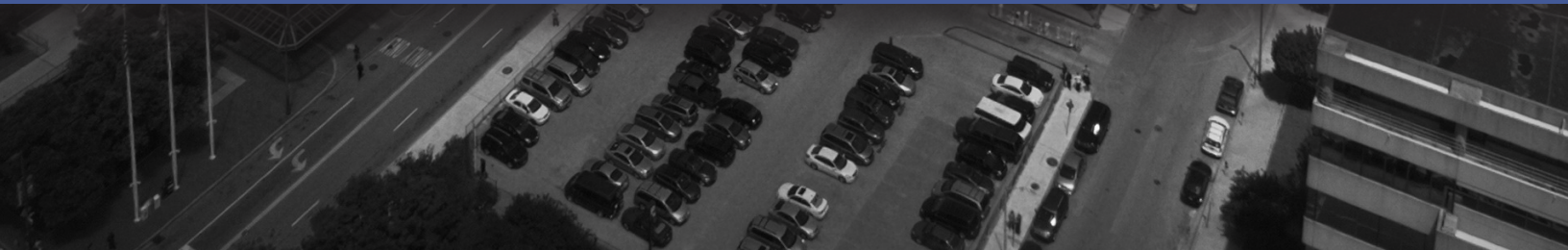
CITY OF BALTIMORE

Disaster Preparedness and Planning Project

A COMBINED ALL HAZARDS MITIGATION AND CLIMATE ADAPTATION PLAN

OCTOBER, 2013



Chapter 1

Introduction

Overview of the Project

Recognizing the City's current vulnerability to the impacts of severe hazard events, Baltimore has undertaken a thorough, forward-thinking approach to the hazard mitigation planning process. Baltimore's Disaster Preparedness and Planning Project (DP3) was created by the Department of Planning as an effort to address existing hazards while simultaneously preparing for predicted hazards due to climate change. This project develops a program that integrates hazards mitigation planning, floodplain mapping, and climate adaptation planning. DP3 links research, outreach, and actions to create a comprehensive and new risk-preparedness system for addressing existing and future impacts.

Integrating hazard mitigation planning, which focuses on past events, with climate adaptation planning, which focuses on what will likely happen in the future, offers an innovative solution for Baltimore City. Completing a detailed inventory of natural hazards, a risk assessment, and a vulnerability analysis, informs actions to mitigate hazards and adapt to predicted climate impacts. This provides clear guidance and a unified strategy that supports Baltimore's sustainability and resilience.

In 2000, the President signed into law the Disaster Mitigation Act of 2000 (DMA 2000) in order to reduce the damages associated with natural hazards. The Federal Emergency Management Agency (FEMA) requires that every local jurisdiction in the United States develop and adopt an All Hazards Mitigation Plan (AHMP) as a condition to be eligible for disaster-related assistance. While FEMA requires that local governments update their AHMPs every five years, this plan is much more than a routine update.

Hazard mitigation can be described as the process of developing strategies that will reduce or eliminate loss of life and/or property damage resulting from natural hazard events. Baltimore's hazard mitigation planning process identifies the various hazards which the City faces, either currently or potentially, and assesses the potential risks and vulnerabilities associated with those hazards.

Both human and natural activities are causing the Earth's atmosphere to experience changing conditions. Because of climate change, many of the natural hazards now facing Baltimore may become even more dangerous, while new hazards could at the same time begin to present themselves. Regardless of how quickly or stringently cities are able to reduce greenhouse gas (GHG) emissions, impacts related to climate change will continue to be felt now and into the future. In the past, societies have generally been able to adapt to weather extremes and climate variability. Climate change, however, continues to produce new conditions which are beyond the scope of previous experiences. As a result, historical records are quickly becoming inadequate models for future planning and risk preparedness.

Considering this, the City of Baltimore has recognized the need to pursue a proactive approach to planning for natural hazards and climate change. Building upon the City's previous All-Hazards Mitigation Plan (2006), Baltimore is integrating various mitigation and adaptation programs into a comprehensive plan that addresses both existing and future impacts. This plan provides a framework for the City to identify strategies and actions for mitigating the impacts from natural hazards and adapting to changing conditions. Combining an all-hazards mitigation approach with climate adaptation will proactively strengthen Baltimore's resiliency.

Baltimore's proactive approach includes incorporating strategies that will increase the City's Adaptive Capacity. Climate adaptation recommendations are intended to reduce vulnerability to the impacts of climate change. This approach has a number of benefits. Most significantly, preemptive action offers tremendous cost savings. This project assures that adaptation-related recommendations are included in capital and operating budget decision-making and prioritized in planning processes. Federal efforts to strengthen a city's preparedness for hazards, for instance, costs only a fraction of what governments typically spend to repair the damage from a hazard after the event. In fact, for every dollar spent on disaster prevention, the federal government spends more than $6 in recovery efforts.[1]

Storm Surge after Hurricane Isabel, 2003 *Source: Baltimore Sun*

While proactive efforts should be increased, Baltimore still intends to enhance its response and recovery capacity. The City must be able to withstand the impacts of more frequent and intense extreme weather events and quickly bounce back from any disruptions. For Baltimore to become more resilient, the City must focus on improving essential infrastructure and buildings, protecting people and property, and embracing its natural systems. Most importantly, Baltimore must not wait for a crisis to transpire before acting. Implementing the strategies and actions listed herein will take time; and it is vital that the City act today in order to ensure a future for Baltimore that is sustainable and growing.

The DP3 plan addresses and reviews the natural hazards affecting the City. This process includes:

- Profiles and historic occurrences of hazard events;
- An assessment of geographic extent and Baltimore's risk and vulnerability for each hazard;
- A review of the potential impact of each hazard on community and critical assets; and
- Hazard-specific loss estimations in terms of economic damage;

Scope & Purpose of the Plan

Climate change is a global issue and the DP3 plan addresses not only the potential impact of natural hazards and climate change to Baltimore City, but also looks beyond Baltimore City's borders recognizing that hazard events do not stop at the City's edge.

Climate-related impacts are already affecting Baltimore; therefore the DP3 plan was created to address existing hazards, as well as hazards that are being predicted in Baltimore's future. The plan identifies changes which can be made to better prepare Baltimore to respond to new climate conditions, thereby reducing harm and taking advantage of opportunities. Heat waves, sea level rise, and flooding due to more extreme precipitation events are all projected to impact the City's environmental, social, and economic systems more intensely than they have in the past. Building adaptation into this plan will allow Baltimore City to reduce risks associated with natural hazards and increase overall resiliency.

Relationship to the Sustainability Plan

Baltimore's Sustainability Plan was adopted in March, 2009. It was created to serve as a guide for the City in its efforts to move towards sustainability, and identified various goals and strategies for doing so. The purpose of the Sustainability Plan is to:

- Engage the Baltimore community in a comprehensive discussion on sustainability;
- Inventory existing programs, organizations, and resources;
- Articulate and prioritize sustainability goals for the Baltimore community;
- Serve as a road map for future legislation, public/private partnerships, programs, and educational campaigns.

The Sustainability Plan promotes 29 priority goals with strategies to realize a clean, healthy, efficient, green, mobile, aware and invested community. While the Baltimore Sustainability Plan is a broad, comprehensive strategy, the DP3 Plan is a targeted effort to address various components of sustainability. Many of the goals, strategies and actions contained with the DP3 Plan relate to strategies within the Sustainability Plan. Direct connections between the plans will be identified using the tri-colored symbol above.

Relationship to the Climate Action Plan

The City of Baltimore adopted and released the Baltimore Climate Action Plan (CAP) in 2012 with the goal of achieving a target of a 15 percent emissions reduction by 2020. Chapter four of the CAP focuses on climate adaptation. It explores ways that Baltimore can efficiently manage risks and protect vulnerable populations from the anticipated impacts of climate change. Key recommendations from the CAP document include integration of climate adaptation into the AHMP update, in addition to conducting vulnerability and risk assessments. The DP3 Plan acts as a vehicle for accomplishing these recommendations, providing further detail of action and comprehensive implementation steps for both hazard mitigation– and climate adaption–related CAP measures. Measures that address energy savings and conservation, land-use and transportation, and the protection of Baltimore's natural systems are explicitly highlighted in the CAP as having the co-benefit of climate adaptation.

The CAP also considers the importance of assessing Baltimore's response capacity. Likewise, this is a priority for addressing hazard mitigation, and many DP3 strategies identify methods for strengthening emergency response activities. Similarly, as the CAP prioritizes the development of a Communications Plan, DP3 considers strategies and actions for establishing more robust and comprehensive methods for increasing awareness of climate change, climate adaptation, and natural hazards. Throughout this document, specific strategies that overlap with the CAP will be identified using the sun and cloud symbol above.

The Baltimore Sustainability Plan was adopted in 2009

The Climate Action Plan was adopted in 2012

Relationship to Emergency Operations Planning

Emergency Operations Plans (EOPs) designate agencies and individuals who will be responsible for what — as well as when, with what resources, and by what authority — before, during, and immediately after an emergency. Alongside local hazard mitigation plans, which help to facilitate Federal funding and actions during and after hazard events, EOPs are tools for establishing a framework to execute emergency response activities.

Baltimore's EOP, maintained by the Mayor's Office of Emergency Management, includes annexes for each hazard and for all Emergency Support Functions (ESFs). Emergency Support Functions represent services, or sets of services, that are likely to be needed during a hazard event or incident (e.g. the Baltimore City Police Department, the Baltimore City Fire Department, etc.). The services provided by ESFs are Baltimore's EOP is coordinated with—and incorporates—all other City plans, policies, and procedures that pertain to emergency response and recovery, including DP3 and the previous AHMP. When defining strategies and actions, the DP3 process considered various EOP and ESF overlaps, which are indicated in Chapter 5 of this document.

Figure 1–1 Hazard Preparedness Planning Process

Building Connections with Surrounding Counties and Cities

The City of Baltimore has a variety of strong partnerships at the local, state and federal level. The City understands how important collaboration with surrounding communities is to achieving its mitigation and adaptation goals. As part of this planning process, city staff participated in regional working groups, national and international conferences, and hazard-related forums to integrate regional considerations and cooperation into the DP3 efforts.

Regionally, DP3 planners participated as active consultants in the Maryland Climate Communication Consortium as both core consortium members and panelists at the Maryland Climate Summit. Planners also worked with the Baltimore Metropolitan Council to build relationships with surrounding Counties (Baltimore, Howard, Anne Arundel, and Carroll) to ensure collaboration in implementation efforts. Additional regional efforts include planning meetings and information sharing with surrounding urban areas such as Washington DC and Philadelphia.

Nationwide, city planners presented at and attended conferences related to climate adaptation to facilitate information sharing and networking with other cities working on mitigation and adaptation. Planners also actively participate in climate and sustainability networks such as the Urban Sustainability Directors Network (USDN) and the American Society of Adaptation Professionals (ASAP)

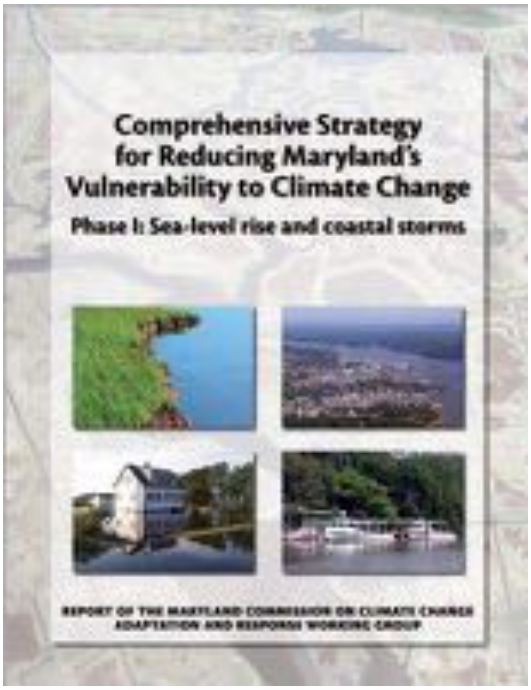
The purpose of mitigation planning is to identify policies and actions that can be implemented over the long-term to reduce risk and future losses associated with natural hazards. Baltimore City's DP3, informed by the previous AHMP, serves as the foundation for mitigation efforts. In addition to the hazard mitigation plan requirements and procedures outlined by FEMA, the DP3 is directly informed by other recent and ongoing efforts — both locally and nationally — that address climate change, adaptation, and mitigation.

Hazard mitigation and climate adaptation efforts are produced at range of scales and geographic levels. The National Climate Assessment (NCA), for instance, is an assessment produced by the U.S. Global Change Research Program (USGCRP) and a key resource for understanding climate change science and for conveying potential changes in climate systems and trends across the United States. The First and Second NCAs were published in 2000 and 2009 respectively, and the Public Comment Draft of the Third National Climate Assessment is currently under review. The Draft National Climate Assessment is overseen by a 60-person Federal Advisory Committee (The "National Climate Assessment and Development Advisory Committee" or NCADAC), which is supported by the National Oceanic and Atmospheric Administration (NOAA). NOAA is a Federal agency that conducts research in order to better understand and predict changes in climate, weather, oceans, and coasts—providing resources and services to share this information. NOAA provides a significant contribution of knowledge that helps cities to understand how and why climate conditions are changing and how to prepare. Many local hazard mitigation plans, including the DP3 plan, are guided by the climate data and information produced by NOAA.

The President's Climate Action Plan was published in June 2013 under the Obama Administration. Much like Baltimore's CAP, the President's Climate Action Plan outlines initiatives to cut carbon pollution and slow the effects of climate change. The President's Plan draws a clear connection between the Climate Action Plan and recent weather and climate disaster events, citing the far-reaching consequences and quantifiable economic costs suffered as a result. The President's Plan identifies three key pillars, which aim to (1) cut carbon pollution in America; (2) prepare for the impacts of climate change, and (3) lead international efforts to combat global climate change and prepare for its impacts. The President's Plan, through pillars two and three, directly incorporates climate resiliency, adaptation and mitigation efforts, recognizing the role of federal government in supporting local preparedness and resiliency efforts.

In Maryland, other initiatives still have been implemented and explored. The Maryland Department of Natural Resources (MDNR), as a means to adapt to a changing climate, has considered solutions for protecting resources and citizens from extreme events, rising sea level, and higher temperatures. In doing so, it developed two strategies (phases) that are currently being used to guide and prioritize state-level activities with respect to both climate science and adaptation policy. First, the Phase I Adaptation Strategy addresses sea level rise and coastal storms. Phase II identifies a strategy for reducing vulnerability to climate change and outlines a collection of steps that should be taken to address changing climate patterns.

At the same time, the Maryland Emergency Management Agency had been developing the 2011 Maryland State Hazard Mitigation Plan Update. The Maryland Plan facilities local governments in their efforts to reduce human and economic costs of natural hazard events, providing a framework for connecting pre- and post-disaster mitigation planning efforts with mitigation planning projects and initiatives for a comprehensive approach. The Maryland Plan investigated Baltimore's previous AHMP to evaluate measures being taken locally, and also determined key areas of exposure within Baltimore City.



This past summer, at the July 25th Climate Change Summit, Governor O'Malley announced a new state plan for cutting greenhouse gas emissions.[2] The Greenhouse Gas Reduction Action Plan was mandated by — and will advance the target identified within — the Greenhouse Gas Emissions Reduction Act of 2009, which effectively required Maryland to reduce GHG emissions by 25 percent of the 2006 baseline by the year 2020. The plan identifies more than 150 programs and initiatives to help the State meet the 25 percent reduction target. Greenhouse gas emissions reductions, as will be discussed throughout the DP3 plan, complements hazard mitigation and climate adaptation measures as through anticipated benefits such as higher air quality, improved environmental health, and reduced dependence on non-renewable energy, to name just a few. Addressing climate change, the Greenhouse Gas Reduction Action Plan — along with other federal, state, and local initiatives — help to progress Baltimore's efforts to become a more resilient City.

Climate Change

General Overview

Climate Change refers to any significant change in the measures of climate lasting for an extended period of time. This includes major changes in temperature, precipitation, wind patterns, or other effects, that occur over several decades or longer. Over the past century, Maryland's average temperatures have risen by 1.8°F and are projected to continue rising. These rising temperatures have already led to changes in weather and climate including more extreme weather events, longer and more frequent heat waves, and a rise in sea level to name a few.

We are already seeing the local effects of climate change around the world. While models of the potential impact of climate change have primarily been developed at global and regional scales, climate change is beginning to impact Baltimore residents, businesses and visitors through events such as higher, prolonged summer temperatures and intense storm events. These changes have the capacity to impact the economy, environment, public health and lifestyle of people throughout Baltimore.

Figure 1–2 Diagram showing the Interrelatedness Between Climate Change and Natural Disasters

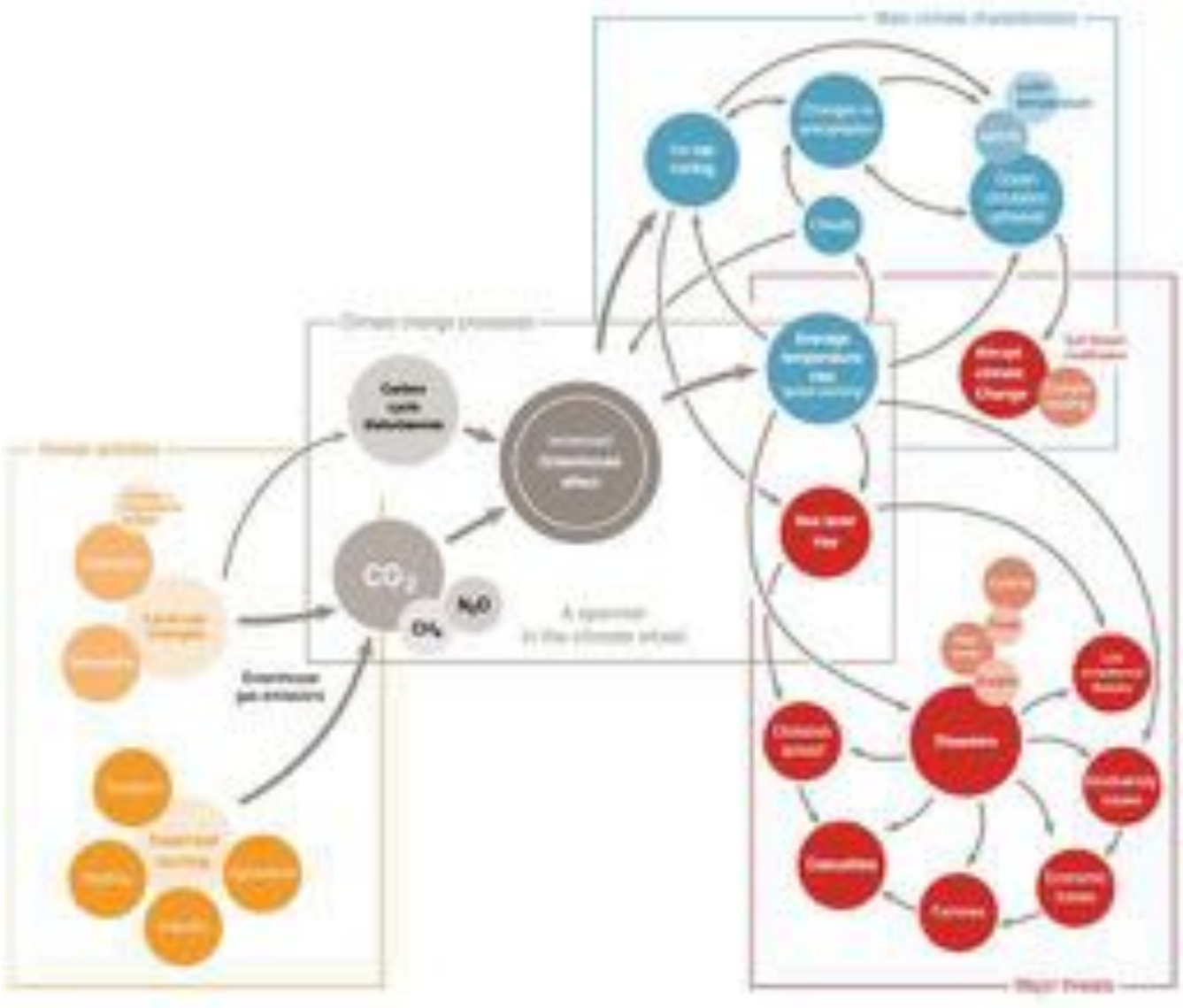


Table 1–2 Climate v. Weather

	Climate	Weather
Definition	Describes the average conditions expected at a specific place at a given time.A region's climate is generated by the climate system, which has five components: atmosphere, hydrosphere, cryosphere, land surface, and biosphere.[1]	Describes the atmospheric conditions at a specific place at a specific point in time. Weather generally refers to day-to-day temperature and precipitation activity
Components	Climate may include precipitation, temperature, humidity, sunshine, wind velocity, phenomena such as fog, frost, and hail storms over a long period of time.	Weather includes sunshine, rain, cloud cover, winds, hail, snow, sleet, freezing rain, flooding, blizzards, ice storms, thunderstorms, steady rains from a cold front or warm front, excessive heat, heat waves and more
Forecast	By aggregates of weather statistics over periods of 30 years	By collecting meteorological data, like air temperature, pressure, humidity, solar radiation, wind speeds and direction etc.
Determining Factors	Aggregating weather statistics over periods of 30 years ("climate normals").	Real-time measurements of atmospheric pressure, temperature, wind speed and direction, humidity, precipitation, cloud cover, and other variables
About	Climate is defined as statistical weather information that describes the variation of weather at a given place for a specified interval.	Weather is the day-to-day state of the atmosphere, and its short-term (minutes to weeks) variation
Time Period	Measured over a long period	Measured for short term
Study	Climatology	Meteorology

Adapted from http://www.diffen.com/difference/Climate_vs_Weather

Climate vs. Weather

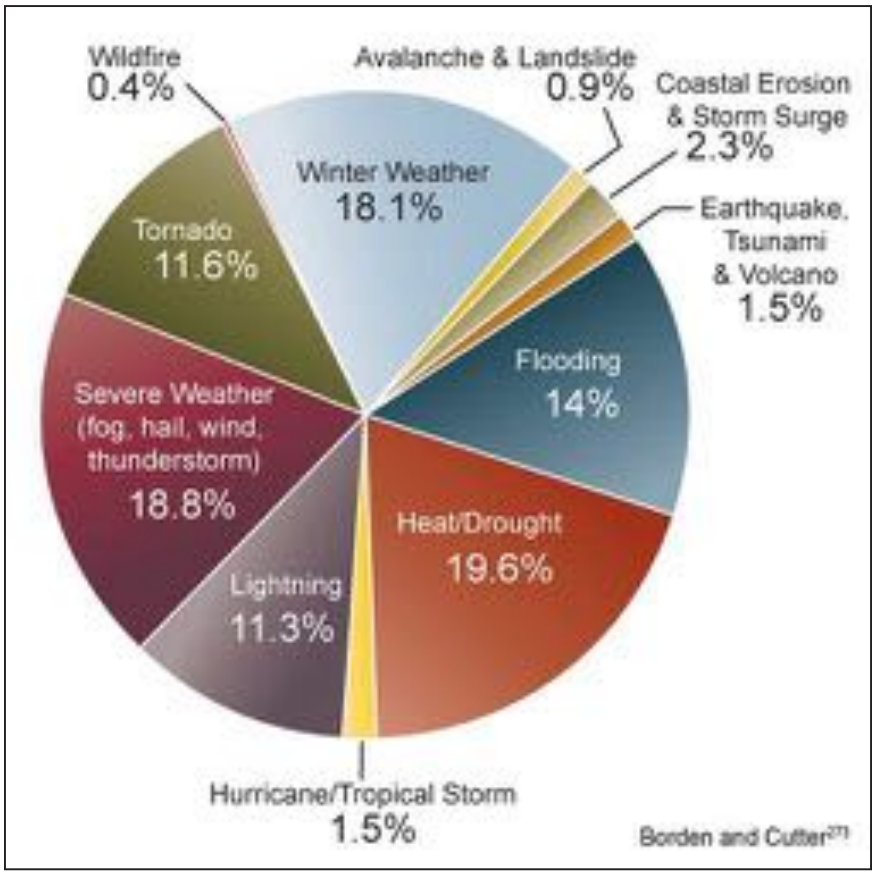
Climate and weather are two terms that are sometimes misunderstood and used incorrectly. While similar, the difference in meaning rests in the period of time being described. “Weather” refers to what changes we experience on a day-to-day basis or over a short period of time, whereas “climate” describes the long-term trends of atmospheric conditions in particular regions. Weather may describe current temperature, humidity, precipitation, wind, or other similar conditions. A weather forecast may predict conditions for the coming week, while a climate prediction consolidates weather patterns over a period, typically 30 years, to determine expected changes in averages, called “climate normals.”

Current and Most Recent Science

Looking to the most reliable scientific resources for climate data, the DP3 has utilized recent climate projections for Baltimore, Maryland, the Mid-Atlantic Region, and for the Country as a whole. This data conveys what Baltimore's future may bring, and what hazards the City may soon face.

Key sources that were utilized to better understand future climate change impacts included the National Oceanic and Atmospheric Administration (NOAA); NOAA's National Climatic Data Center (NCDC); NOAA's National Weather Service (NWS); the National Climate Assessment (NCA) reports produced by the U.S. Global Change Research Program (USGCRP); the Maryland Department of Natural Resources (MDNR); the Federal Emergency Management Agency (FEMA), in addition to the Maryland Emergency Management Agency (MEMA); MADECLEAR, a regional climate change institute; and the Intergovernmental Panel on Climate Change (IPCC); among other sources.

Table 4–3 Human Health Impacts of Natural Hazards



Source:

This pie chart shows the percentages of deaths (out of 19,958) blamed on 11 hazard categories from 1970-2004. Heat/ Drought caused the most deaths, followed by severe weather. The analysis was performed before the 2005 hurricane season, which resulted in approximately 2,000 deaths.

Table 4–4 Major Impacts of Climate Change and Natural Hazards on Selected Sectors

Source: IPCC

Overview of Methodology

Documentation of the process to create the plan

The DP3 has utilized the following process throughout plan development:

1. Identify and profile existing hazards.
2. Conduct an inventory that identifies all assets such as hospitals, schools, etc.
3. Utilize modeling to identify risk from existing hazards and predicted climate impacts.
4. Complete a vulnerability analysis of identified assets and critical facilities. Identify exposure, sensitivity and adaptive capacity.
5. Identify actions and recommendations to deal with existing hazards and predicted impacts.
6. Develop implementation plans for these actions, as well as recommendations for stakeholder involvement and funding strategies.

In order to jointly determine what shared values and potential solutions work best for the greater Baltimore community, sustainability and resilience will be incorporated into all natural hazards decision making.

In an effort to amalgamate the hazards mitigation and adaptation processes, the City of Baltimore has utilized two methods to frame this plan. First, the Federal Emergency Management Agency's (FEMA's) Local Multi-Hazard Mitigation Planning Guidance and Crosswalk planning tool (Figure 1–3), and also the ICLEI-Local Governments for Sustainability's Climate Resilient Communities Five Milestones framework.

LOCAL HAZARD MITIGATION PLAN REVIEW CROSSWALK **FEMA REGION VIII**

Jurisdiction: Wheatland County, Montana

Instructions for Using the Plan Review Crosswalk for Review of Local Mitigation Plans

Attached is a Plan Review Crosswalk based on the ***Multi-Hazard Mitigation Planning Guidance Under the Disaster Mitigation Act of 2000***, published by FEMA, dated March 2004. This Plan Review Crosswalk is consistent with *44 CFR Part 201 – Mitigation Planning, Interim Final Rule* (the Rule), in accordance with the *Stafford Act* (42 U.S.C. 5165), and *44 CFR Part 78.5 – Flood Mitigation Plan Development*, in accordance with the *National Flood Insurance Act of 1968 (42 U.S.C. 4104c et seq)*.

SCORING SYSTEM

N – Needs Improvement: The plan does not meet the minimum for the requirement. Reviewer's comments must be provided.

S – Satisfactory: The plan meets the minimum for the requirement. Reviewer's comments are encouraged, but not required.

Each requirement includes separate elements. All elements of a requirement must be rated "Satisfactory" in order for the requirement to be fulfilled and receive a summary score of "Satisfactory." A "Needs Improvement" score on elements shaded in gray (recommended but not required) will not preclude the plan from passing.

When reviewing single jurisdiction plans, reviewers may want to put an N/A in the boxes for multi-jurisdictional plan requirements. When reviewing multi-jurisdictional plans, reviewers may want to put an N/A in the prerequisite box for single jurisdiction plans.

States that have additional requirements can add them in the appropriate sections of the *Multi-Hazard Mitigation Planning Guidance* or create a new section and modify this Plan Review Crosswalk to record the score for those requirements.

Optional matrices for assisting in the review of sections on profiling hazards, assessing vulnerability, and identifying and analyzing mitigation actions are found at the end of the Plan Review Crosswalk.

The example below illustrates how to fill in the Plan Review Crosswalk.

Example

Assessing Vulnerability: Overview

- **Multihazard Requirement §201.6(c)(2)(ii):** *[The risk assessment **shall** include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description **shall** include an overall summary of each hazard and its impact on the community.*
- **FMA Requirement §78.5(b):** ***Description of the existing flood hazard and identification of the flood risk, …., and the extent of flood depth and damage potential.***

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE Stafford N	Stafford S	FMA N	FMA S
A. Does the plan include an **overall summary** description of the jurisdiction's **vulnerability** to each hazard?	Section II, pp. 4-10	The plan describes the types of assets that are located within geographically defined hazard areas as well as those that would be affected by winter storms.		✓		✓
B. Does the plan address the **impact** of each hazard on the jurisdiction?	Section II, pp. 10-20	The plan does not address the impact of one of the five hazards addressed in the plan. **Required Revisions:** • Include a description of the impact of earthquakes on the assets. **Recommended Revisions:** • This information can be presented in terms of dollar value or percentages of damage.	✓			✓
		SUMMARY SCORE	✓			✓

Figure 1–3 FEMA Crosswalk Planning Tool

Advisory Committee

The Department of Planning assembled a group of experts from around the City and State to help gather essential data and draft recommendations for the DP3 plan. The purpose of the Advisory Committee was to bring together stakeholders from key agencies, institutions, businesses, and neighborhoods in order to identify actions and recommendations for the plan.

The Advisory Committee consisted of city directors from Department of Public Works, Department Of Transportation, Baltimore City Health Department, Mayor's Office of Emergency Management, Fire, Police and Department of General Services, community leaders, business leaders, climate scientists and representatives from Federal Emergency Management Agency, Maryland Emergency Management Agency, Maryland Department of Natural Resources, local Universities, the Port, and Baltimore Gas & Electric. The Advisory Committee met four times throughout the winter and spring of 2013, beginning in February of 2013. Additionally, members participated in subcommittees based on their specific areas of expertise. Additional information about the Advisory Committee can be found in Appendix D: Advisory Committee.

DP3 Advisory Committee Meeting, March 2013

Public Meetings

Throughout plan development, community input was solicited and encouraged. Two Town Hall events were held in spring 2013 and served to educate the public about the DP3 process and request their feedback regarding natural hazards affecting Baltimore. Additionally, representatives from Baltimore's Department of Planning attended community association meetings to explain the impacts of specific hazards and have intimate discussions with community members about their understanding of natural hazards and hazard mitigation planning. Additional information about these events can be found in Appendix E: Public Process.

DP3 Town Hall Meeting, July 30th, 2013

Additional Stakeholder Input

The Local Emergency Planning Committee (LEPC) of Baltimore City is a forum for citizens, businesses, and government to share information and collaborate on disaster plans to improve the City's preparedness for all future hazards. Staff facilitated discussions throughout the DP3 process and involved the LEPC through a number of presentations. A list of LEPC members can be found in Appendix D: Advisory Committee.

In addition to the LEPC, the Baltimore City Commission on Sustainability's Climate Committee had been involved in the DP3 Plan development process, providing input on the draft strategies and actions. Climate Committee members also assisted in developing implementation guidelines that are to be utilized in coordination with existing and ongoing CAP implementation efforts.

Furthermore, throughout plan development, DP3 worked with the Waterfront Partnership of Baltimore, Inc.; the Baltimore chapter of the American Institute of Architects (AIA); various community groups; State and Federal agencies; and with surrounding the Counties. All groups were given the opportunity to provide feedback on the draft strategies, actions, and draft plan throughout the process. The input provided through these resources had been invaluable to the development of the DP3 Plan.

Scope and Content

This document outlines the DP3 development process and strategies and actions that will help the city achieve its hazard mitigation and climate adaptation goals.

Chapter 2: Mitigation and Adaptation This chapter defines hazard mitigation and climate adaptation and highlights why Baltimore City decided to combine these two plan development processes. It explains the structure of a risk assessment and how risk is determined throughout the next two chapters.

Chapter 3: Hazard Identification This chapter identifies and defines natural hazards that threaten the City of Baltimore. It includes the severity, probability and location of each historical hazard and reports on the damages and consequences experienced by each. This chapter also integrates predicted changes due to climate change in order to address the need to adapt.

Chapter 4: Risk and Vulnerability Assessment This chapter builds upon the hazard identification process to further inform the risk assessment by assessing vulnerability. This chapter evaluates the potential losses associated with a given hazard and estimates the degree to which property damage, economic loss, physical injury, or death are likely to occur. It will highlight why Baltimore is at risk and where that risk is greatest.

Chapter 5: Strategies and Actions This chapter explores ways that Baltimore can best manage risks, protect people and property, and pro-actively plan for the current and future impacts of climate change. It explains the vision and goals for the plan and provides key strategies and actions divided into four sectors areas: infrastructure, buildings, natural systems and public services.

Chapter 6: Implementation, Monitoring and Evaluation This chapter identifies how implementation of the DP3 strategies and actions will begin. It identifies lead agencies, stakeholders, timeline, financing options and policy mechanisms for each action.

Appendices Detailed appendices provide information on the DP3 Advisory Committee, the public process, critical facilities, health impacts assessments, engineering studies, and all HAZUS-MH modeling data.

Vision, Goals and Objectives for the Plan

VISION

Baltimore will be a city whose daily activities reflect a commitment shared by government, business, and citizens to reduce or eliminate impacts from current and future natural hazards.

GOALS

GOAL 1 Protect the health, safety and welfare of Baltimore City residents and visitors

GOAL 2 Prevent damage to structures, infrastructure, and critical facilities

GOAL 3 Build resilience and disaster prevention and planning into all programs, policies, and infrastructure (public and private)

GOAL 4 Enhance the City of Baltimore's adaptive capacity and build institutional structures that can cope with future conditions that are beyond past experience

GOAL 5 Promote hazard mitigation and climate adaptation awareness and education throughout the City of Baltimore

GOAL 6 Become a Community Rating System (CRS) classified community

Community Rating System (CRS)

The National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the program:

- Reduce flood damage to insurable property;
- Strengthen and support the insurance aspects of the NFIP, and
- Encourage a comprehensive approach to floodplain management.

For CRS participating communities, flood insurance premium rates are discounted in increments of 5% (i.e., a Class 1 community would receive a 45% premium discount, while a Class 9 community would receive a 5% discount). The CRS classes for local communities are based on 18 creditable activities, organized under four categories:

- Public Information,
- Mapping and Regulations,
- Flood Damage Reduction, and
- Flood Preparedness.

Overview of the City of Baltimore

History and Geography

The City of Baltimore, Maryland, is located on the eastern seaboard in the Mid-Atlantic region (also referred to as the Northeast, or Northeastern, region of the United States). Situated on a natural harbor near the mouth of the Patapsco River where it empties into the Chesapeake Bay, the City features 60 miles of waterfront land within four major watersheds.

Founded in 1729, the City of Baltimore is a major U.S. seaport. Baltimore's port has been considerably successful. One particular economic advantage is that Baltimore is situated closer to major urban markets in the Midwest than any other major seaport on the East Coast. Additionally, the depth of Baltimore's harbor has continually provided access to the larger ships traveling from the Panama Canal. Today, Baltimore is one of only two East Coast port facilities that are deep enough to accommodate the new, substantially larger ships that will arrive following the Panama Canal expansion in 2015.

Baltimore's Inner Harbor was once the second leading port entry for Immigrants to the United States and a major manufacturing center. After a decline in manufacturing industries in the 1970's and 1980's, Baltimore shifted to a service sector-oriented economy. Now, Johns Hopkins University, Johns Hopkins Hospital, and the University of Maryland are the city's largest employers.

The port and waterfront remain extremely important assets in Baltimore, providing an abundance of job opportunities as well as some of the City's strongest property tax base. Today, the Inner Harbor is home to Harborplace, a festival marketplace that opened in 1980. Recognized as an international model for urban waterfront development and revitalization, Harborplace transformed Baltimore's Inner Harbor and is now a shopping, entertainment, and tourist destination that also features attractions like the National Aquarium in Baltimore and the Maryland Science Center. Daily visitors number in the hundreds of thousands, adding up to more than 20 million visitors each year. In fact, summer tourist season sometimes swells the City population to over 1 million.

Baltimore City's 80 square miles of land encompass the most heavily developed area within the State of Maryland; the City is characterized by brick row houses, office centers, and university campuses, to name a few key features.

Pier Four Power Plant adaptive reuse *Source: thecitrusreport.com*

Population, Households, Employment, Property Values and other Demographics

Baltimore is one of the nation's largest cities. According to Census Data, Baltimore reported a population of 620,961 residents in 2010. Since the 1950's, Baltimore has lost about one-third of its population due, generally, to the suburbanization of the region. However, the latest Census data indicates that Baltimore's population is stabilizing. In 2012, the Census Bureau Population Estimates indicated that the City's population was 621,342, a small increase.

In Baltimore, the median age is 34 years, and there are slightly more females (at 52.9 percent) than male residents.

Data from the 2010 Census indicated that 64 percent of the population identified themselves as black and 29.4 percent as white. Both demographic groups, however, experienced a decline in numbers since 2000, while smaller demographic groups experienced significant increases. The percent of Baltimore's population that identify as Asian, for instance, increased 45.7 percent, while those who noted they were "some other race" increased by 159.1 percent. Additionally, the number of residents who indicated they were Hispanic increased 134.7 percent; with the largest increase — 161.9 percent — in Mexican Hispanic residents.

Hazards and Historic Assets

Baltimore is an historic port city, with its oldest communities located on or near the waterfront. These intact maritime communities, such as Fells Point, Federal Hill, and Locust Point, are particularly threatened by sea level rise and storm surges. While the threat of climate change and coastal hazards are great in these coastal communities, other aspects of climate change threaten historic resources across the city.

The city has over 80,000 historic properties designated on the National Register of Historic Properties individually or contributing to a district, or locally designated as a Baltimore City Landmark or contribution to a Baltimore City Historic District. The city also possesses significant historic landscapes, sites, and archaeological sites. These historic resources play a defining role in our city's heritage and are a vital part of its economy.

Historic structures, landscapes, and sites are non-renewable resources, making it of the utmost importance to proactively plan for their protection and resiliency. Many historic resources in Baltimore have already survived significant climatic changes in the past, and may demonstrate resiliency in the future. However, future climate hazards will likely affect more historic resources than ever before. It is possible that future impacts to historic resources may cause irreparable damage or lead to the loss of the cultural or economic benefits of these resources. There is also the potential that poorly designed climate adaptation and mitigation responses could damage or destroy the significance and integrity of these historic resources as well. Thus, it is critical that consideration of historic resources to be integrated into any hazard or climate change planning.

It is important to look to federal standards and the best practices in the field in planning for hazards and climate change and impacts to historic resources. This includes engaging with other maritime communities that are involved in innovative planning measures for their vulnerable historic resources, such as the City of Annapolis, and other partners such as the National Trust for Historic Preservation, federal and state preservation agencies, non-profits, and other partners. Other actions include:

1. Develop and implement a hazard mitigation planning strategy for the city's historic resources. Integrate a variety of tools, such as engineering surveys, to determine neighborhood-specific adaptation strategies.

2. Prioritize all historic resources vulnerable to climate change and climate hazards based on their significance and level of threat, and develop a schedule to complete investigations of all priority sites that have had little or no previous investigation.

3. Protect historic sites and buildings in place where financially and technically feasible using a variety of measures.

4. Create financial incentives for historically-sensitive adaption strategies that increase the resiliency of historic buildings.

5. Promote the use of historic preservation tax credits or other funding sources to offset costs of retrofits or other adaptation strategies where they are appropriate.

6. Develop guidelines and requirements for the potential displacement of vulnerable historic resources when preservation in place is not a feasible strategy for permanent protection.

7. Develop a Historic Property Resiliency Toolkit for property owners.

8. Explore the greater utilization of legislative and legal tools, such as historic designations and easements in the effort to protect historic resources.

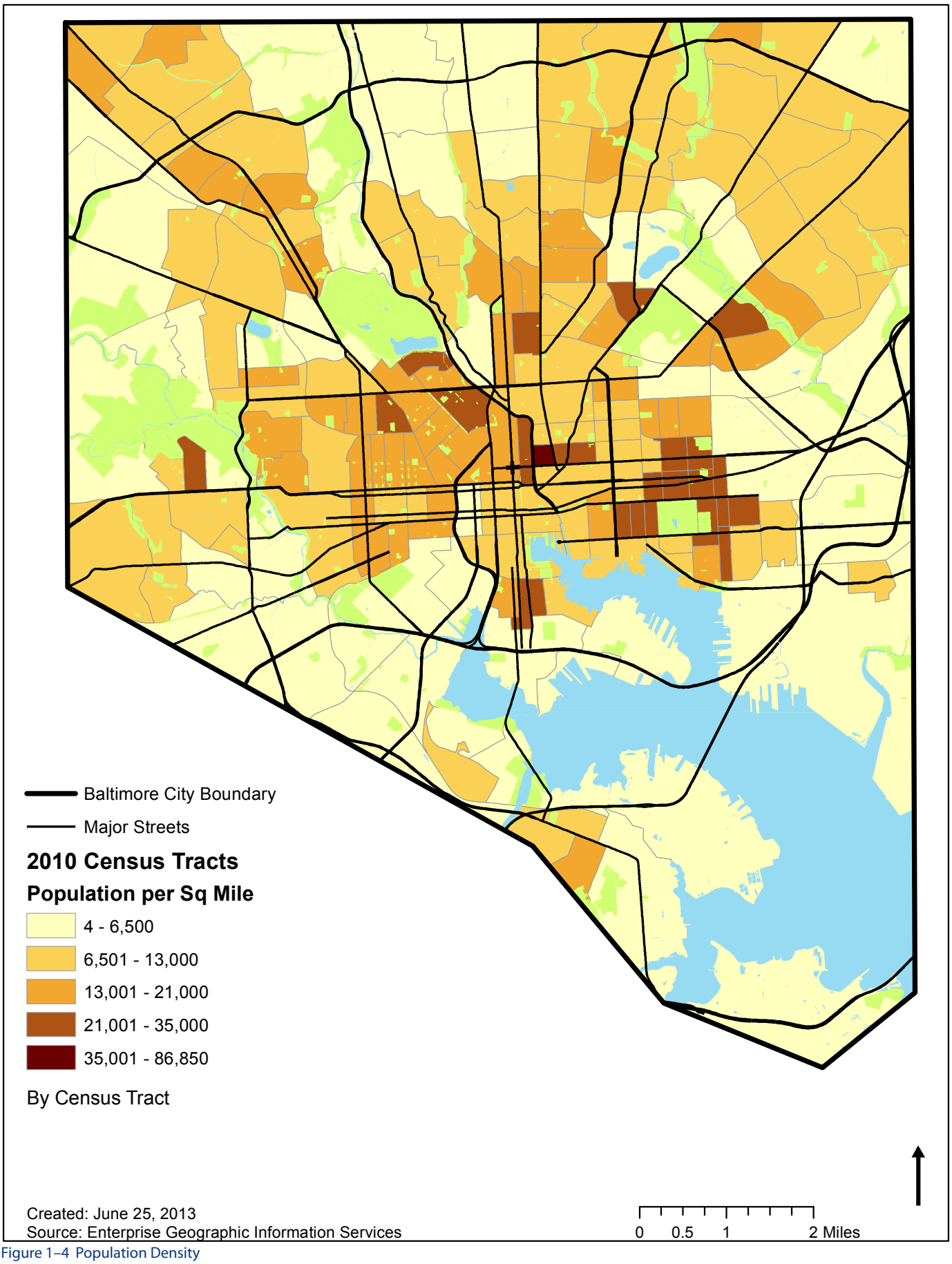


Figure 1–4 Population Density

As the map here (Figure 1–4) illustrates, Baltimore's population density is dispersed differently throughout the City. Concentrations of population groups with distinct demographic characteristics — including age, ethnicity or primary language, poverty status, individuals and families receiving federal assistance, and educational attainment levels — may be distributed in clusters (Maps showing demographic concentrations of populations by these characteristics may be found in Appendix K: Supporting Information).

When certain populations are grouped together, the impacts from natural hazards may unequally impact some individuals more significantly, increasing vulnerability to certain hazards of one cohort more than others. Environmental justice ensures the fair treatment and the equal protection of an individual — regardless of race, ethnicity, or income — from environmental and health hazards, as well as uniform access to planning and decision-making processes which provide residents with a healthy environment in which to live, earn, play, and learn.[3] This plan attempts to provide disaster preparedness and planning opportunities for more vulnerable populations.

Table 1–5 Baltimore Households

	Number	Percent
Total households	**249,903**	**100**
Family households (families)	134,038	53.6
With own children under 18 years	55,848	22.3
Husband-wife family	60,293	24.1
With own children under 18 years	20,963	8.4
Male householder, no wife present	14,156	5.7
With own children under 18 years	5,412	2.2
Female householder, no husband present	59,589	23.8
With own children under 18 years	29,473	11.8
Non-family households	115,865	46.4
Householder living alone	90,092	36.1
Male	39,916	16
65 years and over	8,138	3.3
Female	50,176	20.1
65 years and over	17,095	6.8

Source: 2010 Census

Households

Baltimore is often referred to as a "City of Neighborhoods" for its many unique districts and communities. The characteristics of each neighborhood can vary greatly across the City, influencing the levels to which one community may or may not be vulnerable to various events.

In 2010, there were 249,903 households in Baltimore City (Table 1–5), 47.7 percent of which were owner-occupied (Figure 1–5), an 8.2 percent decrease since 2000. Family households in Baltimore City fell 8.9 percent in 2010, constituting 53.6 percent of all households. In 2010, the Median Household Income (Figure 1–6) grew to an estimated $50,046, up from just $39,368 in 2000 (2010 adjusted dollars) (2010 ACS 1-Year Estimates).

Comparing 2010 ACS 1-Year Estimates with 2000 SF3 Census data reveals that poverty status decreased, both for families — down from 18.8 percent in 2000 to 11.3 percent— and for all residents — from 22.9 percent in 2000 to 15.3 percent in 2010.

Interestingly, according to 2010 American Community Survey 1-Year Estimates, although Pre-K through 12th grade enrollment levels fell across the board, the number of high school graduates rose 2.3 percent and residents with college-level or higher educational attainment increased by 23.2 percent. Residents with similar education attainment levels are generally living in concentrated areas. The map below (Figure 1–7), for instance, shows that north Baltimore neighborhoods have high concentrations of residents with a high school diploma or greater. In this map, the darkest brown indicates areas where between 91 and 100 percent of residents had received a high school diploma or above, with the lightest yellow indicating areas where only 46 to 50 percent of residents had done so.

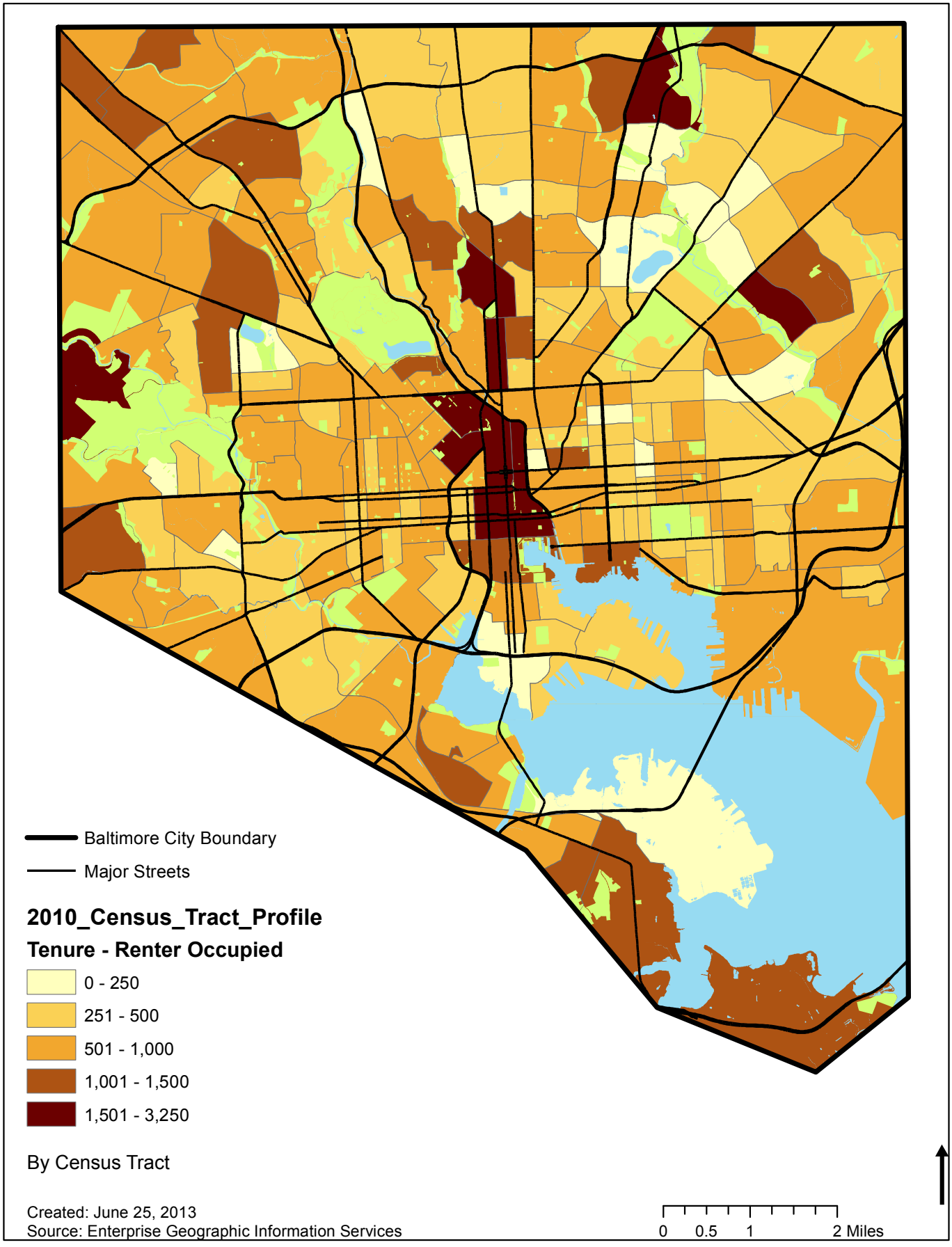


Figure 1–5 Baltimore City Tenure

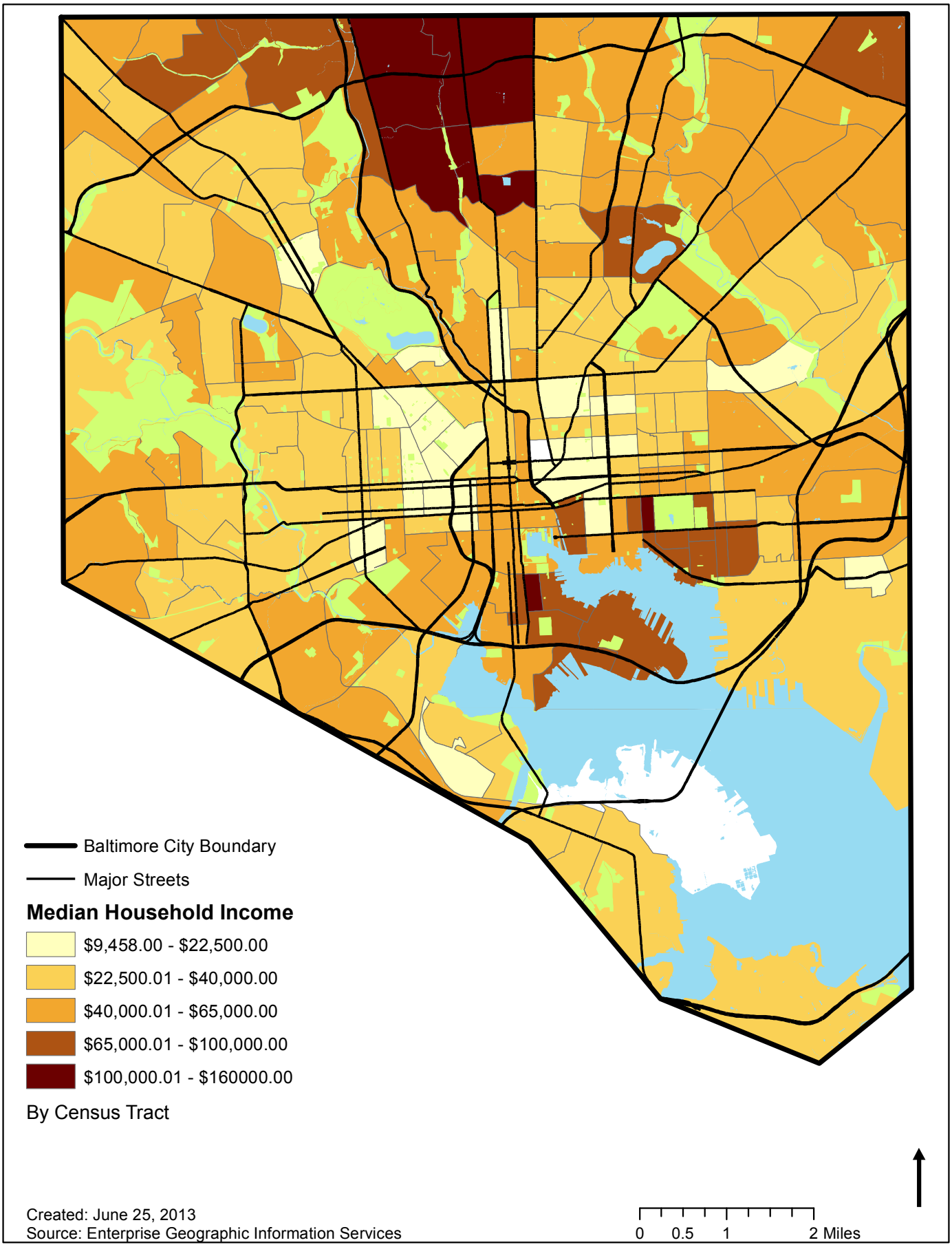


Figure 1–6 Median Household Income

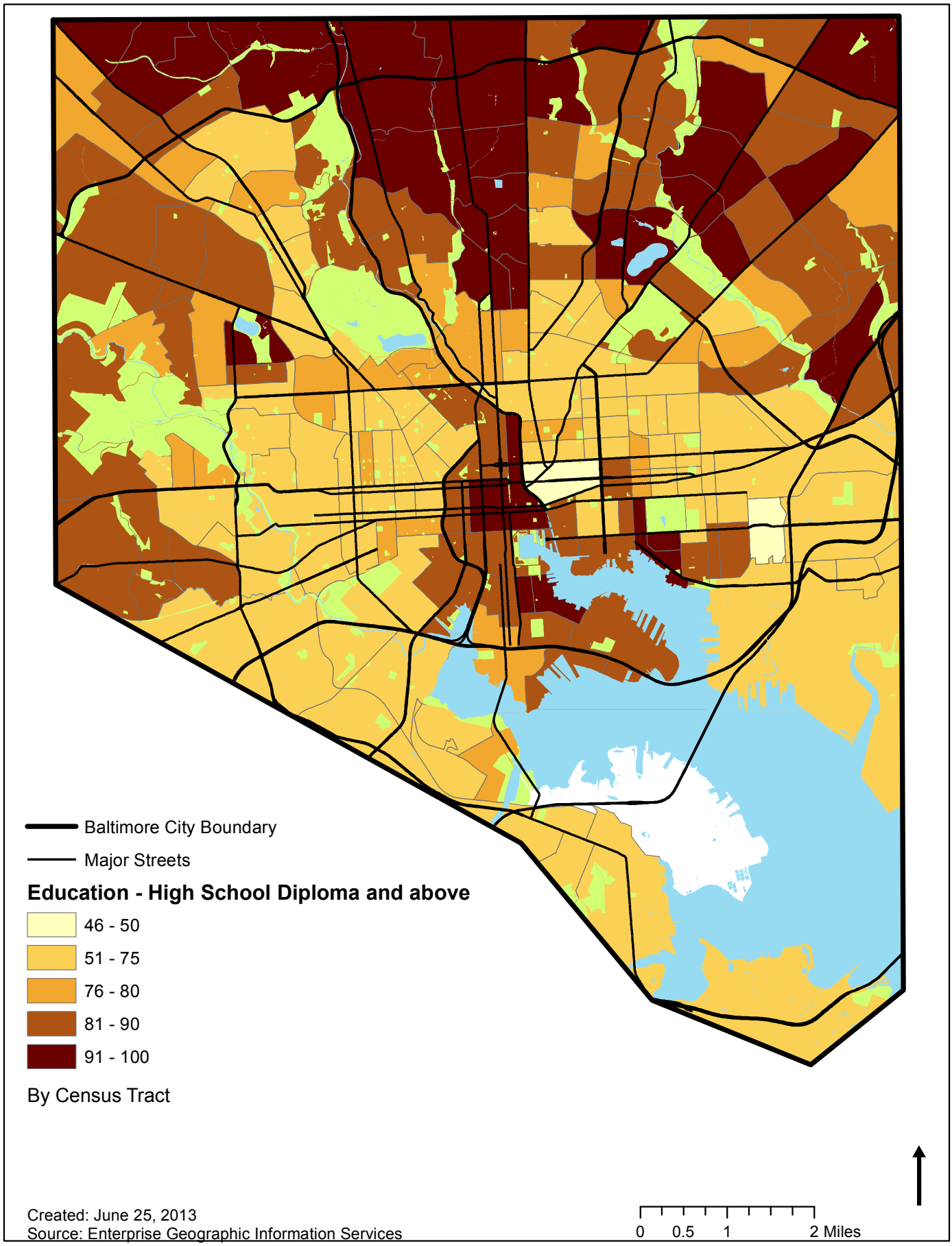


Figure 1–7 Educational Attainment

Table 1–6 Baltimore Top Revenue Generating Companies with More than 1000 Employees

Employer	Number of Employees	Neighborhood
Abacus Corporation	1000 and over	Pulaski Industrial Area
Baltimore Sun	1000 and over	Mount Vernon
Bon Secours Hospital	1000 and over	Penrose/Fayette Street Outreach
Broadway Services	1000 and over	Orangeville Industrial Area
Helix Health System	1000 and over	Loch Raven
Johns Hopkins Bayview Medical Center	1000 and over	Pulaski Industrial Area
Johns Hopkins Health System	1000 and over	Pulaski Industrial Area
Johns Hopkins Hospital	1000 and over	Dunbar-Broadway
Johns Hopkins University	1000 and over	Charles Village
Kennedy Krieger Institute	1000 and over	Middle East
Loyola College	1000 and over	Loyola/Notre Dame
Maryland General Hospital	1000 and over	Mount Vernon
Mercy Hospital	1000 and over	Downtown
Mv Contract Transportation	1000 and over	Curtis Bay Industrial Area
St Agnes Hospital	1000 and over	Violetville
Sinai Hospital	1000 and over	Levindale
T Rowe Price Associates	1000 and over	Inner Harbor
University Of Maryland Medical System	1000 and over	University Of Maryland

Johns Hopkins Hospital

Source: archdaily.net

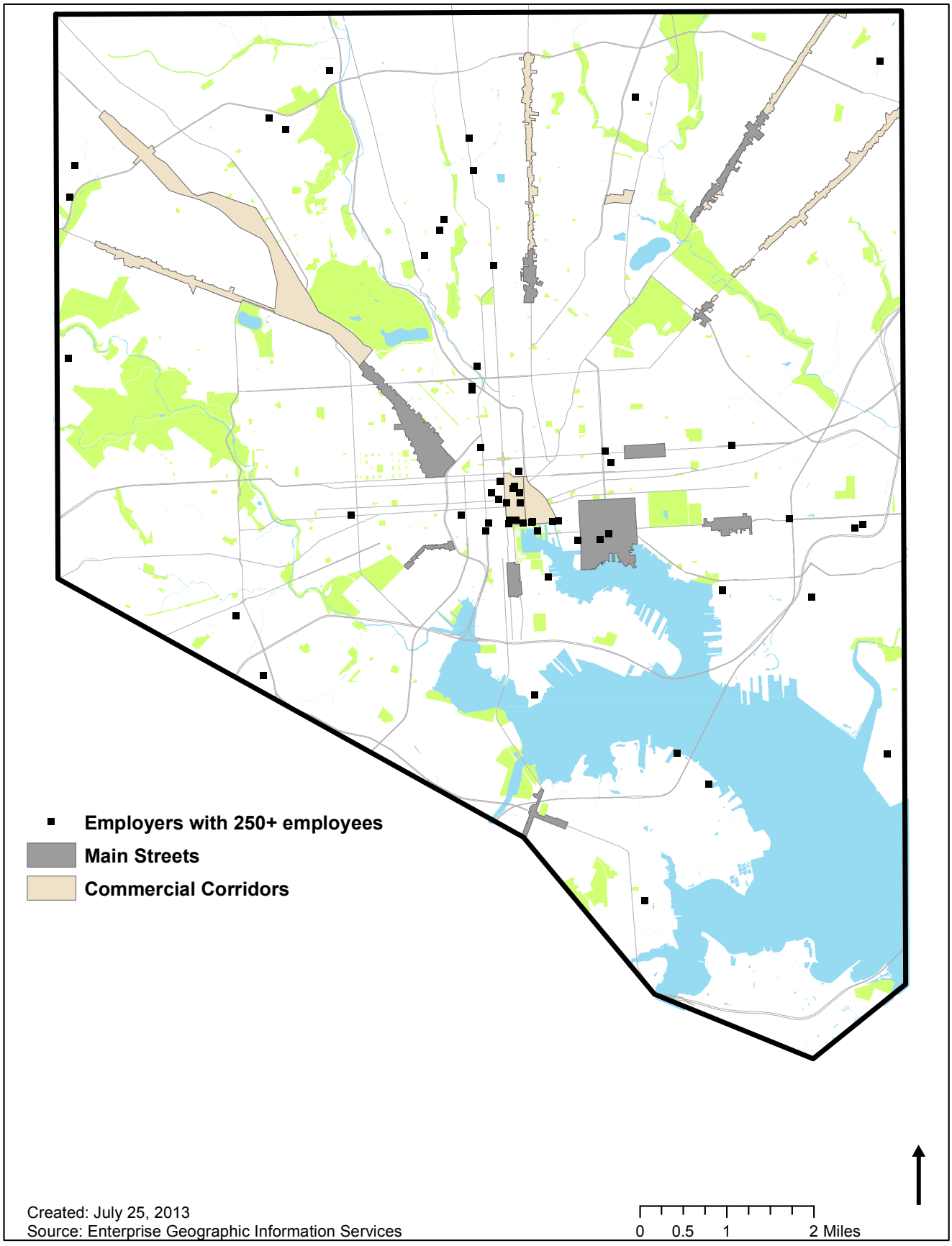


Figure 1–8 Economic Centers

Economic Development, Land Use and Zoning

The top five, largest industries in Baltimore are Education and Health Services (23.2 percent), Retail Trade (11.7 percent), Professional (10.6 percent), Manufacturing (10.4 percent), and the Arts (9.2 percent) (ACS 2010 1-Year Estimates). As Baltimore's population has declined, however, the total number of City jobs has also fallen (Table 1–7).

Historically, Baltimore's economic activity has largely centered on waterfront development and redevelopment. Baltimore's waterfront includes a wide variety of land uses, including industrial, commercial, recreational, and residential development.

Additionally, Baltimore features high revenue-generating companies. Table 1–6, below, lists top revenue-generating companies in Baltimore which have 1,000 or more employees. While these, and other leading industries, are dispersed across the City, some neighborhoods have high concentrations of these major employers. For instance, about 35 percent of Baltimore's major employers are located within the Inner Harbor and Downtown Baltimore neighborhoods, together, which are major economic centers in the City (Figure 1–8).

Table 1–7 Jobs in Baltimore City 1970-2010

1970	1980	1990	2000	2005	2010	2013*
533,697	503,343	508,534	446,406	397,852	386,532	363,100

Source: 1970-2010 Data from the U.S. Bureau of Economic Analysis.
**2013 numbers, reported as of March 2013: http://www.bls.gov/ro3/cesqbalt.htm#ro3qcesbalt*

Downtown Baltimore

Source: Baltimore Sun

Climate of Baltimore

Baltimore has a temperate climate and experiences four, distinct seasons each year. Baltimore's winters are cool and damp, with limited snow fall. Summers are warm and humid. In Baltimore, an average annual rainfall of 41.99 inches has been measured. Average annual temperatures in Baltimore are measured at 55.1°F, and the City is generally warmer than the surrounding Counties due to an urban heat island effect (discussed in more detail in the "Extreme Heat" Hazard Profile in Chapter 3).

Baltimore is vulnerable to many natural hazards, including coastal storms, flooding, extreme heat and high winds. In the past, natural hazards like these have damaged property and infrastructure, and have resulted in the injury or fatality of Baltimore residents (Baltimore's history of natural hazard events will be discussed in more detail in Chapter 3).

Additionally, the City's risk of experiencing natural hazards is expected to rise with projected changes in climate, which Baltimore has already begun to experience. Consider, for instance, some of the significant trends observed over the last century:

- Average temperatures have increased by 1.8°F in Maryland.[4]
- At BWI Airport, the most recent 30-year average (normal) temperature has increased by 0.5°F since the 1970-2000 measured normals.[5] (Typically, however, actual Baltimore City temperatures are a few degrees warmer than temperatures measured at BWI.)
- There has been a general increase in the number of heat waves.
- Average precipitation has increased by 10% in most of Maryland.[6] Meanwhile, intense precipitation events have increased by 20% over the last century.[7]
- Extreme weather events increase in intensity and frequency; in the case of hurricanes, storms are less frequent, yet there has been more intensity and damage associated with each storm.
- Relative sea level has risen 13 inches in Baltimore between 1902 and 2006, or at a rate of about 0.125 inch each year.[8] The global average is 0.08 inch/year.[9]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107.4 HEAT RECORD SET IN CITY; 29 OVERCOME; NATION'S TOLL IS 421

Record Heat Wave And That Of 1918

TEMPERATURE RECEDES 12 DEGREES DURING RAI

Two Days More Of Torrid Weather In Sight

Baltimore—43 Are Prostrated Here In Three Sweltering Days

1936 Article in the Baltimore Sun *Source: marylandweather.com*

These trends are likely to continue throughout this century (Table 1–8 Climate Hazards Projections for Baltimore City and the State of Maryland) and into the future. For instance, scientists predict:

- Maryland's average annual temperatures will increase 3-8°F by the end of the century.[10]
- By 2100, average annual temperatures are expected to increase 12°F in Baltimore — which will at that point feel more like New Orleans, LA.[11]
- As many as 95% of summer days could reach extreme maximum temperatures by the end of the century.[12]
- Projected increases in average precipitation typically hover around 10%. At the same time, heavy storm events are expected to increase in frequency; winter precipitation is likewise expected to increase by an estimated 40%, although more of that precipitation will be rain as opposed to snow.[13]
- In Baltimore, relative sea level is expected to rise another 13 inches by 2050; while Maryland sea level could rise to between 24 and 48 inches by the end of the century.[14]

Table 1–8 Climate Hazards Projections for Baltimore City and the State of Maryland

Maryland	2012	2025	2050	2100	Notes
Annual Average Temperature(°F)	55.1°	57.1°	58.1°	58.1-63.1°	
Higher Temperatures (summer days reaching maximum temperature extremes)	75 – 90%	80 – 95%	85 – 95%	90 – 95%†	Foot, Rich. (2013, June).
Increase in Annual Precipitation	40.76"	42.8"	43.53"	45" – 45.9"	
Sea Level Rise	n/a	--	.6' – 1.3'	2.7' – 3.4'	
Baltimore	**2012**	**2025**	**2050**	**2100**	**Notes**
Annual Average Temperature(°F)	54.6°	56.6°	--	66.6°	
Higher Temperatures (summer days reaching maximum temperature extremes)	75 – 90%	80 – 95%	85 – 95%	90 – 95%†	Foot, Rich. (2013, June).
Increase in Annual Precipitation	41.94"	44"	44.8"	46.3 – 47.2"	Using statewide projections
Sea Level Rise	n/a	--	13"	--	

† Projection for the year 2090.

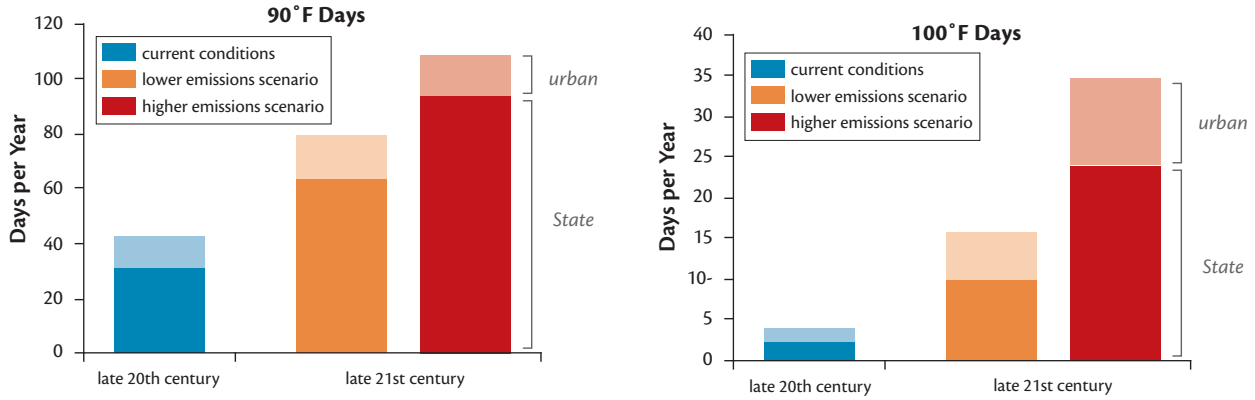


Figure 1–9 Projected Number of Days with High Temperatures Reaching or Exceeding 90°F and 100°F in the Late 21st Century. This image compares recorded temperature measurements over the 20th Century with projected rises in temperatures based on both low and high emission scenarios. Note how temperatures are and will be even greater in urban areas.

Source: Figure 1.8 of the Maryland Commission on Climate Change, 2008: Ch. 2, Pg. 17.

United States Heat Wave of 2012

2012 was the warmest year on record for the contiguous 48 states

Changing trends continue to set new records. In 2012, more than 3,500 monthly weather records were broken across the country. Extreme weather events, like droughts, large wildfires and Hurricane Sandy, devastated communities. It was the warmest year on record, according to the National Oceanic and Atmospheric Association (NOAA). In Baltimore, residents experienced a winter warm spell, intense heat waves, and a significant derecho storm (see a description of derechos in the Wind Hazards Profile). With continuing climatic shifts, frequency and severity of natural hazard events are expected to increase significantly. Furthermore, with a projected rise in sea level of more than one foot, impacts will be spread over a much larger area of the City and threaten regionally significant utilities such as sewage treatment plants and a Baltimore waste-to-energy facility.

It is essential, therefor, to mitigate hazards and to adapt to changes in climate that we're already seeing, as well as other changes we can anticipate. This means ensuring the protection of Baltimore's residents, landscape, and the facilities and services upon which the City depends.

Existing Hazard Mitigation and Adaptation Projects

Baltimore City has an ever-growing record of important programs and actions which are centered on mitigation and adaptation. Although many will be expanded upon through the DP3 Plan, there are a few processes recently completed which will assist in these efforts.

Climate Committee

Through the Commission on Sustainability and recent adoption of the City's Climate Action Plan, the City's first Climate Committee was developed in early 2013. This committee is tasked with prioritizing climate-related strategies, identifying funding sources, and overseeing implementation. Although climate mitigation efforts related to reduction in CO2 emissions is the Committee's primary focus, climate adaptation strategies and actions

Sustainability Commission Meeting, 2013 *Source: Office of Sustainability*

Heat-Related Projects

The Urban Heat Island Mitigation Project is funded through the Public Service Commission Customer Investment Fund. This program supports the planting of additional trees and installs reflective roofs in low income communities identified as suffering from extreme heat. This project compliments existing initiatives in the Baltimore City Recreation and Parks Forestry Division which have prioritized development of an extensive tree inventory and tree planting and maintenance program.

Flood Map Changes

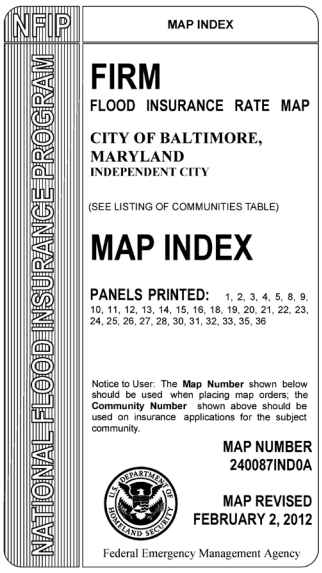
In 2012, the City digitized its floodplain maps which allow integration of floodplain information with existing GIS resources. In addition to this upgrade, the City also updated and adopted its non-tidal floodplain maps which will assist with both mitigation and adaptation efforts. Expanding upon this effort, staff is working with State and Federal assistance to further refine non-tidal studies in key redevelopment areas and will adopt new tidal floodplain maps in spring, 2014.

Tree Planting at local school *Source: Office of Sustainability*

The Baltimore City Health Department plays a vital role in heat-related hazard mitigation and adaptation. Baltimore City has been using the Code Red Alert System for a number of years to provide vital information to residents during high heat events. The purpose of the program is to prevent heat-related hospitalizations and deaths by allowing the health commissioner to declare a Code Red Heat Alert during periods of extreme heat.

Mitigation and adaptation efforts related to emergency response and recovery are also being addressed through plans and initiatives in the Mayor's Office of Emergency Management.

Utilizing new technology to display flood information *Source: Google Earth*

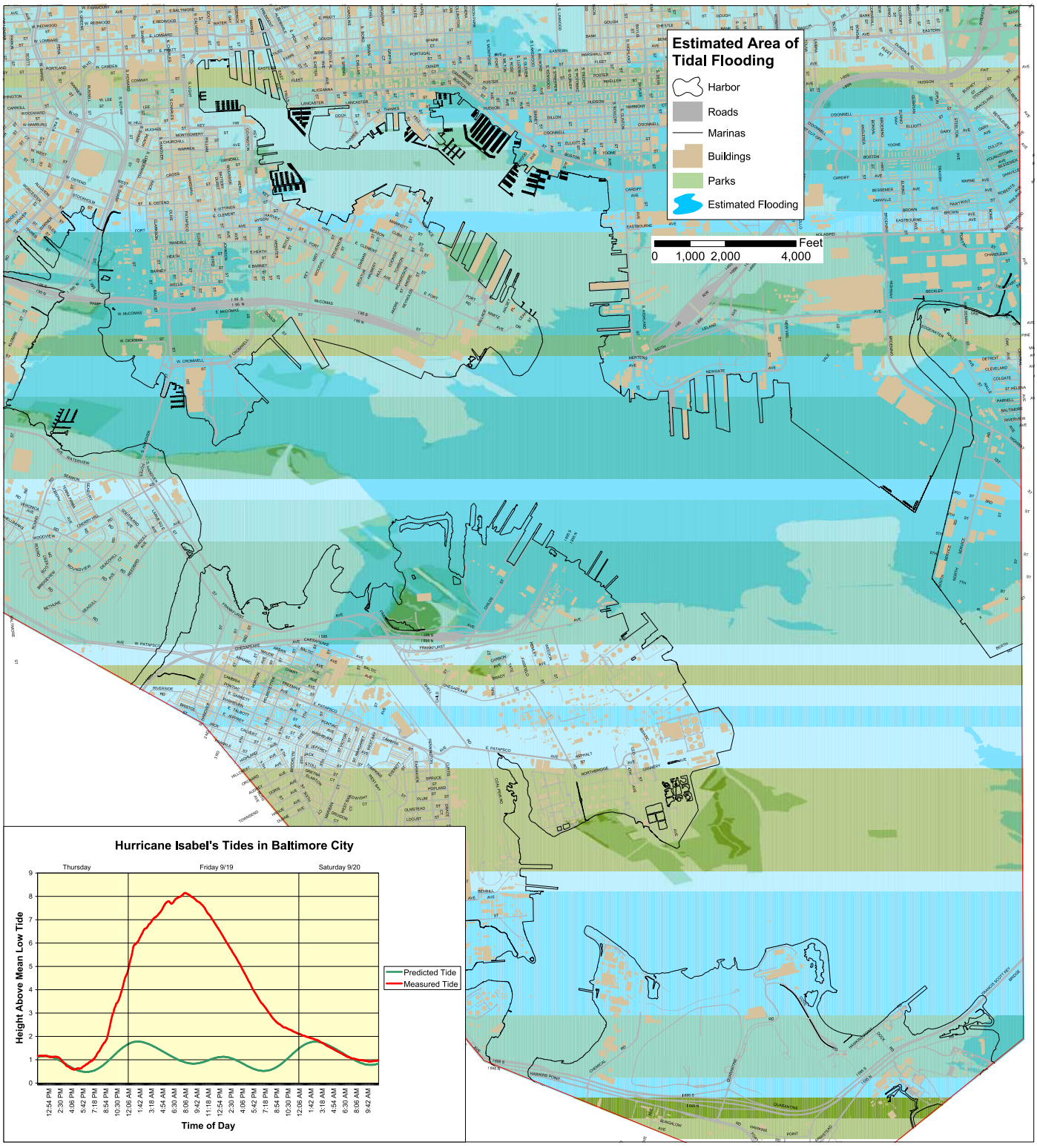


Flood Insurance Rate Map *Source: City of Baltimore*

Baltimore's Flood Insurance Rate Map (FIRM) Index Panel cover sheet is shown to the left. These maps are officially adopted by the City and are used for both flood insurance and regulatory development controls.

On February 2, 2012, the City adopted a new set of maps (i.e. FIRM) replacing the September 30, 1988, FIRM. The new FIRM is also a digital product. This is a significant advancement in bringing the flood insurance and regulatory program into the 20th century

The above map is an example of the future in displaying flood information. The image was created with Google Earth (February 2, 2012, FIRM 100-year flood). Google Earth allows City Planners to import digital files that will reflect a 3-dimensional representation. Some of the buildings in this image are not properly sized but the image shows the extent of waters from the Hurricane Isabel Flood in 2003. This type of graphic resonates with the public and will be used in our future campaigns to promote private sector preparedness.



Martin O'Malley
Mayor
City of Baltimore

Otis Rolley, III
Director
Department of Planning

September
2003

According to the National Oceanic and Atmospheric Administration (NOAA), the tidal gauge at Ft McHenry recorded an elevation of 8.15 feet above "mean lower low tide" (MLLT). This was recorded at 7:06 am on Friday morning, September 19th and represented a storm surge of 7.26 feet over the expected tide level. This exceeded the previous record tide recoded in 1933 by 4/10ths of a foot.

The tide is actually measured by taking a reading every second for the three minutes before and after the time of the reading. The median value of these samples is then used so waves and troughs are balanced out. Some flooding above this could occur though out the basin due to local conditions and waves.

The storm also matched the Base Flood Elevation (BFE) as established by the Federal Emergency Management Agency (FEMA) for the Baltimore Harbor making this a 100-year tidal flood. It is important to note that this level of flooding has a one percent chance of occurring in any given year- it may occur again before 100 years.

Hurricane Isabel Impact, 2003

Source: City of Baltimore