensure that aquifer information is integrated into all planning efforts.

A. Alignment with Existing Priorities & Co-Benefits

- The Lewes Comprehensive Plan includes the following two high-priority actions that directly align with this action:
  - Consider developing a joint Board of Public Works (BPW)/Planning Commission planning process or develop a parallel BPW long-range plan that reflects the core values of the certified Municipal Comprehensive Development Plan.
  - Continue to coordinate planning and strengthen the cooperative relationship between BPW and City management.
- The Lewes Comprehensive Plan has a number of high priority items related to water-recharge areas listed below that would benefit from this integration:
  - Create and adopt a conservation-design ordinance and regulations including wetlands, wellhead and recharge protections, open-space preservation, open-space and wetlands buffers and clustering to encourage environmentally sensitive development.
  - Research, write and adopt ordinances to protect wetlands, wellhead and water-recharge areas, including riparian buffer zones.

B. Administration and Staffing

- Co-led by the BPW and the Planning Commission. The BPW General Manager or President would be the BPW contact and Planning Commission Chairperson would represent the Planning Commission.

C. Implementation Steps

Step 1. Create an informational event for area citizens and Lewes staff on the local aquifer and what are its real threats and what they can do to address those risks.

Step 2. The BPW should identify the meetings and plans for which additional aquifer information is required in order to better protect this resource.

Step 3. Establish working relationship with appropriate boards and departments that oversee the decisions and plans that require additional aquifer data.

Step 4. Create model language that can be used to help ensure that aquifer information is included in plans and decisions.

D. Timeline Information

- This strategy can be considered an ongoing strategy with no particular end date; however, it can be started as soon as the BPW is ready to take on the project.

E. Monitoring

- Success of this effort should be monitored at the initiation of a planning process or a planning decision. During a planning process, if those with aquifer knowledge are not present and if aquifer information is not collected, then this effort has not been successful. Similarly, if planning decisions are made without this knowledge, then the effort has not achieved its goal.

Guidance for Implementation:
Proposed Evacuation Route Assessment Strategy for the City of Lewes

Specific action: Use elevation data and flood sensors to determine road levels and evacuation route vulnerability.

A. Alignment with Existing Priorities & Co-Benefits

- This strategy aligns with the following two strategies in the current hazard mitigation plan:
  - Review and update evacuation and notification procedures for the City.
  - Continue data acquisition and enhancement to the City's GIS.
- Additionally, this strategy aligns with the County's hazard mitigation goal of working "with DelDOT to improve all emergency access routes throughout the County." Lewes' evacuation routes are a part of this system and, therefore, Lewes could possibly get data through this effort.
- The Lewes comprehensive plan lists the following actions to which road evacuation data should be integrated:
  - Consider publishing and issuing a brochure describing flood hazards and evacuation procedures in Lewes.
  - Develop a City landowner education program to encourage the proper care and maintenance of ditch and drainage systems.

B. Administration and Staffing

- This strategy would be led by the Mitigation Planning Team with the City Manager as a primary point of contact. Additional members of the Mitigation Planning Team will provide assistance as needed.
- This strategy will require additional support and coordination from agencies outside of the City. DelDOT, Delaware DNREC (Flood Mitigation Program), the U.S. Geological Survey (USGS), Sussex County Emergency Operations Center, Delaware River and Bay Authority (DRBA) or the Delaware Emergency Management Agency (DEMA) Hazard Mitigation Officer may be able to provide assistance – especially data needed to complete the analysis.

C. Implementation Steps

Step 1. Based upon existing data of known evacuation routes, determine the evacuation routes of greatest interest for elevation assessments. Do not select New Road, Cedar Street and Savannah Road as elevation data has already been acquired for these routes.

Step 2. Work with DelDOT and DNREC's Flood Mitigation Program manager to determine if any routes in Lewes are an appropriate setting for sensors[3] that DelDOT may be able to put into place.

Step 3. Work with DNREC's Flood Mitigation Program manager to have LiDAR data used to determine the road elevations of the roads of greatest interest identified in Step 1. **Note:** When doing an infrastructure survey, be sure to survey some road elevations in order to ground truth the LiDAR data.

Step 4. Work with DNREC to select the most appropriate flood scenarios to use and then overlay those scenarios on the elevation data acquired in Step 3. **Note:** It is recommended that Lewes consider using the 10-year and the 100-year storm events from current FEMA maps, and the three sea level rise planning scenarios used by DNREC – 0.5 meters, 1.0 meters and 1.5 meters.

[3] DelDOT has sensors assessing the wetness of roads and is looking for recommended locations for these sensors. The City should work more closely with DelDOT to determine the criteria for these sensors and recommend locations for their use within Lewes.

Step 5. Working with the Sussex County Emergency Operations Center and DEMA, determine if the flood scenarios from Step 4 will impact current evacuation plans. In the case where evacuation plans are impeded, develop an improved plan that will allow for the safe evacuation of citizens.

D. Timeline Information

- This strategy can/should be started when the Mitigation Planning Team is ready to take on the coordination that it will require; however, it should be noted that the DelDOT sensors may not be available in the coming months.
- From start to finish this strategy could take a total of 6 months to a year.
- The first two steps would require a very limited amount of time; however, the first part of Step 4, which could be started without the completion of earlier steps, could be more time consuming as it may be a more difficult decision to make.
- The time commitment for Steps 3 and 5 could be minimal; however, it may take identified partners a longer period of time to complete these tasks.
- The flood overlay part of Step 4 may also require outside assistance and may take Lewes more time to secure this help.

E. Financing and Budget

- Much of the difficult time-consuming work may be done by outside agencies and departments; therefore, it will likely require a very limited amount of time from internal Lewes staff who are currently committed to updating evacuation procedures as part of the Mitigation Planning Team efforts.
- If additional funding were to be needed, Lewes could consider looking to DEMA or FEMA for planning assistance through the hazard mitigation grant program.

F. Monitoring

- Indicators of success for this strategy would include a completed database of roads and their current and future flood risks and maps or graphics showing current and future flood risks to roads.
- An additional indicator of success would be altered evacuation route procedures where necessary.

Guidance for Implementation:
Proposed Infrastructure Analysis Strategy for the City of Lewes

Specific action: Evaluate the City and the Board of Public Work (BPW) infrastructure's flood vulnerability from direct flood impacts as well as from indirect flood impacts to access routes[4].

A. Alignment with Existing Priorities & Co-Benefits

- The Lewes Hazard Mitigation Plan has stated that one of the City's priorities is to continue data acquisition and enhancement to the City's GIS. This project would link directly with that goal while simultaneously helping the City to understand its existing and future flooding risk in more detail.
- A co-benefit of this analysis is that as the City looks to make repairs or improvements to its infrastructure, it will be able to incorporate future flood projects and, therefore, design these improvements in a way that is more resilient.

B. Administration and Staffing

- This strategy would be led by the Mitigation Planning Team with the City Manager as a primary point of contact. Additional members of the Mitigation Planning Team, the General Manager of the BPW, and the City engineer will provide assistance as needed.
- Other facility managers, City departments and City commissions would be called upon to provide data as requested by the City Manager. These departments could include, but are not necessarily limited to:
  a. Building Official
  b. Police Department
  c. Board of Public Works
  d. Planning Commission
  e. Historic Preservation Commission
  f. Parks and Recreation Commission
  g. Lewes Public Library
  h. Lewes Fire Department
  i. Commercial Architectural Commission
- This effort could require additional support from agencies outside of the City. DNREC's Flood Mitigation Program manager would the point of contact should additional assistance be needed.

C. Implementation Steps

Step 1. Based upon existing knowledge of known infrastructure, identify the infrastructure of greatest interest and priority to the community for elevation analysis.

Step 2. Analyze indirect flood vulnerability through determining the identified infrastructure's access route flood vulnerability. **Note:** This step could include a separate decision of what flood scenarios to use or it could use the same flood scenarios as the evacuation route analysis. Consistency between the two analyses would be beneficial to the City.

- Recommended flood scenarios are the 10-year and the 100-year storm events from current FEMA maps and the three sea-level rise planning scenarios used by DNREC – 0.5 meters, 1.0 meters, and 1.5 meters.

Step 3. Determine if the existing data from the *Hazard Vulnerability Study for The City of Lewes, Delaware* and *Flood Mitigation Plan for the City of Lewes, Delaware* prepared by Greenhorne & O'Mara Inc., are sufficient to conduct a full analysis of direct future flood vulnerability.

Step 4. If the data is not sufficient, the City and the BPW will have to acquire additional data through a registered professional surveying company.

Step 5. Using the flood scenarios selected in Step 2, determine the infrastructure's current and future flood risks.

[4] Infrastructure should be all-encompassing and should include pump stations and other non-building facilities.

D. Timeline Information

- This strategy should be started when the Mitigation Planning Team is prepared to further update the City's GIS data as this project would benefit from being integrated into the GIS system.
- From start to finish, this strategy could take a total of 4 months if no additional surveys are required; however, if surveys are required, the process could take significantly more time as funding would also need to be secured.
- Step 2 of the process would benefit from the completion of the evacuation route analysis strategy, so it may take more time.

E. Financing and Budget

- The analysis of City infrastructure is an ongoing priority for the Mitigation Planning Team, and therefore, the basic steps in this analysis could be completed as part of their ongoing efforts.
- If additional surveys of infrastructure (Step 4) are required, this could cost approximately $10,000 for all the work that the survey company would need to do to cover 10 infrastructure sites.
- Additional funding or outside help may be required if this analysis were to use GIS.

F. Monitoring

- Indicators of success for this strategy would include a database of infrastructure and their access route and direct flood vulnerability.

Guidance for Implementation:
Proposed Community Rating System Strategy for the City of Lewes

Specific action: Improve the City's level of participation in the Community Rating System (CRS).

A. Alignment with Existing Priorities & Co-Benefits

- This strategy is directly aligned with existing community priorities identified in the City of Lewes Hazard Mitigation Strategy (2004-2008): Increase participation in the National Flood Insurance Program.
  - There are many co-benefits that can be achieved by implementing this measure. In addition to saving residents money, the CRS has been shown to provide an effective incentive to implement and maintain floodplain management activities.
  - Additional benefits of remaining in full compliance with the NFIP and improving the City's CRS rating include:
    - Ensuring that new development is properly protected from flood damage.
    - Continuation of making flood insurance available for all properties in Lewes.
    - Continuation of the provision of Federal financial assistance programs.
    - Continuation of the City's Community Rating System insurance premium rate reductions.

B. Administration and Staffing

- This effort would be led by the Lewes Building Inspector Department, with the Lewes Building Official and CRS Coordinator as primary point(s) of contact.
- Additional support can be provided by Mitigation Planning Team members, including the Deputy Building Official.
- In addition, DNREC's Flood Mitigation Program coordinator, DEMA's hazard mitigation officer, and FEMA's community liaison staff may provide assistance as needed. The Delaware Sea Grant College Program will also provide assistance with efforts related to achieving additional CRS rating system credits.

C. Implementation Steps

Step 1. Synthesize comments and recommendations received as a result of the City's CRS 5-year cycle review. The City of Lewes presently participates in the National Flood Insurance Program (NFIP), and has recently met with FEMA's representative ISO/CRS specialist for the 5-year cycle review of the City's CRS rating. Final implementation steps will be developed after comments and suggestions are received from FEMA's representative ISO/CRS specialist regarding the City's current level of participation in the CRS.

Step 2. Create table of current CRS activities and scores. Develop a list of possible action items and additional activities that could improve the City's CRS rating (see example table included at end of section).

Step 3. Research other community best practices that could enhance the City's CRS rating.

Step 4. Provide regular updates to the Mitigation Planning Team and Lewes Planning Commission about CRS program status, along with floodplain management, zoning code updates and mitigation activities that could assist the City to improve to the next higher class.

Step 5. Develop an Outreach Projects Strategy (OPS), including initiating an outreach strategy team and associated written document (CRS Activity 330). This could be accomplished in partnership with the Mitigation Planning Team.

Step 6. Continue to coordinate with local, State and Federal agencies and partners to ensure that the City's floodplain ordinances reflect current flood hazards; consider implementation of floodplain

ordinances that reflect future flood hazards – these steps will likely improve the City's CRS rating (e.g., higher regulatory standards).

Step 7. Continue work to educate Lewes residents about flood issues and actions they can implement to mitigate the flood risk.

Step 8. Assess and review opportunities for continuing education courses offered by FEMA's Emergency Management Institute (EMI), including courses on flood plain management and the NFIP's Community Rating System.

D. Timing Information

- As a participant in the NFIP and the CRS, the City of Lewes is presently working to maintain its current credit level. Many of the implementation steps included in this action plan are either currently underway or should be considered before the next annual review. A timeline can be developed after comments are received from FEMA's representative ISO/CRS specialist.
- Step 1 will be accomplished after the City receives FEMA's representative ISO/CRS specialist suggestions and guidelines regarding implementation of measures to improve the City's level of participation in the CRS.
- Steps 2 and 3 can be done independently and can be initiated as staff time permits.
- Step 4 can be accomplished through coordination of regular meeting schedules and agendas. Communication with appropriate City committees and commissions about opportunities to improve the City's CRS rating should be accomplished on a semi-annual basis.
- Step 5 can be initiated in partnership with the Mitigation Planning Team after collaborative discussions regarding prioritization of action items and commitment of City staff time and resources.
- Step 6 would require a coordinated planning effort among several Lewes committees and State/Federal agencies. Although review of current floodplain ordinances should be accomplished within the next 6-12 months, consideration of higher regulatory standards will likely involve considerable review and discussion. Timing of this activity should be aligned with Lewes Planning Commission updates to the zoning code and the Comprehensive Plan.
- Step 7 is an ongoing activity that is presently incorporated into the City's mitigation planning efforts and CRS program.
- Step 8 can move forward immediately and is dependent on the City's commitment of staff time and the EMI course calendar.

E. Financing and Budget

- The City of Lewes will determine budget needs.
- Additional funds may be needed for education/outreach activities (e.g., annual mailing), mitigation planning activities, zoning code improvements and/or other activities required for maintaining and improving compliance with the NFIP and improving the City's CRS rating.
- Minimal funding support is required to attend FEMA's EMI courses. Tuition for these courses is free for State and local government officials and travel stipends are available.
- Funds and assistance for CRS rating improvement activities may be available from FEMA, DEMA and/or DNREC. Additional research should be done on agencies that could provide expertise, assistance and funding to improve Lewes' CRS rating.
- After review of specific actions and recommendations provided by the 5-year cycle review, it will be easier to determine what level of funding will be required.

F. Monitoring

- The City presently submits annual cycle reports to FEMA's ISO/CRS representative regarding its CRS program activities (CRS Annual Recertification Reports). It is important that the City monitor the CRS rating so that its status can be maintained through continued implementation of credited activities.
- In the short-term, activity updates and progress reports are current, and provided on a quarterly or semi-annual basis during Lewes Mitigation Team meetings.
- In the long-term, comments and recommendations made by NFIP representatives will be provided during the 5-year cycle review of the Lewes CRS program.

The City of Lewes Community Rating System Credit Points				
Activity	**Max Possible Points**	**Current Scores**	**Proposed Additional Points**	**Possible Action Item**
300 Public Information Activities				
310 Elevation Certificates	162			
320 Map Information Service	140			
330 Outreach Projects	380			
340 Hazard Disclosure	81			
350 Flood Protection Information	102			
360 Flood Protection Assistance	66			
400 Mapping and Regulatory Activities				
410 Additional Flood Data	1,346			
420 Open-Space Preservation	900			
430 Higher Regulatory Standards	2,740			
440 Flood Data Maintenance	239			
450 Stormwater Management	670			
500 Flood Damage Reduction Activities				
510 Floodplain Management Planning	359			
520 Acquisition and Relocation	3,200			
530 Flood Protection	2,800			
540 Drainage System Maintenance	330			
600 Flood Preparedness Activities				
610 Flood Warning Program	255			

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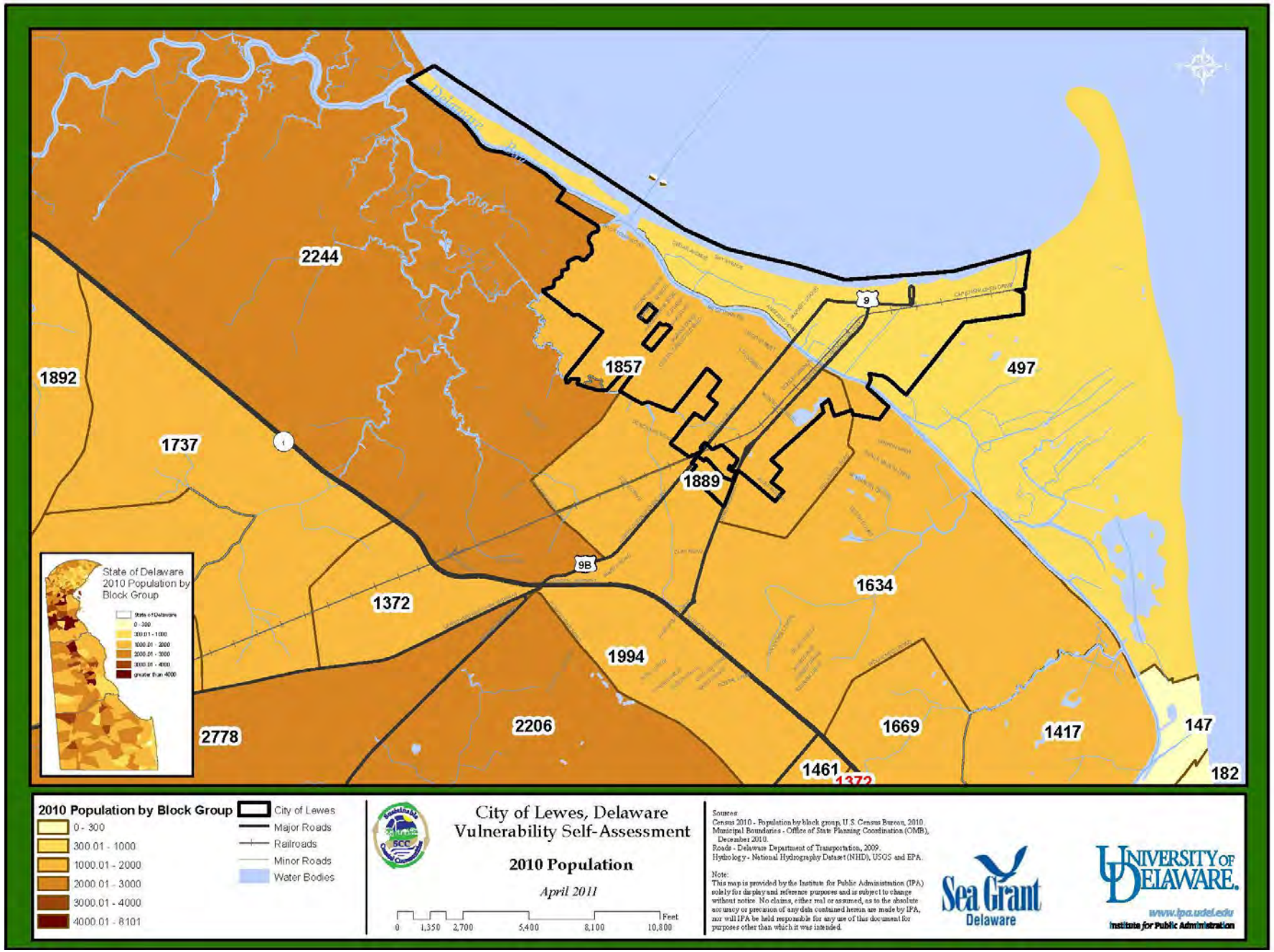
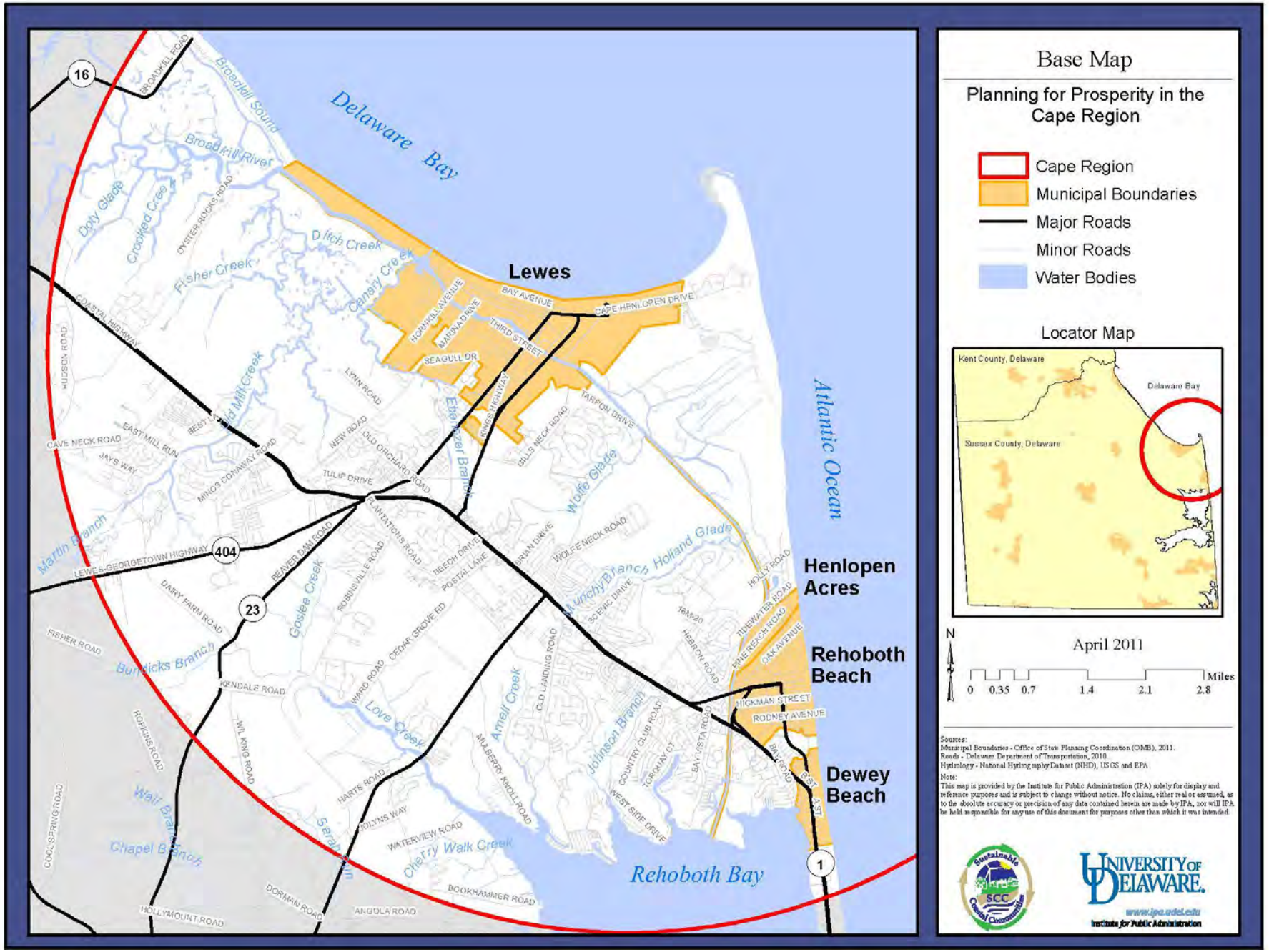
Appendix A: Maps

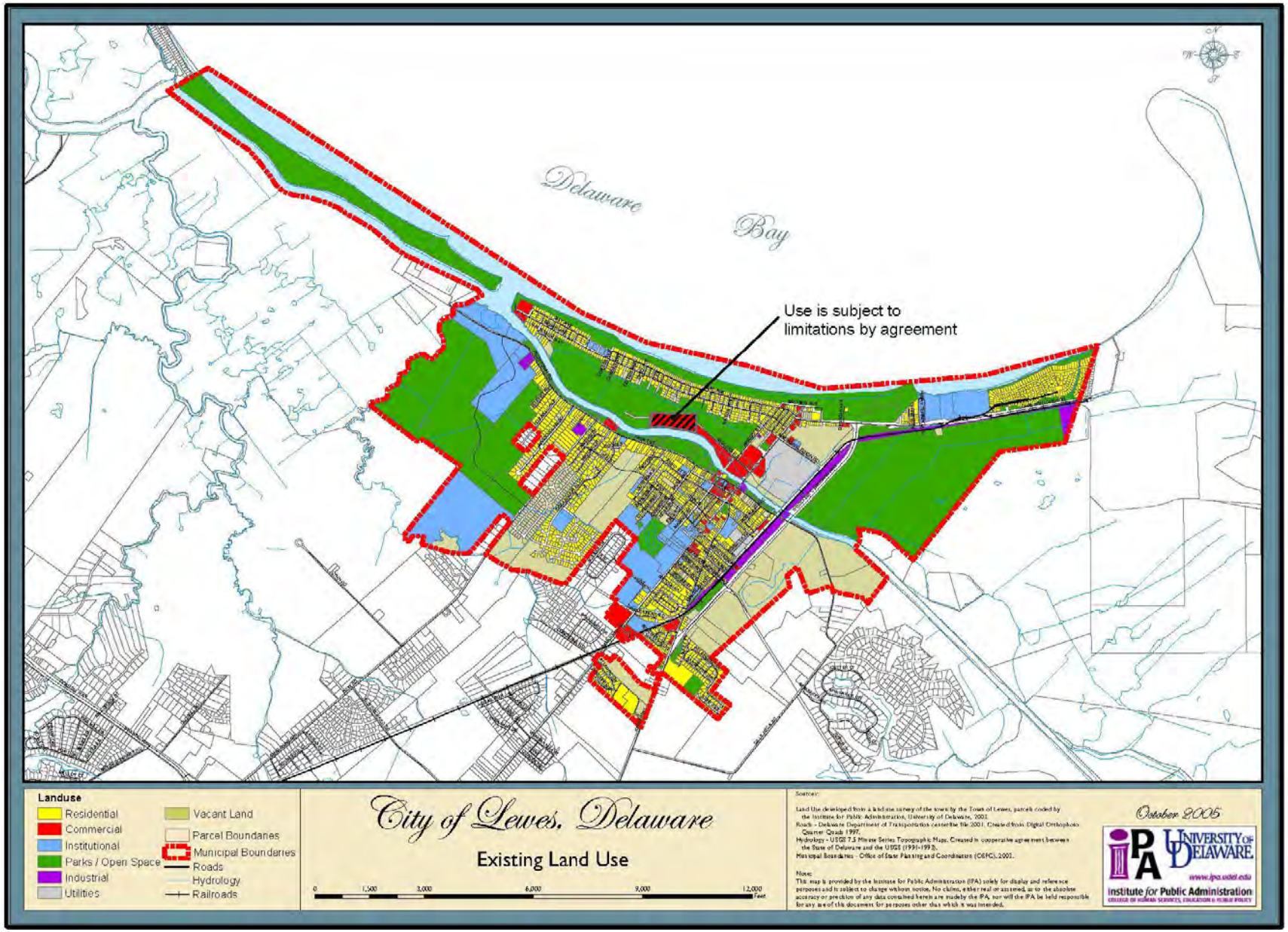
Map A-1: Aerial view of the City of Lewes, municipal boundaries, and surrounding area.



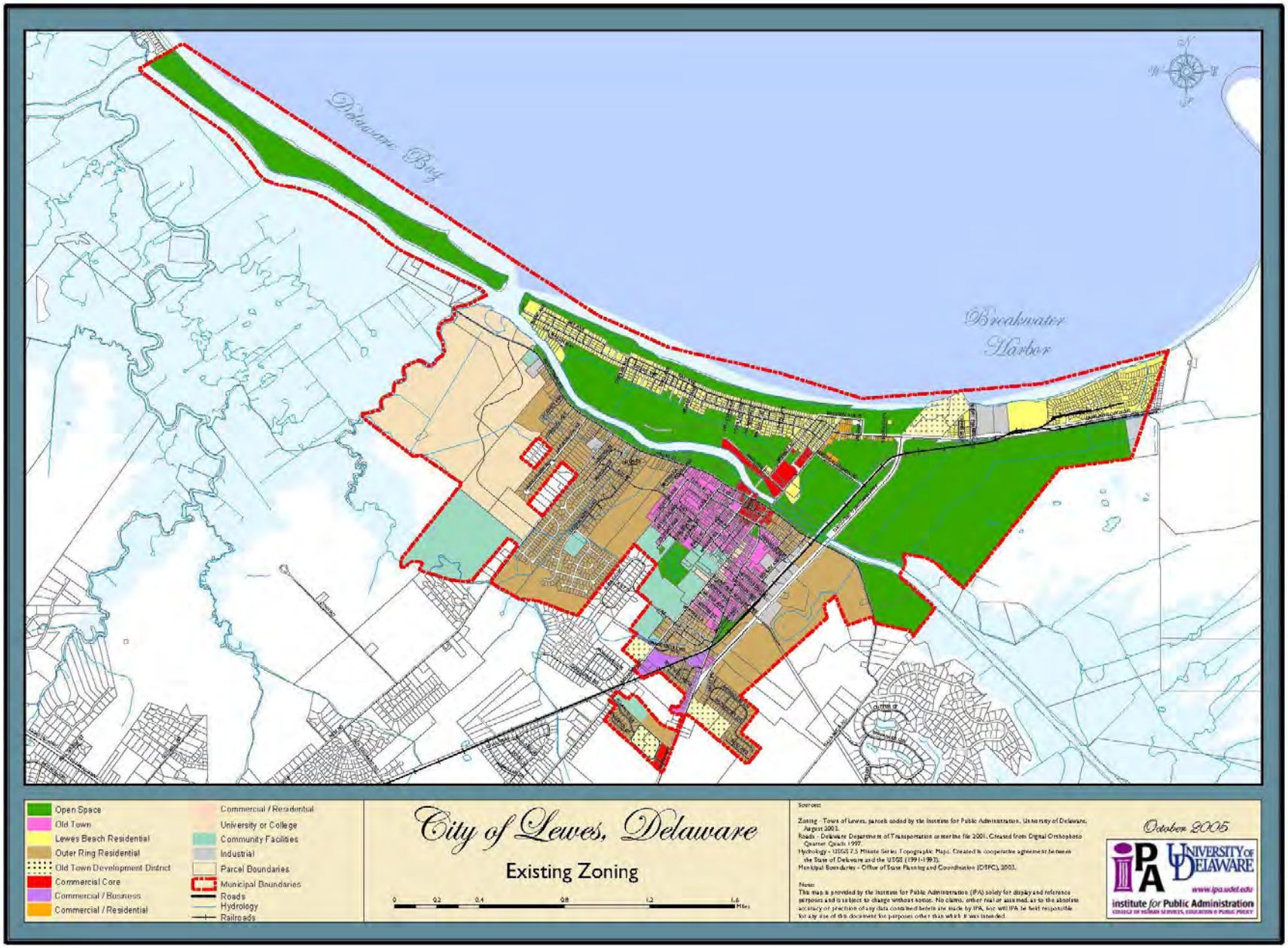
Map A-2: Population by Block Group – Lewes and vicinity (U.S. Census, 2010).



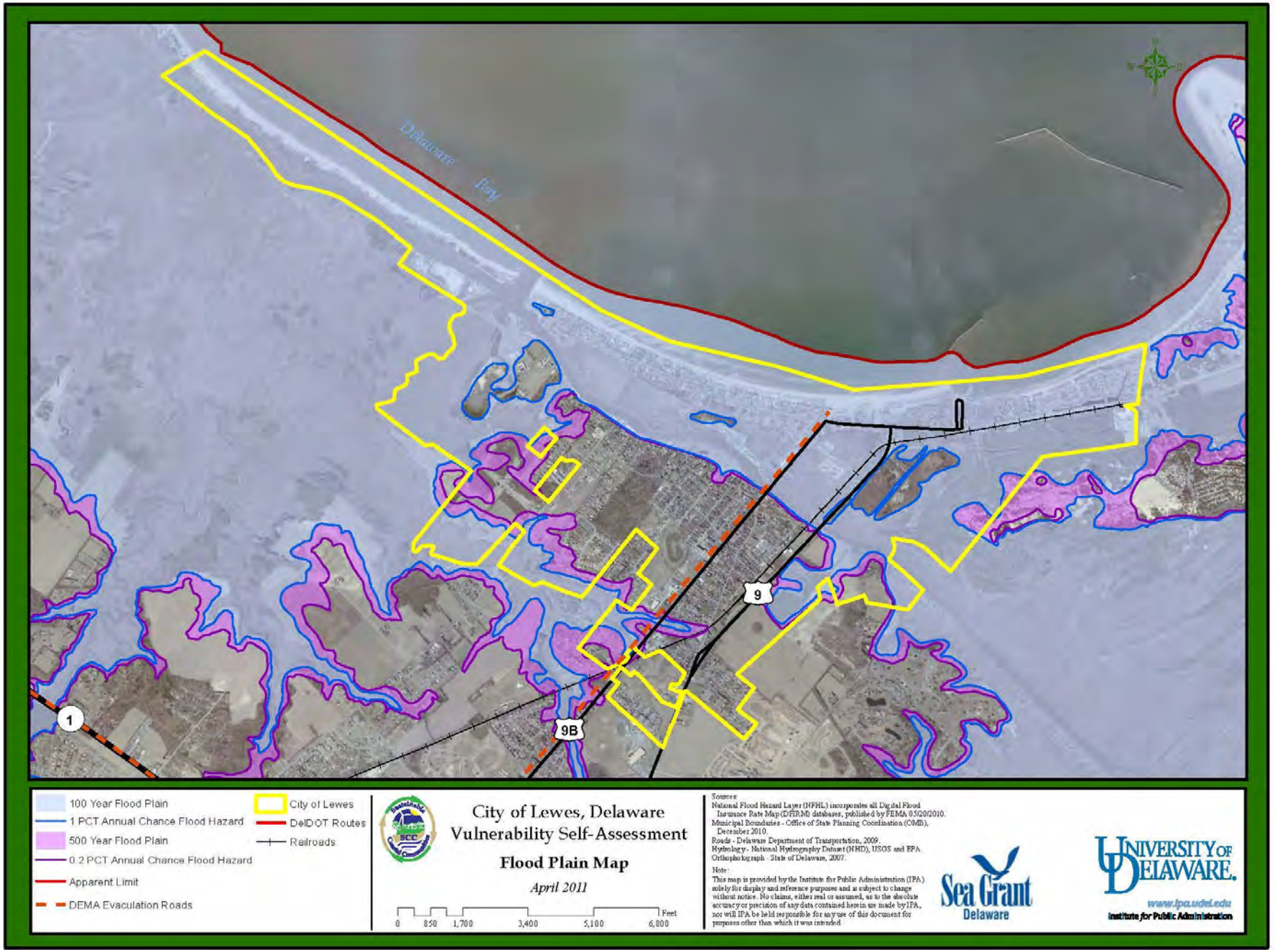
Map A-3: Regional planning base map (map courtesy of the Planning for Prosperity in the Cape Sub-Region project).



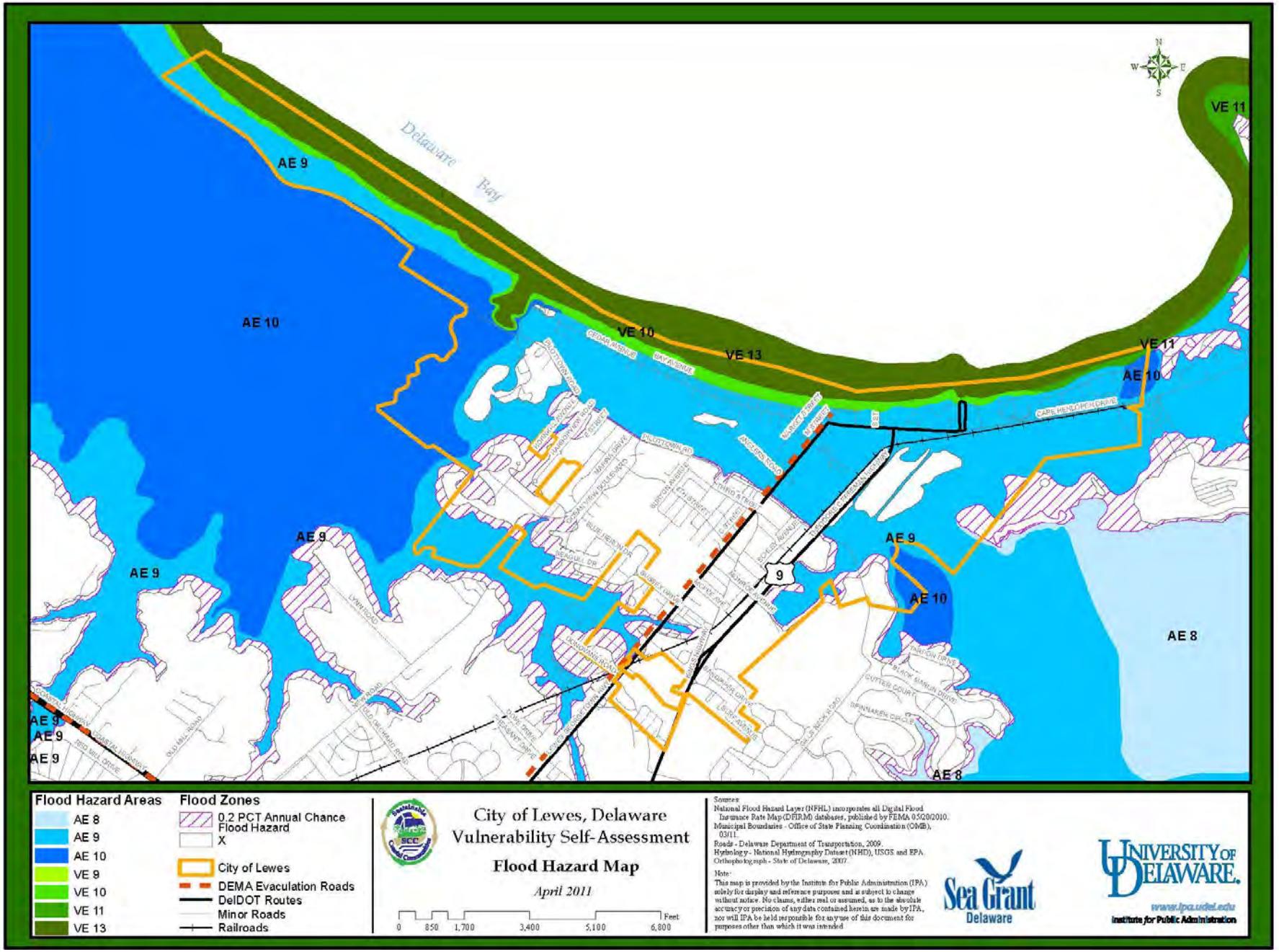
Map A-4: Existing land use in the City of Lewes (Lewes Comprehensive Plan, 2005).



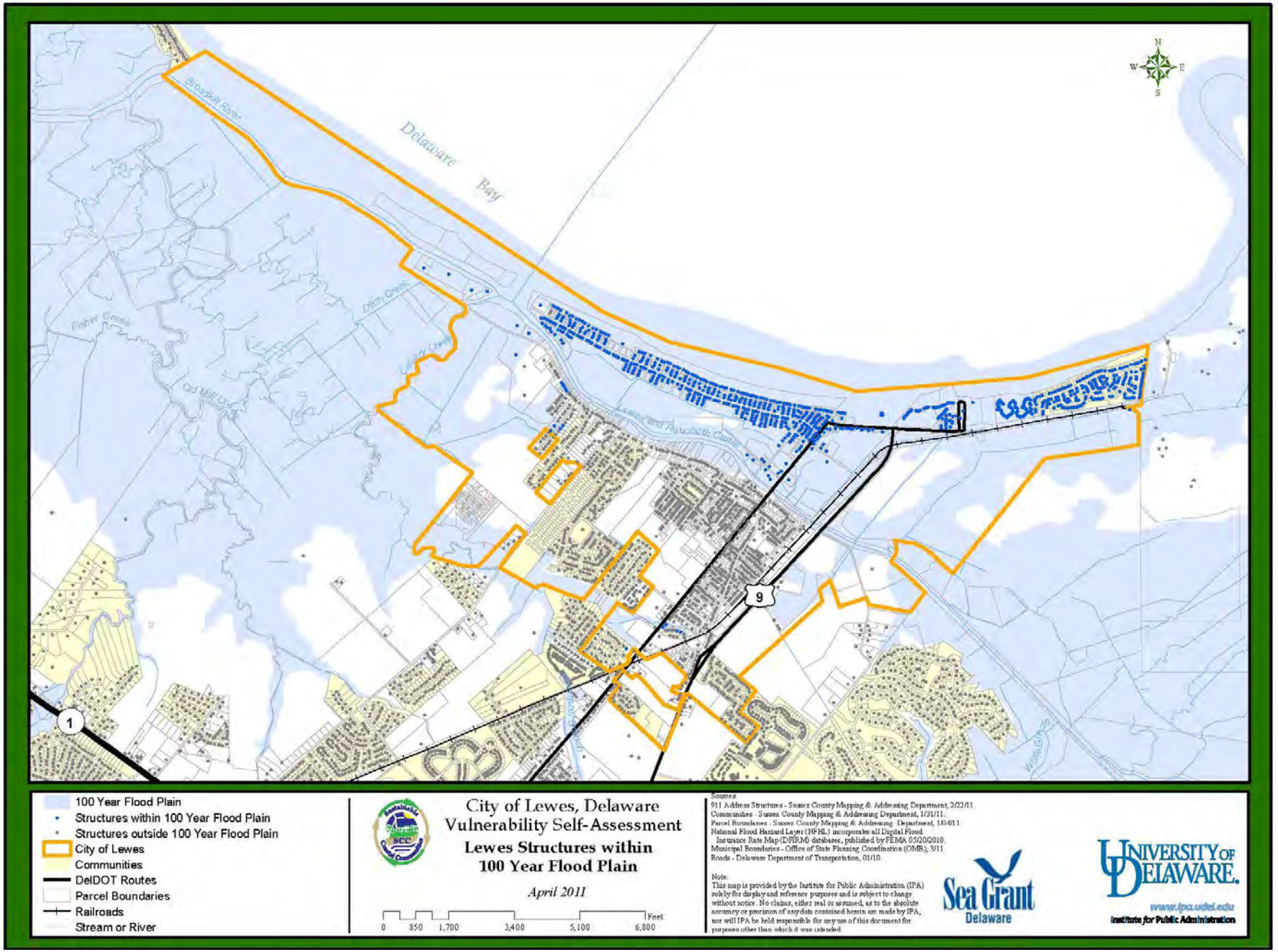
Map A-5: Existing zoning in the City of Lewes (Lewes Comprehensive Plan, 2005).



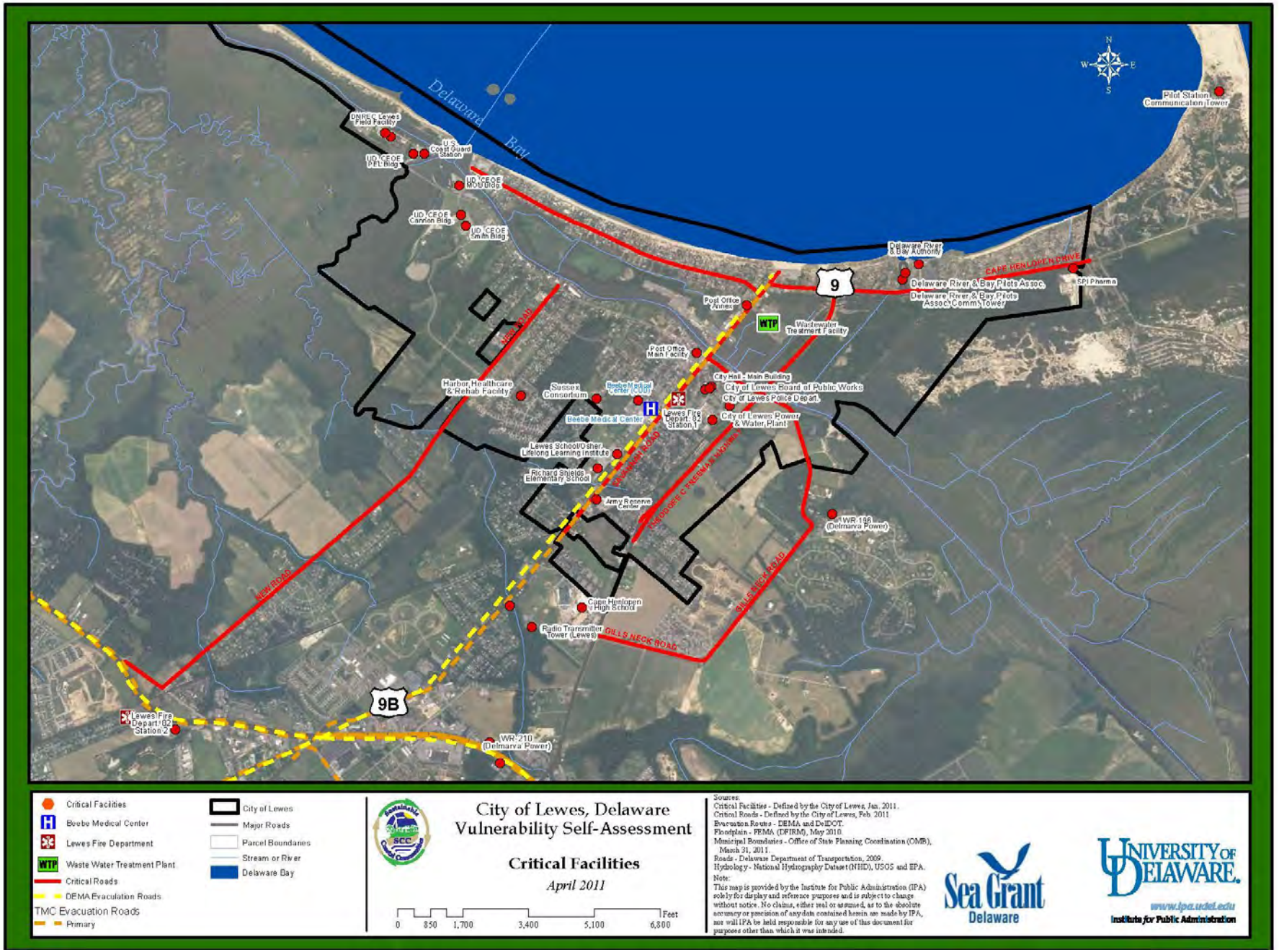
Map A-6: FEMA-designated 100-year and 500-year floodplain areas (2010 DFIRM database).



Map A-7: FEMA-designated flood hazard areas (2010 DFIRM database).

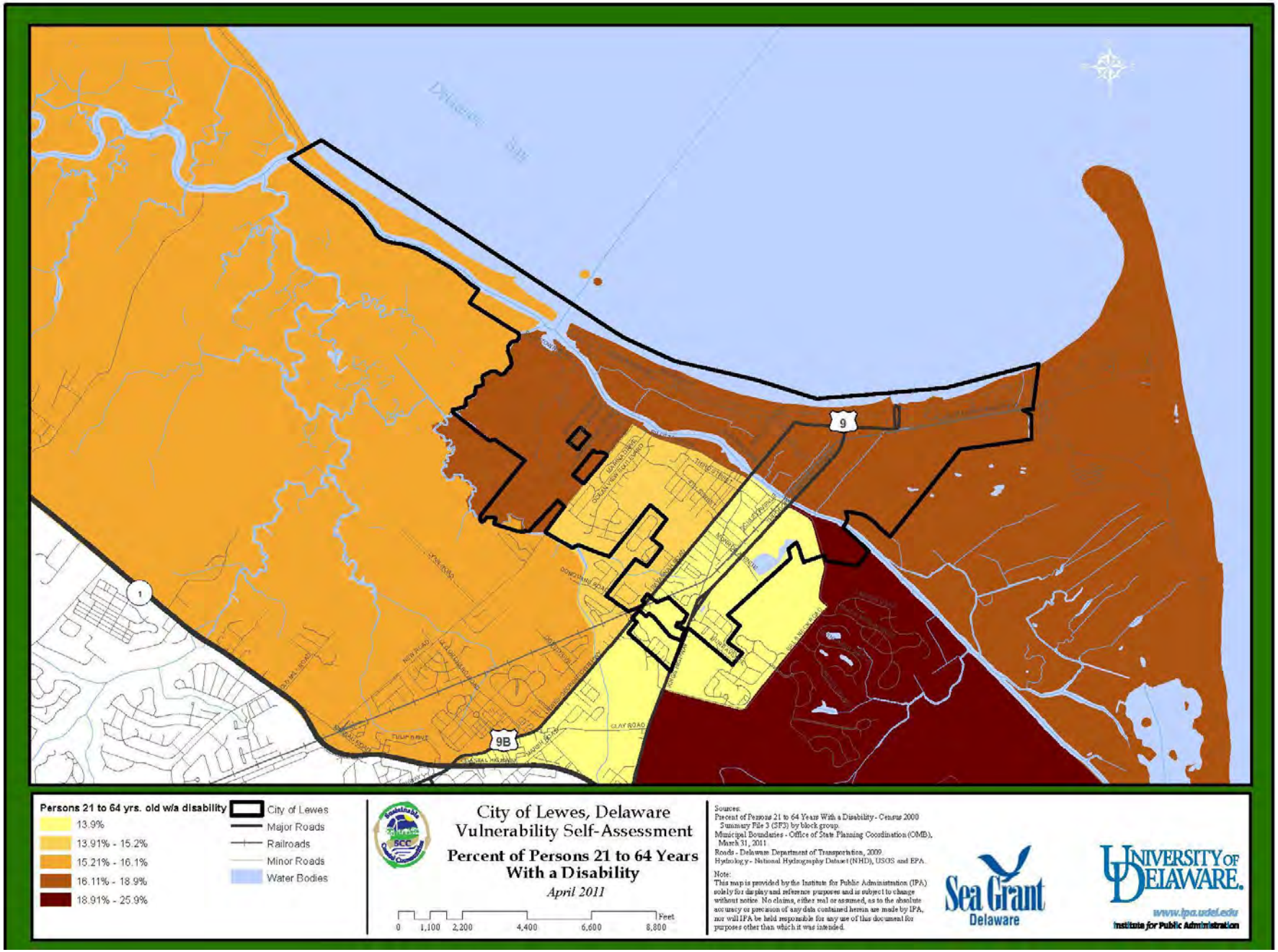


Map A-8: Lewes structures located within the 100-year floodplain (2010 DFIRM database).

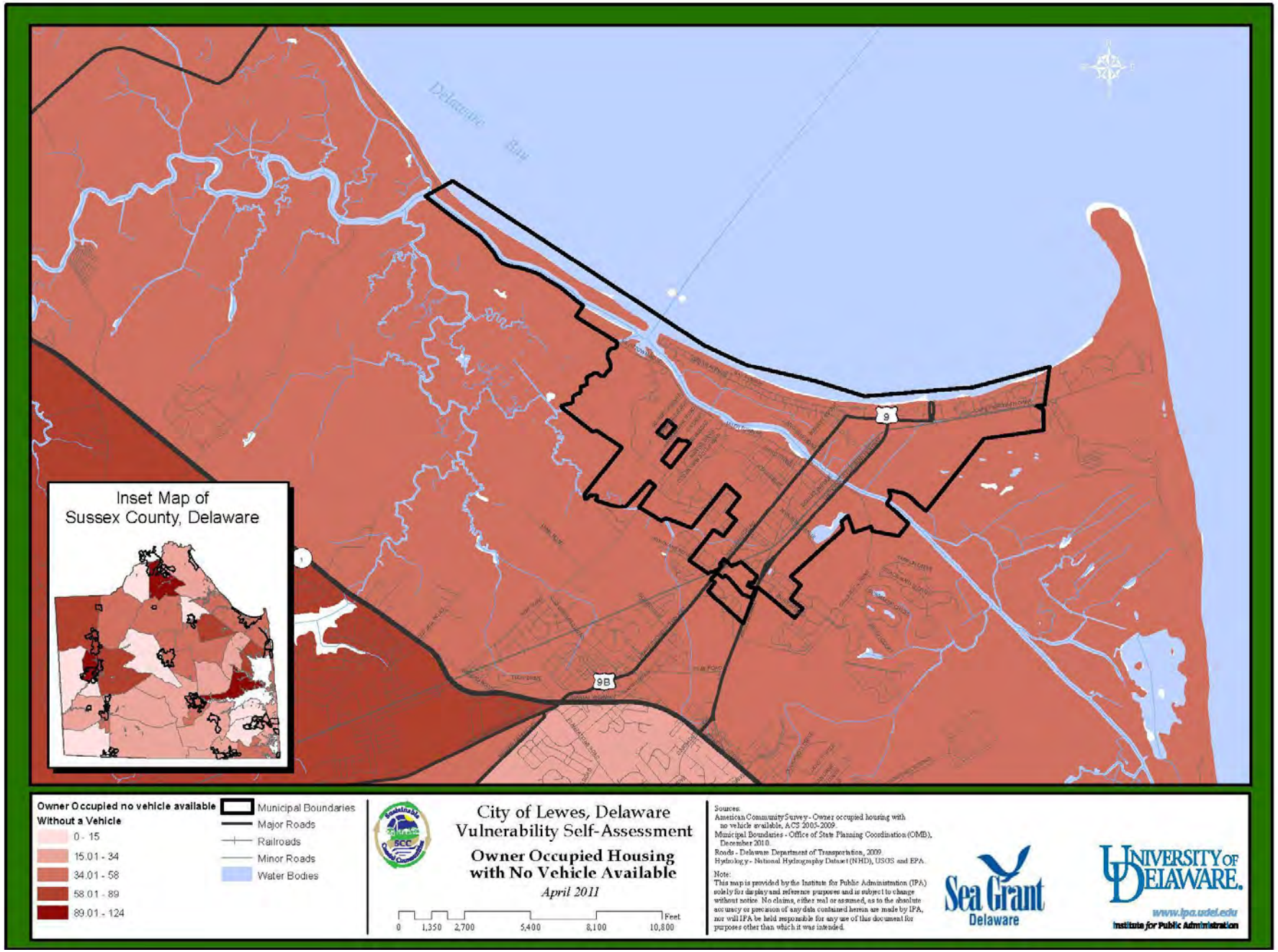


Map A-9: Critical facilities and roadways in Lewes, Delaware.

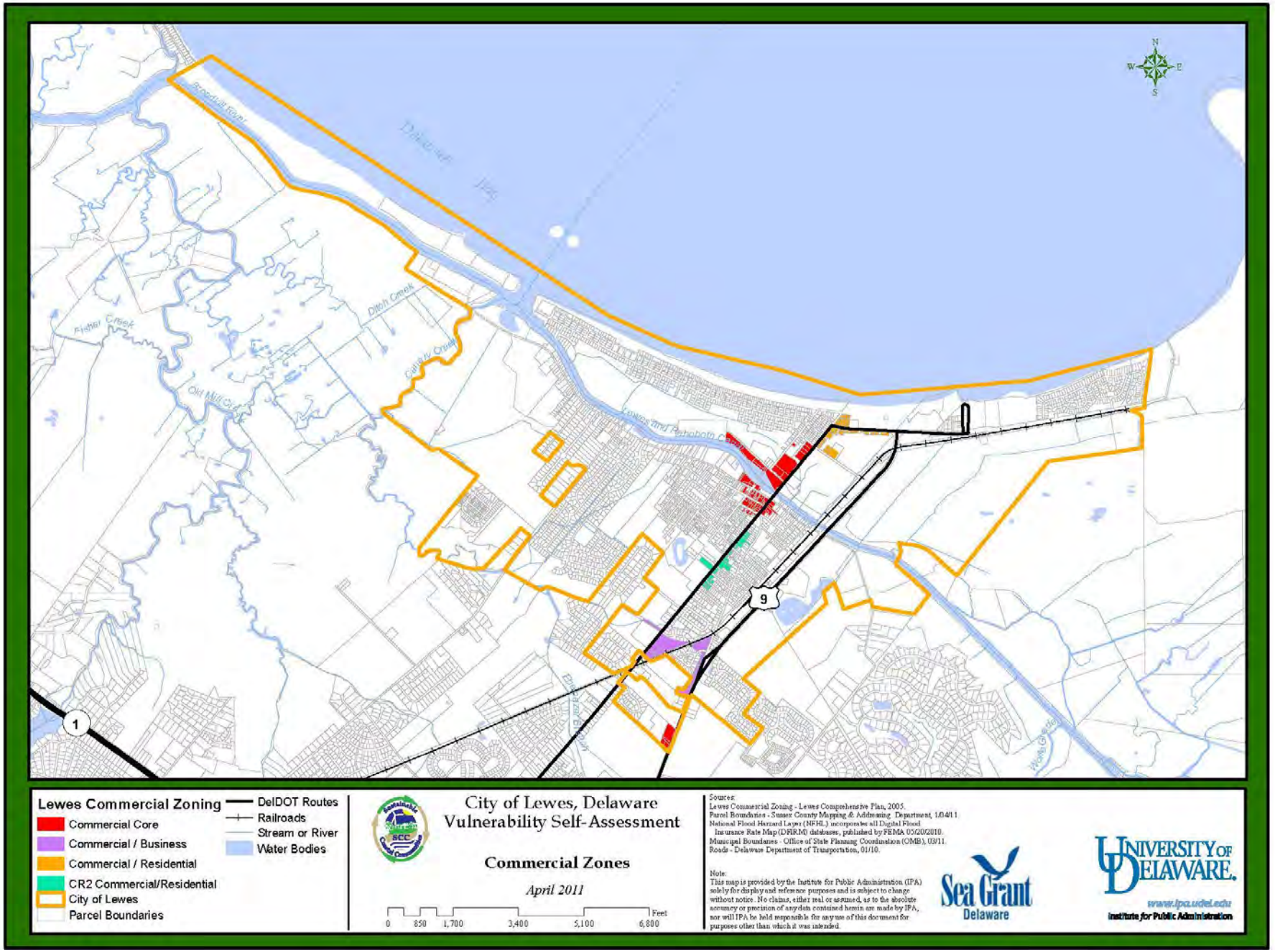
Map A-10: Lewes critical facilities and roadways with 100-year floodplain overlay.



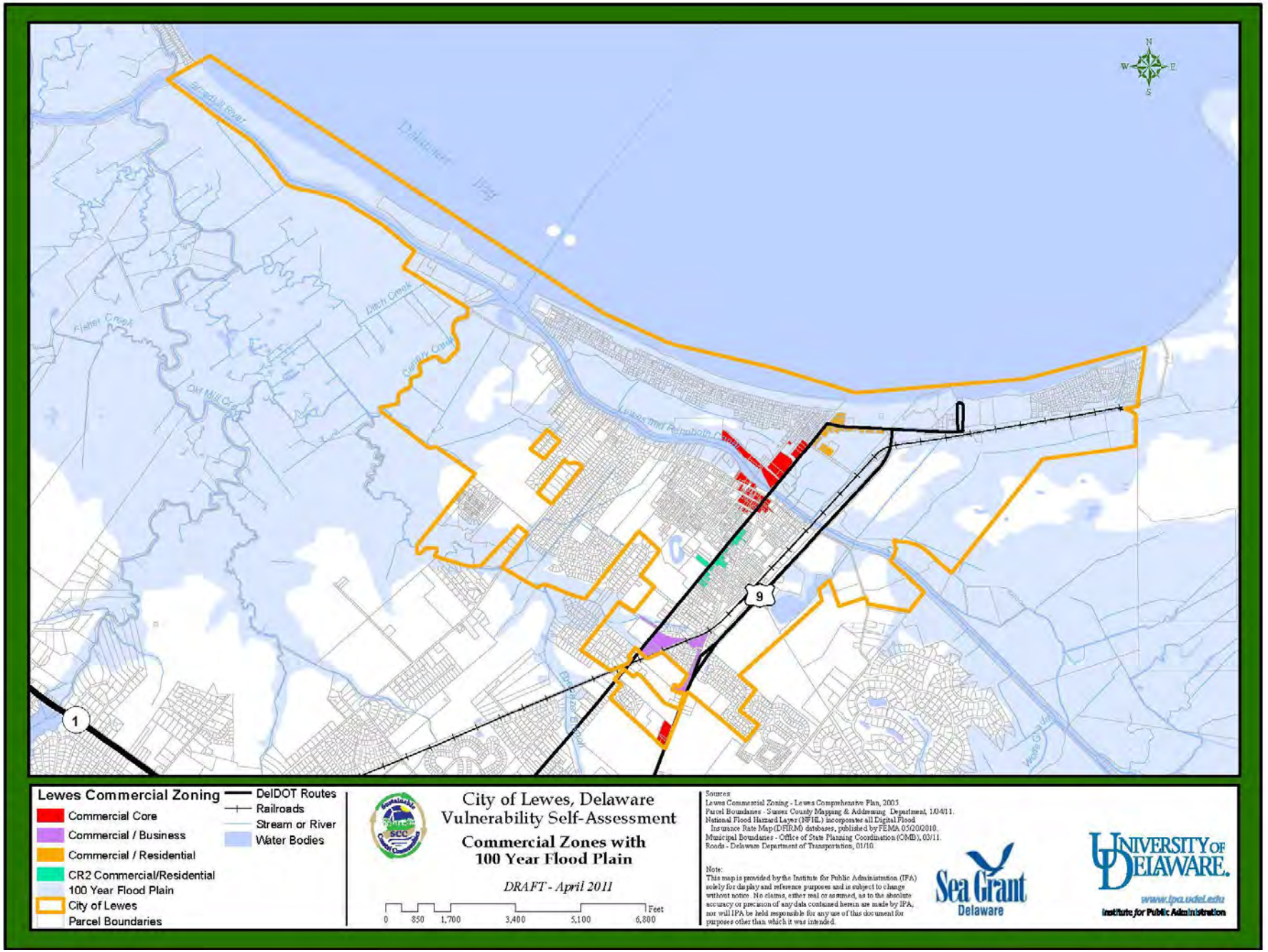
Map A-11: Percent of person 21 to 64 years with a disability (U.S. Census, 2000).



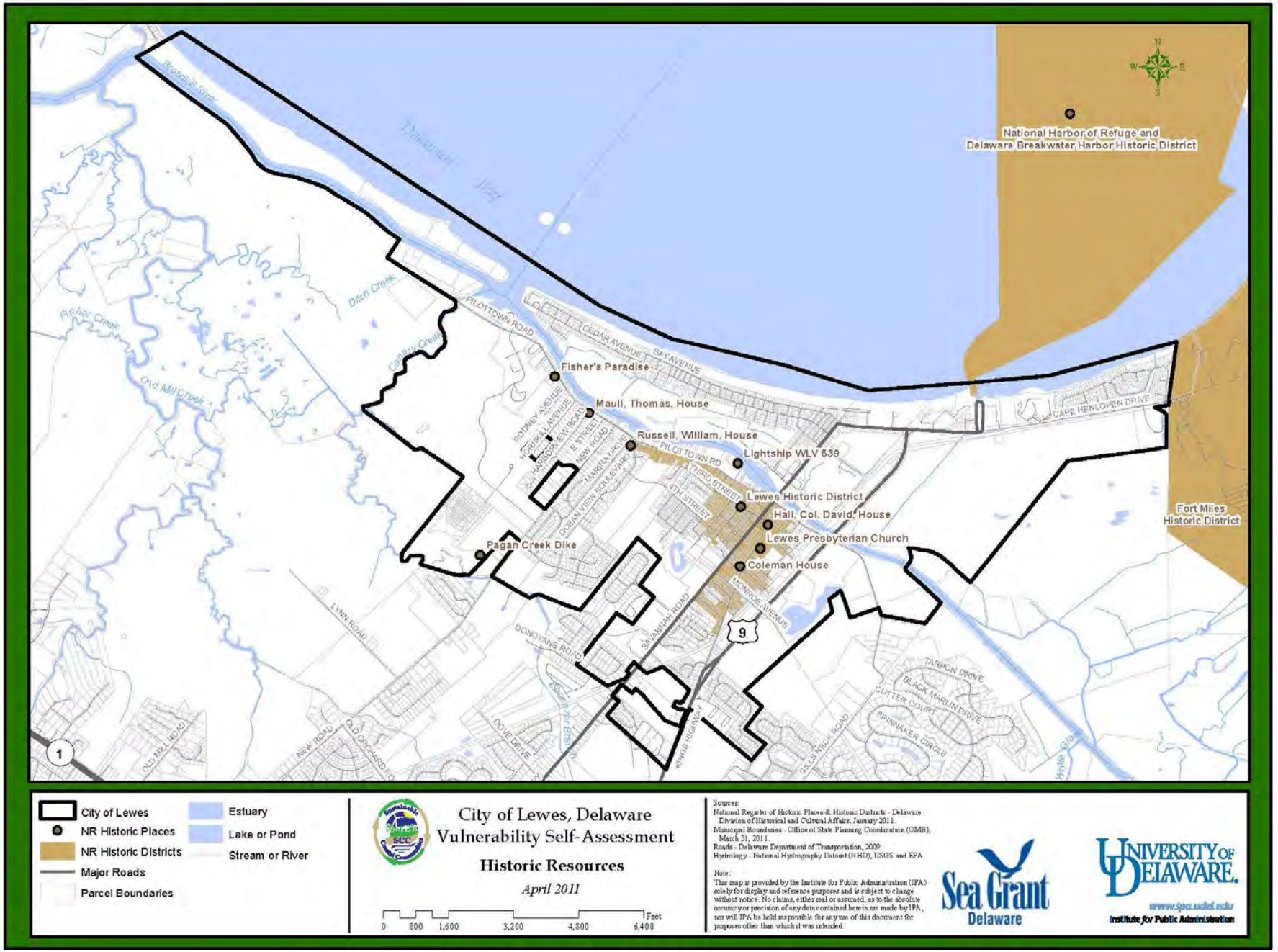
Map A-12: Owner-occupied housing with no vehicle available (American Community Survey, 2005-2009).



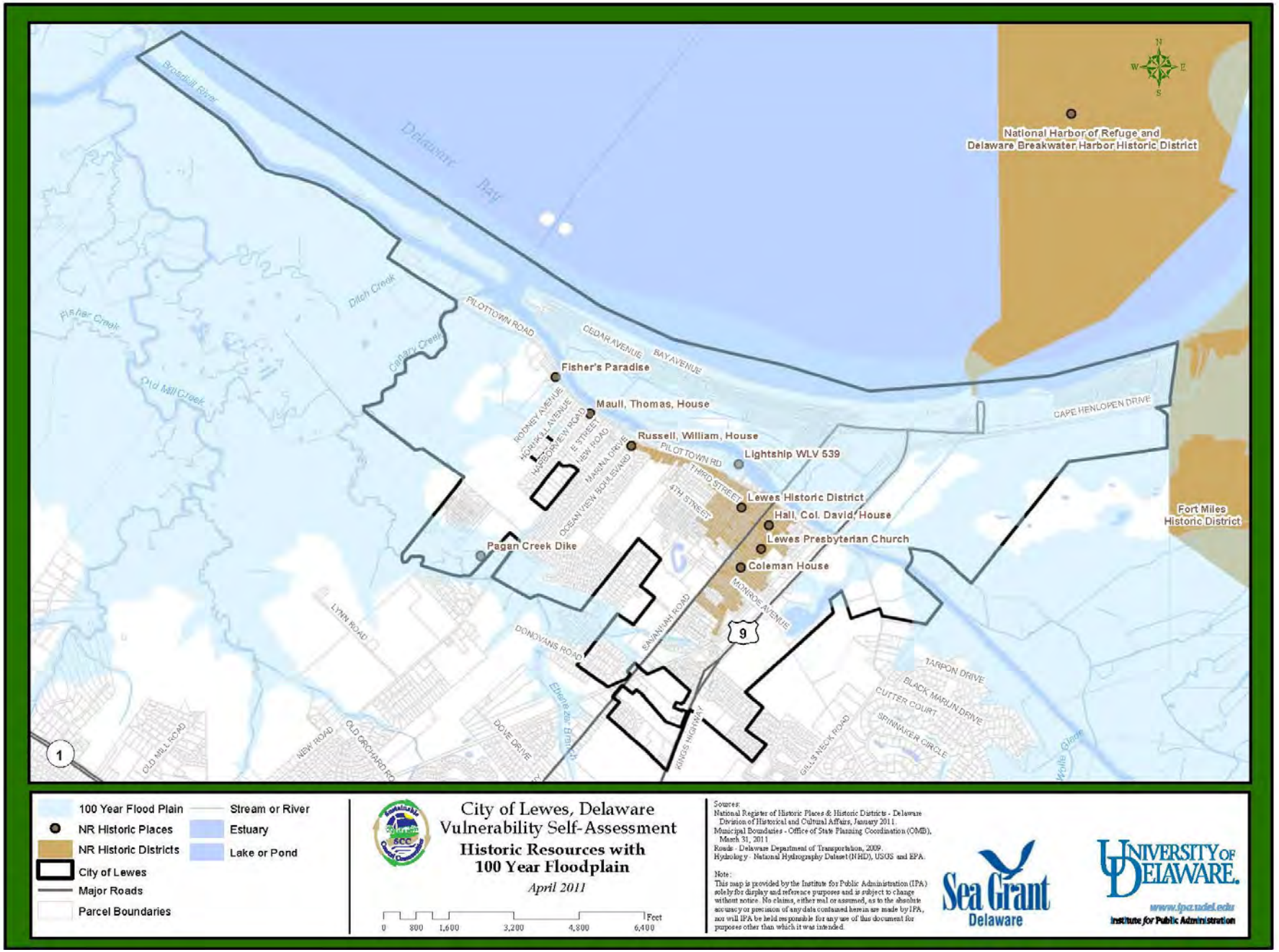
Map A-13: Commercial Zones (as proxy for economic activity centers) in the City of Lewes.



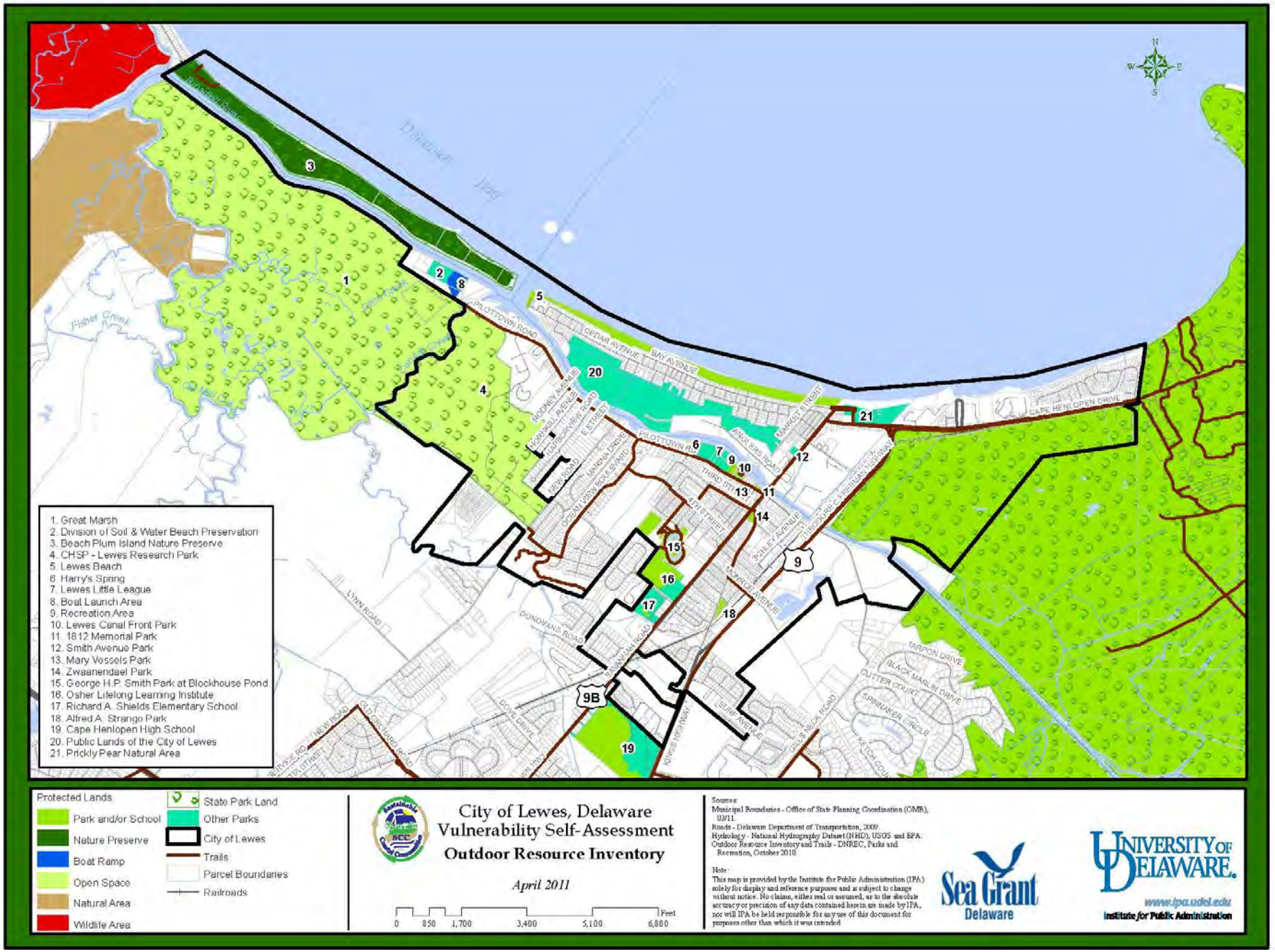
Map A-14: Commercial zones and 100-year floodplain overlay.



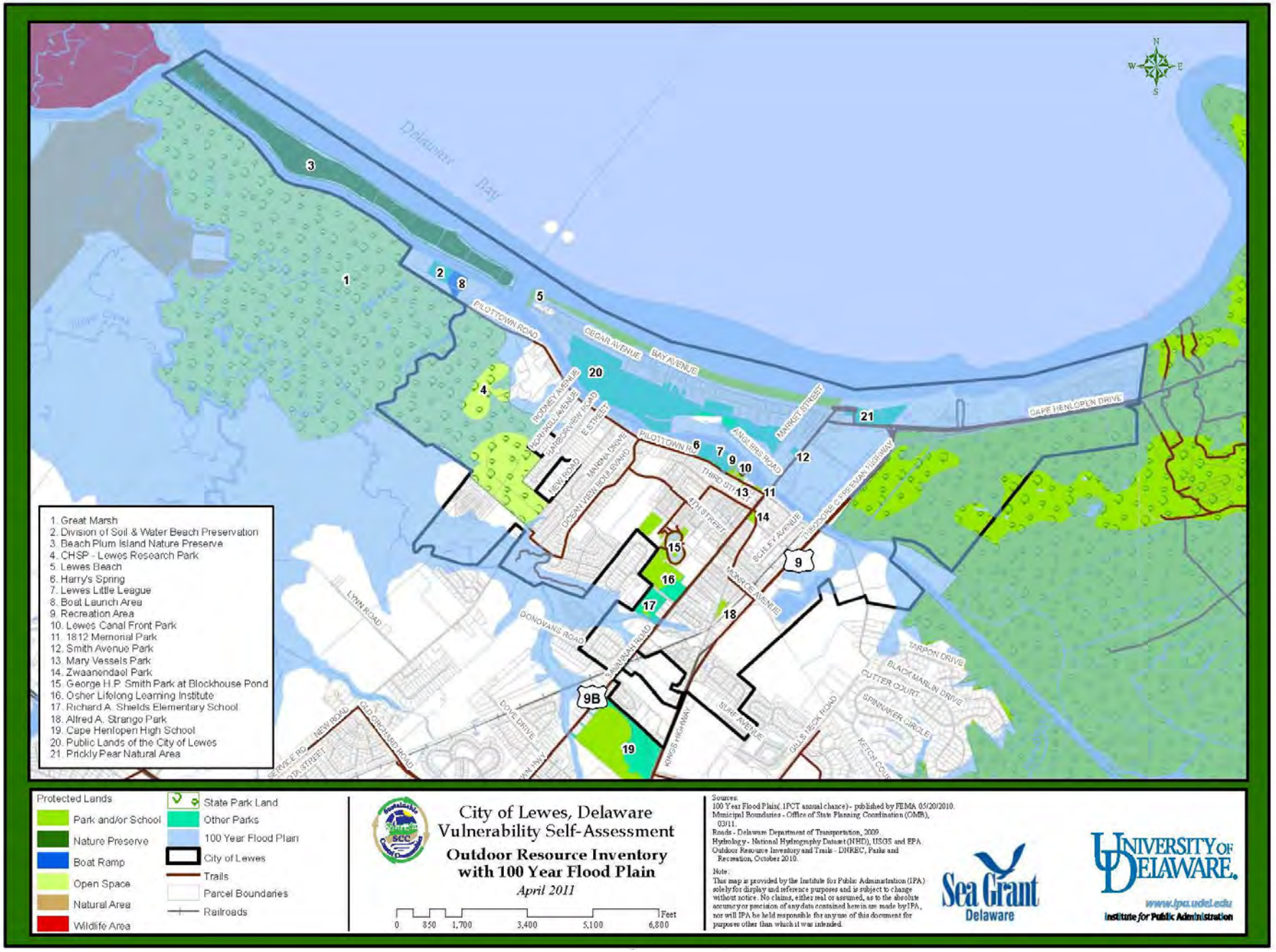
Map A-15: Historic resources in Lewes, Delaware.



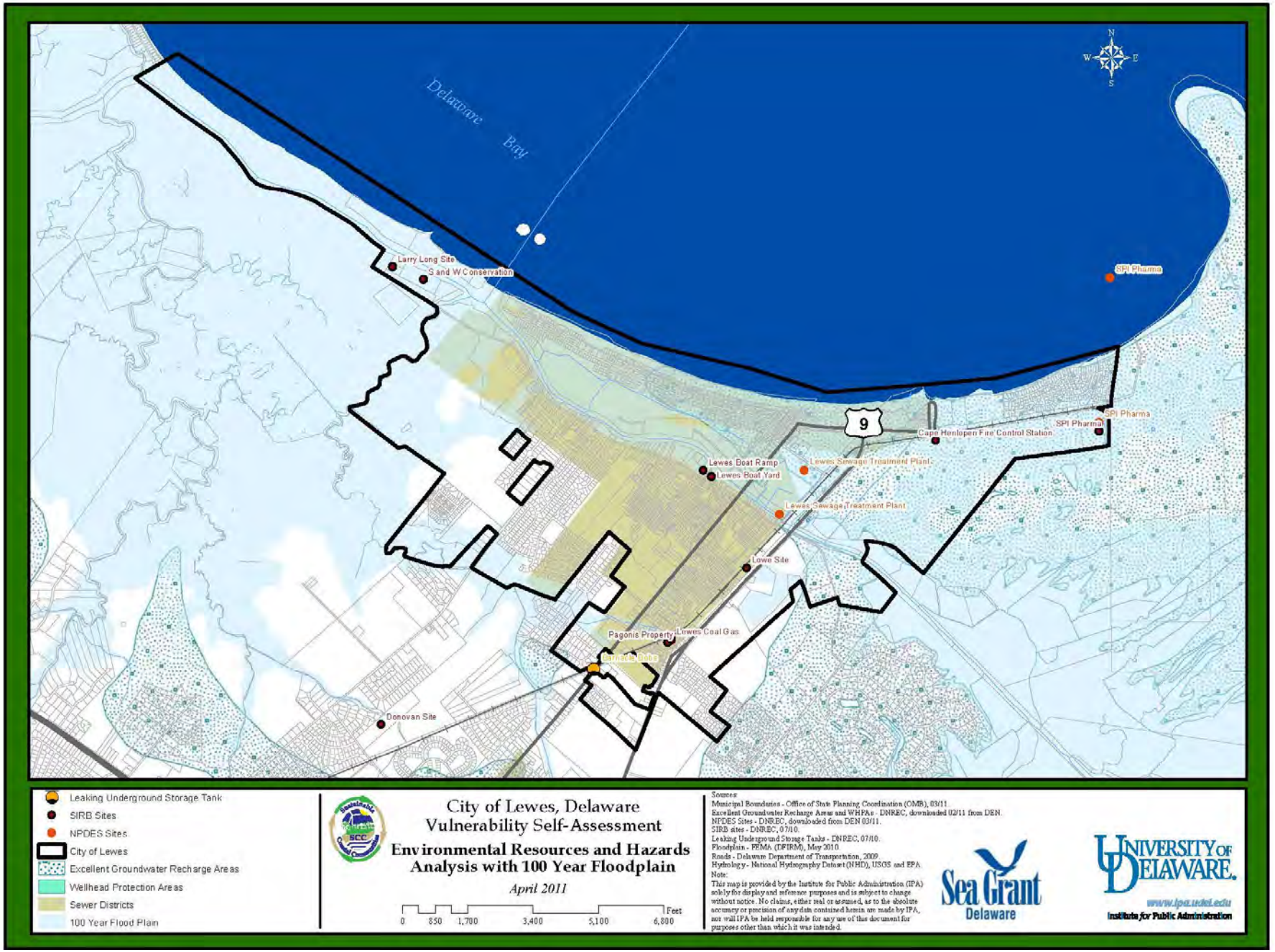
Map A-16: Historic resources with 100-year floodplain overlay.



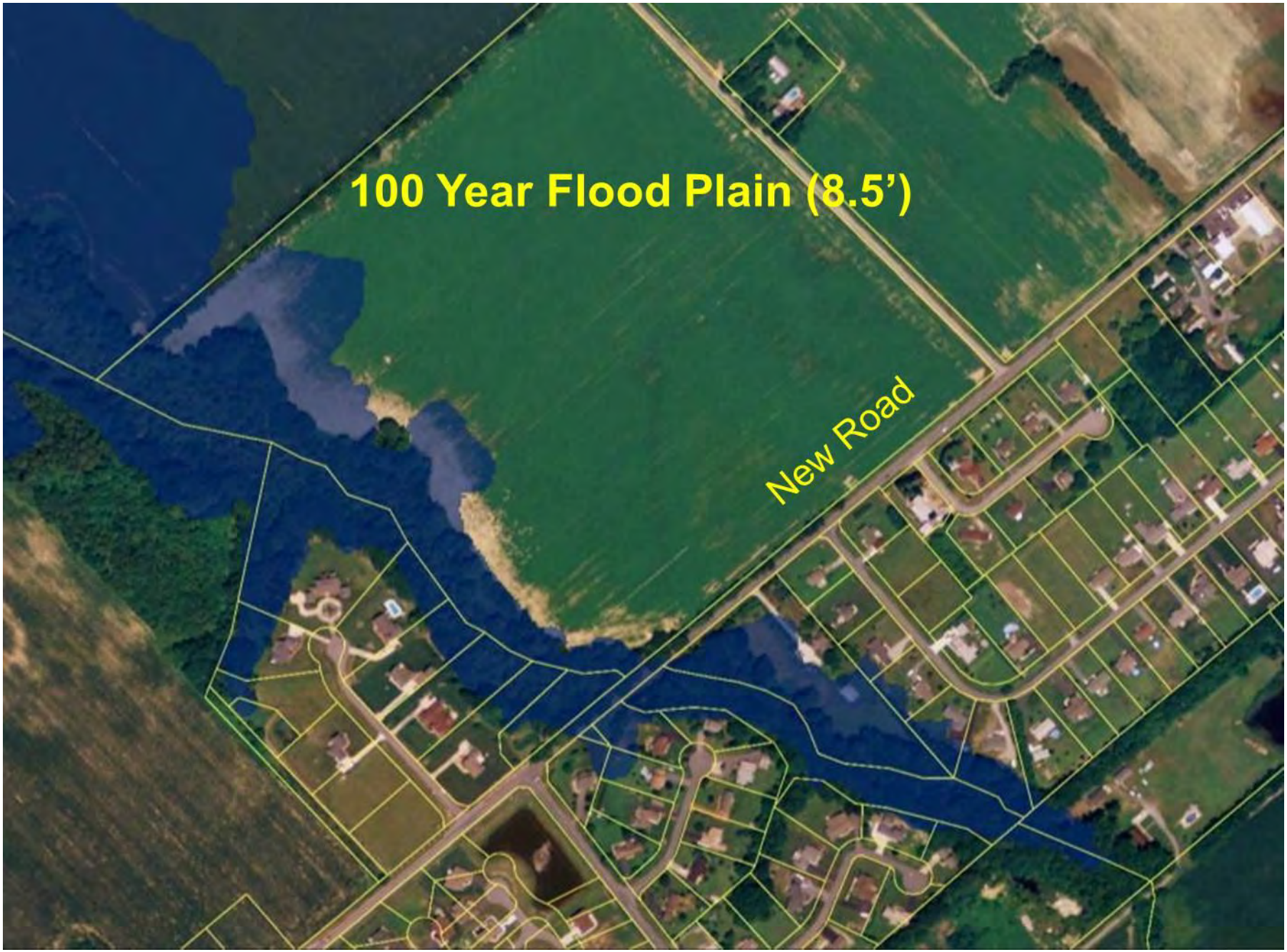
Map A-17: Outdoor resource inventory sites in Lewes and vicinity.



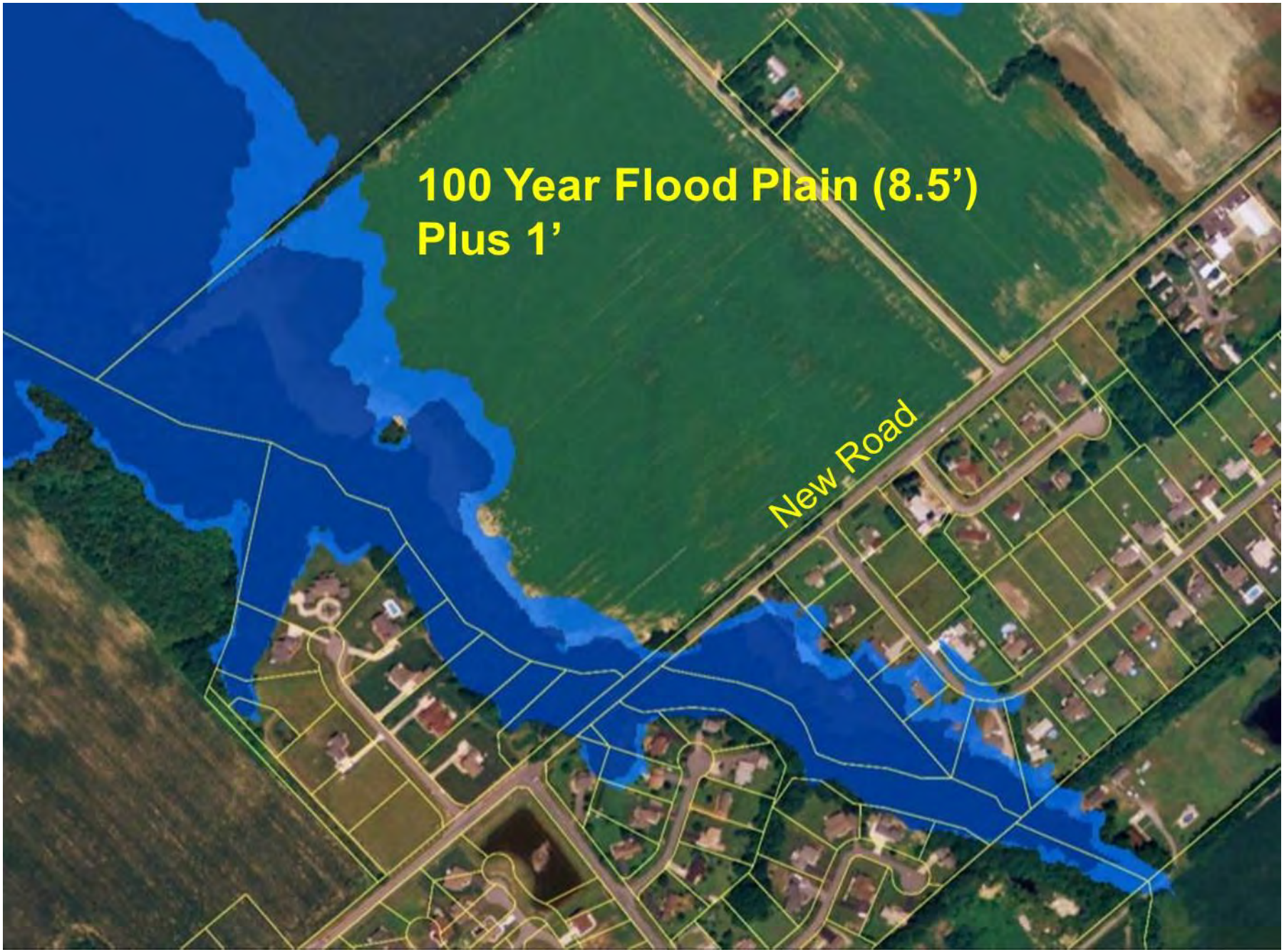
Map A-18: Outdoor resource inventory sites and 100-year floodplain overlay.



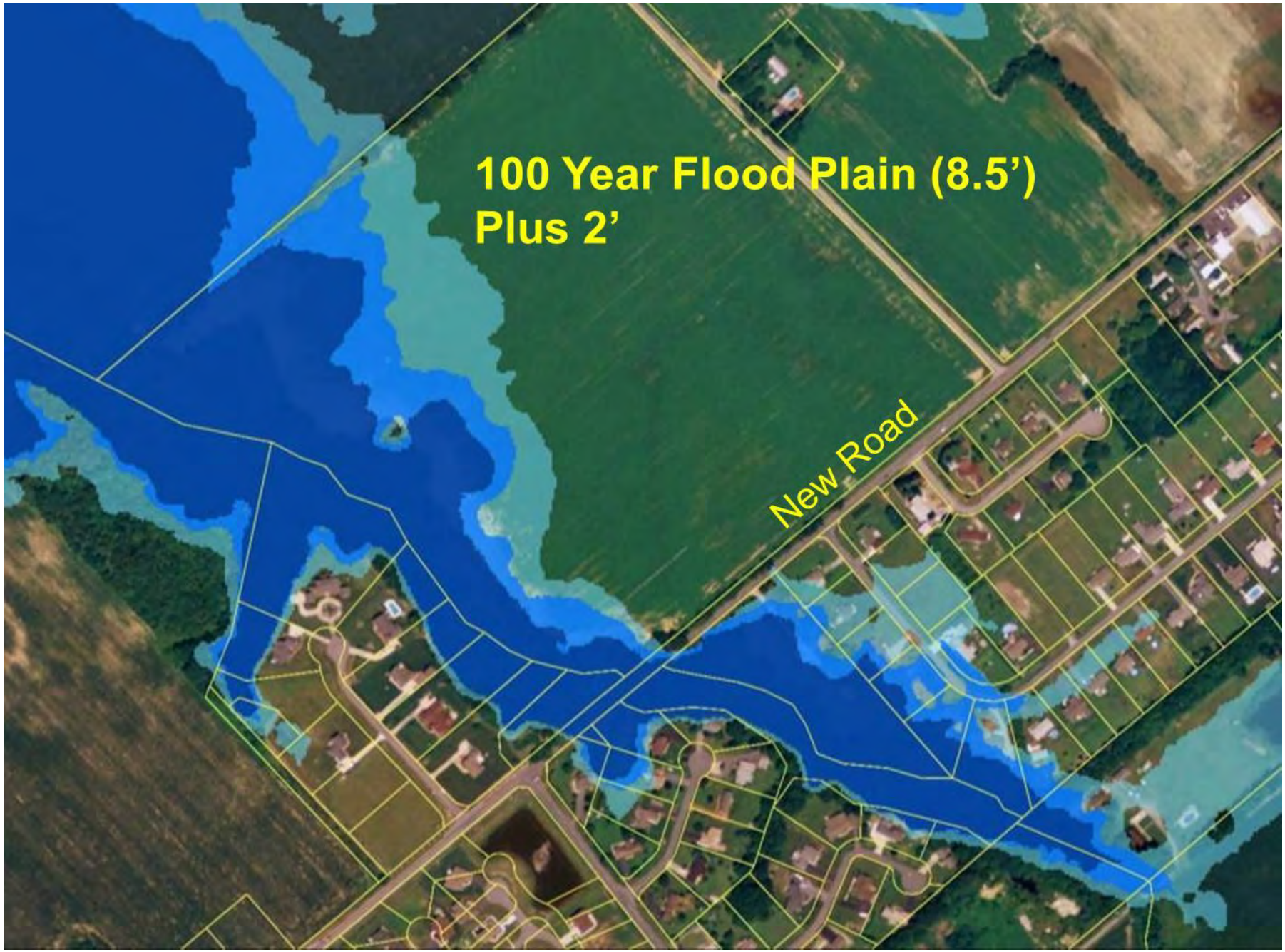
Map A-19: Environmental resource and hazard material sites with 100-year floodplain overlay.



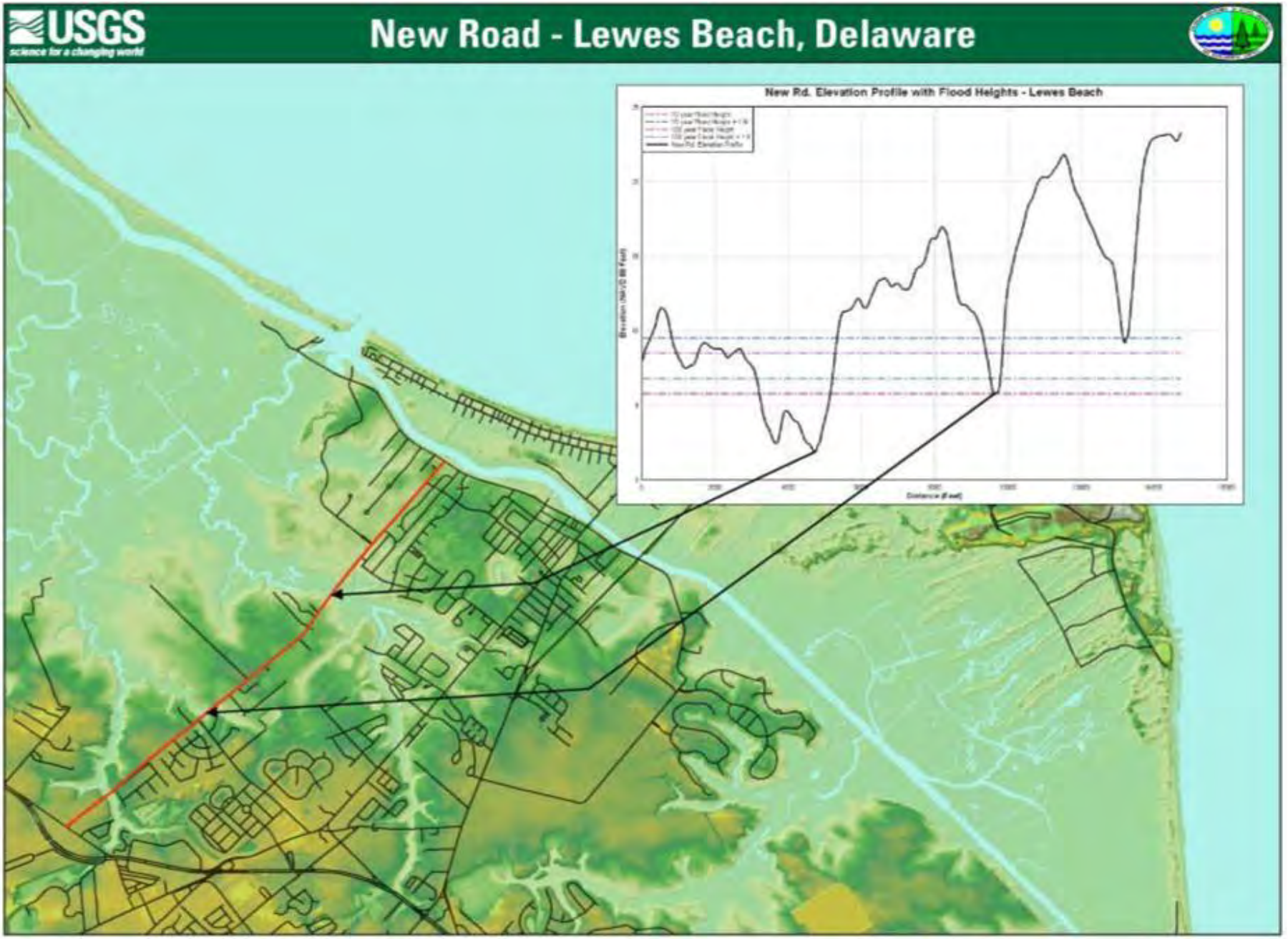
Map A-20: Current FEMA-designated 100-year floodplain in the vicinity of New Road *(map and data courtesy of Mike Powell (DNREC)/Mark Nardi (USGS))*.



Map A-21: Potential future flooding in vicinity of New Road with 1-foot rise in water levels *(map and data courtesy of Mike Powell (DNREC)/Mark Nardi (USGS)).*



Map A-22: Potential future flooding in the vicinity of New Road with 2-foot rise in water levels *(map and data courtesy of Mike Powell (DNREC)/Mark Nardi (USGS))*.



Map A-23: New Road with road elevation profile and future flood heights *(map and data courtesy of Mike Powell (DNREC)/Mark Nardi (USGS)).*

Appendix B: Sussex County Multi-Jurisdictional All Hazard Mitigation Plan (2010) Data and Charts

Table B-1 Summary of Thunderstorm Activity Reported Specifically for Lewes (1997-2009)

(data obtained from Sussex County 2010 Multi-Jurisdictional All Hazard Mitigation Plan)

Storm Location	Date	Time	Type	Magnitude	Deaths	Injuries	Property Damage
Lewes	08/13/1997	1530	Thunderstorm Winds	0 kts.	0	0	0
Lewes	03/06/1999	2155	Thunderstorm Winds	57 kts.	0	0	0
Lewes	06/02/2000	2025	Thunderstorm Winds	50 kts.	0	0	0
Lewes	08/13/2001	2000	Thunderstorm Winds	50 kts.	0	0	0
Lewes	04/03/2002	1602	Thunderstorm Winds	61 kts.	0	0	0
Lewes	08/30/2003	1715	Thunderstorm Winds	52 kts.	0	0	0
Lewes	06/28/2005	1400	Thunderstorm Winds	52 kts.	0	0	0
Lewes	07/04/2006	1835	Thunderstorm Winds	52 kts.	0	0	0
Lewes	08/16/2007	2204	Thunderstorm Wind	52 kts.	0	0	0
				TOTALS:	**0**	**0**	**0**

Source: National Climatic Data Center

Table B-2 Potential Annualized Losses per Jurisdiction

(data obtained from Sussex County 2010 Multi-Jurisdictional All Hazard Mitigation Plan)

Jurisdiction	Flood	Tropical Storm Wind	Thunder-storm	Tornado	Drought	Winter Storm
Lewes	$700,624	$7,481	Negligible	Negligible	$65,458	Negligible
MCD Lewes	$19,357,870	$367,759	$14,471	Negligible	$1,261,154	$29,303

Table B-3 Potential Damage to Critical Facilities from Tropical Storm Winds[7]

(data obtained from Sussex County 2010 Multi-Jurisdictional All Hazard Mitigation Plan)

Jurisdiction	Total Number of Critical Facilities	100-year Wind			500-year Wind			
		Moderate Damage	Slight Damage	Negligible Damage	Extensive	Moderate Damage	Slight Damage	Negligible Damage
Lewes	40	30	10	0	15	8	17	0
MCD* Lewes	175	136	36	3	127	31	14	3

[7] The definitions used are as follows. Negligible: less than 1 percent damage. Slight: 1 to 5 percent damage. Moderate: 5 to 30 percent damage. Extensive (where applicable): 30 to 60 percent damage.

* *MCD = Minor Civil Divisions (US Census 2000)*

Table B-4 Summary of Extreme Heat Occurrences in Sussex County (1995-2009)

(data obtained from Sussex County 2010 Multi-Jurisdictional All Hazard Mitigation Plan)

Storm Location	Date	Time	Type	Death	Injuries	Property Damage
Countywide	07/12/1995	0000	Heat Wave	0	0	0
Countywide	07/23/1995	0000	Unseasonably Warm	1	0	0
Countywide	08/12/1995	0000	Heat Wave	0	0	0
Countywide	08/12/1995	0000	Heat Wave	0	0	0
Countywide	08/16/1995	0000	Heat Wave	0	0	0
Countywide	05/19/1996	1000	Excessive Heat	0	0	0
Countywide	06/21/1997	0900	Excessive Heat	0	0	0
Countywide	07/12/1997	10000	Excessive Heat	0	0	0
Countywide	08/16/1997	0900	Excessive Heat	0	3	0
Countywide	06/25/1998	0900	Hot Spell	0	0	0
Countywide	07/20/1998	0900	Excessive Heat	0	8	0
Countywide	08/22/1998	1000	Heat Wave	0	0	0
Countywide	09/27/1998	0900	Unseasonably Hot	0	0	0
Countywide	06/07/1999	0900	Excessive Heat	0	5	0
Countywide	07/04/1999	0800	Excessive Heat	4	10	0
Countywide	07/16/1999	0900	Excessive Heat	0	0	0
Countywide	07/23/1999	0900	Excessive Heat	0	10	0
Countywide	08/01/1999	0000	Excessive Heat	0	0	0
Countywide	05/02/2001	1100	Unseasonably Hot	0	0	0
Countywide	08/06/2001	0900	Excessive Heat	0	0	0
Countywide	06/24/2002	0900	Excessive Heat	0	0	0
Countywide	07/01/2002	0900	Excessive Heat	0	0	0
Countywide	07/15/2002	0900	Excessive Heat	0	0	0
Countywide	07/28/2002	0900	Excessive Heat	0	0	0
Countywide	08/01/2002	0000	Excessive Heat	0	0	0
Countywide	08/11/2002	1100	Excessive Heat	0	0	0
Countywide	06/24/2003	0900	Excessive Heat	0	0	0
Countywide	07/25/2005	0900	Excessive Heat	0	0	0
Countywide	08/02/2005	0900	Excessive Heat	0	0	0
Countywide	08/11/2005	0900	Excessive Heat	0	0	0
Countywide	08/01/2006	0900	Excessive Heat	2	5	0
Countywide	06/26/2007	1100	Excessive Heat	0	0	0
Countywide	07/08/2007	1100	Excessive Heat	0	0	0
Countywide	08/07/2007	1100	Excessive Heat	0	0	0
Countywide	08/25/2007	1000	Excessive Heat	0	0	0
Countywide	06/07/2008	0900	Excessive Heat	0	0	0
Countywide	07/16/2008	0900	Excessive Heat	0	0	0
Countywide	08/10/2009	0900	Excessive Heat	0	0	0
			TOTALS:	**7**	**41**	**0**

Source: National Climatic Data Center

Table B-5 Summary of Tornado Activity in Sussex County (1950-2003)

(data obtained from Sussex County 2010 Multi-Jurisdictional All Hazard Mitigation Plan)

Tornado Location	Date	Time	Type	Magnitude	Death	Injuries	Property Damage
County	08/12/1955	1526	Tornado	F2	0	1	$3,000
County	07/05/1957	1600	Tornado	F1	0	0	$3,000
County	09/10/1957	1624	Tornado	F1	0	0	$3,000
County	06/24/1962	1700	Tornado	F1	0	0	$25,000
County	03/19/1975	1015	Tornado	F1	0	0	$3,000
County	08/04/1975	1230	Tornado	F0	0	0	$3,000
County	06/30/1976	1230	Tornado	F0	0	0	0
County	05/08/1984	1630	Tornado	F1	0	2	$250,000
County	05/08/1994	1630	Tornado	F1	0	8	$250,000
County	07/18/1984	0730	Tornado	F2	0	0	$25,000
County	08/15/1989	1309	Tornado	F1	0	0	0
County	07/15/1992	1800	Tornado	F0	0	0	0
County	07/15/1992	1800	Tornado	F0	0	0	0
County	07/15/1992	1800	Tornado	F1	0	0	$25,000
County	08/28/1992	1620	Tornado	F0	0	0	0
Bridgeville	04/01/1993	1915	Tornado	F0	0	0	$5,000
Bridgeville	06/26/1995	1315	Tornado	F0	0	0	$1,000
Dewey Beach	08/13/1998	1233	Tornado	F0	0	0	0
				TOTALS:	**0**	**11**	**$596,000**

Source: National Climatic Data Center

Table B-6 Potential Damage to Critical Facilities from Flood[5]

(data obtained from Sussex County 2010 Multi-Jurisdictional All Hazard Mitigation Plan)

Jurisdiction	Total Number of Critical Facilities	100-year Flood			500-year Flood		
		Moderate Damage	Slight Damage	Negligible Damage	Moderate Damage	Slight Damage	Negligible Damage
Lewes	40	0	39	1	0	40	0
MCD Lewes	175	8	166	1	30	145	0

[5] The definitions used are as follows. Negligible: less than 1 percent damage. Slight: 1 to 5 percent damage. Moderate: 5 to 30 percent damage. Extensive (where applicable): 30 to 60 percent damage.

* *MCD = Minor Civil Divisions (US Census 2000)*

Table B-7 Sussex County: Probability of Future Events (All Hazards)

(data obtained from Sussex County 2010 Multi-Jurisdictional All Hazard Mitigation Plan)

Hazard	Number of Events	Time Period	Events per Year	Probability of Future Occurrence
Flood	57	1993 – 2009	3.563/0.0100	High/Low
Tropical Storm	22	1877 – 2009	0.167	Low
Severe Thunderstorm	287	1950 – 2009	4.864	High
Tornado	18	1950 – 2009	0.305	Medium
Wildfire	8	1993 – 2009	0.500	Low
Drought	45	1995 – 2009	3.214	High
Extreme Temperature	78	1995 – 2009	5.286	High
Winter Storm	66	1993 – 2009	4.125	High
Coastal Erosion	Unknown	N/A	Unknown	Low
Tsunami	Unknown	N/A	Unknown	Low

Table B-8 Sussex County – Estimated Level of Risk by Hazard (High, Moderate, Low)

(data obtained from Sussex County 2010 Multi-Jurisdictional All Hazard Mitigation Plan)

Flood	Hurricane Wind	Thunder-storm	Tornado	Drought	Winter Storm
High	Low	Moderate	Low	High	Moderate

Table B-9 Overall Risk Ranking for Sussex County

(data obtained from Sussex County 2010 Multi-Jurisdictional All Hazard Mitigation Plan)

Hazard	Rank
Flood	1
Drought	2
Winter Storm	3
Thunderstorm	4
Extreme Heat/Cold	5
Tornado	7
Hurricane Wind	8
Wildfire	Unranked
Coastal Erosion	Unranked
Tsunami	Unranked

Appendix C: Workshop 2 Materials – Complete List of Participant Concerns

Specific Concern	System
Beach erosion from sea level rise	Beaches
Beach erosion from sea level rise	Beaches
Cape shores beach erosion from sea level rise	Beaches
Decreasing availability of usable beaches for tourists and the new residents from sea level rise/erosion of the beaches	Beaches
Damage to critical facilities in extreme weather events	Critical Facilities
Beebe Hospital due to flooding	Critical Facilities
Fire department on Savannah Road due to flooding	Critical Facilities
Fire/emergency	Critical Facilities
Loss of homeowner and business insurance due to sea level rise	Economy
Evacuation of residents due to flooding from storms	Emergency services
How people can seek a safe haven in a sea level rise event	Emergency services
Wildfire and plant life/wetlands from sea level rise and drought	Environment
Environmental resources due to sea level rise	Environment
Loss of wildlife and habitat	Environment
Loss of wetlands & corresponding habitat due to sea level rise	Environment
Food supply from rising temperature and precipitation	Food/Agriculture
Strain on agriculture from increased temp & increased precipitation	Food/Agriculture
The impact on farming from precipitation changes	Food/Agriculture
Health impacts from climate change impacts on air quality	Health
Increases in skin cancers due to increased exposure	Health
Increased flooding and inundation due to sea level rise	Homes
Changing building codes today to meet future vulnerabilities from flooding	Homes
Beach front property from sea level rise	Homes
Savannah Road, Lewes Beach, Pilottown Road due to sea level rise	Homes
Flooding from sea level rise and increased precipitation	Homes
Land use decisions today that do not consider future impacts of sea level rise	Homes
Lack of sea walls in Lewes to protect Savannah Road	Homes
All of the beach side of town being lost to sea level rise and major storm events	Homes
Sea level rise and extreme weather leading to increased flooding on coastal communities	Homes
Structural damage from sea level rise (coastal storms)	Homes
Flooding due to sea level rise	Homes
Wildfires caused by drought and fueled by wind	Homes/Infrastructure/Environment
Most of the City of Lewes flooding from sea level rise	Homes/Infrastructure/Environment
Certain geographical features of Lewes due to expected 1.3' - 5.6' sea level rise	Homes/Infrastructure/Environment
Increase in populations and lack of infrastructure from temperature increase	Infrastructure

Specific Concern	System
Population growth in Delaware as a result of rising temperature down south	Other
Small population of low-income people who will suffer	Social
Cemeteries	Social
St. Peter's cemetery (old and new) due to flooding	Social
Preservation of historic character with adaptation	Social
Protecting historic structures from extreme weather patterns and their resulting impacts	Social
Access to shelter from flooding roads during storm events	Transportation
Transportation infrastructure due to sea level rise	Transportation
Mobility, accessibility (roads/paths) from sea level rise and temperature	Transportation
Walk-ability due to prolonged high temperatures	Transportation
Road infrastructure due to sea level rise	Transportation
Access on streets from sea level rise	Transportation
Loss of access during storm to/from Beebe Hospital because of long-term sea level rise	Transportation
Sea level rise flooding New Road (local evacuation route)	Transportation
The wastewater treatment plant being lost to erosion and sea level rise	Wastewater
Low water table from lack of rain	Water
A rise in contamination levels at the public water wells due to sea level rise and drought events	Water
Lack of knowledge about the uses of water or just overuse	Water
High water use to water grasses	Water
Ground water level from sea level rise and drought	Water
Drinking water supply being impacted by drought, sea level rise, and saltwater intrusion	Water
Water quality from temperature, precipitation and sea level rise	Water
Saltwater intrusion from sea level rise and drought	Water
Drought due to lack of precipitation	Water
Saltwater intrusion into our well water system due to sea level rise	Water
Potable water supply from sea level rise	Water
The impact of sea level rise on our water supply	Water
Seasonal drought on our water supply	Water
Saltwater intrusion in water supply	Water
Drinking water quality and quantity	Water
Water supply from precipitation and rising temperatures	Water
Water supply for Lewes from saltwater intrusion caused by sea level rise	Water
Sea level rise's impact on our drinking water supply	Water
Water system due to sea level rise	Water
Saltwater intrusion in the Columbia Aquifer	Water

Appendix D: Workshop 3 Materials – Proposed Hazard Mitigation & Climate Adaptation Actions

The following is the complete list of actions originally proposed in no particular order to address flooding to homes:

1. Update mapping of flood zones to include sea level rise
2. Conduct survey of vulnerable homes based upon home heights to get a better picture of Lewes' vulnerability
3. Improve outreach and education particularly focused on successful behavior changes related to home building and retrofits
4. Review and update the building and zoning codes
5. Create additional financial incentives for building above the building code
6. Create real estate disclosure statements and policies that cover current and future risks from floods and other possible hazards (erosion)
7. Create a stormwater utility for improved management of the area and increased pervious pavement
8. Improve the City's level of participation in the community rating system (CRS)
9. Review and understand options for stabilizing the shoreline including costs and potential loss of natural habitats
10. Better understand sediment movement along beaches – equalize sediment distribution along coast (e.g., sharing sand resources)
11. Creation of a tax district to cover beach nourishment efforts
12. Improve dune and marsh health/quality
13. Purchase vulnerable lands
14. Enhance stormwater management practices and increase storage capacity

The following is the complete list of actions originally proposed in no particular order to address flooding to City infrastructure:

1. Conduct survey of vulnerable homes based upon home heights (elevation certificates) to get a better picture of Lewes' vulnerability
2. Use LiDAR data to determine road levels and evacuation risk
3. Perform a vulnerability assessment of historic landmarks and properties of high cultural significance to determine whether City is able to protect, move or reinforce them.
4. Elevate certain roads
5. Increase maintenance frequency
6. Explore other road surface types
7. Incorporate climate change impacts information into design, construction, operations and maintenance of near-coast City infrastructure projects by educating City staff and sharing information on the projected impacts of climate change
8. Update mapping of flood zones to include future sea level rise
9. Review and understand options for stabilizing the shoreline including costs and potential loss of natural habitats
10. Enhance stormwater management practices and increase storage capacity

The following is the complete list of actions originally proposed in no particular order to address water resource concerns:

1. Acquire and maintain detailed information on the aquifer.
2. Ensure that aquifer information is integrated into all planning efforts
3. Create/improve water resource monitoring program
4. Engage in regional water management and create agreements with neighboring areas
5. Study and potentially create water reuse programs
6. Study mechanisms to decrease demand through water conservation efforts
7. Study potential for water reuse in Lewes – personal rain barrels and City-wide gray water.
8. Improve developer agreements so that onsite water treatment/recharge systems are maintained
9. Make sure that "as built" data (not just proposed plans) is collected from all completed projects.
10. Create plans to address potential chemical contamination of the aquifer and its recharge areas.

Appendix E: Workshop 4 Materials – Ranking Exercise – Method and Results

Ranking exercise materials available separately.

Lewes Prioritization Exercise - Ranking Exercise Results

Climate Change Adaptation / Hazard Mitigation Measure	Category	Group 1 Scores	Group 2 Scores	Group 3 Scores	Group 4 Scores	Group 5 Scores	Ave
Incorporate climate change concerns into building and zoning codes	Homes	24	30	20	27	30	26.2
Improve outreach and education particularly focused on successful behavior changes related to home building and retrofits	Homes	28	30	21	26	24	25.8
Ensure that aquifer information is integrated into all planning efforts	Water	25	30	21	28	23	25.4
Using elevation data to determine road levels and evacuation risk	Infrastructure	27	30	23	18	29	25.4
Evaluate the City infrastructure's flood vulnerability	Infrastructure	25	23	22	28	28	25.2
Improve the City's level of participation in the community rating system (CRS)	Homes	30	25	19	30	22	25.2
Develop improved maps of current and future flood risks from factors such as precipitation and sea level rise	Homes	28	25	19	23	26.5	24.3
Establish a water conservation program for the City of Lewes - include studying of conservation of mechanisms	Water	20	28	25	25	23	24.2
Improve developer agreements and oversight of those agreements so that on site water treatment / recharge systems are maintained	Water	22	27	18	22	30	23.8
Develop comprehensive stormwater management plan	Homes	21	24	20	28	24	23.4
Incorporate climate change impacts information into design, construction, operations, and maintenance of near-coast city infrastructure projects by educating City staff and sharing information on the projected impacts of climate change	Infrastructure	20	23	21	24	28	23.2
Expand regional potable water management and create new agreements with neighboring areas	Water	26	17	20	17	19	19.8
Elevating certain roads	Infrastructure	6	11	11	18	6	10.4

Appendix F: Outreach Materials
Fact Sheets, Presentations and Talking Points, Case Study

Fact Sheets

Hazard Mitigation and Climate Change Adaptation Pilot Project, Lewes, Delaware

Climate Change in Lewes Delaware: Impacts, Consequences, and Adaptation

PowerPoint Presentations and Talking Points

City of Lewes Pilot Project: Hazard Mitigation and Adaptation to Climate Change – Planning and Building Resilient Coastal Communities

Climate Change in Lewes, Delaware: Building Resilience

Case Study

Integrating Climate Change Adaptation and Natural Hazard Mitigation in Lewes, Delaware

Hazard Mitigation and Climate Change Adaptation Pilot Project
Lewes, Delaware

Project Overview:

The overall goal of the Hazard Mitigation and Climate Change Adaptation pilot project is to provide assistance and guidance to the City of Lewes in the development of a unified plan for natural hazard mitigation and climate change adaptation that will improve community sustainability and resilience. Local officials and residents have been engaged throughout this process to determine the City's greatest existing and future vulnerabilities and to chart a course of action to reduce these vulnerabilities. With this goal in mind, the following objectives were the focus of this project:

- Increase overall awareness of the threats from natural hazards and climate change and create outreach materials for City officials to keep citizens and others informed.
- Design a methodology that combines climate change adaptation and hazard mitigation planning, enabling the City to engage in a combined planning effort in the future.
- Enhance the understanding of Lewes's vulnerability to climate change and natural hazards and identify data gaps.
- Utilize a prioritization system to select hazard mitigation / climate adaptation strategies from national best practices for coastal communities.
- Create a final action plan that the City can use to implement the chosen initiatives.

City staff, City board and commission members and citizens participated in four workshops in order to better understand the City's climate change and natural hazard vulnerabilities and determine the best strategies to address these concerns. The four workshop topics were:

1. Introduction to Hazard Mitigating and Climate Change Adaptation
2. Assessing Existing and Future Vulnerability in Lewes, Delaware
3. Prioritizing Approaches for Climate Change Adaptation and Hazard Mitigation in Lewes, Delaware
4. Selecting Primary Climate Change Adaptation and Hazard Mitigation Actions in Lewes, Delaware

Reasons for action:

Lewes is vulnerable to many natural hazards including coastal storms, flooding and high winds. More than one third of all structures in the City (898 of 2210) are within the FEMA 100-year (1 percent chance) floodplain and a flood of this nature could cause $23.8 million in flood damages (Greenhorne & O'Mara, 2000). Moreover, it is known that the climate is changing and that these changes will exacerbate hazards in Lewes in a number of ways. Given these threats, below are a number of reasons to act today to build preparedness:

1. Climate change impacts are projected to get worse in the coming years.
2. Today's choices will shape tomorrow's vulnerabilities.
3. Climate change poses threats to existing community priorities.
4. Significant time is required to motivate and develop adaptive capacity, and to implement changes.
5. Planning now can save money, while inaction now will lead to higher costs in the future.
6. Preparing for climate change can be integrated into existing processes.
7. Cities have a moral and practical imperative to act.

Climate Change Overview:

Over the past century there have been numerous documented changes in climate both globally and locally. To-date, the world has seen increases in annual average temperatures, altered precipitation patterns, and sea level rise (SLR), as well as other trends, such as increases in weather extremes, changes in the onset of seasons and the melting of glaciers (IPCC, 2007). As an example, the City of Lewes has seen an increase of 12.7 inches of sea level rise over the past century (Figure 1).

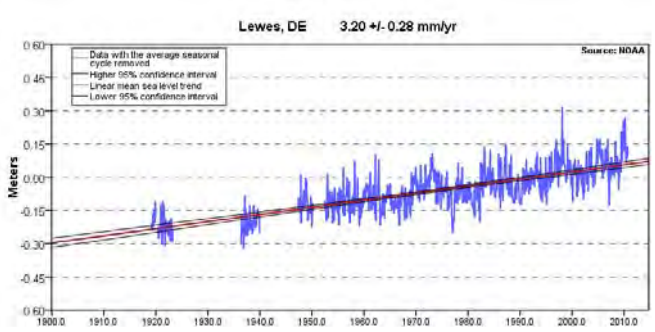


Figure 1: Observations of relative sea-level for Lewes, Delaware and trend lines (NOAA, 2010)

A number of summary regional reports were reviewed in order to determine the likely impacts of climate change on the City of Lewes. It was found that temperatures are very likely to rise making the region feel more like North Carolina in the coming century. As a coastal community, sea level rise will pose many and varied threats to Lewes – likely changing flood patterns in the City, causing current design flood events to occur more frequently. Additionally, sea level rise will likely cause coastal flooding to reach farther landward thus covering greater areas of land in the City of Lewes. Sea level rise will also likely cause certain areas in Lewes to become inundated, meaning that they will become permanently wet. A third effect of sea level rise in Lewes is on erosion, which will also likely be greater in the coming century.

Selected Key Vulnerabilities:

Key vulnerabilities are those that are of greatest concern to a community and can be based upon a number of considerations including exposure, sensitivity, adaptive capacity, magnitude of impact, timing of impact, distributional nature of the impact, and others. Based upon presentations and exercises that enhanced participant understanding of current and future threats to the City, participants in the second workshop selected the following three key vulnerabilities to be the focus of the City's integrated climate change adaptation and hazard mitigation actions:

1. Homes and land uses threatened by flooding today and in the future with higher water levels.
2. City infrastructure threatened by flooding today and in the future with higher water levels.
3. The local aquifer and drought threats posed by potential precipitation pattern changes and saltwater intrusion caused by sea level rise.

Primary Recommended Hazard Mitigation and Climate Change Adaptation Actions:

Participants then ranked potential actions to address the aforementioned vulnerabilities based upon the actions' social, technical, administrative, political, economic and environmental feasibility and collective benefit. Through this analysis the following six actions were recommended to the City for implementation. These actions can help to create a foundation towards other actions that were also highly regarded by participants but were not selected as final actions for recommendation. Four of these actions (starred below) align with the Hazard Mitigation Planning Team's priorities listed in the current hazard mitigation strategy as part of the County's Multi-Hazard Mitigation Plan.

1. Incorporate climate change concerns into the comprehensive plan and into future reviews of the building and zoning codes.
2. Improve outreach and education particularly focused on successful behavior changes related to home building and retrofits.*
3. Ensure that aquifer information is integrated into all planning efforts.
4. Use elevation data to determine road levels and evacuation risk.*
5. Evaluate the City and the Board of Public Works (BPW) infrastructure's flood vulnerability from direct flood impacts as well as from indirect flood impacts to access routes.*
6. Improve the City's level of participation in the community rating system (CRS).*

Climate Change in Lewes Delaware: Impacts, Consequences and Adaptation

Over the past century there have been numerous documented changes in climate both globally and locally. To-date, the world has seen increases in annual average temperatures, altered precipitation patterns, and sea level rise (SLR), as well as other trends such as increases in weather extremes, changes in the onset of seasons and the melting of glaciers (IPCC, 2007).

To determine global and regional future climate estimates, scientists rely on models that are based on different greenhouse gas emissions scenarios. Factoring in several variables – population growth, energy use, and societal choices – these models create projections, often grouped into high and low emissions scenarios, that provide a range of future climates. Though there is some uncertainty in the models, most scientists agree that for the Mid-Atlantic region, by the end of the 21st century warming temperatures and rising sea levels are considered extremely likely (>95%), while changing precipitation patterns and the associated effects are considered to be likely (>66%) (Najjar, 2010).

The sections below provide regional information relevant for Lewes, Delaware on three primary climactic conditions – temperature, sea level and precipitation – as well as several changes that are the consequence of combining these factors. Each section includes impacts, consequences and potential adaptation measures the City can take to increase its resilience.

Temperature: Table 1 below provides a summary of regional downscaled temperature changes that can be expected by 2100. The lower numbers represent a low emissions scenario and the higher values represent a high emissions scenario. One way to look at these future changes is through a heat index, which is a measure of how hot it feels. For southern coastal New Jersey, which can be used a proxy for Lewes, by 2100 the area's summers will feel like northern North Carolina under a low emissions scenario, and like southern Georgia under a high emissions scenario (Figure 1).

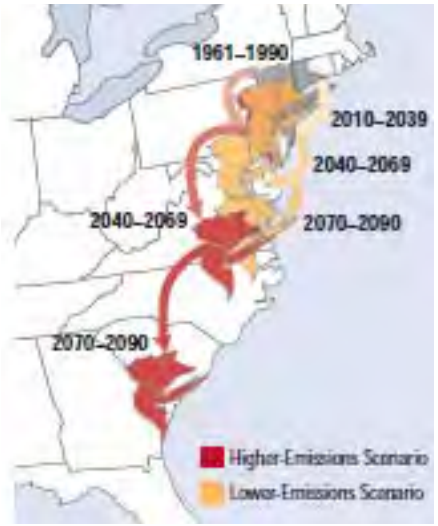


Figure 1: Heat index for the Tri-State Area (NECIA, 2007)

Climate Condition		Delaware	Maryland	New Jersey
Temperature	Annual Average (°F)	3.6 – 7.2	4.0 - 9.8	2.0 - 8.0
	Extreme Heat Days	significant increase	double - triple	significant increase

Table 1: Downscaled temperature predictions for 2100 under high and low emissions scenarios. (DE – Kreeger, 2010, MD – CACCIM, 2008, NJ – CIER, 2008.)

As the temperature increases, there are likely to be an array of social, economic, built and natural system impacts. The box below lists likely impacts and consequences associated with temperature increases:

Associated Impacts

- Heat waves
- Drought
- Wildfires
- Invasive species
- Shift in species range
- Changes in timing of ecological events
- Spread of vector borne diseases

Associated Consequences

- Illnesses, injuries and loss of life
- Loss / degradation of ecosystems and the services they provide
- Decline in the quantity / quality of freshwater[1]
- Economic losses

[1] All highlights indicate consequence that participants in Lewes Workshop 2 identified as being of greatest concern

There are a number of different adaptation measures that a community can take to address these consequences. Below are several measures that Lewes could consider to address increasing air temperatures:

1. Increase shaded areas
2. Create early heat warning systems and cooling centers
3. Reduce vehicular traffic
4. Enhance water management programs
5. Improve management of potential wildfire outbreak areas
6. Create wildlife corridors
7. Increase information (and access to information) for those that rely on natural resources (farmers / fisherman)

Sea Level Rise: By 2100, global or eustatic sea level is expected to reach between 0.59 feet (IPCC, 2007) and 4.6 feet (Rahmstorf, 2009) depending on greenhouse gas emissions and on assessment methodology. Several additional factors, including circulation patterns and land elevations changes, are known to impact local or relative sea level rise. Table 2 below provides a summary of low and high sea level rise figures, compared to 2000 levels, taken from a number of regional reports. This table also includes the State of Delaware's Department of Natural Resources and Environmental Control's (DNREC) future sea level estimates that are currently being used for planning purposes. To the right, Figure 2 demonstrates historical sea level rise in Lewes over the last century (roughly 12.7 inches).

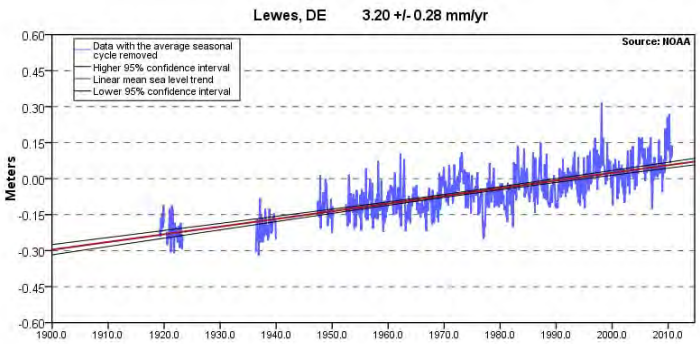


Figure 2: Observations of relative sea-level for Lewes, Delaware and trend lines (NOAA, 2010)

Report Name	Location	Low SLR (Ft)	High SLR (Ft)
Department of Natural Resources & Environmental Control Administrative Policies and Provisions	Delaware	1.6	4.9
Climate Change and the Delaware Estuary Three Case Studies in Vulnerability Assessment and Adaptation Planning	Delaware Estuary	2.6	5.6
Future Sea Level Rise and the New Jersey Coast	New Jersey Coast	2.1	3.9
Maryland Commission on Climate Change – Climate Action Plan	Maryland	2.7	3.4
Climate Change and Chesapeake Bay State-of-the Science Review and Recommendations	Chesapeake Bay	2.3	5.3
Governor's Commission on Climate Change – Final Report: A Climate Change Action Plan	Virginia	2.3	5.2
North Carolina Sea-Level Rise Assessment Report	North Carolina	1.3	4.6

Table 2: Relative sea level rise estimates for 2100 under a low and high emissions scenarios.

There are numerous impacts and consequences associated with increasing sea levels. The table below highlights impacts likely to occur in Lewes:

Associated Impacts

- Coastal inundation
- Erosion
- Storm surge flooding
- Rising water tables
- Saltwater intrusion
- Nonpoint source pollution
- Introduction of toxic materials

Associated Consequences

- Illnesses, injuries and loss of life
- Destruction and damage to coastal property and infrastructure
- Loss / degradation of ecosystems and the services they provide
- Loss of beach access
- Decline in the quantity / quality of freshwater
- Loss of cultural resources
- Population displacement
- Economic losses

There are a number of different adaptation measures that a community can take to address these consequences. Below are several measures that Lewes could consider to address sea level rise.

1. Increase understanding of areas of greatest vulnerability
2. Improve building code and zoning standards for new homes and retrofits, including limiting development in vulnerable areas
3. Create real-estate disclosure statements
4. Improve the City's level of participation in the community rating system (CRS)
5. Research shoreline stabilization options
6. Improve dune quality and marsh quality
7. Create stormwater / beach nourishment districts
8. Purchase vulnerable lands

Precipitation: Despite some uncertainty, the average of 14 climate models indicates that the annual mean precipitation rate for the state of Delaware is expected to increase. These models show greater increases in precipitation in winter months than in summer months. Furthermore, three quarter of the models predict that there will be substantial increases in the frequency of extreme precipitation events, meaning that there will likely be more heavy downpours followed by consecutive dry days (Kreeger, 2010).

Climate Condition		Delaware	Maryland		New Jersey
		2100	2050	2100	2100
Precipitation	Annual Average (% increase)	7 - 9			10 - 20
	Winter Precipitation (% increase)		6.6 - 6.8	10.4 - 12.6	
	Winter Snow Volume (% decrease)		25	50	

Table 3: Shows downscaled precipitation data for high and low emissions scenarios. DE – Kreeger, 2010, MD – CACCIM, 2008, NJ – CIER, 2008

Below are lists of impacts and consequences associated with changes in precipitation patterns:

Associated Impacts

- Flooding
- Erosion
- Nonpoint source pollution
- Introduction of toxics
- Salinity shifts
- Possible drought
- Spread of vector borne diseases

Associated Consequences

- Decline in the quantity / quality of freshwater
- Damage to property and infrastructure
- Loss / degradation of ecosystems and the services they provide
- Economic losses
- Illnesses, injuries and loss of life

There are a number of different adaptation measures that a community can take to address these consequences. Below are measures that Lewes could consider to address changing precipitations patterns.

1. Acquire and maintain detailed information and monitoring of water resources
2. Engage in regional water management and create agreements with neighboring areas
3. Enhance stormwater management practices
4. Initiate water reuse programs
5. Enhance water conservation efforts
6. Integrate future projects into capital improvement plan and water management plan

Intersections: In addition to the primary changes in climate conditions noted above, there are a number of changes that are likely to come as a result of the interactions of these primary changes. Increases in extreme weather events, a consequence of warmer temperatures and increased precipitation, is one that Lewes should be aware of. In addition to impacts and consequences noted above, an increase in extreme weather events is associated with high winds which can result in greater destruction of homes and infrastructure. Increasing water temperatures and ocean acidification are two other intersections that the City ought to be cognizant of. Below are lists of impacts and consequences associated with increasing water temperatures and ocean acidification:

Associated Impacts

- Coral bleaching
- Hypoxia
- Pathogens and disease outbreaks
- Harmful algal blooms
- Invasive species
- Shifts in species range
- Change in timing of ecological events
- Dissolution of calcium carbonate in marine shell-forming organisms

Associated Consequences

- Loss / degradation of ecosystems and the services they provide
- Decreased water quality
- Illnesses, injuries, and loss of life
- Economic losses

Consequences / Vulnerabilities of Greatest Concern: At the workshop – *Assessing Existing and Future Vulnerabilities in Lewes, Delaware* – participants identified systems in Lewes that they felt were most vulnerable to the changing climate. The participants identified (1) homes / land use, and (2) water resources as the most vulnerable systems to the aforementioned changing climate conditions. In groups, the participants then identified a number of actions that could be taken to address these concerns.

Actions to Increase Resilience: Below are the measures identified by workshop participants that Lewes could consider to address increased vulnerability of homes and properties:

1. Comprehensive review of how the building code could be improved to address hazards with a specific look at impervious surfaces.
2. Integrate future concerns into renovations requirements not just new construction requirements.
3. Improve outreach and education particularly focused on successful behavior changes. Messages on the following subjects, audiences and modes should be considered:
    - Subject: Building resilience
    - Subject: Retrofits
    - Mode: Via tax bills
    - Mode: Via building contracts
    - Audience: Non-year-round residents
4. Survey of vulnerable homes based upon home heights (elevation certificates) to get a better picture of Lewes' vulnerability.
5. Review and understand options for shoreline stabilization – consider costs and loss of natural habitats.
6. Better understand sediment movement along beaches – equalize sediment distribution along coast (e.g. sharing sand resources).
7. Creation of real estate disclosure statements that cover current and future risks from floods and other possible hazards (erosion).
8. Creation of financial incentives for building above the building code.
9. Creation of a tax district to cover beach nourishment efforts.
10. Creation of a stormwater utility for improved management of the pervious pavement.

Below are the measures identified by workshop participants that Lewes could consider to address the increased vulnerability of the water resource system:

1. Acquire accurate information and use as the basis for all decisions. Questions needing answer include:
    - What is the growth that the aquifer can sustain?
    - How would seasonal changes in precipitation patterns affect the aquifer?
    - Have the changes in irrigation amounts affected the aquifer and could they in the future?
    - Improved understanding of the area's recharge system.
    - Study what water conservation and water reuse would do to the aquifer.
2. Engage in regional cooperation regarding Lewes' water source. Specifically, Lewes could improve its working relationship with the county on land use decisions around the aquifer
3. Actions 1 and 2 should inform the steps taken by the City. More specifically:
    - Improve the incorporation of future climate projections into the capital improvement plan and the water infrastructure plan.
    - Study mechanisms to decrease demand through water conservation efforts.
    - Study potential for water reuse in Lewes – personal rain barrels and city wide gray water.
    - Improve developer agreements so that on site water treatment / recharge systems are maintained.
    - Make sure that "as built" data (not just proposed project plans) is collected from all completed projects.
    - Understand the monitoring that is done of the wells and see if better monitoring is needed in the future as climate change affects regional water resources.
    - Create plans to address potential chemical contamination of the aquifer and its recharge areas.

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City of Lewes Pilot Project

Hazard Mitigation and Adaptation to Climate Change – Planning and Building Resilient Coastal Communities

Outline

1. Background
2. Project Overview
3. Project Process
4. Workshops & Associated Report Chapters
5. Project Outcomes – Selected Actions & Implementation
6. Next Steps

Hazard Mitigation – Lewes' Leadership

- **Hazard Mitigation** – Any action taken to reduce or eliminate **long-term** risk to people and property from natural hazards and their effects.
- Hazard mitigation aims to break the cycle of disasters

- **Lewes** participated in Project Impact an initial FEMA hazard mitigation effort.
- Lewes created a Mitigation Planning Team – a unique group able to help the City mitigate the effects of natural hazards.
- Great success to date in wildfire mitigation and disaster preparedness efforts.

Addressing Climate Change

- **Climate Adaptation** – Any measure or action that reduces the negative impacts of climate change or increases new opportunities.
- **Climate Mitigation** – Any measure or action taken to reduce greenhouse gas emissions.
- **Adaptation and Mitigation are not mutually exclusive!**

Why Plan for Natural Hazards and Climate Change

1. The climate is already changing and climate change impacts are projected to get worse in the coming years.
2. Today's choices will shape tomorrow's vulnerabilities.
3. Climate change poses threats to existing community priorities.
4. Significant time is required to motivate and develop adaptive capacity, and to implement changes.
5. Planning now can save money, while inaction now will lead to higher costs in the future.
6. Preparing for climate change can be integrated into existing processes.
7. Cities have a moral and practical imperative to act and protect their citizens.

Project Overview – Purpose and Goals

- Increase overall awareness of threats from natural hazards and climate change.
- Enhance the understanding of Lewes' vulnerability to climate change and natural hazards, and identify data gaps.
- Provide assistance and guidance to the City of Lewes to develop a plan for hazard mitigation and climate adaptation that will improve community sustainability and resiliency.
- Design a methodology that combines hazard mitigation planning and climate change adaptation, enabling the City, local officials and residents to engage in a combined planning effort with the following elements
  - synthesizing available information on risks and hazards in the community;
  - assessing vulnerabilities and identifying data/planning gaps, especially related to natural hazards, climate change and associated risks;
  - developing best practice recommendations and model ordinances for mitigation and adaptation; and
  - identifying strategic opportunities to increase community resiliency.
- Create a final action plan that the City can use to implement the chosen initiatives.

Pilot Project – Process

Work with **relevant stakeholders** in the City of Lewes through a series of workshop and meetings to ensure outcomes are reflective of local needs and capabilities and that any identified strategies will ultimately assist the City in increasing community resilience to changes in climate and natural hazards.

The following 5 steps were used to create a final hazard mitigation / climate change adaptation action plan:

1. Identify existing hazards and associated vulnerabilities
2. Identify climate change impacts on existing hazards and associated vulnerabilities
3. Identify two key vulnerabilities for which to plan
4. Select hazard mitigation/climate adaptation actions
5. Create implementation plans

Role of the Lewes Mitigation Planning Team

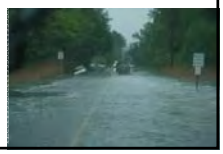
- Provided project guidance
- Reviewed and approved steps in the project
- Participated in workshops
- Provided additional information and data as needed
- Keepers of the report
- Assist and ensure implementation
- Tracking success of the projects

Workshop 1 – July 14, 2010

Discussion on Mitigating and Adapting to Natural Hazards and Climate Change in the City of Lewes

- Overview of historic and current natural hazards in Lewes
- City of Lewes mitigation strategies - 2010 update (*Chatham Marsch, City of Lewes)*
- Preparing for future flood risk *(Mike Powell, Delaware DNREC)*
- Discussion and identification of associated risks and vulnerabilities
- Vulnerability self-assessment exercise – breakout sessions
- ICLEI – Climate Resilient Communities™ program and climate adaptation

Chapter 3: Overview of Current Natural Hazards



Key Points

- Based primarily on existing reports - Greenhorne and O'Mara assessments & Sussex County All Hazard Mitigation Plan Update
- Focuses on known natural hazards
- Appendix A Maps 5 -12 provide information on potential locations of impacts

Identified Hazards

1. Coastal Storms
2. Floods
3. Severe Thunderstorms
4. Wind
5. Winter Storms
6. Drought / Extreme Heat
7. Wildfire
8. Coastal Hazards – Erosion, Waves, and High-Velocity Flow
9. Tornadoes
10. Tsunamis

Workshop 2 – October 21, 2010

Assessing Existing and Future Vulnerability in Lewes

- Overview of regional climate change methodologies and predictions
- Review of potential climate change impacts in Lewes
- Dialogue about potential impacts of climate change on existing hazards and identified vulnerabilities in Lewes
- Group identified issues of concern including drought, erosion and shoreline change, sea-level rise, extreme weather, human impacts
- Breakout session dialogues to discuss possible actions to reduce vulnerabilities and impacts

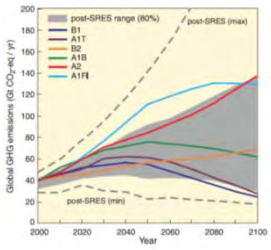
Chapter 4 Overview of Climate Change

Changing Climate Conditions

Temperature	Precipitation	Sea Level Rise

Chapter 4
Overview of Climate Change
Information in the Report

Global Scientific Foundation | **Regionally Relevant Science**

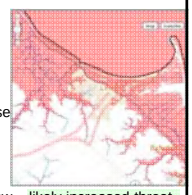


Chapter 4
Overview of Climate Change
Significance for Lewes's Natural Hazards

Key Points

- Based primarily on current science and regional assessments of climate change
- Focuses on climate change impacts to Lewes's natural hazard threats
- Appendix A Maps 13 -15 provide potential future inundations for Lewes

Specific Changes to Natural Hazards



1. Coastal Storms – more severe
2. Floods – more extensive
3. Severe Thunderstorms – possible severity increase
4. Wind – possible intensity increase and frequency decrease
5. Winter Storms – possibly less snow, more flooding
6. Drought / Extreme Heat – likely increase in both
7. Wildfire – possibly an increased threat
8. Coastal Hazards – Erosion, Waves, and High-Velocity Flow – likely increased threat
9. Tornadoes – no significant connection
10. Tsunamis – no significant connection

Dialogue about potential impacts of climate change on existing hazards and identified vulnerabilities in Lewes.

Groups identified issues of concern including flooding, drought, erosion and shoreline change, sea-level rise, extreme weather, human impacts.

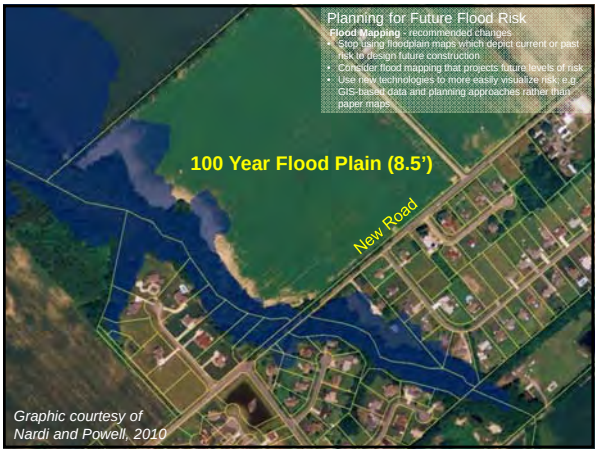
Systems/issues of greatest concern identified by participant vote:

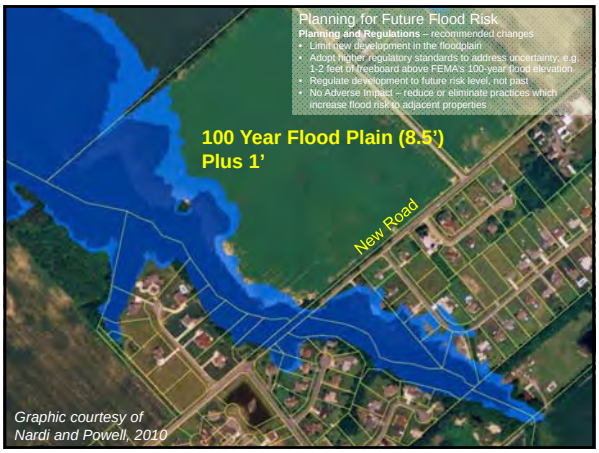
1) impacts to homes, property and land use;
2) impacts to city infrastructure;
3) impacts on water systems and water resources.

Workshop 3 – December 9, 2010

Prioritizing Approaches for Climate Change Adaptation and Hazard Mitigation in Lewes, Delaware

- Managing flood risk with rising sea levels *(Mike Powell, DNREC & Mark Nardi, USGS)*
- Best practices & possible actions for increasing resilience
- Assessing feasibility and prioritizing adaptation actions
- Implementing mitigation actions – A FEMA perspective *(Tess Grubb, FEMA Region III)*
- Hazard mitigation grant funding *(Dave Carlson, DEMA)*





Assessing Feasibility and Prioritizing Adaptation Actions

Breakout sessions narrowed actions to top 5 per key vulnerability

Lewes Prioritization Exercise - Addressing Flooding to Homes

Climate Change Adaptation / Hazard Mitigation Measure	Votes Received
Improve mapping of flood zones to include sea level rise	9
Improve the City's level of participation in the community rating system (CRS)	5
Enhance stormwater management practices and increase storage capacity	5
Improve outreach and education particularly focused on successful behavior changes related to home building and retrofits	4
Review and update the building and zoning codes including	4

Lewes Prioritization Exercise - Addressing Flooding to City Infrastructure

Climate Change Adaptation / Hazard Mitigation Measure	Votes Received
Improve mapping of flood zones to include sea level rise	5
Survey of infrastructure based upon heights (elevation certificates) to get a better picture of Lewes' vulnerability	5
Incorporate climate change impacts information into design, construction, operations, and maintenance of near-coast city infrastructure projects by educating City staff and sharing information on the projected impacts of climate change	5
Using LiDAR data to determine road levels and evacuation risk	4
Elevating certain roads	3

Lewes Prioritization Exercise - Addressing Water Resource Concerns

Climate Change Adaptation / Hazard Mitigation Measure	Votes Received
Ensure that aquifer information is integrated into all planning efforts	6
Engage in regional water management and create agreements with neighboring areas	4
Improve developer agreements so that on site water treatment / recharge systems are maintained	3
Study potential for water reuse in Lewes – personal rain barrels and city wide gray water	3
Study mechanisms to decrease demand through water conservation efforts and potentially improve water conservation efforts	3

Workshop 4 – January 26, 2011

Selecting Primary Climate Change Adaptation and Hazard Mitigation Actions in Lewes, Delaware

- Top-ranked climate change adaptation and hazard mitigation actions – A look back and a look ahead
- Exploring key best practices – map revisions, the Community Rating System, outreach efforts, and stormwater management
- Selecting primary climate change adaptation and hazard mitigation actions to propose to the City of Lewes
- Implementation in Lewes, Delaware - who, what, when, where, why, and how

Goal - finalize the selection of at least three (3) climate change adaptation and hazard mitigation actions that will be proposed to the City of Lewes for implementation.

The following criteria were used to select primary strategies and actions:

Social (citizen support; equitable action; lead to increased social resilience?)

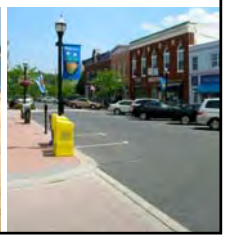
Political (does action have political support?)

Technical (can action be implemented; can action handle range of climate change impacts?)

Economic (cost effectiveness; existing or acquired funding?)

Administrative (does city have operational control to implement action; can implementation occur in timely manner?)

Environmental (does action increase resilience of natural environment; positive side effects on environment?)



Specific actions identified and prioritized in Workshop 4:

1. Incorporate climate change and natural hazard concerns into the comprehensive plan and the zoning code.
2. Improve outreach and education particularly focused on successful behavior changes related to home building and retrofits.
3. Ensure that aquifer information is integrated into all planning efforts.*
4. Use elevation data and flood sensors to determine road levels and evacuation route vulnerability.*
5. Evaluate the City and the Board of Public Work (BPW) infrastructure's flood vulnerability from direct flood impacts as well as from indirect flood impacts to access routes.*
6. Improve the City's level of participation in the Community Rating System (CRS).*

* Align with City and / or County Hazard Mitigation Plan Actions

Implementation Guidance

A. Alignment with existing priorities and co-benefits

B. Administration and Staffing

C. Potential Implementation Steps

D. Timeline Information

E. Financing and Budget

F. Monitoring

Next Steps

- Initiate implementation of selected actions
- Continue to monitor progress on actions
- Identify stumbling blocks and set backs so as to move actions forward
- Include climate understanding in future hazard mitigation updates

Questions

Extra Slides

These slides come from other presentations and can be used if your presentation were to take on a different focus.

For example if you wanted to focus on the contents of the report you could use the next two slides.

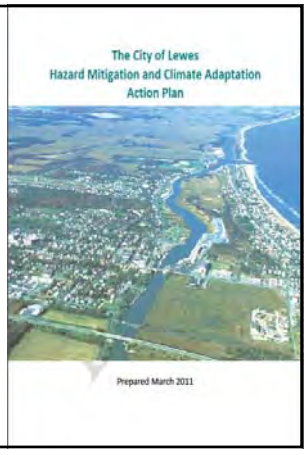
Purpose of the Report

- To establish the climate change background and lay the groundwork for implementing the identified climate change and natural hazards strategies.

- Report Contents
- **Introduction**
- **Why Plan**
- **Overview of Current Natural Hazards**
- **Overview of Climate Change**
- **Vulnerability Assessment**
- **Identified Strategies**
- **Implementation Plans**

Introduction

- Lewes Context
- Project Overview
- Methods Overview



Chapter 5
Vulnerability Assessment

Self Assessment
- Critical Facilities
- Societal Analysis
- Economic Analysis
- Environmental Analysis

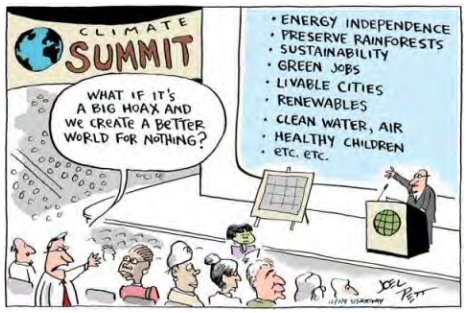
Key Vulnerabilities – Workshop 2
- Homes and land use - Flooding
- City Infrastructure - Flooding
- Water resources – Precipitation pattern changes, salt water intrusion and flooding

Connections – Climate Change Adaptation and Hazard Mitigation Planning

Throughout the project's process, it's important to integrate hazard mitigation planning with climate change adaptation work.

Possible connections to mitigation actions submitted by Lewes to the Sussex County 2010 Multijurisdictional All Hazard Mitigation Plan Update:

- Improve stormwater management throughout the City.
- Increase participation in the National Flood Insurance Program.
- Minimize damages from high wind events.
- Reduce vulnerability to wildfires.
- Implement a community outreach program.
- Continue data acquisition and enhancements to City GIS system.



Talking Points for Project Overview Presentation

Slide 1
Welcome. Today's presentation is about a pilot project that the City of Lewes, Delaware started in July 2010 that integrated climate change adaptation with hazard mitigation in order to make the City more resilient and safer in the future.

Slide 2
In this presentation we will cover some basic background to the project, as well as project details. We will then wrap up with next steps for the City of Lewes.

Slide 3
Hazard mitigation is considered by the Federal Emergency Management Agency (FEMA) to be any cost effective action taken to eliminate or reduce the long-term risk to life and property from natural hazards. These efforts are intended to break the cycle of disaster and put a community on a more sustainable long term path.

Lewes' proximity to water and well understood threats from coastal storms and flooding has put natural hazards at the forefront of the City's mitigation efforts and the City has been a leader in this field. Its participation in Project Impact and subsequent creation of a Mitigation Planning Team are examples of the City's leadership.

Slide 4
The other component of this project, climate change adaptation, is one of two ways to address climate change. The other is climate mitigation. Can anyone tell me the difference between the two?

Great, here are the terminologies from the IPCC report.

Climate mitigation refers to any measure or action taken to reduce greenhouse gas emissions (renewable energy, smart growth, TOD, urban gardening, etc.).

Climate adaptation refers to any measure or action taken to reduce the negative impacts of climate change or actions that increase opportunities embodied in a changing climate. Climate adaptation isn't about reducing greenhouse gas emissions, although that can certainly be a side benefit, instead, it's about preparing for the impacts associated with a changing climate.

Importantly, climate adaptation and climate mitigation are not mutually exclusive. What we mean here is that many adaptation strategies can also be mitigation strategies and vice versa. For examples of strategies, please see the adaptation-mitigation co-planning guidance ICLEI has on their website. http://www.icleiusa.org/action-center/planning/The%20Mitigation-Adaptation%20Connection.pdf

Slide 5
There are many reasons for adaptation planning.

First, the climate is already changing. We are seeing evidence on the ground today of these changes.

Second, many of the choices we make today will shape tomorrow's vulnerabilities. For example a building with a 50 + year life span that is built based on historic flood understanding could likely be in tomorrow's floodplain.

Also, climate change poses threats to existing community priorities. A community that is committed to hazard mitigation, but is focused on past hazard events will not truly be able to achieve its hazard mitigation priorities because climate change threatens to create enhanced or new natural hazard events.

Then there's the fact that significant time is required to motivate and develop adaptive capacity, and to implement changes. Thus getting started now can help place a community ahead of the curve of pending climate change impacts.

Also, it's well known that advanced planning can save money by enabling a community to make wiser choices and avoid certain pitfalls.

Preparing for climate change does not have to be a burdensome process. Instead it can be integrated into existing processes thereby making it easier to achieve.

Finally, cities have a moral and practical imperative to act and protect their citizens. Climate change adaptation is part of providing that protection.

Slide 6
The overall purpose of the Hazard Mitigation and Climate Change Adaptation pilot project is to provide assistance and guidance to the City of Lewes in the development of a unified plan for natural hazard mitigation and climate change adaptation that will improve community sustainability and resilience. To achieve this purpose, the project focused on five deliverables (outlined above).

Slide 7
The pilot project was undertaken in closely collaboration with **relevant stakeholders** in the City of Lewes. This included City staff, members of different City boards and commissions, relevant state and federal partners, as well as representatives of businesses and homeowners associations. Additionally, workshops were open to the public allowing citizens to express their concerns and opinions throughout the process.

The following 5 steps were used to create a final hazard mitigation / climate change adaptation action plan:
Identify existing hazards and associated vulnerabilities
Identify climate change impacts on existing hazards and associated vulnerabilities
Identify two key vulnerabilities for which to plan
Select hazard mitigation/climate adaptation actions
Create implementation plans

Slide 8
The Lewes Mitigation Planning Team played a critical role in this process. The team helped to guide the project and will become the keeper of the action plan going forward.

Slide 9
To complete the purpose and achieve the goal established for this project, four community workshops were held. This slide shows the overview of the topics covered in workshop 1. The primary focus was on understanding the City's current flood exposure and using that to develop an understanding of vulnerabilities. Additionally, ICLEI's Climate Resilient Communities program, which helps communities engage in climate change adaptation planning, was introduced.

Slide 10
Chapter three of the final Lewes Climate Change and Natural Hazard Action Plan, summarizes the findings presented during workshop 1 as well as the information contained in several local reports on natural hazards.

Through this process 10 hazards were identified as possibly being of concern to Lewes. These hazards are listed in order of greatest concern based on their potential to impact the largest area of the City. Coastal hazards such as erosion ranked relatively low as they will only impact a limited area of the City. Coastal storms on the other hand can impact the entire City as the rain that accompanies these storms may impact inland areas as well as coastal parts of the City.

Slide 11
This slide shows the overview of the topics covered in workshop 2. The primary focus was on understanding the City's future hazard threats given climate change and determining the City's key vulnerabilities.

The breakout sessions then discussed possible actions that the City could take to address these concerns.

Slide 12
According to the Delaware State website:
"While past climate change undoubtedly occurred without human influence, there is <u>little doubt</u> among the world's top scientists that human activity is the *main cause* of the global warming evident in recent decades. "

There are considered to be three primary changing climactic conditions – temperature, precipitation and sea level rise – which are the focus of the project's climate change work. From these conditions, interactions and impacts are considered.

For more detailed climate change information relevant to Lewes, please refer to chapter 4 of the action plan, the climate change fact sheet or the climate change presentation.

Slide 13
The project used important global scientific research and regionally relevant science to create a local understanding of climate change impacts.

Slide 14
A key piece of this project was the use of regional reports to determine how climate change could impact natural hazards. The information collected indicated that coastal storms and floods would become more severe. Additionally there were indications that drought / extreme heat and coastal hazards such as erosion would likely increase.

Slide 15
Using this scientific background and the potential natural hazard exacerbations on the lower left, participants discussed the many possible impacts the City of Lewes could experience from changing climate conditions. The group identified the systems on the upper right as being ones that could be impacted.

Slide 16
Based upon the climate change understanding from regional science, workshop participants voted on systems and associated climate change impacts that they believed were of greatest concern to Lewes. These primary vulnerabilities identified by stakeholders are:
1) impacts to homes, property and land use;
2) impacts to city infrastructure;
3) impacts on water systems and water resources.

Slide 17
This slide shows the overview of the topics covered in workshop 2. The primary focus was on understanding the City's future hazard threats given climate change and determining the City's key vulnerabilities.

The breakout sessions then discussed possible actions that the City could take to address these concerns.

Slide 18
Presented here is the current 100 year floodplain in the New Road area. Notice that there are a few roads and homes in the floodplain; however there are many more just on its cusp.

Slide 19
Here is the floodplain with an additional foot of water level. This water level could come from increased precipitation or from sea level rise. In either case flooding would expand to impact more homes in the New Road area.

Slide 20
To address Lewes existing and future vulnerabilities, many best practices were presented to the participants – a complete list is available in the appendix of the action plan. During workshop three participants worked in breakout groups to narrow the options down to 5 top actions per key vulnerability.

Slide 21
Finally, workshop four focused on selecting the primary climate change adaptation and hazard mitigation actions that participants would recommend that the City move forward with implementing. Participants also helped to brainstorm how the City could implement these actions.

Slide 22
The following six criteria were used to select primary strategies and actions:
1. Social feasibility / benefit
2. Technical feasibility / benefit
3. Administrative feasibility / benefit

4. Political feasibility / benefit
5. Economic feasibility / benefit
6. Environmental feasibility / benefit

Slide 23
These are the 6 actions the workshop participants selected for the City to start implementing. Though these actions were the ones prioritized, participants agreed that the other actions identified as part of the project should be listed in the report and that the City should continually review this list to see if these options are more viable in the future.

Of the six actions selected by the stakeholders, the four starred actions are ones that directly align with current city and county hazard mitigation plan actions.

Slide 24
To complete the pilot project implementation guidance was created in conjunction with the City. This guidance included information on how the measure aligns with existing priorities, who should be the primary contact in this effort, some potential steps needed to achieve the measure as well as some timeline information.

The information is guidance that strives to help the City to implement the measure when the timing is appropriate.

Slide 25
Going forward the City should look to being implementing the selected actions, monitor their progress and in the case of stalled actions, the City should create an understanding of what is preventing this progress. Additionally, the City is encouraged to share their successes, lessons learned, and other general information with surrounding municipalities – thereby helping others to benefit from Lewes' process.

Slide 26
Thank you for your attention. I'd be happy to take any questions.

Slide 27
ADDITIONAL SLIDES FOR USE AS NEEDED

Slide 28
The capstone deliverable of the project was a final report that summarizes the information collected as part of the Lewes effort, the process Lewes undertook, the final outcomes, and the implementation guidance for the City. This slide provides an overview of the contents provided in this report.

Slide 29
The introduction to the report provides detailed information about the City of Lewes, an introduction to the project, and a quick overview of the project's methods.

Slide 30
Chapter Five of the report details the vulnerability assessment method the City undertook. This involved stakeholder engagement in a self assessment of critical facilities, society, economy, and

environmental systems likely to be affected by climate change. From this analysis, stakeholders in the project identified three primary vulnerabilities to focus on throughout the remainder of the project:
Flooding of homes and land
Flooding of city infrastructure
Salt water intrusion and flooding of water resources

Slide 31
One of the keys to this project is the true integration of hazard mitigation and climate change adaptation rather than the efforts being done in isolation. Shown here some connections between the climate adaptation work undertaken as part of this project and the hazard mitigation work the Lewes' Hazard Mitigation Team has been undertaking. As can be seen, there are a number of overlaps – thus expanding on the natural logical of integrating climate change considerations into community based hazard mitigation planning.

Climate Change in Lewes, Delaware Building Resilience

Name

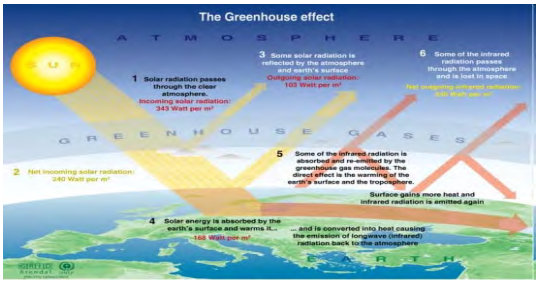
Date

Overview

1. General Climate Change Background
2. Downscaling – Creating an Understanding of Climate Change in Lewes
3. Regional Climate Change – Trends and Specifics
4. Potential for Adaptation
5. Case Studies of Climate Adaptation

General Climate Change Background

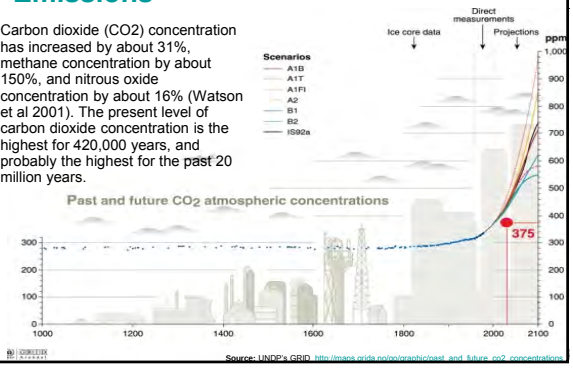
Understanding the Climate



Source: UNDP's GRID maps.grida.no/go/graphic/greenhouse-effect

Past and Future Greenhouse Gas Emissions

Carbon dioxide (CO2) concentration has increased by about 31%, methane concentration by about 150%, and nitrous oxide concentration by about 16% (Watson et al 2001). The present level of carbon dioxide concentration is the highest for 420,000 years, and probably the highest for the past 20 million years.



Source: UNDP's GRID http://maps.grida.no/go/graphic/past_and_future_co2_concentrations

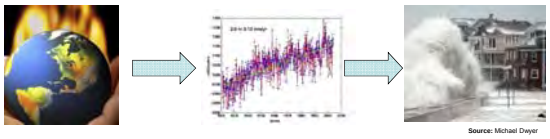
The Evidence is Seen Everywhere

Changing Climactic Conditions

Temperature	Precipitation	Sea Level Rise

Climactic Conditions and Their Impacts

Climate Change	Climactic Condition	Intersection

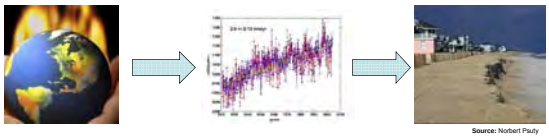


Source: Michael Dwyer

Climate Change	Sea Level Rise	Extreme Weather
	Precipitation	

Climactic Conditions and Their Impacts

Climate Change	Climactic Condition	Impact



Source: Norbert Psuty

Climate Change	Sea Level Rise	Coastal Erosion

Downscaling

Creating an Understanding of Climate Change in Lewes

Why Climate Change Matters for Delaware

Public Health
- More extreme heat days
- Spread of vectors

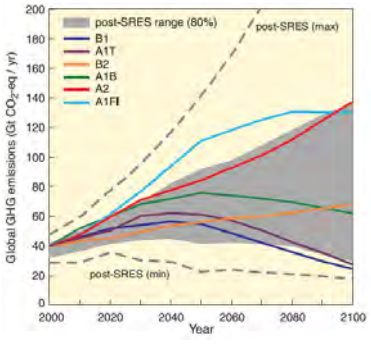
Coastal Impacts
- Coastal damage due to rising sea levels
- More intense Nor'easters and Hurricanes
- Loss of wetlands

Water Resources
- More droughts and flooding
- Increased salt water intrusion on groundwater

Forests

Agriculture
- Loss of species
- Decreased productivity

Predicting Future Circumstances - Projections

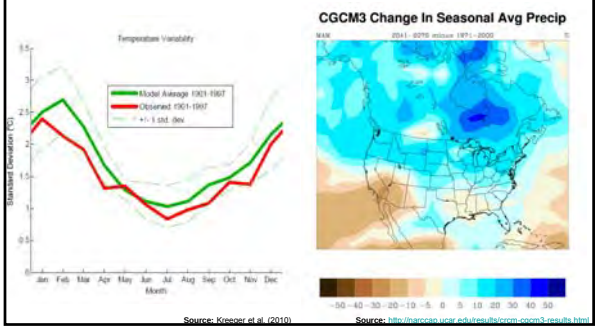


Various future possibilities created through greenhouse gas emissions scenarios

Based on population growth and policy choices

Getting Regional Climate Projections – Downscaling

Statistical | **Dynamical**



Source: Kreeger et al. (2010)

Source: http://narccap.ucar.edu/results/crcm-cgcm3-results.html

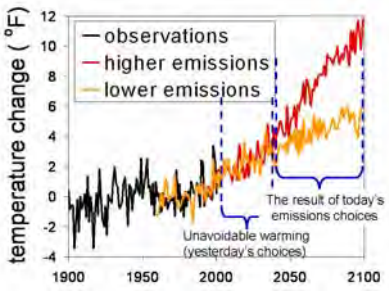
Downscaling to the Mid Atlantic

Projected Change	Likelihood
Warming	Extremely Likely
Higher Sea Levels	Extremely Likely
Higher Winter and Spring Precipitation	Very Likely
Higher Annual Precipitation	Likely

Sources: Boesch (2008), Christensen et al. (2007), Hayhoe et al. (2007), Najjar et al. (2009)

Regional Climate Change Trends and Specifics

Range of Regional Climate Condition: Temperature



Source: NECIA (2006)

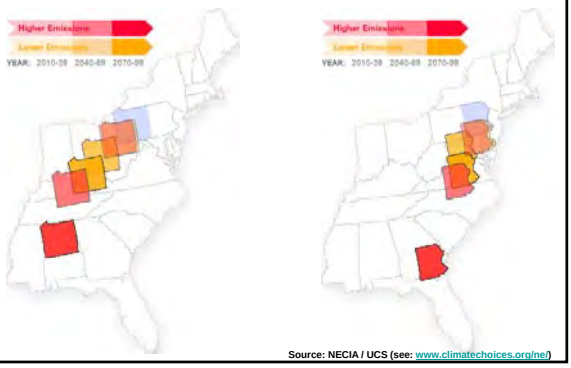
Range of Regional Climate Condition: Temperature

	Delaware	Maryland	New Jersey
Average Annual Change	3.6 – 7.2	4.8 – 9.0	2.0 – 8.0
Extreme Heat Days	Significant Increase	Double - Triple	Significant Increase

Sources: Kreeger et al. (2010), CACCIM (2008), CIER (2008)

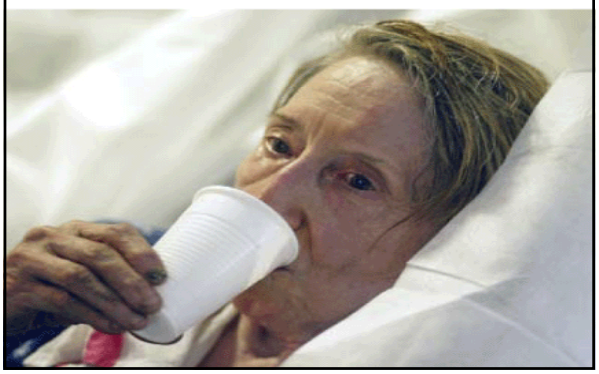
Summer heat index

How hot will summers "feel" in the Pennsylvania region?

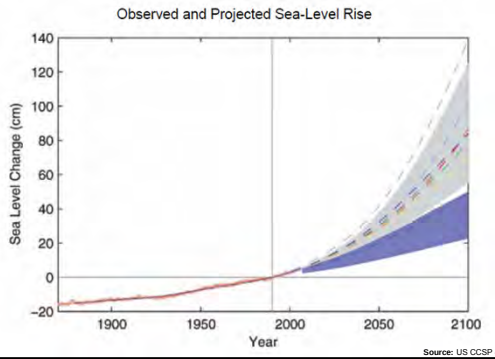


Source: NECIA / UCS (see: www.climatechoices.org/ne/)

Vulnerable to Extreme Heat

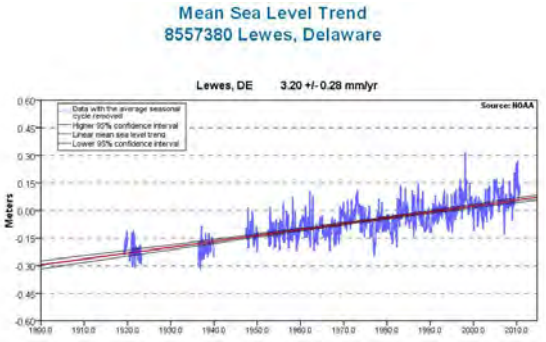


Range of Regional Climate Condition: Sea Level Rise



Source: US CCSP 4.1 (2009)

Range of Regional Climate Condition: Sea Level Rise



Source: NOAA http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8557380%20Lewes,%20DE

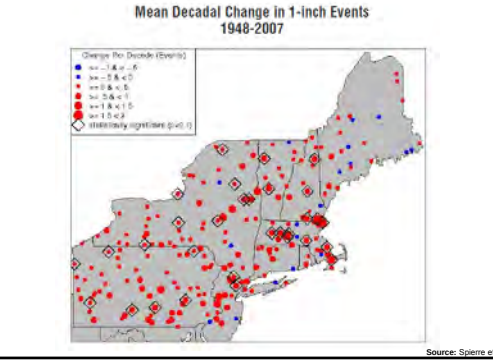
Range of Regional Climate Condition: Sea Level Rise

Report Region	Low SLR (ft)	High SLR (ft)
Delaware State Policy	1.6	4.9
Delaware Estuary	2.6	5.6
New Jersey Coast	2.1	3.9
Maryland	2.7	3.4
Chesapeake Bay	2.3	5.25
Virginia	2.3	5.2
North Carolina	1.31	4.59

Sources: DNREC (2010), Kreeger et al. (2010), CIER (2008), CACCIM (2008), Pyke et al. (2008), GCCC (2008), NC-CRCSP (2010)

Coastal Flooding and Inundation

Range of Regional Climate Condition: Precipitation



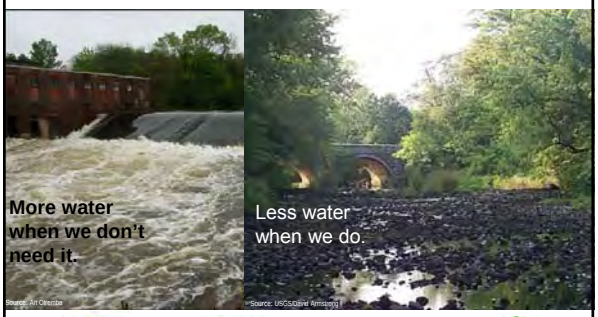
Source: Spierre et al. (2010)

Range of Regional Climate Conditions – Precipitation

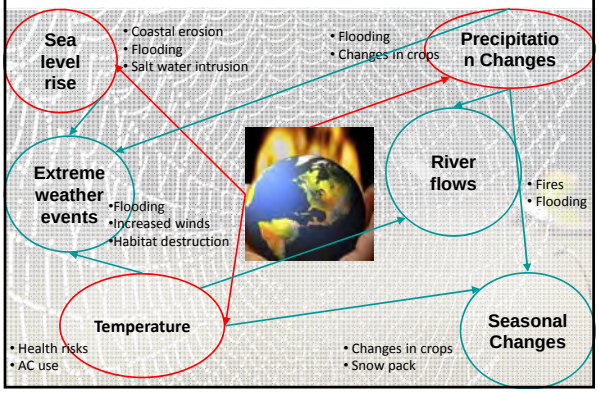
	Delaware	Maryland	New Jersey
Annual Average (% increase)	7 - 9		10 – 20
Winter Precipitation (% increase)		6.6 – 6.8	

Sources: Kreeger et al. (2010), CACCIM (2008), CIER (2008)

Changing Water Resources



What Are Some of the Impacts?



Decline of Traditional Crops

Potential for Adaptation

Addressing Climate Change

Climate Adaptation – Any measure or action that reduces the negative impacts of climate change or increases new opportunities.

Climate Mitigation – Any measure or action taken to reduce greenhouse gas emissions.

Adaptation and Mitigation are not mutually exclusive!

Why Plan for Natural Hazards and Climate Change

1. The climate is already changing and climate change impacts are projected to get worse in the coming years.
2. Today's choices will shape tomorrow's vulnerabilities.
3. Climate change poses threats to existing community priorities.
4. Significant time is required to motivate and develop adaptive capacity, and to implement changes.
5. Planning now can save money, while inaction now will lead to higher costs in the future.
6. Preparing for climate change can be integrated into existing processes.
7. Cities have a moral and practical imperative to act and protect their citizens.

ICLEI's Approach to Adaptation Planning

Pre-Milestone One: Getting Started

- Identify who should be involved
- Build support and provide education
- Formalize commitment (resolution)
- Start messaging and outreach
- Form and hold first Preparedness Team meeting

Milestone One: Conduct Vulnerability Assessment

- Assess how regional climate is expected to change
- Assess regional/community ***impacts*** predicted from these changes in climate
- Identify systems that could be impacted (+/-) from forecasted changes in climate
- Identify how systems are already impacted by weather/climate
- Conduct climate vulnerability assessment (**sensitivity x adaptive capacity**)
- Identify key vulnerabilities

Milestone Two: Establish Preparedness Goals

- Analyze results of vulnerability assessment
- Establish goals for the systems that have the highest vulnerability
- Consider short, medium, and long-term goals
- Consider alignment with existing community goals

Milestone Three: Create Preparedness Plan

- Review goals established for vulnerable systems
- Identify actions that capitalize on opportunities and reduce vulnerability to climate change
- Prioritize actions
- Draft Adaptation Plan or integrate into existing plans
  - Framework (roadmap) for approaching adaptation
  - Outlines preparedness goals
  - Actions to achieve goals
  - Timelines and associated costs with actions

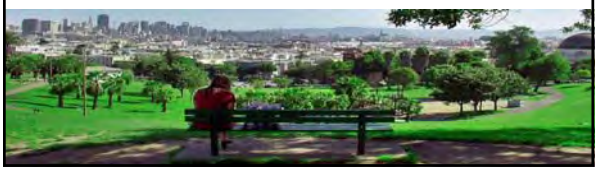
Milestone Four: Implement Preparedness Plan

IMPLEMENT identified actions

- Create and adopt policy
- Identify funding, staffing, other resource needs, etc.
- Create a timeline and designate responsibility parties
- Share implementation results with community and ICLEI
- Celebrate successes!

Milestone Five: Monitor, Evaluate, and Re-Assess

- Continue implementation and keep track of progress
- Report progress to the elected officials, community, funders, and ICLEI (annually)
- 2 to 5 years in – take stock and evaluate focus
- Revisit updated climate forecasts
- Change course, if needed
- Continue to celebrate successes!



Climate Adaptation in Action

Example: Adaptation in Keene, NH

Full Planning Process – looking holistically at climate impacts and vulnerabilities

Member of ICLEI's CRC Pilot

Established Committee of Department Heads to go through process (inc. Mayor, Chief of Police, etc.)

Completed Milestones 1-3; currently in implementation phase

Currently looking to include adaptation in:

- Capital Improvement Program
- Wetlands ordinances
- Land rights issues along watershed
- Culvert studies

Including adaptation and mitigation in Community Visioning and Comprehensive Planning

Example: Engagement in Groton, CT

Unite together federal, state, and local stakeholders to discuss strategies for increasing coastal resilience

Three step process:

- Align on the science of climate change
- Identify vulnerabilities
- Start defining strategies that can be taken to increase resilience or seize opportunities

Focus on respective roles each agency can fill

Provide recommendations on next steps for all levels of governance

Example: Miami-Dade County, FL

Adaptation and Mitigation Planning Together

Formed Climate Change Advisory Task Force in 2006 to address both mitigation and adaptation (6 subcommittees):

- Science
- Built Environment
- Greenhouse Gas Mitigation
- Natural Systems
- Economic, Social, and Health
- Intergovernmental Affairs

Last year, 34 recommendations were made – being analyzed and prioritized now

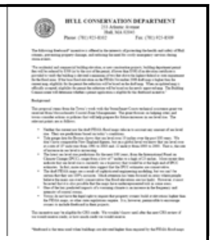
Working on updated sea-level rise mapping

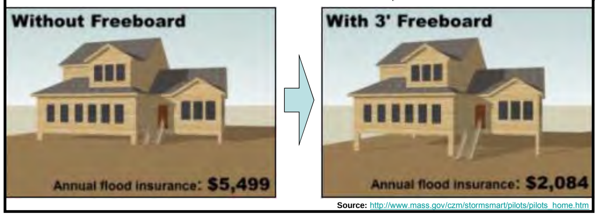
Working with USGS to analyze how SLR will impact drinking water

Example: Hull, MA

Building a case for adaptation with 3D photorealistic images of flooding impacts

The Board of Selectman unanimously passed a freeboard incentive - gives citizens up to $500 in building permit fees if the builder elevates the home 2 feet above the current highest standard





Source: http://www.mass.gov/czm/stormsmart/pilots/pilots_home.htm

Example: Oak Bluffs, Massachusetts

- Focused on a floodplain overlay zoning bylaw change
- Worked across town boards:
- Used a good / better / best framework in conjunction with parcel maps to assist in decision making
- Created support for the change through public meetings, letters to the editor and mailings to citizens
- The citizens voted to adopt the new bylaw that prohibits new development in the most hazardous flood zones and has a special review process for all flood zones

Source: http://www.mass.gov/czm/stormsmart/pilots/pilots_home.htm

Questions?

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Talking Points for Climate Change Presentation

Slide 1
Welcome everyone! My name is XXX and it's my pleasure to speak with you today about some of the existing and projected future climate change impacts for the Delaware region. I do want to note that I am not a climate scientist so I will do my best to answer your questions. However, a complete list of references will be presented at the end should you want to learn more.

Slide 2
During this presentation we will cover these 5 topics. We will start with a broad view of climate change narrowing in on climate impacts for the Lewes area. We will then talk about how we can move forward with adaptation to address these threats.

Slide 3
To start we will provide some basic climate change background.

From DE State website:
"While past climate change undoubtedly occurred without human influence, there is little doubt among the world's top scientists that human activity is the *main cause* of the global warming evident in recent decades. "

Although a few remaining skeptics would argue that there is insufficient evidence to draw a definitive causal link between human activity and climate change, the most recent report by the Intergovernmental Panel on Climate Change (IPCC) puts this debate to rest. Three main points are clear:

1. Warming of the Earth's climate is unequivocal;
2. Human activity (e.g. the burning of fossil fuels) has dramatically increased atmospheric carbon dioxide and other greenhouse gas emissions since the Industrial Revolution;
3. Human activity has *very likely* (greater than a 90% chance) contributed to recent global warming—and this trend will continue over the coming decades, if not centuries.

Slide 4
When speaking about climate change, one needs to understand the greenhouse effect.
The greenhouse effect is a process by which the sun's radiation, after entering the atmosphere and being reflected back off the earth surface, is than re-radiated by gaseous particles such as carbon dioxide and methane back towards the earth. The process of re-radiating leads to warmer temperatures. The greenhouse gas effect is the reason that Earth is habitable as it keeps the planet at a livable temperature. However, adding more greenhouse gases is known to lead to warmer average temperatures across the globe.

The greenhouse effect has been understood for over a century. It was discovered by Joseph Fourier in 1824, first reliably experimented on by John Tyndall in 1858, and first reported quantitatively by Svante Arrhenius in 1896.

Slide 5
Scientists, using a variety of measurement techniques have created historic greenhouse gas trends dating back millions of years. Shown here is that trend along with current measurements and future projections. Since the start of the industrial revolution carbon dioxide (CO2) concentration has increased by about 31%, methane concentration by about 150%, and nitrous oxide concentration by about 16% (Watson et al 2001).

The present level of carbon dioxide concentration is the highest for 420,000 years, and probably the highest for the past 20 million years. These higher concentrations cause changes in the way the greenhouse gas effect works resulting in higher temperatures and other related changes.

Slide 6
Physical evidence of climate change is seen everywhere.

Joking aside, it is important to recognize that evidence of climate change is not captured in any one single event, but in collective averages and large scale trends.

One physical example that people may be able to relate to is that the bloom date for lilacs has shifted four days earlier since the 1960s (NECIA, 2007, p. 11).

Slide 7
Although climate change affects many physical elements of our world, there are considered to be three primary changing climactic conditions – temperature, precipitation and sea level rise.

Globally, temperatures have increased 1.3°F over the past century resulting in less snow accumulation in winters and an earlier arrival of spring. In regards to precipitation, from 1900 to 2005 the world experienced changes in precipitation patterns over large areas, including an increase in eastern North America. Sea level rise, another documented impact of global climate change, has been rising globally at a rate of 0.8 inches per decade or 0.67 feet over the century.

Slide 8
There are also intersections of the three primary climate conditions that are important to note.

For example, when there is more extreme precipitation and sea level rise, we experience more severe weather events. Another example is when hotter temperatures are combined with precipitation pattern shifts we get altered seasonal patterns.

Slide 9
Additionally, there are impacts associated with changing climactic conditions that communities must consider. Shown here is one example where sea level rise causes erosion along coastal shorelines. Another example would be high temperatures causing more heat related illnesses in citizens.

Although, it may seem that all of these different changes can be complex to follow and fully understand, lots of work has already been done to get a handle of existing and potential future global and regional climate changes and their associated impacts. The next section will help to explain how global trends are converted into regional / local understanding. Then we will look at the known impacts for the Mid Atlantic.

Slide 10
So far we have focused on general climate change information and global climate changes. Much of the initial research has been done at this scale; however work has also been done to understand this large scale information at smaller scales to help citizens and decision makers address climate related threats. This conversion is called downscaling.

Slide 11
You might ask, why bother with downscaling, if climate change is only a large scale trend or global averages then there is no need to bother getting smaller scale data.

The answer to this is simple, climate change evidence and support comes from large scale trend and global averages; however the experience of climate change is at the local level and in order to prepare for its impacts we need to understand the impacts of climate change locally.

Through downscaling and the use of local knowledge, we know that the following are specific sectors that could be impacted by climate change in Delaware:
Public Health
- More extreme heat days
- Spread of vectors

Coastal Impacts
- Coastal damage due to rising sea levels
- More intense Nor'easters and Hurricanes
- Loss of wetlands

Water Resources
- More droughts and flooding
- Increased salt water intrusion on groundwater

Forests
Agriculture
- Loss of species
- Decreased productivity

Slide 12
The first step in creating an understanding of future circumstances at both the global and regional scale is understanding the amount of greenhouse gas emissions. To do so, scientists have created different greenhouse gas (GHG) emissions scenarios, such as those used by the Intergovernmental Panel on Climate Change (IPCC). These scenarios factor in different variables including population growth, energy use, and other societal choices.

The graph shown here shows the IPCC scenarios. The extremes are the dotted grey lines. Many analyses of climate changes and their associated impacts use one high greenhouse gas emissions scenario often A1FI (light blue) and one low one high greenhouse gas emissions scenario – often B1 (dark blue) (IPCC, 2007, p. 44)

Slide 13
There are two different ways that scientists downscale climate information to smaller scales. The first is called statistical downscaling. In this case scientists create a model that correlates global

data with local data. Then using this statistical model with the emission scenario they can project future circumstances. The other way to create regional data is by creating an actual model of the region and running emissions scenarios through this model.

Both methods result in some uncertainty.

Slide 14
This table shows the results of downscaling global climate models to the mid-Atlantic region. The likelihoods listed in the second column are based upon IPCC terminology.

Extremely likely, which can be applied to high temperatures and sea level rise is greater than a 95% confidence interval. Very likely, which is applied to higher winter and spring time precipitation, is greater than a 90% confidence interval. Finally, changes in precipitation patterns and their effects are considered to be likely, which is greater than a 66% confidence interval.

Slide 15
In this next section we will look at regional trends created through both methods of downscaling and describe some specific impacts of these trends.

Slide 16
This first graph shows historic temperature trends as well as future temperature projections based on high and low emissions scenarios. In both cases we see temperatures increasing over the coming century.

It is important to note that temperature changes between now and approximately 2040 follow a similar path for both the low and high emissions scenarios. This is because the near term changes are based mostly on emissions already in the atmosphere, while longer term projections are based on today's greenhouse gas emissions choices.

Therefore, curbing greenhouse gas emissions (mitigation) is critical for the long-term; but communities should start planning now for existing and future changes in climate that are due regardless of the GHG emissions scenarios.

Slide 17
This table shows data from three regional reports that provide Lewes with a range of possible temperature futures.

The average of 14 models downscaled for Delaware show that temperatures by the end of the century are expected to increase by 3.6 – 7.2°F above the recent past (1980 – 1999). In both the high and low emissions scenarios, the summer months are expected to see greater warming than the winter months, which includes an increase in extreme heat days (above 80°F) (Kreeger, 2010, p. 24).

In Maryland, the mean of seventeen models shows an increase of 2°F by 2025, an increase that can be expected regardless of which emissions scenario is followed. By the end of the century, summer temperature increases are expected to be 4.8°F under the low emissions scenario and 9°F under the high emissions scenario. Also in Maryland, by 2100 the number of days with temperatures above

90°F is projected to double or triple under the low and high emissions scenarios, respectively (CACCIM, 2008, p. 16).

New Jersey is also expecting future temperature increases between 2 – 8°F for annual average temperature and a significant increase in extreme heat days (CIER, 2008, p. 17). These regional temperature changes are summarized in the above table.

Slide 18
This map on the right shows how summers in Eastern PA will *feel* over the next century.

Under the lower emissions scenarios in yellow, Eastern Pennsylvania could feel more like Virginia does today, while under the higher emissions scenario in red, it shows that Pennsylvania could feel more like North Carolina. A similar trend should be expected for Lewes.

What does this mean to our daily lives and quality of life?

Slide 19
The impacts on human health are significant, putting our most vulnerable populations, particularly elderly and children, at risk.

Slide 20
Presented here in red is the global historic sea level rise trend. This trend is expected to progress at an accelerated rate over the coming century.

Global or eustatic sea level rise is based on rising waters due to the thermal expansion of water and the melting of land-based ice commonly called glaciers. The IPCC estimated that global sea level rise will increase from 0.59 ft to 1.9 ft based solely on thermal expansion of water.

Most scientists consider these estimates to be low due to the fact that they do not include glacial melt. More recent estimates suggest that global sea level rise could be as high as 4.6 ft (Rahmstorf, 2009). The range of future sea level rise estimates is shown in this graph.

Slide 21
Several additional factors, including circulation patterns and land elevations changes, are known to impact local or relative sea level rise. The historic sea level rise observations and trend for Lewes is shown here. This trend indicates that Lewes has seen about 1 foot (0.32m) of sea level rise over the past century.

Were this trend to continue, the City could, at a minimum, expect another foot this coming century. However, as with global sea level rise, it is thought that local sea level rise will also accelerate.

Slide 22
Many regional reports summarized in the table here have taken this expected increased rate of sea level rise and incorporated it with specific local data to create ranges of relative sea level rise predictions for the coming century.

Based on this information, the State of Delaware's Department of Natural Resources and Environmental Control is currently working with the range of future sea level rise between 1.6 ft and 4.9 ft for planning purposes.

Slide 23
Sea level rise on its own might not pose a threat to a specific location, but when combined with current development patterns, sea level rise can cause many threats listed below to Lewes and other coastal communities.

- Changed flood patterns – causing current design flood events (100 year storm) to occur more frequently.
- Cause coastal flooding to reach farther landward thus covering greater areas of land in the City of Lewes.
- Cause certain dry areas in Lewes to become inundated, meaning that they will become permanently wet.
- Sea level rise can cause increased erosion in Lewes.
- In some places sea level rise is known to cause saltwater intrusion into coastal aquifers.
- Could also alter local habitats and natural systems.

Slide 24
The third changing climatic condition is precipitation. Generally it is thought that average precipitation will increase in most regions of the world due to higher rates of evaporation; however, as noted above, there is more uncertainty surrounding this climate variable than temperature and sea level rise. This image shows an increase in extreme rain events in the northeast.

Slide 25
This table shows data from three regional reports that indicate that precipitation will increase in the Mid Atlantic in the future. The information provides Lewes with a range of possible precipitation futures.

Slide 26
One of the key issues with precipitation changes is ***when*** the rainfalls and ***how much*** falls at once. There is increasing evidence that we will see increases in extreme rainfall resulting in swollen rivers followed by long dry periods resulting in water shortages.

Slide 27
This web shows some of the intersections of the basic climactic conditions – temperature, precipitation and sea level rise shown in red. The intersections shown in green here are seasonal changes, river flows, and extreme weather events. Though there are many more, these help to show how interlinked the systems are.

Also shown are some impacts associated with both the basic climactic conditions and their intersections. One example is the increased coastal erosion that is associated primarily with high sea levels.

Slide 28
As an example of an impact - many fruit such as apples, blueberries, raspberries, concord grapes, cranberries, and other fruits require 1,000 hours below 45 degrees each winter in order to produce good fruit yields. By late century, higher emissions scenarios show that winter temperatures will be too warm to meet these growing requirements.

Similar concerns exist for corn and soybean production with some estimates stating that by 2100 production could decrease by as much as 80%.

Slide 29
Although all this information can be very disconcerting and distressing, there is a bright side. Many of these changes are still a number of years away and efforts can be made today to prepare.

In this next section we will discuss climate change adaptation planning and provide some guidance on how to make your community more resilient and prepared for future impacts.

Slide 30
The first step in climate planning of any type is understanding what type of climate planning you are doing. There are two types of climate planning --- climate mitigation and climate adaptation. Can anyone tell me the difference between the two?

Great, here are the terminologies from the IPCC report.

Climate mitigation refers to any measure or action taken to reduce greenhouse gas emissions (renewable energy, smart growth, TOD, urban gardening, etc.).

Climate adaptation refers to any measure or action taken to reduce the negative Impacts of climate change or actions that increase opportunities embodied in a changing climate. Climate adaptation isn't about reducing greenhouse gas emissions, although that can certainly be a side benefit, instead, it's about preparing for the impacts associated with a changing climate.

Importantly, climate adaptation and climate mitigation are not mutually exclusive. What we mean here is that many adaptation strategies can also be mitigation strategies and vice versa. For examples of strategies, please see the adaptation-mitigation co-planning guidance we have on our website. http://www.icleiusa.org/action-center/planning/The%20Mitigation-Adaptation%20Connection.pdf

Slide 31
There are many reasons for adaptation planning, some of which will already be obvious on the basis of today's presentations.

First, the climate is already changing. We are seeing evidence on the ground today of these changes.

Second, many of the choices we make today will shape tomorrow's vulnerabilities. For example a building with a 50 + year life span that is built based on historic flood understanding could likely be in tomorrow's floodplain.

Also, climate change poses threats to existing community priorities. A community that is committed to hazard mitigation, but is focused on past hazard events will not truly be able to achieve its hazard mitigation priorities because climate change is likely going to change the types, extent, and intensity of many historic hazards.

Then there's the fact that significant time is required to motivate and develop adaptive capacity, and to implement changes. Thus getting started now can help place a community ahead of the curve of pending climate change impacts.

Also, it's well known that advanced planning can save money by enabling a community to make wiser choices and avoid certain pitfalls.

Preparing for climate change does not have to be a burdensome process. Instead it can be integrated into existing processes thereby making it easier to achieve.

Finally, cities have a moral and practical imperative to act and protect their citizens. Climate change adaptation is part of providing that protection.

Slide 32
ICLEI, an international membership association of local governments that are working on issues of climate protection and sustainable development has developed a 5-Milestone process for Climate Adaptation as part of its climate resilient communities (CRC) program. This is a planning process that can help build resilience. The 5-important steps in this process include:

- Conduct a climate resiliency study
- Set preparedness goals
- Develop preparedness plan
- Implement preparedness plan
- Measure progress, evaluate, and repeat cycle.

Additionally there is a key step – making a commitment that occurs before engaging in this process.

Slide 33
Pre Milestone One – or Getting Started is the first informal step in ICLEI's CRC program. This step involves conducting a very basic, preliminary assessment of changing climate conditions and possible impacts for a given location, starting your efforts to build support for climate adaptation, identifying stakeholders that should be involved in the full climate preparedness/adaptation process, and formalizing your community's commitment to climate adaptation.

A big piece of this step is also providing education to the public, elected officials, peers, etc., about the need for preparing for climate change. Conducting preliminary research into existing and future climate changes and impacts will help create educational materials that are relevant to the local condition and local audiences.

As part of the Getting Started process, ICLEI encourages communities to pass a resolution committing them to climate adaptation. However, this is not a requirement. I'll show you all a sample resolution in just a moment.

At the end of the Pre-Milestone/Getting Started phase, a community should have identified a handful of individuals who will serve on their Preparedness Team. If possible, ICLEI encourages local governments to hold their first Preparedness Team meeting as part of the Getting Started process --- the purpose of this meeting would be to introduce everyone on the Team to the process they will be undertaking and to answer any questions before the formal process begins.

As an example of potential team members that may be included in a Preparedness Team, here is a list compiled by the City of Keene (these are the exact people who went through their climate preparedness process): Mayor, City Manager, Emergency Management, Public Works Director, Planning Director, City Engineer, Local University Representatives, Regional Planning Council Representatives, Climate Scientist, Hospital Representatives, ***industry specialist***, and members of the climate mitigation committee.

Slide 34
Milestone One – the first official step in the ICLEI Adaptation program, is Conducting a Vulnerability Assessment. There are many ways to conduct a climate vulnerability assessment – from analyzing 1-2 systems of concern for your community, to conducting a community-wide analysis.

A vulnerability assessment is an analysis of the sensitivity of a sector/planning area as well as a look at the adaptive capacity of that system/planning area. To help guide communities in this process, ICLEI has devised a series of tools, trainings, and support resources – which I'll speak about later.

At a high level, the main steps in conducting a vulnerability assessment are:

1. Assessing how regional climate is already changing and how it is projected to change in the future
2. Determining what systems are likely to be affected by changes in climate
3. Determining how those systems are likely to be affected by changes in climate AS well as how they are already affected by weather and climate
4. Analyzing the exposure, sensitivity, and adaptive capacity of each system and/or sub-system in the community
5. Identification of key vulnerabilities by using a series of decision criteria pulled from the Intergovernmental Panel on Climate Change.

At the end of Milestone One, users will have selected which key vulnerabilities are of concern to their community and those key vulnerabilities will be the ones they move forward with through the remainder the milestone process.

Slide 35
The second Milestone in the CRC program is the establishment of preparedness goals. Users will review the key vulnerabilities they have just determined from the vulnerability assessment and, working in their preparedness team and/or other group setting as deemed appropriate, establish short, medium, and long term goals for each of those vulnerabilities.

In doing this step, it's important to align preparedness goals with existing community priorities and to ensure you have the support of both the implementers (people responsible for the vulnerable system) as well as elected officials.

Slide 36
The third Milestone in the CRC program is the creation of plan for how your community will meet its preparedness goals. This is generally considered to be a preparedness plan. This plan does not have to be a stand alone plan, but rather can be part of existing plans such as hazard mitigation planning or comprehensive and master planning etc.

Lewes's pilot project (full presentation available separately) has worked through these initial three steps and resulted in a unified hazard mitigation climate change adaptation action plan.

Slide 37
Once Milestone Three is completed and a community has a plan/strategy for their preparedness efforts, it is time to implement that plan/strategy. The fourth Milestone in ICLEI's program focuses on generating the support and resources necessary for implementing the strategies your community has identified as being important to build your local preparedness to climate change.

Going forward, Lewes's Mitigation Planning Team and Planning Commission will work towards implementing the actions identified in the action plan.

Slide 38
The fifth and final Milestone in ICLEI's CRC program is to Monitor, Evaluate, and Re-Assess. This step is about measuring the success of actions or strategies your community has implemented, evaluating their overall effectiveness in helping you advance local resilience and revising them as needed.

Milestone Five closes the milestone loop and effectively brings communities back to the beginning where they once again start their preparedness efforts.

As you can tell, this is a living, iterative process that is meant to help communities understand their preparedness efforts and evolve in regards to the level of sophistication they obtain in regards to their preparedness efforts.

Slide 39
Presented next are examples of climate change adaptation activities in communities around the US.

Slide 40
Keene, a moderately sized rural City in New Hampshire has been deeply involved in climate change adaptation planning for a number of years. The City has actively integrated climate change adaptation into its comprehensive plan and can be looked to as a model for this kind of integration.

Slide 41
ICLEI, in collaboration with Connecticut Department of Environmental Protection, partnered with the Town of Groton to undertake a climate adaptation process that brought together local, regional, state, federal, and non-profit partners to explore strategies for increasing the Town's resilience towards climate change. The process was the first effort to bring together various entities to foster place-based collaboration.

The year-long process that unfolded in Groton ended with a recommendations document that the Town is currently looking to implement. The focus of the project was on helping each entity that participated in the process understand their unique roles, responsibilities, and abilities as it pertained to building local resilience towards climate change.

Slide 42
Another great example of climate adaptation planning is currently happening in Miami-Dade County, Florida. Here, the County is undertaking an initiative to undertake both climate mitigation and climate adaptation in tandem. This is being done through a committee – the Climate Change Advisory Task Force – which is broken down into 6 discrete sub-committees (Committees are: science, built environment, greenhouse gas mitigation, natural systems, economic, social, and health, and intergovernmental affairs).

In addition to the Task Force, the County is also engaging with the three other counties in SE Florida to undertake a regional initiative to build resilience towards climate change while also reducing greenhouse gas emissions. This effort, known as the SE Florida Climate Compact, is one of a few regional initiatives that are recognizing the importance of collaborating across geopolitical boundaries. This exciting effort will culminate in a regional strategy for climate protection (both mitigation and adaptation) by 2012.

Slide 43
Hull is a narrow, low-lying peninsula located 12 miles south of Boston. This town of approximately 11,000 residents covers 33 miles of densely developed shoreline separating Hingham Bay from the Atlantic Ocean. The community experiences regular damages and flood claims from northeasters and is also vulnerable to hurricanes.

In September 2009, the Hull Board of Selectman unanimously passed the state's first freeboard incentive program to encourage elevating buildings above currently predicted floodwater levels to account for future storm events and sea level rise. Hull's Conservation Agent worked with the state's coastal zone management agency and the town's Building Commissioner to develop the freeboard incentive (PDF, 33 KB), which enables the Building Department to offer a $500 credit for permit fees to builders and homeowners who elevate new and renovated structures at least two feet above the highest federal or state requirement.

Slide 44
Oak Bluffs is a resort town on the northeast shore of the island of Martha's Vineyard with approximately 3,700 residents. The coastline is nearly 23 miles long and consists of beaches, barrier beaches, ponds, and bluffs. This island community currently experiences erosion and flooding during coastal storms and recognizes the future threat of sea level rise.

The StormSmart Coasts team, led by the Oak Bluffs Conservation Agent, spent significant time discussing and coming to consensus on proposed amendments to their zoning bylaw for the floodplain. The team launched an impressive outreach campaign for public comments, which were carefully considered and incorporated into the bylaw. In addition, all town boards and departments were fully engaged and, as a result, supportive of the changes before they went to Town Meeting. Consequently, voters adopted amendments to the Town of Oak Bluffs Floodplain Overlay District Bylaw (PDF, 39 KB) by an overwhelming majority at the Spring 2010 Annual Town Meeting.

The zoning bylaw now prohibits new residential development and expansion of existing development in the most hazardous flood zones—those designated as V, VE, or AO zones on the Federal Emergency Management Agency's Flood Insurance Rate Maps (FIRMs). The bylaw also requires that all new development in less hazardous areas—those designated as A zones on the FIRMs—go through a special permit process to ensure proposed development and redevelopment projects meet design criteria and performance standards that minimize threats to public health and safety and increase the town's capacity to recover after a storm by reducing damage to personal and public property.

Slide 45

Those are just a few examples of communities that are undertaking climate adaptation efforts. I look forward to adding Lewes to these slides. Thanks for your time.

Are there any questions?

INTEGRATING CLIMATE CHANGE ADAPTATION AND NATURAL HAZARD MITIGATION IN LEWES, DELAWARE

1. Introduction

The City of Lewes, located in the northeast portion of Sussex County, Delaware, is a thriving bayfront community. Lewes offers both visitors and residents a unique opportunity to experience intimate walkable commercial and historic districts along with beautiful open spaces, including sandy beaches and healthy wetlands. Lewes' proximity to water and well understood threats from coastal storms and flooding has put natural hazards at the forefront of the City's mitigation[1] efforts. Recently, the City, working in collaboration with Delaware Sea Grant (DSG) and ICLEI-Local Governments for Sustainability USA (ICLEI), has embarked on a pilot project that integrates climate change adaptation into hazard mitigation planning and enhanced the field of hazard mitigation. This pilot project resulted in the recommendation of six forward-looking actions, including its intention to integrate climate change into the comprehensive plan, which the City will be updating in the coming years. Through this effort, several key lessons were learned that can be used by other communities looking to improve their hazard mitigation efforts and achieve greater sustainability and resilience.

2. Background

Lewes, often referred to as the First Town in the First State, was founded in 1631 by Dutch Settlers. Today, the City has a population of 2,747 full time residents and a summer resident population that swells to an estimate of 6,235. Lewes is generally characterized by an older population, with a median age of 62.6 years and 44 percent of residents age 65 or older (2010 U.S. Census). The City's population is more highly educated than that of the surrounding county and the state; 85.5 percent of Lewes residents over the age of 25 are high school graduates, and 48.1 percent have earned a college degree (2000 U.S. Census). Residents have higher incomes than the U.S. average (2000 U.S. Census), and the City is somewhat less diverse than either Sussex County or the State of Delaware as of 2010.

Figure 1: Aerial view of Lewes showing canal, bayfront and wetlands.

Characterized by its busy days and quiet nights atmosphere, the City has maintained its intimacy and heritage through architectural building design, historic preservation initiatives, and the aggregation of commercial

[1] Any cost effective action taken to eliminate or reduce the long-term risk to life and property from natural hazards.

districts. It is this atmosphere that brings a significant number of visitors to the City in the summer months. In fact, summer residents, employees and visitors add upwards of 10,000 people to the City (Lewes Comprehensive Plan, 2005, p. 10).

Lewes, bordered by tidal wetlands, tidal creeks and tributaries, sandy beaches, and agricultural land, is also transected by a man-made waterway - the Lewes/Rehoboth Canal. The City is comprised of residential neighborhoods, a central business district, a beachfront area that extends five miles along the Delaware Bay shoreline and an active canal front/harbor area in the center of town. The City's topography is generally flat, ranging from sea level along the shores of Delaware Bay to approximately 20+ feet above sea level at some of the highest points in the City center area.

3. The City's Strong Natural Hazard Mitigation Background

As a low-lying community with several water features in the area, the risk of flooding and erosion is very real to the residents of Lewes. The City has been severely impacted by a number of major coastal storms causing significant damage throughout the City. The most damaging of these storms, the Ash Wednesday storm, was a northeaster that occurred in March 1962 (Figure 2). It produced a record high tide of 9.5 feet above mean lower low water[2] (mllw) causing the Lewes/Rehoboth Canal to overflow and damage properties along the beach and the canal. Even as recently as 2008 and 2009, Lewes was impacted by relatively major northeasters. With high waves, tides and storm surge there was extensive flooding of low-lying coastal areas including roads serving as evacuation routes (Figure 3).

Figure 2: Flooding in Lewes during the 1962 Ash Wednesday Storm.

Figure 3: Flooded roadway (New Road) during 2008 northeaster.

Based upon this known threat, the City has often been at the forefront of national hazard mitigation efforts. Lewes was an early adopter of the National Flood Insurance Program (NFIP), and was the first city in Delaware (one of only 200 cities nationwide) selected to participate in the Federal Emergency Management Agency's (FEMA's) Project Impact initiative. The project resulted in a 1999 Flood Mitigation Plan and a 2000 Hazard Vulnerability Study. Moreover, this work generated the support of former Mayor George H. P. Smith and City Council to establish an ongoing hazard mitigation program and appoint The Lewes Mitigation Planning Team to manage the program.

[2] This is a tidal level showing the average daily low water over a 19-year period.

Having this unique planning team has made the City more effective and proactive in addressing its hazard vulnerabilities. The efforts of the Mitigation Planning Team have led to many successful projects in Lewes, and this mitigation planning group has been instrumental in ensuring the community is continually evaluating its changing risk to natural hazards. The team has coordinated table top exercises and improved emergency preparedness procedures and has created a controlled burn program, making the City significantly less vulnerable to the threat of wildfires. Recently the Mitigation Planning Team updated its hazard mitigation strategy, part of the County's multi-hazard mitigation plan, which has been approved by both Delaware Emergency Management Agency (DEMA) and FEMA[3].

4. Making the Connection to Climate Change Adaptation

While the City of Lewes has done an outstanding job of preparing for historic natural hazards, community residents realized that climate and weather patterns in Lewes were changing, and with those changes were coming changes in natural hazards. Globally, temperatures have increased 1.3°F over the past century, precipitation patterns over large areas have shifted and global (scientifically called eustatic) sea levels have risen at a rate of 0.8 inches per decade (IPCC, 2007, p. 30 & 33). The tide gauge at Breakwater Harbor in Lewes shows that local (scientifically called relative) sea level has been rising at a rate of approximately one foot per century since the 1920s (Figure 4). Additionally there is mounting regional evidence that temperatures have risen and precipitation patterns have started to shift.

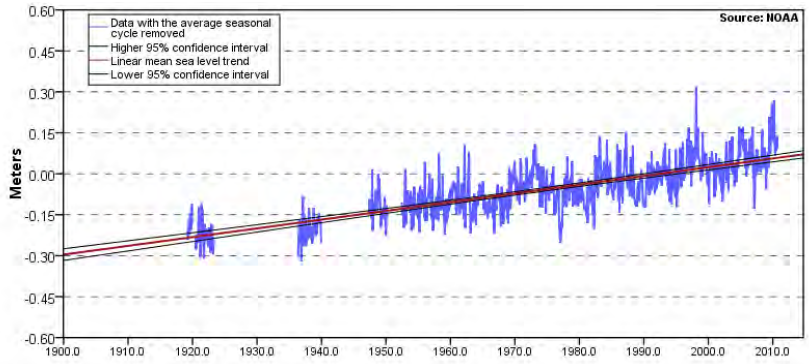

Figure 4: Historic relative sea-level observations for Lewes, Delaware and trend lines.

To augment the understanding of these historic trends, scientists have created models to determine global and regional climate projections. Models for the mid-Atlantic and northeast regions show that more extreme heat events can be expected, seasonal patterns will change thereby extending the growing season, and storms will likely become more severe. Moreover, sea level rise will cause a number of significant impacts including changes in flood patterns. Current flood events considered to have a 1 percent chance of occurrence in any given year will occur more frequently in the future. In fact, in nearby Atlantic City researchers have found that by 2050 the present 1 percent chance storm (100-year storm) would likely be seen as frequently as once every 4 years (Kirshen, 2008). Additionally, floods will impact greater portions of the City and will reach greater heights in the same location. Moreover, the combination of sea level rise and changing precipitation patterns could result in significant impacts to regional and local water sources.[4]

[3] Hazard mitigation plans are typically submitted by counties to the state's emergency management agency and then to FEMA. In some places, such as Lewes, cities create their own chapters within the county plan.

[4] For a more complete summary of regional climate change impacts, see the handout provided in Workshop 3 or Section 4 of the full report available at http://www.icleiusa.org/lewesmeeting.

Based upon these regional projections, it is clear that Lewes and its hazard mitigation efforts are threatened by climate change.

Climate change adaptation is any measure or action that reduces vulnerabilities to current or future climate change impacts. Ultimately the goal of climate change adaptation is to increase resilience to future impacts and enable society to deal with coming changes. In many ways, this goal parallels the efforts of hazard mitigation, the goal of which is to reduce the impacts of hazardous events and enable places to rebound quickly from disasters. In the past, the difference between these two has primarily been that hazard mitigation has traditionally focused on looking backward, creating an understanding of current hazard risk based upon past events. However, as the impacts of climate change have become clearer and better understood scientifically, there has been an increasing push in the hazard mitigation community to have climate change considered when looking at a community's natural hazard threats. Due to these overlapping goals and the understanding that the climate is changing and with these changes will be changes to natural hazards in Lewes, the City made a bold leap to explore avenues for integrating climate change adaptation into the City's existing hazard mitigation process.

5. The Integrated Planning Process

Recognizing this overlap, DSG, ICLEI and the City of Lewes worked together to create an integrated climate adaptation and hazard mitigation planning approach. Pulling from two different processes – ICLEI's Climate Resilient Communities™ (CRC) Five Milestones for Climate Adaptation planning framework (Figure 5), and natural hazard mitigation planning frameworks from FEMA – the five steps outlined below were used to determine Lewes' future hazard threats and select the next steps the City should undertake to address these threats.

Figure 5: ICLEI's Climate Resilient Communities™ Five Milestones for Climate Adaptation.

The Delaware Sea Grant program and ICLEI's CRC program acting as outside experts, helped to guide the City's process to pull together relevant information and to create a series of four workshops focused on developing integrated climate change adaptation and hazard mitigation actions the City can implement. The City supported the effort throughout by ensuring the participation of its staff and informing relevant stakeholders of events. Recognizing that local stakeholder input would be key to the success of this integrated effort, City staff, City Board/Commission members, and Regional/State partners were invited to participate in an initial workshop[5] (Step 1 below) that focused on identifying current hazard threats and potential community exposure. These invitees, as well as the general public, participated in additional workshops (detailed in the steps below) where further local information was gathered and actions to suggest to the City were selected.

[5] All workshops and materials presented are available online at http://www.icleiusa.org/lewesmeeting

Step 1: Identify existing hazards and associated vulnerabilities

- Information was gathered from prior analyses with a specific look at the 1999 and 2000 mitigation planning efforts supported by Project Impact, and the current local hazard mitigation plan developed in conjunction with the Sussex County 2010 Multi-Jurisdictional All Hazard Mitigation Plan Update.
- Workshop 1 confirmed the results of prior assessment and gave participants a chance to identify additional hazard threats to the City.

Step 2: Identify climate change impacts on existing hazards and associated vulnerabilities

- Regional climate change assessments were gathered by DSG and ICLEI to create an accurate local understanding of how climate change will impact current natural hazard threats to the City.
- Given that there are no climate science reports available specifically for Lewes, this effort relied on a number of key regional reports, including *Climate Change and the Delaware Estuary: Three Case Studies in Vulnerability Assessment and Adaptation Planning*, *Comprehensive Assessment of Climate Change Impacts in Maryland*, *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*, and *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*.
- These findings were presented and verified during Workshop 2.

Step 3: Identify two key vulnerabilities for which to plan

- Following the presentation on climate change impacts Workshop 2 participants listed their top three specific concerns and the climate change impact that was the cause of those concerns. For example a participant might state that their concern was "All of the beach side of town being lost to sea level rise and major storm events."
- These concerns were then aggregated into themes, focusing on the primary system that was likely to be impacted. The systems identified through this process were beaches, critical facilities, economy, emergency services, environment, food/agriculture, health, homes, infrastructure, social, transportation, water, and wastewater.
- Participants then voted (each participant had three votes) on the system that was of greatest concern to them. The water system (including water resources and City infrastructure) and its vulnerability to flooding and changing precipitation patterns, as well as property (to which land use was added) and its vulnerability to flooding received the most votes and became the focus of the action selection process (Step 4).

Step 4: Select hazard mitigation/climate change adaptation actions

- Climate change adaptation and hazard mitigation best practices for the three focus areas – homes threatened by flooding, City infrastructure threatened by flooding, water resource threatened by changing precipitation patterns and sea-level rise – were presented by ICLEI, DEMA, Delaware's Department of Natural Resources and Environmental Control (DNREC), the U.S. Geological Survey (USGS) and FEMA during Workshop 3.
- After adding a few additional measures based on local knowledge, participants worked in groups of 5 – 8 to narrow the list of possible hazard mitigation/climate change adaptation actions down to the 5 top actions for each of the three focus areas. These group votes were tallied and the collective top 5 actions were presented at the beginning of Workshop 4.
- Participants, again working in groups, ranked the proposed 15 actions (5 per focus area) with a score of 1 – 5 for the action's social, technical, administrative, political, economic and environmental feasibility and collective benefit.
- Averaging the scores across the groups, the final 6 actions listed in Box 1 below were collectively agreed upon as the best ones for the City to start focusing on to consider for future implementation.

Step 5: Create implementation plans

- Lead contacts for each of the 6 actions selected were identified by representatives of the Mitigation Planning Team, City council and City staff.
- Working directly with these leads through phone conversations, one-on-one meetings, and written feedback, implementation guidance was drafted and revised identifying how each of the 6 actions could move forward and be brought to fruition.

6. Recommendations Made and Moving Forward

Through this process, 6 distinct actions were recommended that the City prioritize in order to continue their hazard mitigation and climate adaptation efforts. These actions fall within 3 primary categories. The first category is knowledge building, which includes gaining a better understanding of evacuation route vulnerability and creating an education and outreach program. Secondly, participants indicated that the City should focus on an incentive program. Specifically it should aim to improve its participation in the Community Rating System (CRS) thus reducing citizen's flood insurance premiums. Finally, there were planning and regulatory recommendations made.

These 6 recommend actions, listed in Box 1, had significant overlap with current priorities identified by the Mitigation Planning Team. Ultimately, the City, with the help of regional agencies and the DSG will work to implement these measures. Additionally, in many cases the selected measure can lead to further work that may require more knowledge, more citizen support, or more time to accomplish.

Box 1 – Recommended climate change adaptation and hazard mitigation actions

The following 6 actions received the highest scores from workshop participants and have been recommended to the City for implementation. Scores as described in Section 5 were based upon the feasibility of implementation and the significance of community-wide impact. Starred actions are those that also align with the Mitigation Planning Team's current priorities.

Knowledge Building

1. * Improve outreach and education plan. Working with DSG the City will assess its current outreach efforts, identify gaps in communication and make a focused plan to improve community wide hazard vulnerability and resilience understanding.
2. * Determine road heights and evacuation risk. Working with state agency partners, the City will use new LiDAR data to assess road elevations and future flood risks.
3. * Evaluate the City and the Board of Public Works (BPW) infrastructure's current and future flood vulnerability. Based upon the road assessment, the City can identify indirect building vulnerabilities.

Incentive Program

4. * Improve the City's community rating system (CRS) score. Based on CRS re-assessment, the City will work toward an improved CRS score and reduce citizens' flood insurance premiums.

Planning

5. Incorporate climate change and hazards into the comprehensive plan and building and zoning codes. The planning commission will work to integrate safety and resilience into future updates to the comprehensive plan as well as future regulatory changes.
6. Ensure that aquifer information is integrated into all planning efforts. The BPW will enhance its coordination with the planning commission to better capture necessary aquifer protections in City and regional decisions.

7. Lessons Learned

Past efforts have shown that climate change adaptation is best achieved in a community when it is integrated into existing efforts. Moreover, given that climate change will exacerbate certain natural hazards – coastal storms and heat waves – and will likely impact others, hazard mitigation will greatly benefit from considering climate change impacts. Given the fact that both efforts would benefit from being paired with the other, the piloting of this integrated approach was rather intuitive. The work in Lewes, Delaware shows that the two approaches can, in fact, be integrated and communities can start to look at including climate change in their hazard mitigation efforts. Additionally, it was found that a strong hazard mitigation background enabled Lewes to be fully engaged in this integration. Finally, the approach in Lewes worked particularly well because there was an exceptionally engaged and active group of participants that included local officials, commissions, boards and citizens.

Despite the fact that climate change adaptation and natural hazard mitigation have a clear overlap, there are two key differences that local governments must remember when engaging in an integrated approach. First, hazards are typically considered to be extreme events that cause disasters and therefore, hazard mitigation tends to focus on these extreme events. Climate change will certainly impact these extremes; however, climate change will also bring about slower onset hazards such as creeping erosion that will ultimately lead to effects such as the elimination of a sand dune. Though hazard mitigation frameworks might overlook these hazards, local governments ought to remember to include them in their integrated assessments.

A second concern that local governments should be aware of when integrating climate change adaptation and hazard mitigation is the differing conceptualizations of vulnerability. In the case of hazard mitigation, exposure is typically used as a proxy for vulnerability; however, climate change adaptation considers vulnerability to be a combination of three primary factors – exposure, sensitivity and adaptive capacity.

1. ***Exposure*** **-** a determination of whether a system or components of that system would experience impacts from changing climate conditions.
2. **Sensitivity -** the degree to which a system would be impacted by the impacts of climate change or a hazardous event were the system to hypothetically experience that impact or event. Systems that are greatly impacted by small changes have a high sensitivity, while systems that are minimally impacted by the same small change in climate have a low sensitivity.

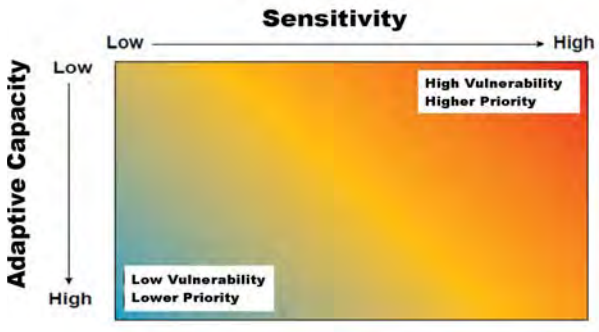

Figure 6: Vulnerability level based on sensitivity and adaptive capacity

3. **Adaptive capacity** - ability of a specific system to make adjustments or changes in order to maintain its primary functions even with the impacts of climate change.

In cases of exposure, sensitivity and adaptive capacity levels are used to create a vulnerability level based upon the general relationship displayed in Figure 6. Local governments should aim to have a complete vulnerability assessment combining all 3 components when doing an integrated climate change adaptation and hazard mitigation plan.

8. Resources

- To learn more about Lewes' Mitigation Planning Team see: http://www.ci.lewes.de.us/index.cfm?fuseaction=plansprojects.hazardmitigationstrategy.
- To learn more about Lewes's Planning Commission see: http://www.ci.lewes.de.us/Planning-Commission-899/.
- To learn more about the Lewes Hazard Mitigation Climate Change Adaptation Pilot Project, see: http://www.icleiusa.org/programs/climate/Climate_Adaptation/lewes-delaware-climate-change-adaptation-and-hazard-mitigation-workshops.
- To learn more about ICLEI's Climate Resilient Communities program, see: www.icleiusa.org/adaptation.

Appendix G: Glossary

100-year flood – The flood elevation that has a 1-percent chance of being equaled or exceeded each year.

500-year flood – The flood elevation that has a 0.2-percent chance of being equaled or exceeded each year.

Action – A step or measure that a local government can take to increase resilience to a climate change impact.

Adaptive Capacity – The degree of built, natural or human systems to accommodate changes in climate (including climate variability and climate extremes) with minimal potential damage or cost, or to take advantage of opportunities presented by climate change.

Base Flood – Flood that has a 1-percent probability of being equaled or exceeded in any given year. Also known as the 100-year flood.

Base Flood Elevation (BFE) – Elevation of the 100-year flood. The BFE is determined by statistical analysis for each local area and is designated on the Flood Insurance Rate Maps. This elevation is the basis of the insurance and floodplain management requirements of the National Flood Insurance Program.

Climate Adaptation – Any measure or action that reduces vulnerability against actual or expected climate change effects.

Climate Mitigation – Any measure or activity taken to reduce greenhouse gas emissions.

Coastal High Hazard Area – Area of special flood hazard (designated Zone V, VE, or V1 - V30 on a Flood Insurance Rate Map) that extends from offshore to the inland limit of a primary frontal dune along an open coast and any other area.

Community Rating System (CRS) - A National Flood Insurance Program that provides incentives for communities to complete activities that reduce flood hazard risk. The insurance premiums of these communities are reduced when the community completes specified activities.

Emergency - Any hurricane, tornado, storm, flood, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, drought, fire, explosion, or other catastrophe in any part of the United States that requires Federal emergency assistance to supplement State and local efforts to save lives and protect property, public health, and safety, or to avert or lessen the threat of a disaster. Defined in Title V of Public Law 93-288, Section 102(1).

Erosion – The wearing away of the earth's surface by any natural process. The chief agent of erosion is running water; minor agents are glaciers, the wind and waves breaking against the coast. (Webster 1913 Suppl.)

Exposure – An exposure unit is an activity, group, region or resource exposed to significant climatic variations.

Flash Flood – Flood that rises very quickly and usually is characterized by high flow velocities. Flash floods often result from intense rainfall over a small area.

Flooding – The exposure of normally dry land to water for short periods of time (minutes to days).

Flood Insurance Rate Maps (FIRMS) – The official map of a community prepared by FEMA, showing base flood elevations along with the special hazard areas and the risk premium zones.

Goal – What a local government wants to accomplish through preparedness actions.

Freeboard – The height above the base flood added to a structure to reduce the potential for flooding. The increased elevation of a building above the minimum design flood level provides additional protection for flood levels higher than the 1-percent-annual-chance flood level and compensates for inherent inaccuracies in flood hazard mapping.

Hazard Mitigation – Action taken to reduce or eliminate the long-term risk to human life and property from natural hazards.

High Velocity Flow – Typically comprised of floodwaters moving faster than 5 feet per second.

Impact – The effects of existing or forecasted changes in climate on built, natural and human systems.

Inundation – The permanent transition of normally dry land to wetland.

Maladaptation – Adjustment to climate conditions in a manner that is ultimately more harmful than helpful.

National Flood Insurance Program (NFIP) – Provides the availability of flood insurance in exchange for the adoption and enforcement of a minimum local floodplain management ordinance. The ordinance regulates new and substantially damaged or improved development in identified flood hazard areas.

Resilience – The ability of a system to absorb disturbances while retaining the same basic structure and ways of functioning; the capacity to self-organize, rebound and/or evolve from stress and change.

Risk – The likelihood of an impact occurring (probability) and the consequence should that impact occur.

Sensitivity – The degree to which a built, natural or human system is directly or indirectly affected by changes in climate conditions or specific climate change impacts. If a system is likely to be affected as a result of projected climate change, it should be considered sensitive to climate change.

Special Flood Hazard Area – Portion of the floodplain subject to inundation by the base flood.

Sustainability – Long-term environmental, social and economic vitality in communities; the capacity to meet current needs without compromising the needs of future generations.

Systems – Built, natural and human networks, organisms, resources, services, assets, and infrastructure that benefit a community or region and could potentially be affected by climate change.

Vulnerability – Susceptibility of a system to harm from climate change impacts. Vulnerability is a function of a system's sensitivity to climate and the capacity of that system to adapt to climate changes. Systems that are sensitive to climate and less able to adapt to changes are generally considered to be vulnerable to climate change impacts.