A Green Infrastructure Plan for Norfolk:

BUILDING RESILIENT COMMUNITIES

THE CITY OF NORFOLK

JULY 2018

Prepared for the City of Norfolk by the Green Infrastructure Center Inc.

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BUILDING RESILIENT COMMUNITIES

Green Infrastructure Center

OLD DOMINION UNIVERSITY

THE CITY OF NORFOLK

Funding for this plan was supported by a grant to the City of Norfolk from the National Fish and Wildlife Foundation and the U.S. Department of the Interior, National Fish and Wildlife Service. The grant funds were allocated to communities to create green infrastructure plans following Superstorm Sandy. Additional funds and matching dollars were provided by the City of Norfolk.

Old Dominion University prepared the sea level rise data used in this plan.

This plan, data and maps were created by the Green Infrastructure Center Inc. for the City of Norfolk.

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Executive Summary

Norfolk has adopted a key focus for its future – that of being a resilient city. It is one of 100 Resilient Cities designated by the Rockefeller Foundation. As a city whose 66 square mile area is about a third water, living with water is a key theme for the city's resilience strategy.

This green infrastructure plan will help the city 'design the coastal community of the future' by using its natural assets to improve environmental and community health and to protect infrastructure, such as roads and buildings. This plan is the culmination of a two-year effort to map and plan for Norfolk's green infrastructure. Just as the city plans for its 'gray infrastructure,' such as roads, sidewalks or storm drains, it also needs to plan for its 'green infrastructure', including the marshes, creeks, parks and trees that provide habitat, filter the air and water, moderate air temperatures, and provide recreation and scenic beauty. These green features are referred to as 'green infrastructure' because they are an important part of the city's infrastructure.

Many community partners, city agencies, and members of the public contributed ideas to create this plan's strategies. A total of ten community meetings were held to inform the plan's development along with consultations with multiple city agencies and community organizations. The plan was reviewed and supervised by the city's Watershed Management Task Force. The ideas provided by these groups are reflected in the strategies on page 50 of this plan.

To better manage its green infrastructure, an assessment was conducted to determine the extent and conditions of the city's natural assets. This assessment included analysis of Norfolk's land cover (tree canopy, water, and impervious surfaces), the connectivity of its trails and parks, and the locations of large patches of intact open spaces, marshes and shorelines. Highlights of findings from the analysis and community input include:

- Norfolk's current urban tree canopy is **25.8%** and the new canopy goal is to increase canopy to **30%**. This will require the planting of **104,000** more trees at a rate of **5,200** trees annually to reach the goal within **20** years. This additional canopy will help the city absorb and clean more stormwater and reduce flooding.
- Of the city's **211** miles of shoreline, **61** miles are currently hardened; of those, **35** miles could be naturalized thereby reducing erosion, protecting property from wave-action, and improving habitats for people and wildlife.
- There are **378** acres (**22%**) of the **50**-foot coastal buffer (**1,695** acres) within the Chesapeake Bay Resource Protection Area, available for planting vegetation to absorb wave and wind energy and to filter runoff to protect surface waters.
- There is currently just one access point (**16** citywide) for every **12** miles of shoreline. The city needs to add dozens of new access points to ensure water access for all residents, regardless of physical abilities.

Norfolk Pier

Existing city goals and programs were reviewed to understand strategic directions, and data and reports were analyzed to determine what is achievable, given current city conditions and anticipated future changes from rising seas and redevelopment.

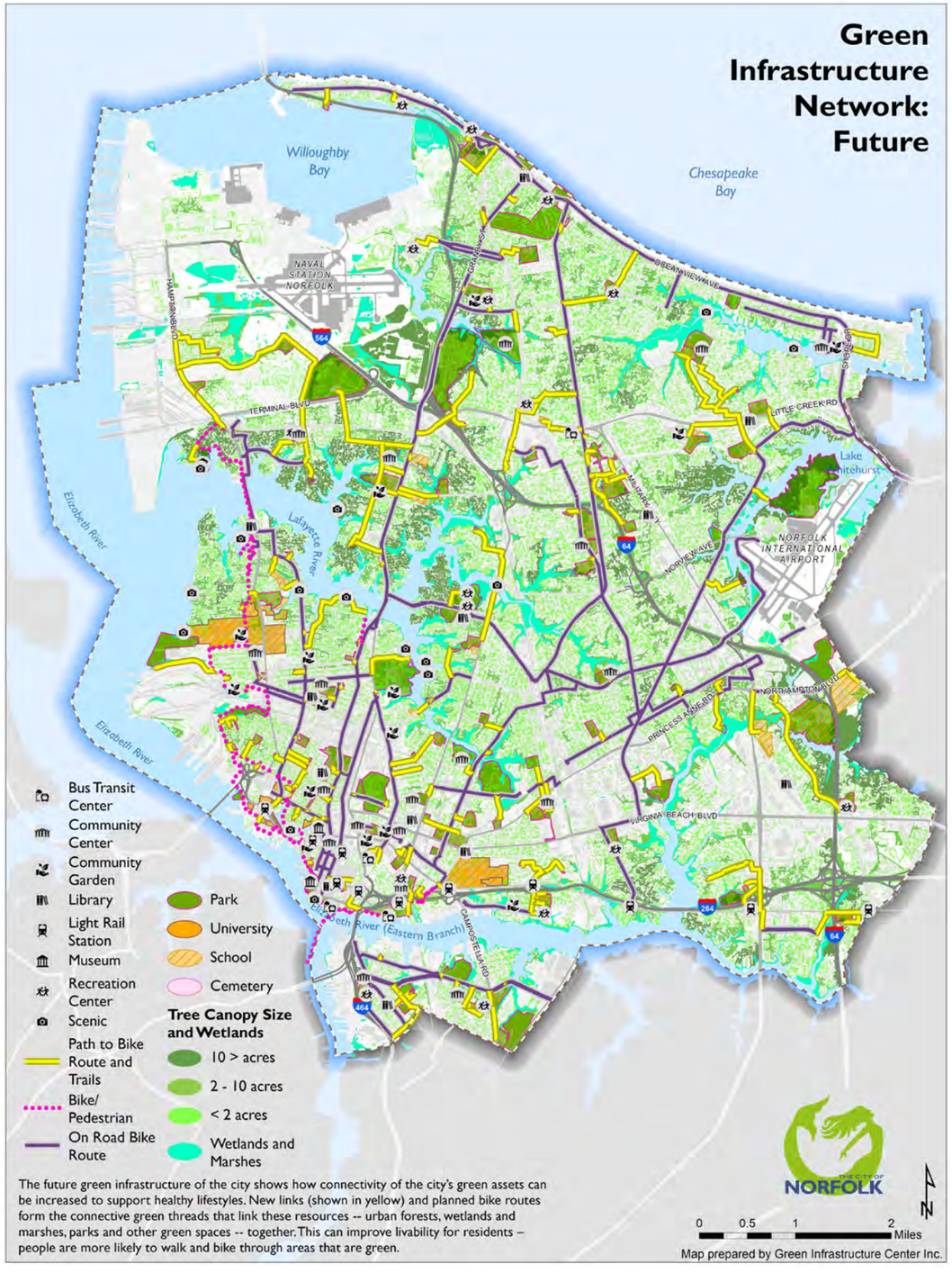
Many more opportunities for enhancing walkability, access to parks, trails, and water were identified. Strategic maps show where trails, green streets, or other key linkages are needed. Implementation strategies were developed around two focal themes described below.

TWO THEMES FOR FOCUS:

For land, the focus is to protect, connect and re-green the landscape to provide pathways for people and wildlife, treat stormwater and reduce flooding, and beautify the city.

For water, the focus is to restore shoreline habitats to support aquatic life, buffer areas from storm surge, and foster recreation, including birding, boating and fishing.

Today, Norfolk is not yet a well-connected green network – but it can be. The future green infrastructure network map shown on the next page identifies new linkages in yellow that can be added to reconnect the city for improved access to nature, cultural sites and public spaces as well as pathways for pollinators or wildlife. Protecting and expanding linkages will facilitate a green network for residents to enjoy a revitalized and resilient Norfolk. The strategies show how to achieve a greener Norfolk that meets the themes for land and water. These strategies are covered in greater detail on page 50.



GOAL SUMMARY:

The following is a summary of goals and objectives. Detailed actions are included in the strategy section on page 50.

Land Goal 1: Increase and maintain natural green infrastructure – urban forest, shrub and meadow habitats – to support wildlife, infiltrate and clean water, improve air quality, reduce high temperatures and provide scenic beauty.

Obj. 1: Create a planting goal for tree canopy to achieve 30% canopy coverage (a 4% increase).

Obj. 2: Create incentives for tree planting by citizens and businesses.

Obj. 3: Protect intact habitat patches in the city and connect or reconnect them with green pathways to support people, plants, and animals. (See map of Future Green Infrastructure Network).

Obj. 4: Encourage the use of native plantings.

Obj. 5: Improve the city's data on trees to ensure good management and longevity.

Obj. 6: Promote urban food production for healthful communities and permeable landscapes.

Obj. 7: Daylight (re-surface) creeks that have been buried to expand channel capacity and provide natural amenities for communities.

Land Goal 2: Install and maintain constructed green infrastructure to detain and retain stormwater and beautify areas where natural green infrastructure practices are less suitable.

Obj. 1: Use schools and parks as demonstration sites for low impact development – constructed and natural green infrastructure – and continue to engage students as designers.

Obj. 2: Retrofit existing parking lots to create room for bioswales and other best management practices to infiltrate or store water.

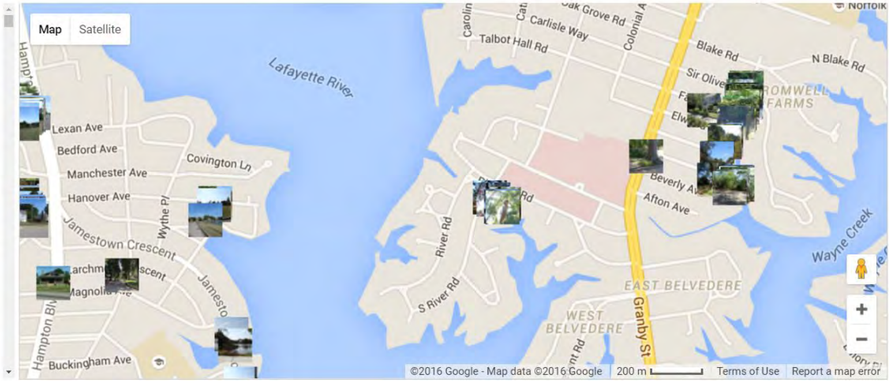
Obj. 3: Encourage building owners to retrofit existing roofs for stormwater treatment.

Obj. 4: Create an annual innovation award for those developments that use the greatest creativity in instituting and maximizing the use of low impact development strategies.

Obj. 5: Create and promote stormwater education through parks to demonstrate low impact development practices.

Obj. 6: Expand or create volunteer programs to maintain the aesthetics and health of green infrastructure projects.

Obj. 7: Increase knowledge about the infiltration capacity of the city's soils to ensure projects account for local soil conditions when designing stormwater projects or land development plans.



Field work for the project included site visits across the city to assess opportunities to improve shoreline habitats, connect and restore landscapes and improve access to the water.

Shaded sidewalks promote walkability.

Land Goal 3: Provide adequate open space access to ensure a healthful city for residents and visitors.

Obj. 1: Increase access to parks and natural areas to support community health and wellbeing by ensuring that all residences are within a quarter mile of a park.

Obj. 2: Create or modify trails to provide more opportunities for recreation and alternative transportation options for pedestrians of all abilities.

Obj. 3: Target streets for conversion to complete green streets to soak up stormwater, improve aesthetic values, increase safety, and provide more opportunities for alternative transportation, (e.g. bike lane streets and entry corridors).

Obj. 4: Protect or enhance landscapes and buffers around and near key historic and cultural sites (see history and culture assets map).

Water Goal 1: Protect and restore natural shorelines to support healthy aquatic life, storm buffering and water filtration.

Obj. 1: Restore and expand wetlands to protect shorelines from storm surges, prevent erosion and filter pollutants.

Obj. 2: Restore vegetated buffers around the city's lakes, ponds, reservoirs, wetlands and shorelines to protect water quality, prevent erosion, and allow inland migration of wetlands as sea level rises.

Obj. 3: Expand programs to engage private property owners in planning for change on those properties where inundation from sea level rise or erosion from storms may occur.

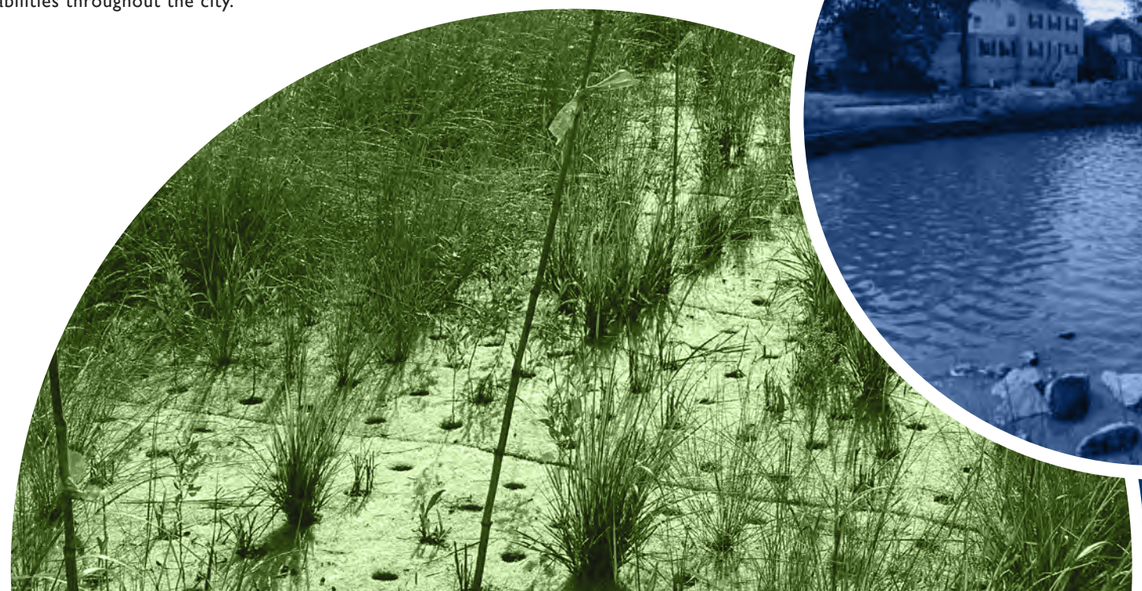
Obj. 4: Remove non-native invasive species and encourage management through partnerships with residents, the military, nonprofit groups and local businesses.

Water Goal 2: Expand water access for boaters, fishermen, birders and walkers (see recreation map).

Obj. 1: Provide new boat ramps for motorized and non-motorized boats, including adequate parking and staging areas.

Obj. 2: Provide access and views of the water by creating new pocket parks, passive green spaces or vistas, especially for those areas which will lose open spaces due to future sea level rise.

Obj. 3: Provide fishing access (piers, docks, cleaning stations) for residents and visitors of all abilities throughout the city.



Introduction & Purpose

This report is the culmination of a two-year effort to map and plan for Norfolk's Green Infrastructure. Just as the city plans for the maintenance, modification, and expansion of its 'grey infrastructure,' such as roads, sidewalks, or storm drains, it must do the same for its 'green infrastructure.' Green infrastructure consists of the marshes, creeks, parks and trees that provide habitat, filter the air and water, moderate air temperatures, and provide recreation and scenic beauty.

Increasingly, cities are also evaluating and managing their 'green infrastructure' in a coordinated fashion. For example, they are linking their tree canopy to stormwater management as they realize that trees and other shrubs help tremendously in intercepting and absorbing rainfall. Many cities also realize that green features, such as parks and open spaces, make cities more livable and attract people to move to and stay in areas that are greener and because they offer healthier lifestyles, such as walking to work or school.

This plan provides the results of the analysis conducted by the city and its partners, as well as strategies to conserve and restore the city's green infrastructure. This plan will help the city realize new or expanded benefits from its green infrastructure such as, clean water, recreation, stormwater uptake, storm buffering, habitat protection and walkable, vibrant neighborhoods.

what is ['GREEN INFRASTRUCTURE'?]

Green infrastructure includes the marshes, wetlands, rivers, parks, and trees that provide for habitat, clean air, recreation, scenic beauty and moderate air temperatures. In developed areas, constructed green infrastructure such as bioswales, green rooftops or permeable pavers may be used to simulate these natural benefits of water absorption, transpiration and cleansing.

PROJECT PARTNERS

In 2015, the City of Norfolk partnered with the nonprofit Green Infrastructure Center Inc. (GIC) and Old Dominion University (ODU) to develop a Green Infrastructure Plan. The plan is a part of a larger grant from the National Fish and Wildlife Foundation (NFWF), through the U.S. Fish and Wildlife Service which had three focal areas:

- **Green Infrastructure Planning: Citywide Study and Implementation Plan developed by the Green Infrastructure Center and the Norfolk Watershed Management Task Force.**
- **Education and Training for Constructed Green Infrastructure (targeted to veterans and youth) by Old Dominion University (see section Partnerships Make It Possible on page 48).**
- **Shoreline restoration projects installed by the city.**

This Green Infrastructure Plan can help the city better utilize its green infrastructure and thereby reduce flooding, clean waterways, improve access to open spaces, support healthy communities, manage resources effectively, and foster vibrant and attractive neighborhoods and commercial districts. It also can support recognition and context for historic and cultural sites.

As a city that depends on access to the water and is greatly affected by tides and storms at the land-water interface, this plan focuses both on the city's landscapes and water resources. The Virginia Coastal Commission refers to this as 'green and blue infrastructure,' but it is referenced throughout this plan simply as 'green infrastructure.'

A RESILIENT CITY – PAST, PRESENT AND FUTURE

The City of Norfolk is a vibrant, progressive community with a rich and complex history. Overcoming many challenges, the city has shown its resilience since its founding by the British in 1682. And since its very beginnings, the City of Norfolk has had to adapt – to changes in government, revolutionary and civil wars, expansion of its boundary, and population and demographic shifts.

First established as a port town of 50 acres, Norfolk was granted borough status in 1736. Over time, the city has faced a multitude of challenges, such as having to rebuild after being burned by the British in 1776, expansions following two world wars, and natural impacts from the many hurricanes and Nor'easters.

Headstone at risk near shore

By 1845, Norfolk was incorporated as a city of more than 10,000 people, although it lost a third of its population to the yellow fever epidemic ten years later. Seven years later the city became famous for the Battle of Hampton Roads between the first two ironclad battleships – the USS Monitor and CSS Virginia (formerly the USS Merrimac). Two months later, in May 1862, Norfolk surrendered to Union forces and was under Federal occupation for the remainder of the Civil War. Throughout all this change, the city has demonstrated its resilient nature, always coming back from adversity.

Since then, Norfolk has grown tremendously to 246,393 residents and embraced its rich cultural heritage through its diverse neighborhoods, a strong presence of Naval Station Norfolk, universities of Old Dominion and Norfolk State as well as Tidewater Community College, and many diverse business and trades, making the city a dynamic and vibrant place to live and work.

Today, the city is facing a new challenge as rising seas require the city to consider new ways of planning and accommodating higher water levels. According to the National Oceanic and Atmospheric Agency (NOAA), challenges posed by sea level rise have made Norfolk the second most threatened landscape in the United States.[1]

This plan helps the city meet those challenges by becoming more resilient. It identifies new places and strategies to soak up water, buffer areas from storms, clean stormwater runoff, support healthy urban ecology, and provide healthful neighborhoods and vibrant commercial districts.

[1] Norfolk is second only to Louisiana in threats from sea level rise. https://coast.noaa.gov/states/stories/sea-level-rise-adaptation-advances-on-multiple-fronts.html

Process to Create the Green Infrastructure Plan

This report is the culmination of a two-year effort to map and plan for Norfolk's Green Infrastructure. As noted earlier, this plan was funded through a joint proposal to NFWF prepared by the City of Norfolk, ODU, and the GIC. This Green Infrastructure Plan was developed to evaluate the city's current and future options to protect, maintain, and expand its green infrastructure assets.

PLAN REVIEW

The planning process was led by staff at the GIC. The Norfolk Department of Public Works served as the lead agency in managing both the process and the grant funds. The Watershed Management Task Force (WMTF) served as the review and planning group to advise on the creation of this plan. The WMTF is a standing committee formed by the city to advise Norfolk on watershed planning and management issues, as well as to coordinate efforts of the various participating groups. Members include environmental organizations working in the city, local education institutions, as well as city departments with a role in environmental planning and management, including Public Works; Recreation, Parks and Open Space; Utilities; Planning; and the Office of Resilience.

The WMTF reviewed maps, added new ideas and priorities, proposed project planning timeframes, sought input from outside stakeholders, and developed strategies for action. Going forward, the WMTF will serve as the review body for this plan; enlisting new partners, participating in the implementation of the plan's objectives, and tracking progress. Every six months, the WMTF will perform a plan 'checkup' to track metrics, adjust actions, plan implementation projects, and add new strategies, if needed. This plan is adopted as an appendix to the plaNorfolk2030 comprehensive plan. City staff will prepare a summary of progress to present to city Executive Staff as part of the biennial plaNorfolk2030 reporting.

The city's Watershed Management Task Force works on the plan ideas led by staff from the Green Infrastructure Center Inc.

PUBLIC ENGAGEMENT

A total of ten community meetings were held to inform the plan's development; five were held in the fall of 2016 and five in fall of 2017. Meetings were held at community recreation centers across the city and at the Slover Library so as to provide multiple options for attendance. Consultations were also held with Norfolk's Departments of City Planning; Recreation, Parks and Open Space; Public Works; the City Manager's Office of Resilience; and Neighborhood Development. Local organizations that have major partnership projects with Norfolk were also consulted including the Elizabeth River Project, Friends of the Elizabeth River Trail Foundation, the Lafayette Wetlands Partnership, Wetlands Watch, the Chesapeake Bay Foundation and others. To identify additional locations for African American heritage sites, faculty from Norfolk State University and the Norfolk New Journal and Guide were also consulted and those locations were added to the history and culture map. Staff from the Navy and ODU were also consulted to learn about their plans for incorporating green infrastructure and planning for sea level rise.

Participants at community meetings were asked questions such as:

Where can shorelines be restored to a more natural state for wildlife and buffering from storms?

Where is flooding a problem?

Where can new trees be added?

Where can new trails or water access be added to enjoy nature?

Comments from stakeholders included desires for additional access points for water recreation, such as boating and fishing; the additions of historic and cultural sites for African American history; concerns for infiltrating water to reduce nuisance flooding; more access to open spaces and trails; green streets for walking to school; more restoration projects and maintenance for already installed projects; and a need for shade trees; not just for streets,

but also for bus stops. Staff from the Navy indicated an interest in naturalizing landscapes, such as converting lawns to meadows to soak in more water and reduce maintenance costs, planting more trees, oyster bed restoration and removal of invasive vegetation.

To avoid duplication and to utilize existing efforts, data were included from recent and concurrent city efforts, such as workshops on Complete Streets, Vision 2100 cultural sites, fishing access, and passive kayak access locations.

Two presentations for this project were made to the Planning Commission. The first presentation explained the plan's purpose and intended outcomes and the second entailed presentation of the full plan. The plan was then presented to City Council for review and adoption as an appendix to plaNorfolk2030.

DATA CREATION AND ANALYSIS

In order to map and evaluate the city's natural green infrastructure, the GIC created a land cover map using imagery from the National Aerial Imagery Project (NAIP).[2] The NAIP imagery are updated every 2-4 years by the US Department of Agriculture during the growing season when vegetation is most easily identified. The data include infrared bands (reflected light) that can be classified to determine land cover types; trees, shrubs, grass, bare soil, and impervious surfaces. This land cover classification was used to determine the city's tree canopy, distinguish pervious and impervious surfaces, and to identify other features. Another data source used was LiDAR (Light Detection and Ranging). LiDAR is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. LiDAR data were used to help distinguish large and small vegetation, such as identifying a tall tree based on its height, as opposed to a short bush.

Excessive impervious surfaces in Norfolk add to urban runoff and flooding.

Maps beginning on page 13 show the results of this analysis, the current green infrastructure network map and proposed future network map.

Aerial imagery is converted to pixels, which are then classified by their spectral signature and shapes – for example, spectral wavelengths for asphalt, vegetation or water are all distinct. These pixels are then converted to GIS data, allowing calculations of which areas are trees, shrubs, roads, buildings etc. Additional city GIS data such as roads and underground utilities, parks and schools and other data were also used.

[2] *Although the State of Virginia created a statewide land cover during the period of this grant, image comparisons analyzed by GIC showed it to be too inaccurate to use in dense urban areas.*

[3] *Geodatabase is a collection of geographic datasets of various types held in a common file system folder.*

Green Infrastructure Plan Focus

The interface between land and water affects almost every aspect of life in Norfolk. To reflect this reality, the plan has two broad themes for focus, one for land and one for water:

> For land, the focus is to protect, connect, and re-green the landscape to provide pathways for wildlife and people, infiltrate stormwater, reduce flooding, and beautify the city.
>
> For water, the focus is to restore shoreline habitats to support aquatic life, buffer areas from storm surge, and foster recreation, including birding, boating and fishing.

The green infrastructure planning process entails setting goals (see above for focus areas), obtaining data, mapping assets, evaluating risks, determining opportunities, and creating an implementation plan.

Green infrastructure was originally defined in 1994 as intact habitats such as forests, wetlands, rivers, meadows and other natural open spaces that provide benefits to people such as cleaning the air, filtering water runoff, and providing access to recreation, and supporting agricultural soils for food (Benedict and McMahon 2006). Twelve years later, in 2006, the U.S. Environmental Protection Agency (EPA) added constructed green infrastructure to the definition. They included best management practices such as bioswales, green rooftops, and planted storm drains using Filterra™ boxes. However, this led to some confusion over the term 'green infrastructure.'

The NFWF grant that funded this plan called specifically for a plan to address 'natural green infrastructure.' Therefore, this plan first looks at how to maximize the city's 'natural green infrastructure' including wetlands, trees, open spaces (parks, meadows, trails, creeks) and second at considering how to mitigate impacts from development (impervious surfaces) with 'constructed green infrastructure'.

Why does this order of focus matter? In some cases, lands are cleared of natural green infrastructure (vegetation) that is already soaking up stormwater and then natural functions are added back in the form of constructed green infrastructure (bioswales) with varying degrees of success. Clearing a lot of all trees and then trying to replicate the hydrology with bioswales or other 'constructed green infrastructure' techniques does not always work. Conserving natural vegetation in the first place and adding it back where possible is the far cheaper and more effective way of infiltrating or evaporating water compared to engineered solutions. In short, the focus is first on conservation, then on restoration, and lastly on mitigation.

The urban forest protects the water quality of the marsh and provides habitat.

Shoreline restoration opportunities have been identified throughout the city.

In urban areas, landscapes are evaluated at smaller scales and even fragmented patches of green space are important to consider because, together, they can make a large, cumulative difference. Smaller urban spaces, such as creeks, vegetated swales, or even pocket parks, and dunes contribute to the connected green landscape. Tree canopy, surface waters and wetlands form the key natural habitats. When evaluating the ecological health of an urban area, urban tree canopy is a key green asset. Trees provide multiple ecosystem services to make a city more livable.

*"In short, the focus is first on **conservation**, then on **restoration**, and lastly on **mitigation**."*

Social and Economic Benefits of Natural Green Infrastructure

Trees create a walkable city! When trees are not present, distances are perceived to be longer and destinations farther away, making people less inclined to walk or bike than if streets and walkways are well treed (Tilt, Unfried and Roca 2007). Existing streets such as Ocean View Avenue, could be retrofitted to realize the benefits of a walkable, green community described below.

- Trees clean the air and well treed neighborhoods suffer less respiratory illnesses, such as asthma. (Rao et al 2014),
- Well-being and mental health – people heal faster when they can see or access green (Ulrich 2012),
- Less crime occurs near trees, especially large ones; this is a key concern for downtowns and public housing areas (Wolf and Mennis 2012; Donovan et al 2012; Kuo and Sullivan 2001).
- One mature tree can uptake 3,000 or more gallons of water annually, making trees a key stormwater management tool (Firehock 2015).
- Urban canopy can reduce a city's stormwater runoff by anywhere from two to seven percent (Fazio 2010).
- People shop for longer and pay more per item in tree lined shopping districts, so trees tree planting in commercial areas can pay for itself through increased tax revenues (Wolf 2003).
- Proximity of parks (within 1,500 feet) increases home sales prices by up to 2000 dollars; proximity to larger naturalized parks shows more significant property value increases than to developed parks such as playgrounds, skate parks or golf courses (Shoup et al 2010).

The urban forest provides many benefits such as keeping the city cool and providing natural beauty.

Even though Norfolk is mostly developed, trees can be planted, marshes and wetlands can be restored, and new open spaces such as parks, trails and boat launches can be added. As the city works to live better with water, it is embracing technologies and conservation approaches that are greener and often less expensive. When more green spaces are saved or created, there is less stormwater runoff, so fewer costly stormwater treatments are needed. These greener approaches increase public safety as flooding risks are reduced. They also provide other benefits such as natural beauty, cleaner air and water, and access to recreation opportunities for people of all abilities. (See sidebar for additional benefits).

Taken together, clusters of trees, along with other native vegetation, such as shrubs and native grasses, wetlands, and marshes provide important habitats for wildlife. In urban areas, smaller habitats add up and provide myriad benefits for organisms, such as frogs, birds, pollinators and other beneficial insects.

One challenge is that many urban trees do not survive to their full potential life span. Lack of watering, insufficient soil volume or compacted soils put stresses on urban trees, stunt their growth, and reduce their lifespans.

For every 100 street trees planted, only 50 will survive 13-20 years (Roman 2014). Much of this mortality is because the wrong species are selected, there is inadequate watering before the trees are established, they are given overly small planting areas, or because of such uncontrollable factors as storm damage and disease. This means that good planting practices, long-term tree care, and adequate maintenance are critical to protect and realize the advantages of a healthy urban forest.

NATURAL ASSETS: HABITATS, WATER, RECREATION, CULTURAL

This project created maps of the city's natural assets, forest canopy, water resources, recreation, and historic and cultural assets which are presented in this section. The city's tree canopy was mapped at a high level of detail, while the best available or collected data were used for other assets. It's important to know where tree canopy, wetlands, and other types of vegetation are located – these are key pieces of the city's green infrastructure.

Maps on pages 13 through 18 show the city's natural assets such as tree canopy, nature based recreation and culture. On page 19, these resources are mapped as the green infrastructure network as it stands today and on page 20, the future desired network is shown with increased connectivity to link parks, trails, and other natural and cultural assets.

How Green Is Norfolk's Land?

Canopy data were created from 2015 National Agricultural Imagery Project data, which were manually updated in 2018 to reflect large scale changes. Norfolk's current urban tree canopy is 24.27% of the land area, including military lands and water. However, since trees can't be planted in open water and the city does not manage the Naval Base, excluding those lands from the denominator, gives a result of 25.8% canopy coverage. (See map on pg. 13.)

Canopy was also analyzed by civic league. Since not all areas of the city are covered by a designated civic league, the remaining areas were grouped into neighborhoods. Depicting the amount of canopy present may motivate civic leagues, the city, and other community partners to collaborate on planting projects. Canopy varies by neighborhood. Collaboration matters, since as the text box on page 11 notes, well treed neighborhoods tend to have lower crime, see more walking and residents suffer less respiratory illness, provide more vibrant commercial districts, and leave less standing water. (See map on pg. 14.)

Water: Living in an altered landscape and hydrology

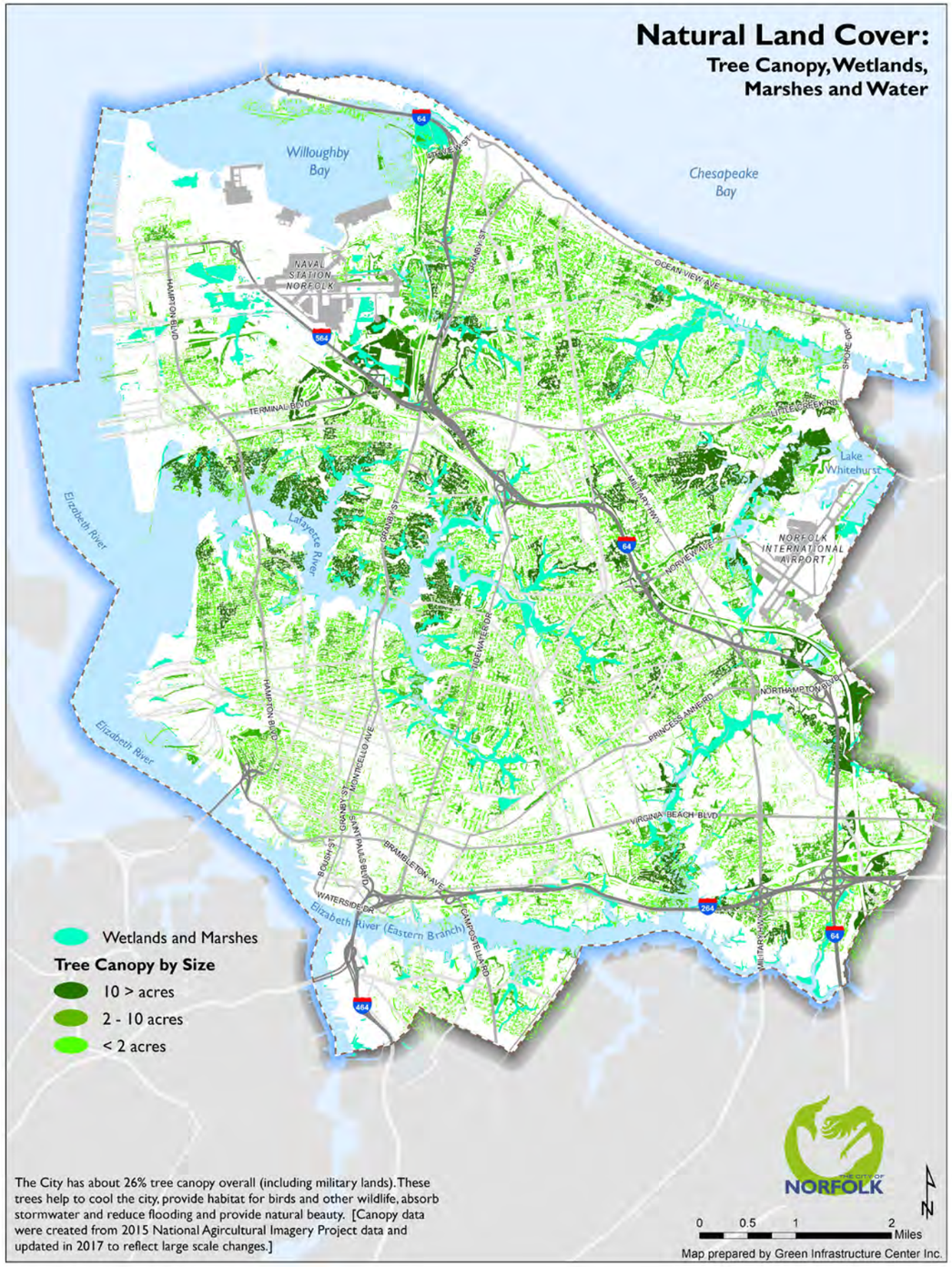
As a city whose 66.32 mi^2 area is about a third water (53.87 mi^2 land and 12.45 mi^2 water), living with water is a key theme in the city's resilience strategy. This area of water also results in 211 miles of shoreline along the rivers, creeks and marshes that drain the city and surround it. At a 10.3-foot average elevation, the city's low profile makes some areas of the city more susceptible to flooding from coastal storms, high monthly spring tides or annual king tides, and rising sea levels.

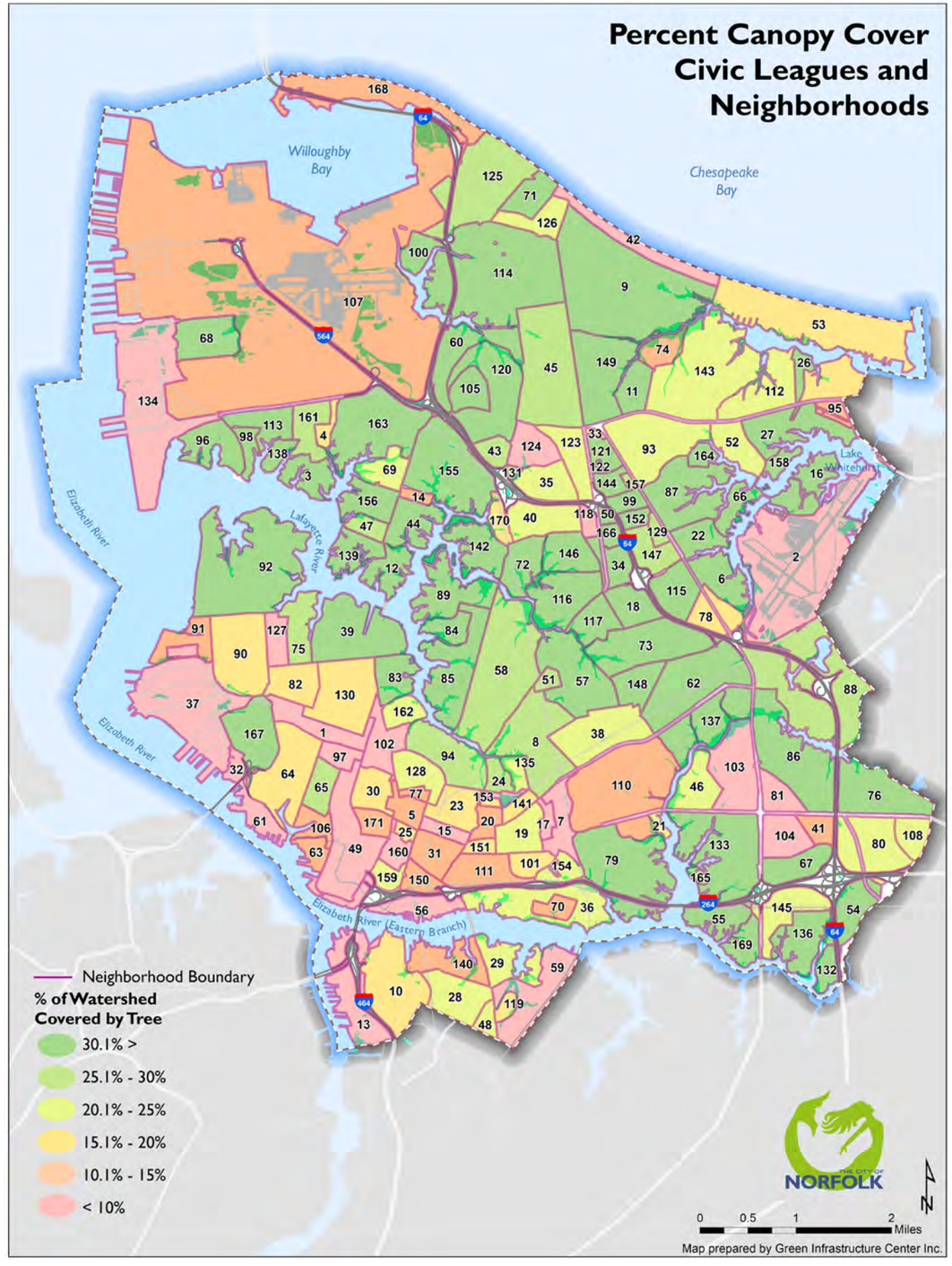
Since settlement, people have been altering the coastal landscape. Shorelines have been hardened to resist wind and wave energy; areas that were once marsh have been filled, and wetlands, meadows and forests along the coast have been cleared to make room for growth. As areas were filled in or paved, water that once flowed in open channels or marshes was put into the city's extensive storm drain network or remaining narrow ditches.

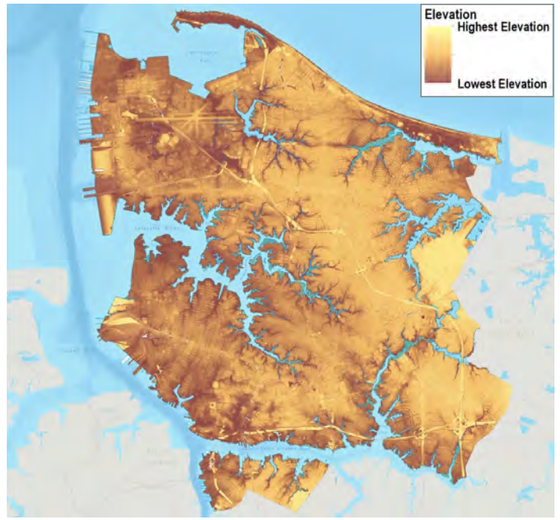
Regulations under the 1987 Clean Water Act Amendments require the city to manage and clean its stormwater runoff. Like most large cities, the Amendments require Norfolk to hold a Municipal Separate Storm Sewer Permit (MS4) that governs how it manages its stormwater and how land disturbance is mitigated. As in many

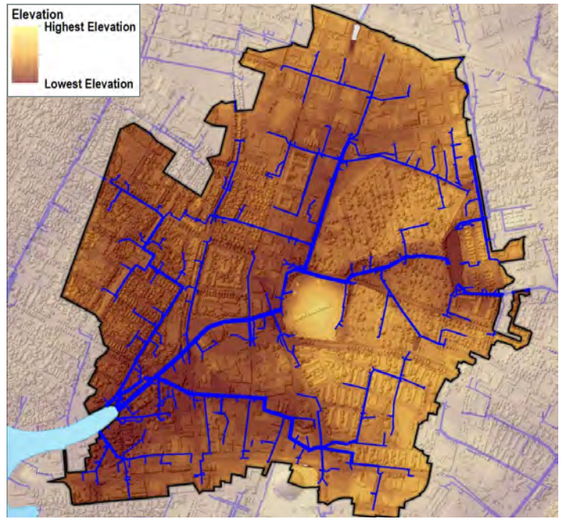
Watershed Name	Mean Elevation (ft.)
Willoughby Bay	9.0
Ocean View	10.2
Mason Creek	11.2
Little Creek	9.8
Lake Whitehurst	14.0
Lafayette River	9.6
Eastern Branch Elizabeth River	11.4
Broad Creek	11.3
Elizabeth River	9.0
Southern Branch Elizabeth River	9.4
Port and Military Base	8.9
City	10.31

This hardened shoreline is intended to resist wave energy.


Natural Land Cover:
Tree Canopy, Wetlands, Marshes and Water
Willoughby Bay
Chesapeake Bay
Elizabeth River
Lafayette River
Lake Whitehurst
NAVAL STATION NORFOLK
NORFOLK INTERNATIONAL AIRPORT
Elizabeth River (Eastern Branch)
Wetlands and Marshes
Tree Canopy by Size
10 > acres
2 - 10 acres
< 2 acres
The City has about 26% tree canopy overall (including military lands). These trees help to cool the city, provide habitat for birds and other wildlife, absorb stormwater and reduce flooding and provide natural beauty. [Canopy data were created from 2015 National Agricultural Imagery Project data and updated in 2017 to reflect large scale changes.]
0 0.5 1 2 Miles
Map prepared by Green Infrastructure Center Inc.


Percent Canopy Cover
Civic Leagues and Neighborhoods
Willoughby Bay
Chesapeake Bay
Elizabeth River
Lafayette River
Lake Whitehurst
Elizabeth River (Eastern Branch)
Neighborhood Boundary
% of Watershed Covered by Tree
30.1% >
25.1% - 30%
20.1% - 25%
15.1% - 20%
10.1% - 15%
< 10%
0 0.5 1 2 Miles
Map prepared by Green Infrastructure Center Inc.





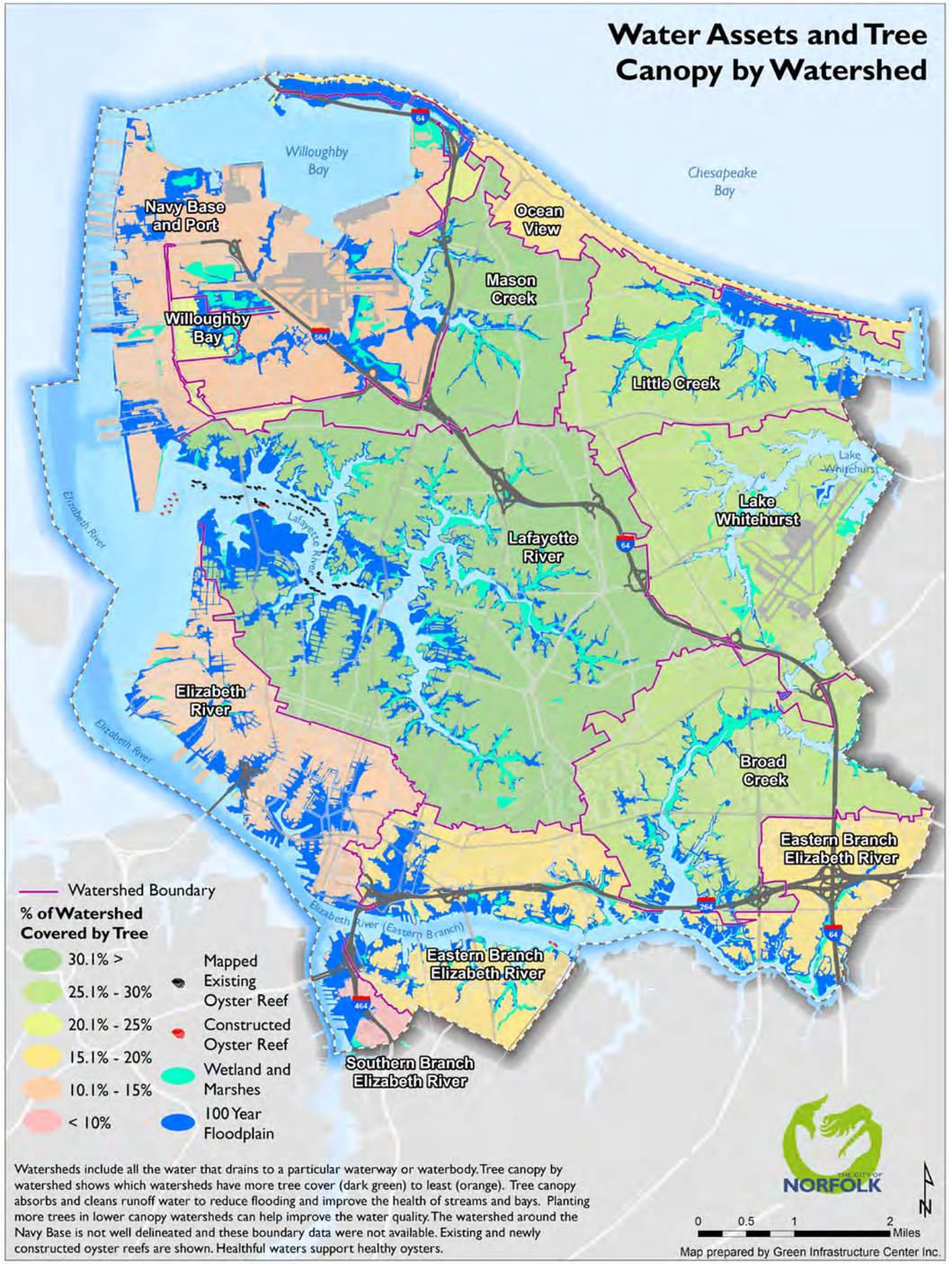
Areas that have poor drainage often occur along places that were once headwaters of creeks and marshes but are now covered over. This image at right shows an area in the Hague where natural drainage once occurred but is now replaced by pipes. Before development, the channel (light blue stream channel in map at right) would have extended inland. As seas rise, some areas are more difficult to drain as water begins to enter storm drain pipes from the sea, limiting the ability of the pipes to handle runoff.

older cities, much of Norfolk's landscape did not have available infrastructure to detain, retain, or treat its stormwater when it was first built, so rainfall carried surface pollution and excessive water volume directly to nearby creeks and the Chesapeake Bay.

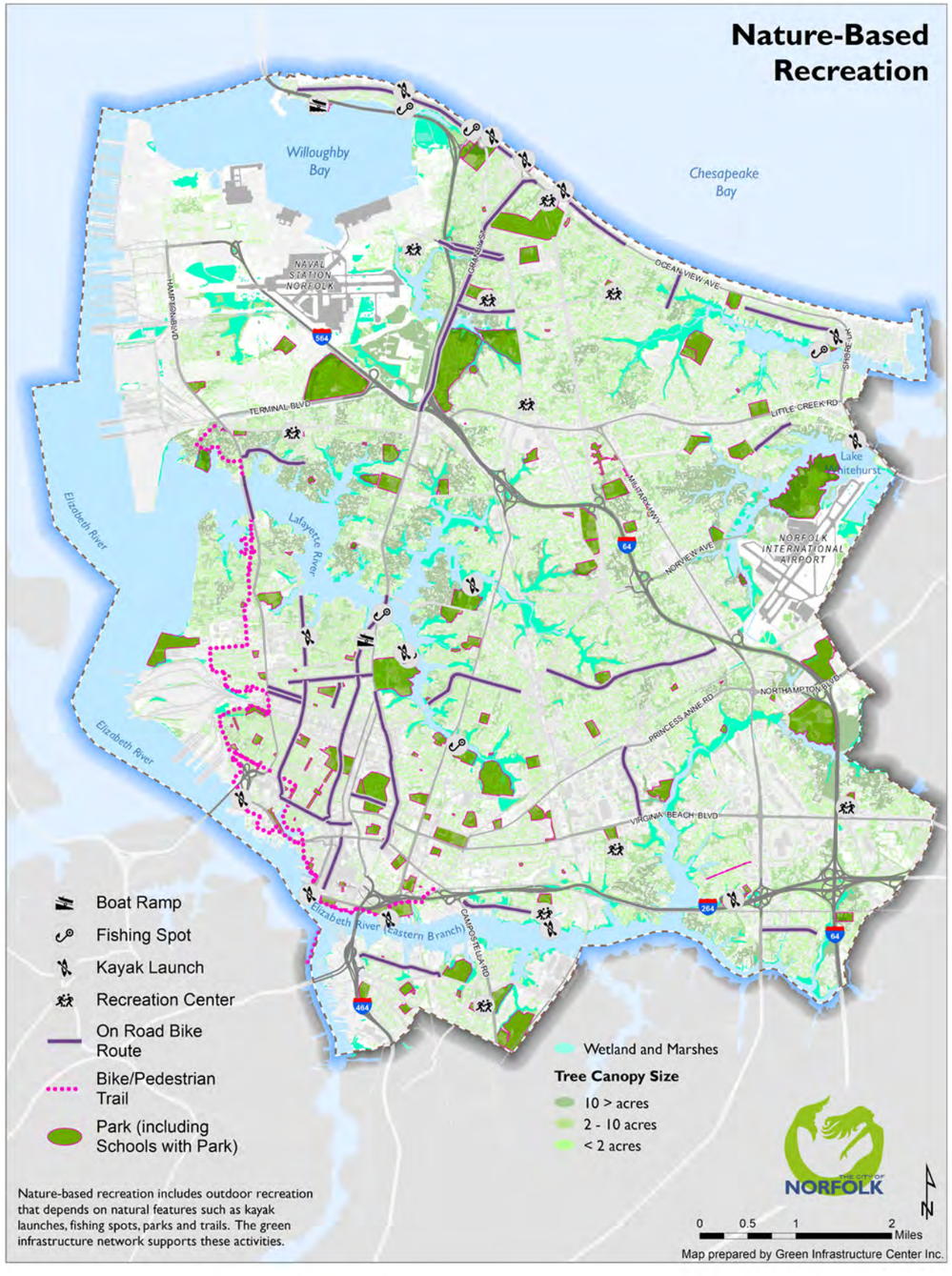
Subsequent regulations addressing the Chesapeake Bay including the Bay Preservation Act and the Chesapeake Bay TMDL, place additional requirements on the city to protect vegetated buffers where possible and to meet new additional goals for water cleanup. Many of the strategies in this plan help the city meet the requirements of these programs. This plan includes strategies that foster stormwater detention and retention, as well as filtration. Most importantly, implementing this plan will reduce the sources of runoff by adding more opportunities for water infiltration or capture, such as planting more trees, planting buffers and innovative practices such as stormwater playgrounds. (See Rainwater Infiltration map on page 40).

Despite manmade modifications, water still drains to the lowest point, so today, areas developed above former creek beds that are now piped, tend to hold standing water or experience flooding. However, the city is undertaking many efforts to mitigate past impacts and to develop in a new way that is sensitive to natural features and works with nature. Restoring these areas by daylighting creeks, constructing ponds, replacing pipes with ditches, or expanding marsh areas can provide more water storage and drainage to alleviate nuisance flooding.

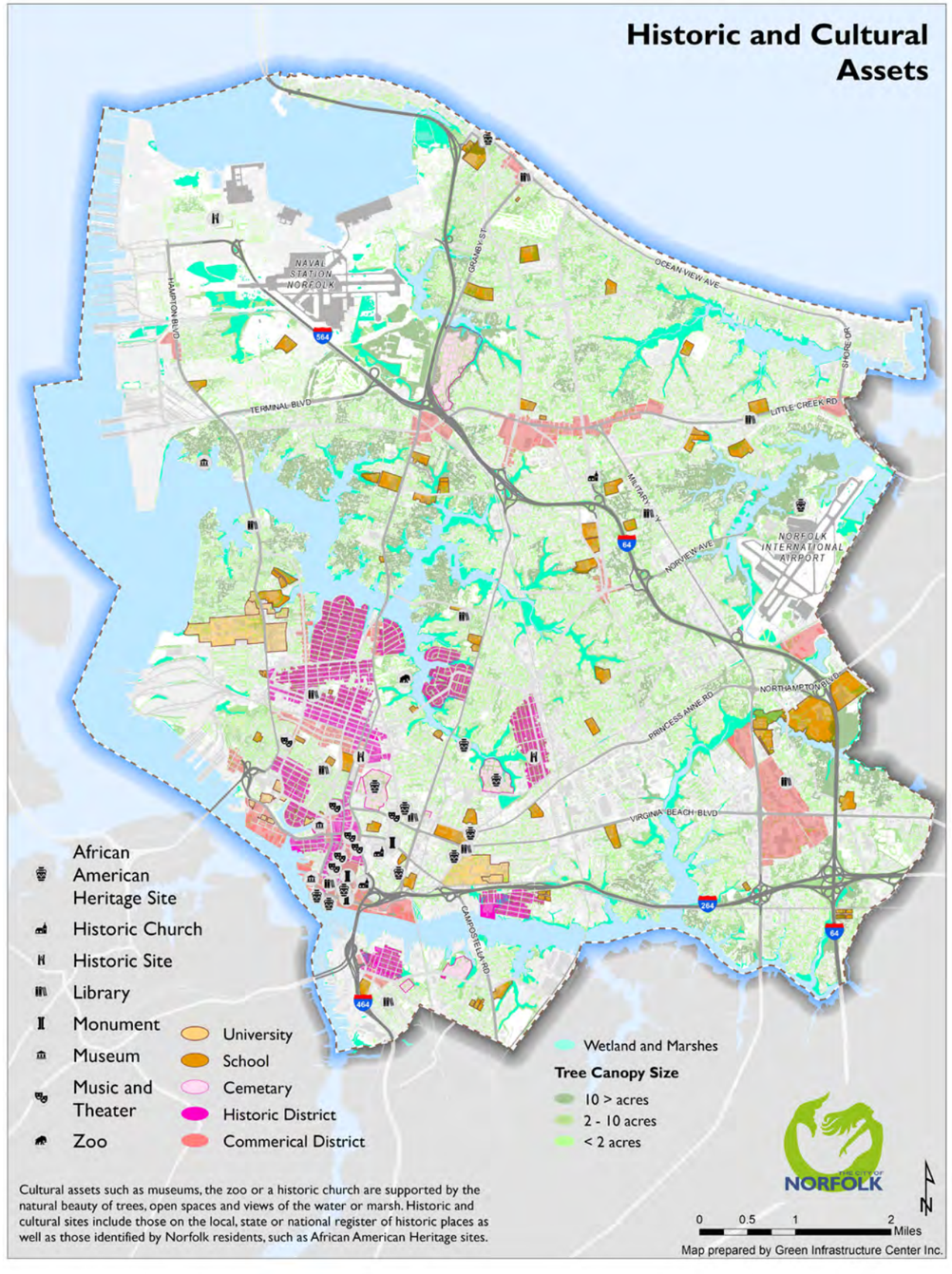
Poor drainage leads to standing water that causes health concerns from mosquitoes.



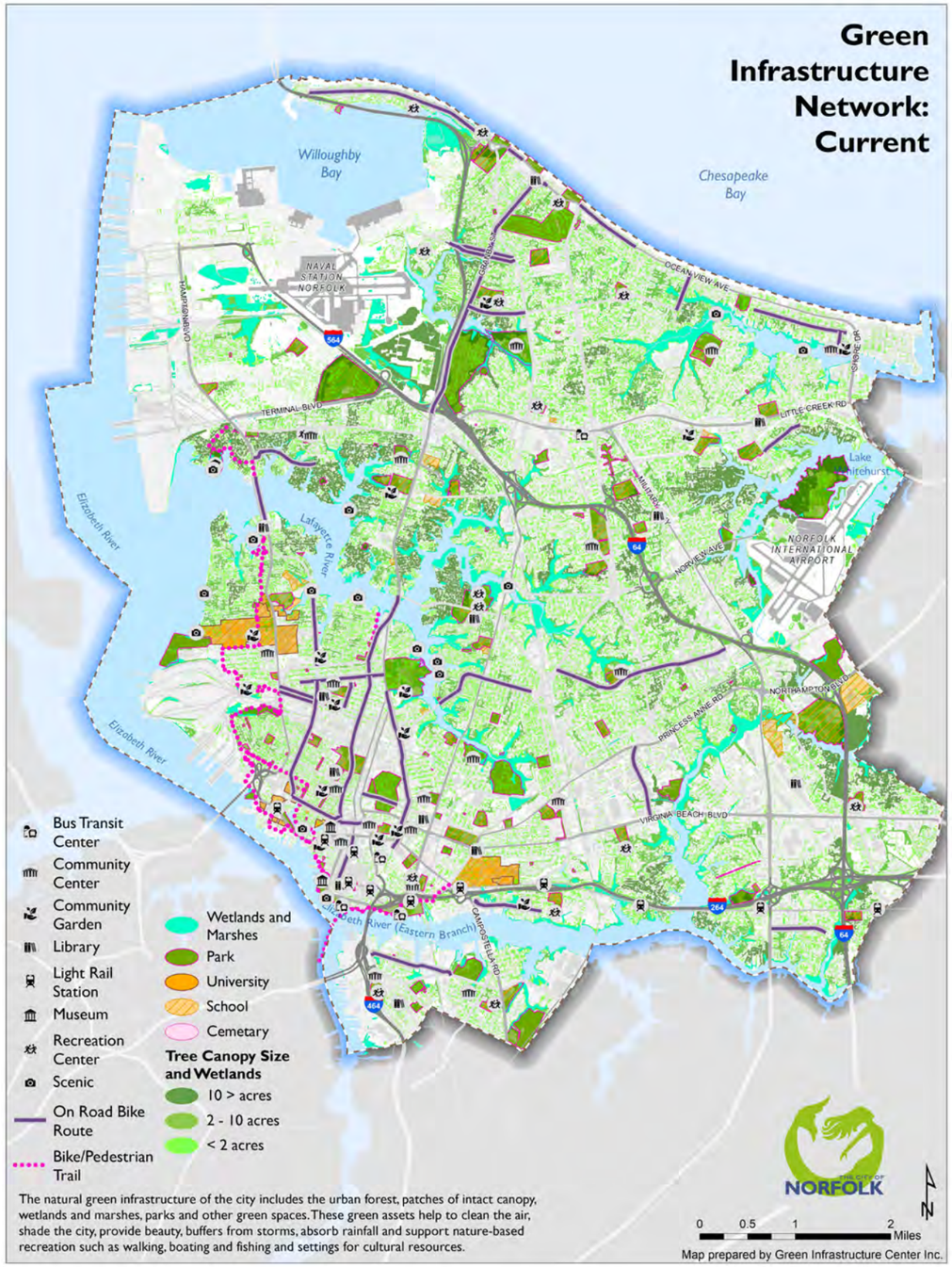
OPEN SPACES AND NATURE BASED RECREATION ASSETS



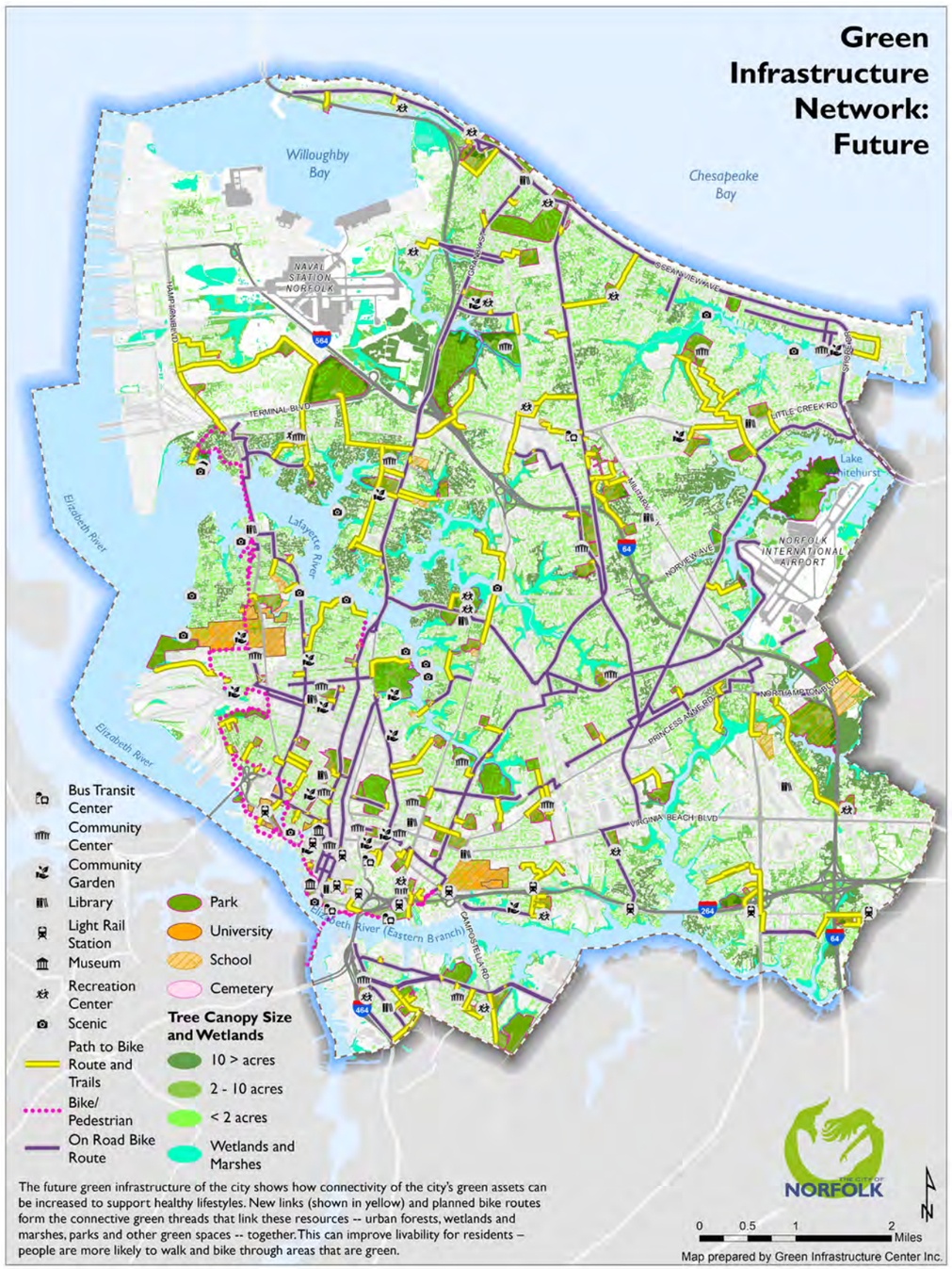
CULTURAL AND HISTORIC ASSETS

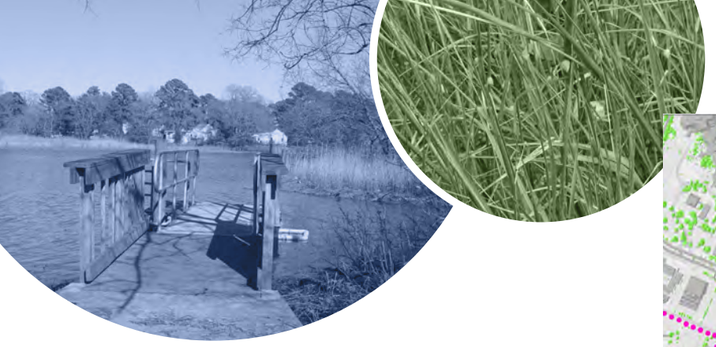


THE GREEN INFRASTRUCTURE NETWORK



THE FUTURE GREEN INFRASTRUCTURE NETWORK





USING THE MAPS

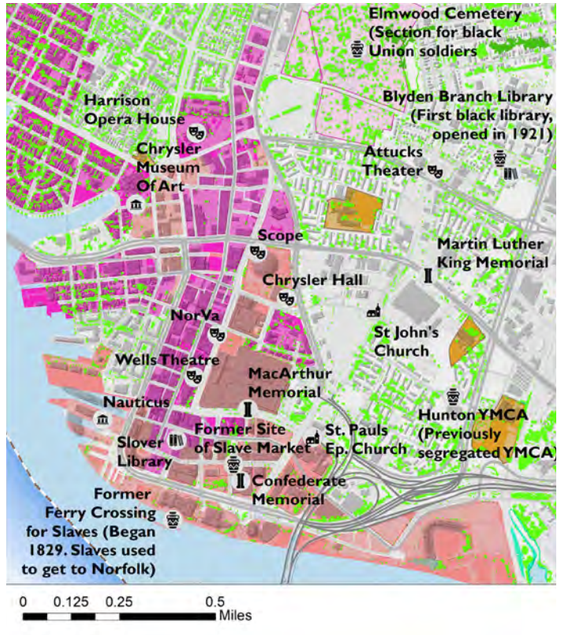
The maps on the previous pages can be used for everyday decision making. As the future green infrastructure map inset shows at right, new green connections, shown in yellow lines, can be made to link trails (pink) to public transportation or to connect parks.

The map of historic and cultural features (see inset below) shows how the tree canopy and water surround and support the historic and cultural elements of the city's downtown.

The recreation map (see inset below) shows the locations of water and park access, allowing planners to identify where additional access points are needed. Norfolk has few public boat ramps considering the size of the city. More access points will be designed to allow everyone to access the water.

Zoom view Future Green Infrastructure Network Map (see full size map on page 20).

Zoom view Nature-based Recreation Map (see full map on page 17).



Zoom view "Historic and Cultural Assets Map (see full map on page 18).

ANALYSIS – OPTIONS TO CREATE A GREENER, MORE RESILIENT CITY

There are many options for creating a greener city. On the land the city can plant more trees, wildflower meadows, and restore inland wetlands and vegetation around lakes to absorb and filter water, provide for cooler summer temperatures, and provide beauty. At the land-water interface of tidal waterways, it can restore vegetated buffers and also create living shorelines that facilitate survival for wildlife, fish, and shellfish, as well as options for people to interact with water through scenic views, pathways, boardwalks, and fishing and boating access. In the following sections, analysis of the shoreline restoration and options for tree planting are discussed. This analysis laid the groundwork for the strategies outlined on page 50.

Tree Canopy

Tree canopy is a key measure of the city's green infrastructure. Trees absorb water, clean particulate matter and volatile organic chemicals (VOCs) from the air, support wildlife and pollinators, shade the city, reduce energy bills and add beauty. Supporting a robust tree canopy is indicated in plaNorfolk2030. The plaNorfolk2030 references the city's canopy goal of 40%. The expressed goal of 40% canopy was based on an earlier, less precise analysis and was likely an overestimation of the baseline. The older land cover analysis showed the city as having 35% canopy, so a 5% increase to achieve 40% canopy seemed reasonable at the time it was proposed.

Current tree canopy was calculated with 2014 imagery and updated in 2017 with major changes noted. Current canopy is actually only 25.8%. To set an achievable goal, the available space for planting needs to be calculated first. So, the question is, how much space is available to add more canopy?

Given a 25.8% tree canopy, and using all available land to plant, the new analysis shows the city could achieve a total canopy of about 36% canopy (roughly 10% more). However, this is an optimistic number because there are more areas that could still be excluded as plantable. Obvious exclusions to open space planting that have been addressed in the analysis as not available for planting include sports fields and paved areas (see text box on PPA, page 24), but other areas could also be off limits, such as a large vegetable garden, where shade is not desired. Planting to a canopy coverage of 36% would require covering every yard and lawn with trees, which is neither possible nor achievable. The chart on the page following shows the ownership percentages of city tree canopy. Note that almost 60 percent of the plantable area is on private property.

Although most of the plantable areas are on private lands, there are opportunities to plant on public spaces, such as parks and schools. For example, tree canopy coverage at schools is currently 19%. There is the potential to plant 4,537 twenty-foot spread canopy

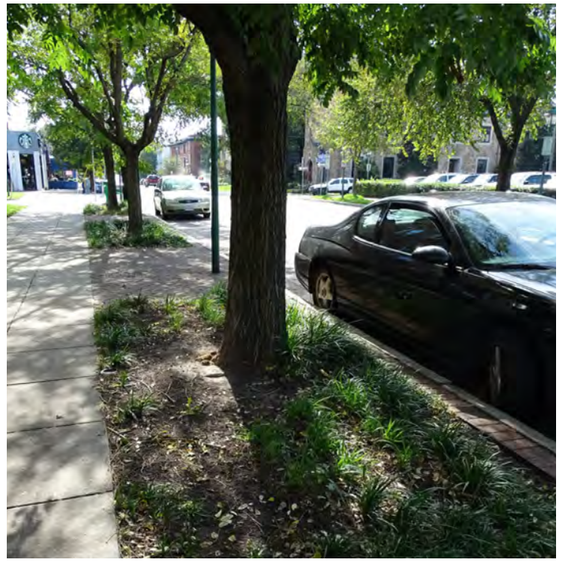
Civic engagement in restoration

Tree planting opportunities

City park with room for new trees

(small) trees and 6,111 forty-foot spread canopy (large) trees, on school sites, accounting for 6.82% PPA.

Since there is about 26% canopy coverage today and only about 10 percent can be planted, only 36% canopy is possible. Since planting every open space with trees is not realistic, a lower target of adding another 4% canopy is reasonable. This achieves a new canopy goal of 30% using up just under about half the available land. (See the text box on the following page 'How Plantable area is determined.')



Having adequate room to grow makes a difference in tree longevity, so careful planning is needed to ensure future trees are planted in the right spaces The tree in the top photo is in too small of a space while the trees in the bottom image have plenty of room to thrive.

Plantable Area Ownership	
City	12.16%
Federal	0.75%
Private	59.25%
State	6.22%
Transportation	21.62%
Grand Total	100.00%

In addition to planting trees in new areas, trees will also need to be replaced where they exist currently. As explained earlier, tree mortality tends to be higher in urban areas and new tree planting is vital to ensuring that annual losses (from removal, old age or disease) do not dramatically outpace plantings. Also, since people are more likely to walk and shop in tree lined streets, this plan looks at street tree canopy to meet city goals for health and economic vitality.

How many trees are needed to reach a 30% target canopy?

1. *To increase canopy from the current coverage 26% to 30% the City of Norfolk needs to plant enough trees to achieve 4% more canopy.*
2. *4% of the plantable area = approximately 84,000 trees (of 20 ft. and 40 ft. canopy spreads).*
3. *1000 trees are lost each year (due to old age, disease, removal, storms).*
4. *The city plants about 2000 trees each year (currently through city plantings and adopted trees)*
5. *This equal a net of 1000 new trees annually (2000 planted minus 1000 lost)*
6. *How many trees need to be planted each year to = 84,000 trees net over a 20 year period? 84,000 + (1000*20 years) = 104,000 trees need to be planted (to account for loss)*
7. *104,000 trees/20 years= 5,200 trees planted annually to cover 4% of plantable area*
8. *This requires an additional 3,200 trees to be planted every year based on 2000 planted now + 3,200 more needed= 5,200 trees per year to plant*

Forested buffers help hold soil in place and filter land runoff.

In summary (see list of calculation steps on prior page) the city needs to plant 5,200 trees annually to reach 30% canopy within a 20-year window of time. This will require the city to plant an additional 3,200 trees more than the current planting levels of 2,000 trees per year. The map of current and potential tree canopy on the following page shows where trees are currently (green) and where more could be added (orange).

Canopy Uptake of Stormwater

Planting trees can also help the city address stormwater runoff. The City of Norfolk is 47.89% impervious with an additional 3.18% that is impervious covered by canopy. A mature large tree can uptake 3000 or more gallons of stormwater annually. However, to reduce runoff and flooding, the city should plant far more trees annually than it does at present to maintain current canopy and to expand it. If just a quarter of the total possible planting area in the city was planted with large canopy trees (spreads of 20 to 40 feet), those could uptake four million additional gallons of stormwater in a 5yr/24 hour storm. Currently the possible planting area for the city's public property is 20% so if 50% of this were planted, it would uptake 1.6 million additional gallons of stormwater (see map on following page).

How plantable area is determined:

Potential Planting Area

The Potential Planting Area dataset has three component data layers. They are created using the land cover layer and relevant data, in order to exclude unsuitable tree planting locations, especially where trees would interfere with existing infrastructure or land uses, such as ball fields. The Potential Planting Area (PPA) is created by selecting the land cover features that have space available for planting trees, then eliminating areas that would interfere with existing infrastructure. So a tree needs to be planted a certain distance away from a building, a light pole, a storm drain or other features. The list below shows what was included as plantable area and the setback distance from those features.

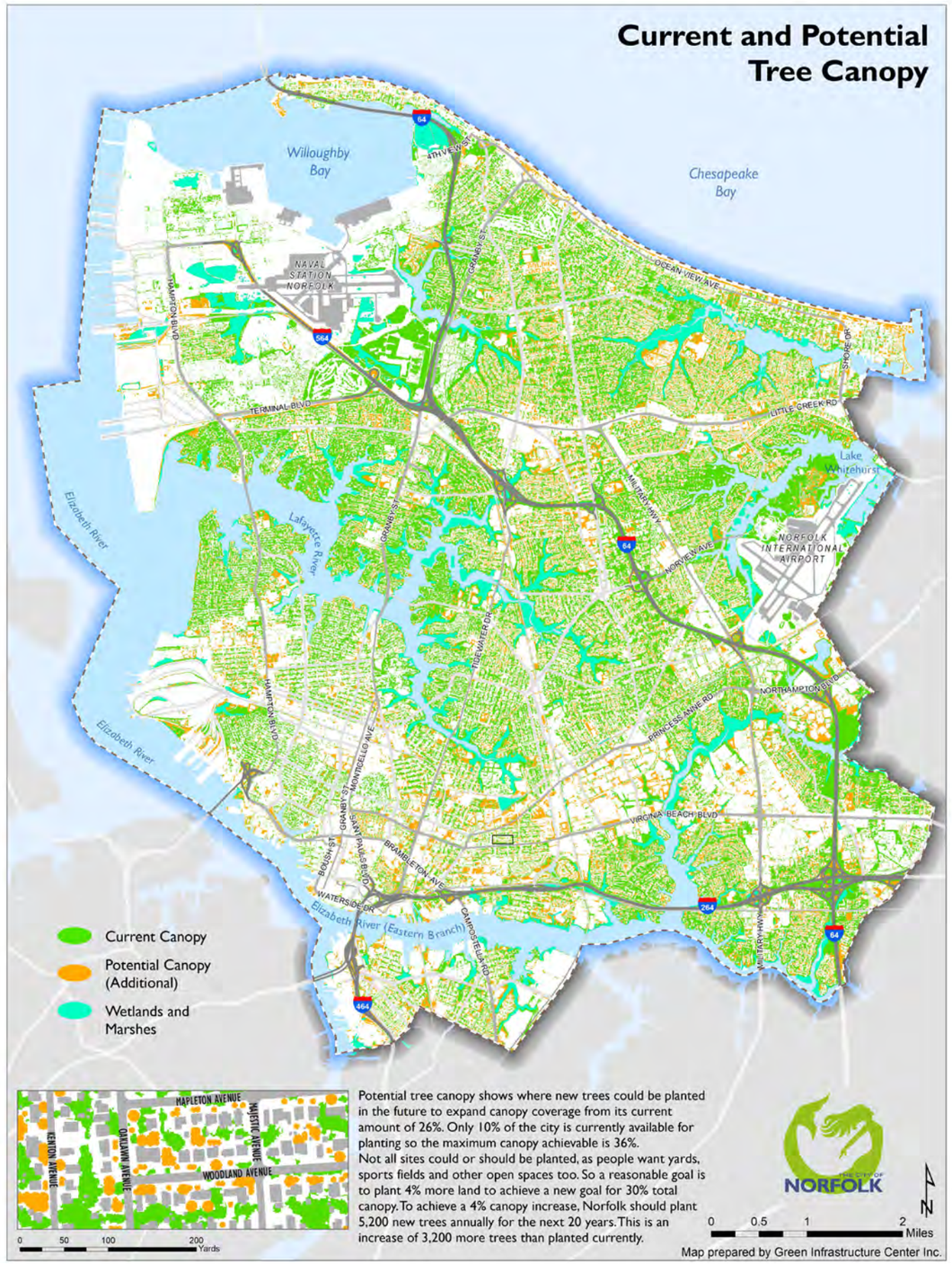
Areas included as plantable from GIC created land cover:

- Pervious surfaces
- Bare earth
- Beach

Areas and features excluded: (setback buffer distance)

- Excluded land cover features
  - Existing tree cover
  - Water
  - Wetlands
  - Imperious surfaces
- Ball fields (i.e.: baseball, soccer, football) where visually identifiable from NAIP imagery. (Digitized by the GIC)
- Golf courses
- Cemeteries
- Roads (based on road width estimate from centerlines) (5ft)
- Sidewalks (5ft)
- Park trails (5ft)
- Railroads (10ft)
- Buildings (15ft)
- Wetlands (10ft)
- Hydrologic features (10ft)
- Active airport area (near and around runways)
- Stormwater ditches (5ft)
- Stormwater pipes (5ft)
- Sanitary pipes (sewer) (5ft)

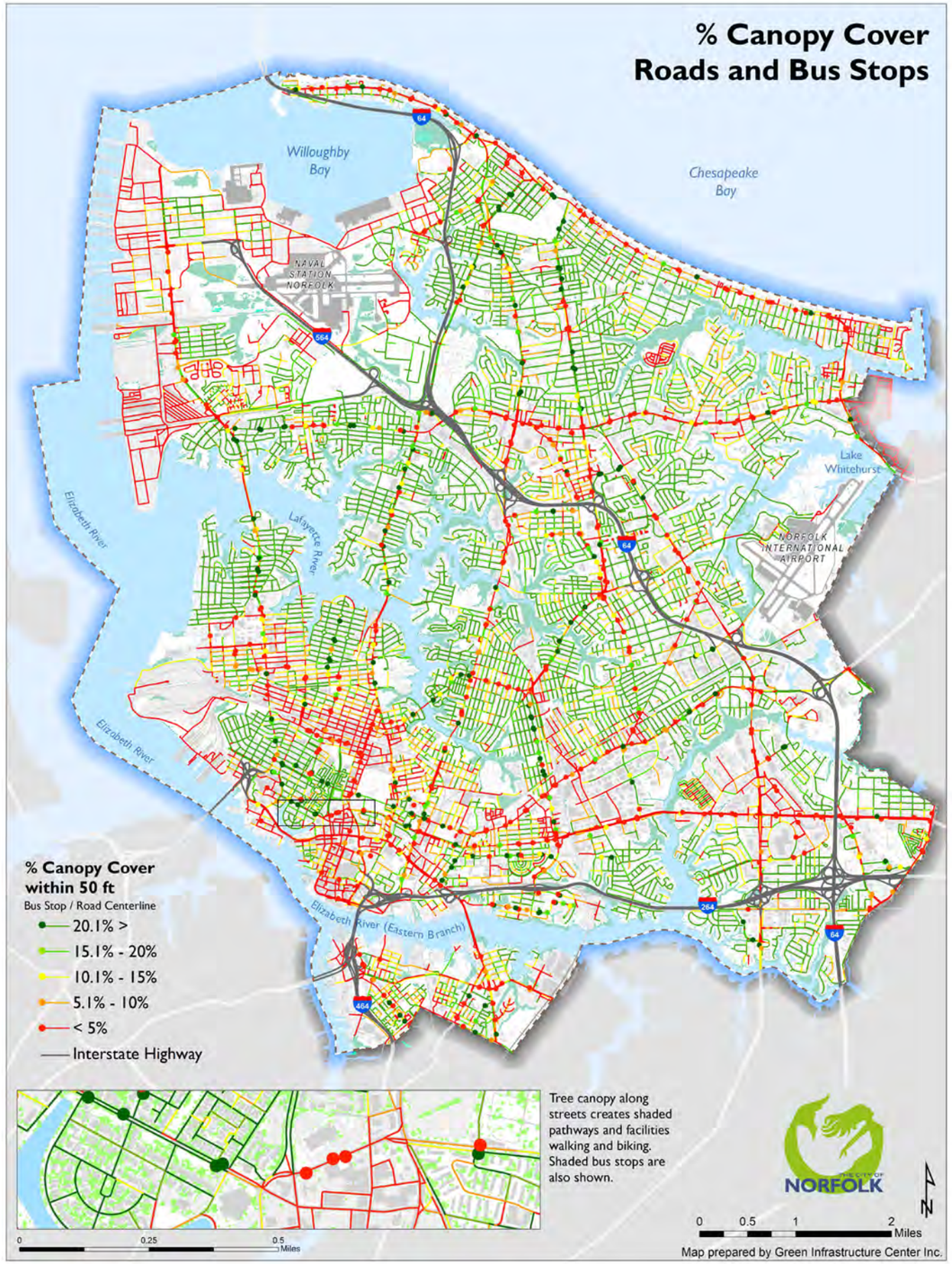
Current and Potential Tree Canopy



Potential tree canopy shows where new trees could be planted in the future to expand canopy coverage from its current amount of 26%. Only 10% of the city is currently available for planting so the maximum canopy achievable is 36%.
Not all sites could or should be planted, as people want yards, sports fields and other open spaces too. So a reasonable goal is to plant 4% more land to achieve a new goal for 30% total canopy. To achieve a 4% canopy increase, Norfolk should plant 5,200 new trees annually for the next 20 years. This is an increase of 3,200 more trees than planted currently.

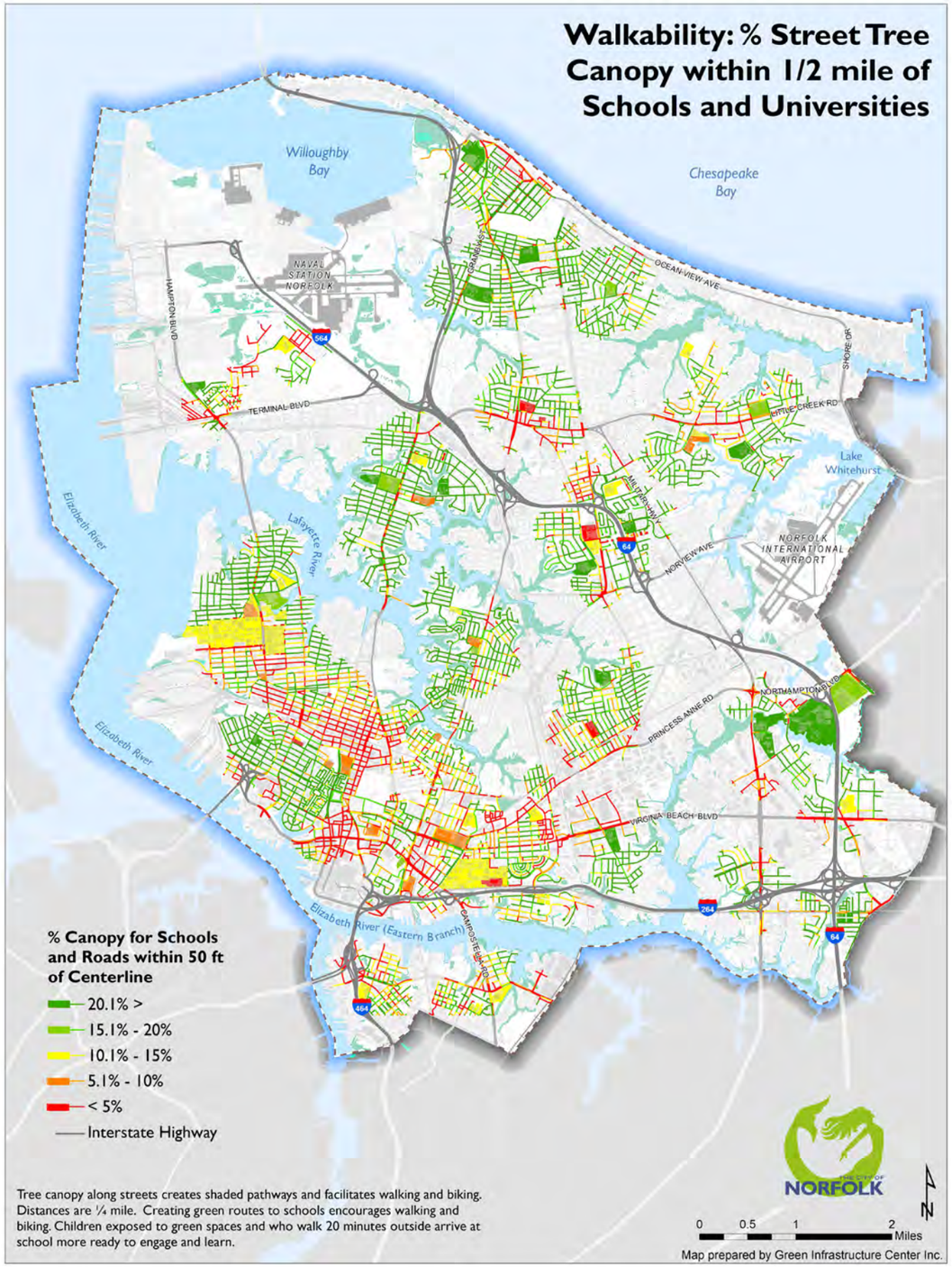
Map prepared by Green Infrastructure Center Inc.

% Canopy Cover Roads and Bus Stops



Tree canopy along streets creates shaded pathways and facilities walking and biking. Shaded bus stops are also shown.

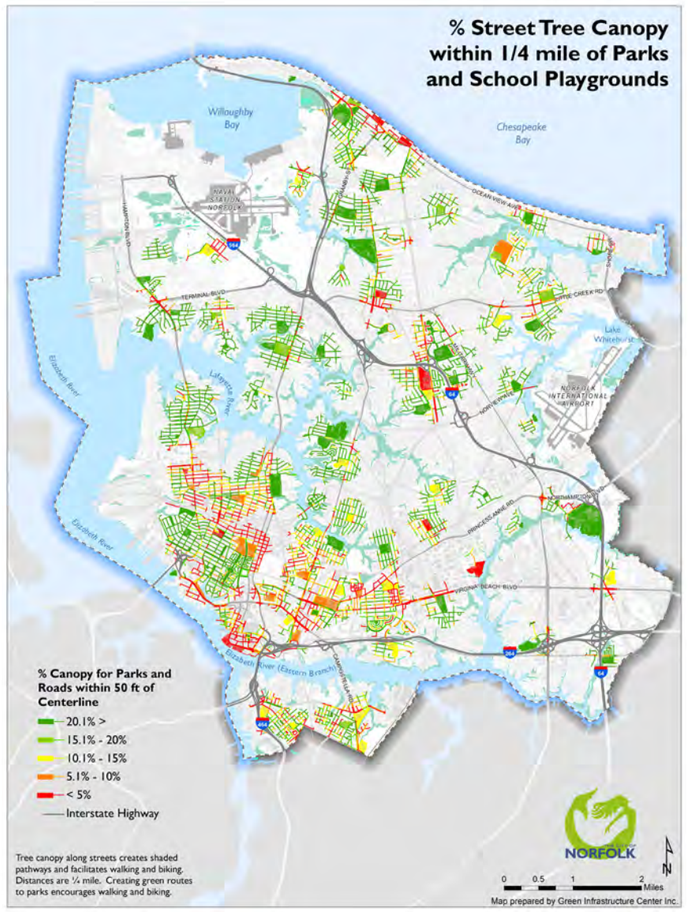
Map prepared by Green Infrastructure Center Inc.



Next, canopy coverage for city streets and bus stops was analyzed. The more canopy the streets have, the greener they feel. Shaded bus stops make using public transit more pleasant. Streets with trees are more attractive for biking and walking as well as for shopping, opening businesses, and buying or renting properties. Future development plans should consider the canopy of the streets when revitalizing areas of the city.

Green streets foster walkability. As this inset map shows, considering canopy on streets leading to schools is a key aspect when planning for walkability. A similar analysis has been completed for parks. One quarter mile was used as the distance for analysis of street tree canopy as data show that is the distance most Americans are willing to walk (Wolch et al 2005).

As this zoom in shows, streets near schools vary in how green they are. Streets that lack canopy and which serve as direct routes to parks and schools should be targeted for tree planting. Creating green routes to schools encourages walking and biking. Children exposed to green spaces and who walk 20 minutes outside, arrive at school more ready to engage and learn (See text box).



Well treed streets encourage walking.

*"Within the span of one generation, the percentage of children walking or bicycling to school has dropped from **50% in 1969 to just 13% in 2009.**"*

– Safe Routes to School National Partnership 2012

*"Just **20-30 minutes of exercise per day** can dramatically increase both health and attention spans!"*

– American Journal of Cardiology, 2007

As this before and after image shows, there are many places available to plant trees and create beauty. In order to ensure the current canopy is maintained and that trees do not become concerns during storms, the city should invest in tree care and the pruning or removal of high risk trees. To address this, the city has recently created one proactive tree crew that is tasked with visiting neighborhood streets and performing necessary pruning and small tree removal. The purpose is to reduce risk levels for tree damage from storms. This preventative maintenance can lessen emergency service requests following storms.

Trees also need to be more diverse. Currently, the city's canopy is estimated to be up to 50% crepe myrtles. While they are lovely and very hardy plants, they do not take up much stormwater, provide much shade, or host beneficial insects such as pollinators and butterflies. Having one type of tree on a street also makes that street more susceptible to being denuded quickly, as happened to America's elm trees when Dutch elm disease moved across the United States. Over time, the city will need to diversify its plantings to ensure there are different species throughout city streets.

In addition, the city has seen tree losses from salt spray and inundation so efforts are needed to both protect trees from inundation and in areas where this is unavoidable, salt tolerant species should be chosen. In the images on the next page, trees have been lost to salt and inundation damages.

Everyone

SHOULD PLANT A TREE!

Most of the land available for planting is on private lands (about 60%). This means that most of the achievement of the city's planting goals will rely on participation by private property owners – residents, businesses, and institutions such as private schools and hospitals.

Green shading shows existing tree canopy. Each dark green tree icon represents a possible tree planting location that avoids buildings, underground utilities, and other infrastructure. Tree spacing is 30 feet.

INDIVIDUALS' ACTIONS CAN MAKE A BIG IMPACT!

- ~ 47,500 parcels with single family homes
- ~ 31,000 of these have room for at least one tree

If each of these parcels had a single new tree, they would intercept 62 million gallons of rainwater every year (1.5 million bathtubs!)

Trees lost to flooding.

Tree root damage.

WHAT IS A GREEN STREET?

A green street provides places for multi-modal travel, enhanced vegetation, and other functions such as 'green' constructed stormwater management. Green streets not only take up excess stormwater, they can be more attractive to prospective businesses. Often, new shops and businesses locate in an area where a green street project has been installed. At right are hypothetical 'before and after' green street simulations to model the visual (aesthetic) improvements a green street can offer.

LIVING SHORELINES

A resilient city also needs to have healthy shorelines that are as natural as possible to absorb wind and wave energy and provide habitat. 'Living shorelines' are a key focus of this plan. There are many variables that affect whether a stabilized shoreline can be natural – also called a living shoreline. Factors such as waves and wind that build up energy over distances ('fetch') can require a hardened shoreline to protect man-made structures. However, there are many shorelines in the city that are unnecessarily hardened

Streets can be redesigned to be green, bringing back life and reducing vacancies in commercial districts.

through methods such as concrete walls, rubble fill, wooden boards, and any manner of structures. Today, landowners are required to obtain a permit to install a hardened shoreline structure or to replace one that is failing. Living shorelines have become the State of Virginia's preferred method for stabilizing shorelines.

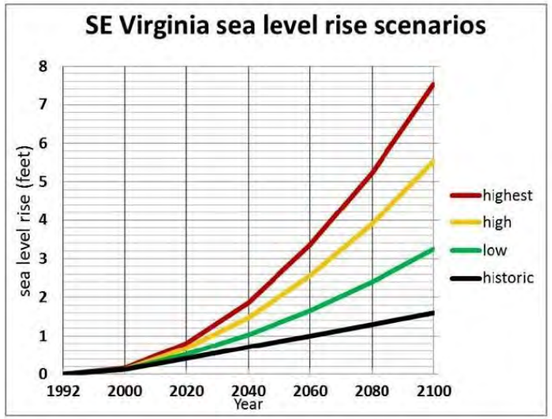
This plan conducted two types of analysis. First, how much shoreline could be naturalized today and second, how will sea level rise impact decision-making? Another consideration however is; should a shoreline restoration project to convert a hardened shoreline to a living shoreline always be attempted given changes expected to occur because of sea level rise (SLR)? To determine a cut off horizon just for shoreline plantings, this study looked for areas first for public land and second for private land that could be made natural. Areas having high fetch were excluded.

The City of Norfolk actively pursues grants to accomplish shoreline restoration projects each year and will continue to apply for grants to restore the shoreline. As the city installs living shorelines, wherever possible it will also use other techniques in the water to slow down wave energy, such as adding sills in near shore shallow water to allow living shorelines to be maintained or re-established. See the map and illustration series on page 35 showing shoreline migration.

SEA LEVEL RISE PLANNING TIMEFRAME

Determining a planning horizon in a coastal environment should include considerations for how rising sea levels may affect the work. Determining the planning horizon has to do with the intended project lifespan. If planning a bridge – a very expensive endeavor – one would hope for a 50 to 75-year lifespan. Similarly, building a structure such as firehouse should come with an expectation to last a similar lifespan. However, vegetation has a lower life expectancy and a much lower financial outlay. Moreover, unlike a bridge or a building, a living shoreline is expected to be able to move landward as waters rise. Given these considerations, the WMTF agreed that the plan should consider planting projects as doable if they will still be viable projects by the year 2040 – in other words not inundated. This assumes about five years to identify, plan for and install a project and about 17 years for the project to remain installed. This means that trees could still be planted today in a zone that may be underwater by 2050, but if they are not underwater by 2040, the project is okay to design and install.

The next step was to map the SLR for the year 2040. GIS analysts at ODU mapped the projected sea level at the year 2040 and found the water rise to be between 1.5 feet (moderate) to 2.5 feet (high). Since the exact number is unknown, the plan used a swath of area



Sea level rise scenarios modeled by the Virginia Institute of Marine Science.

between these two heights as the SLR zone. This was then mapped horizontally across the city using local elevation data to show where this rise might impact planting decisions.

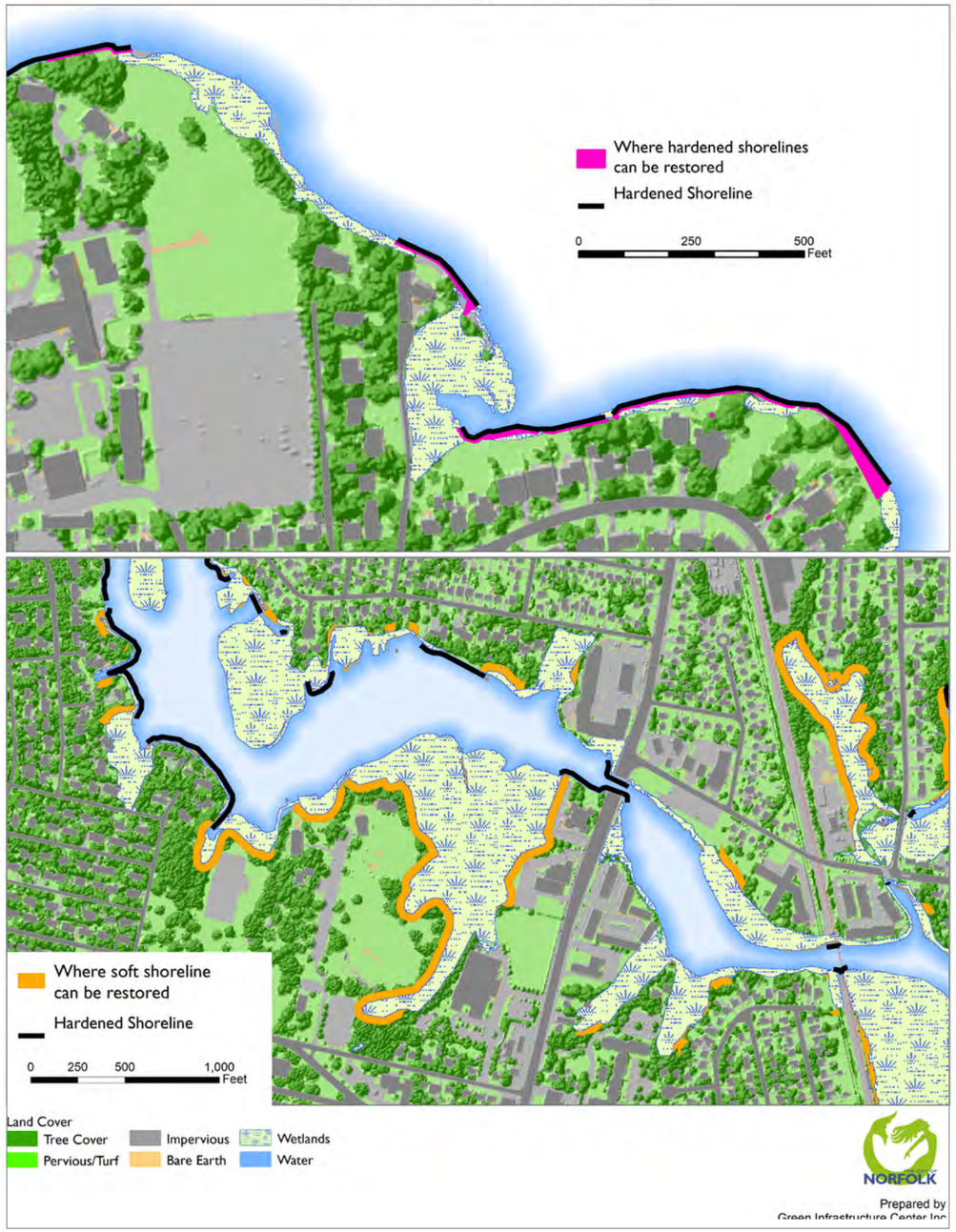
CRITERIA FOR SHORELINE RESTORATION AND MIGRATION

Norfolk has 211 miles of shoreline. Of those 211 miles, 192 miles are within city boundaries (not including the military lands) and 61 miles are currently hardened. Areas were deemed viable for shoreline restoration if the hardened shoreline was less than 4-foot elevation and the parcel does not have a structure or road within 30 feet of the 4 foot elevation zone. Areas that were not easily restored due to physical barriers, such as large dock structures, were also not considered as having potential for restoration.

Opportunities to convert hard shoreline to soft account for 34.7 miles of the 192 miles of coastline, or approximately 18% could be naturalized. However, 29.7 miles will be impacted by SLR, so only 5 miles remain viable. This does not mean those impacted miles of shoreline cannot be restored. What it does mean is that extra care will be needed in planning for restoration. If the shoreline turns out to migrate significantly, a wider area may be needed to allow for that migration inland. Once site-scale analysis has been conducted, some additional areas having high fetch may also need to be excluded as possible to restore. Scenarios on the pages following show how the analysis for this plan informs future planting goals and projects.

[4] Shoreline sill: A sill is a shore-parallel, rock structure that is designed to protect, enhance, or restore existing or newly planted wetland vegetation. Typically, these structures are constructed from rock/riprap or oyster bags, but other materials can be used. This is an environmentally friendly, low-cost option that allows wetland vegetation to migrate with sea level rise and to maintain a natural "living shoreline".

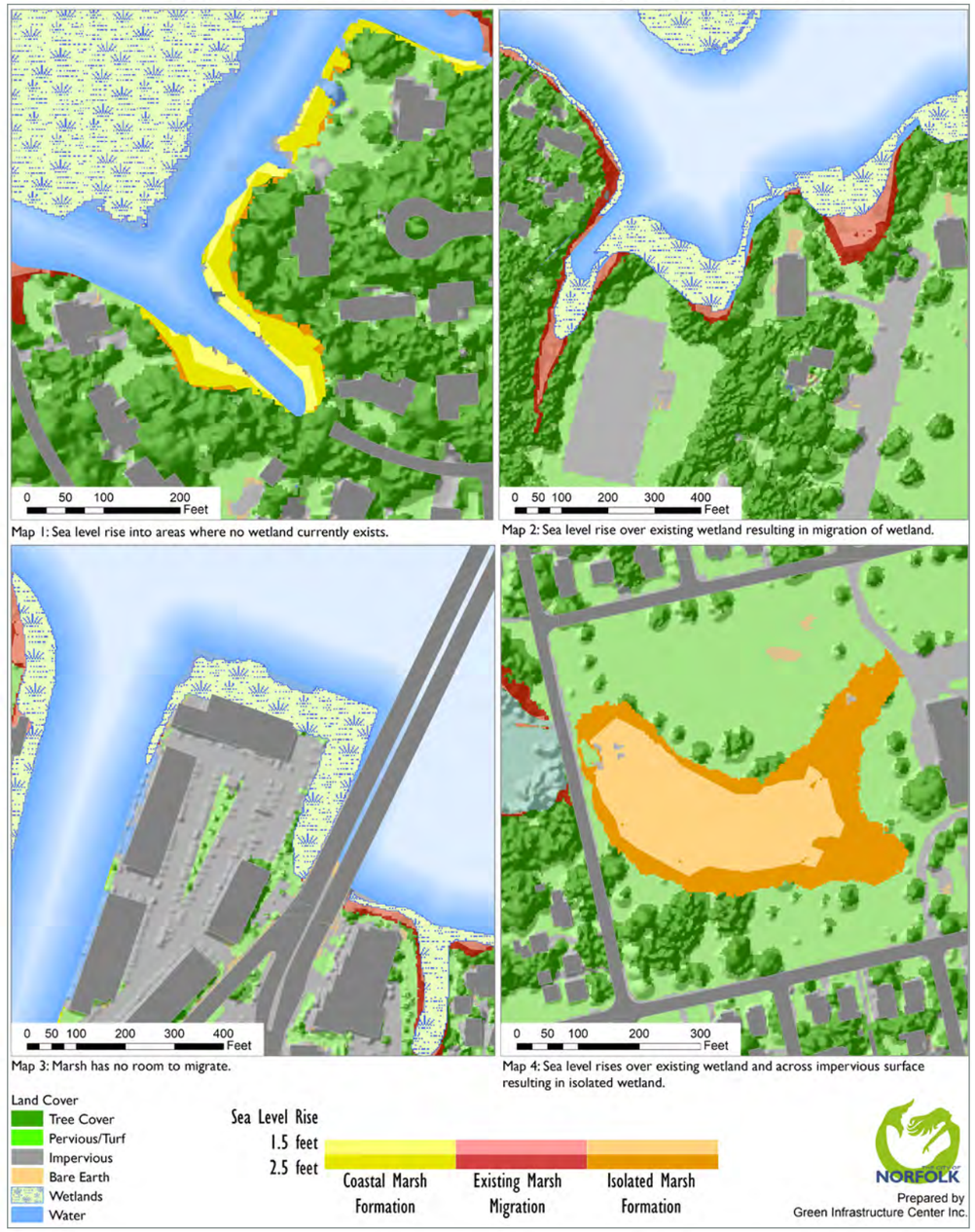
Shoreline Restoration



In this example, black lines indicate existing hardened shorelines (having bulkheads, or other hardened shoreline stabilization features). Pink indicates areas where the analysis shows that the hardened shoreline could be restored to its original configuration as a gradually sloping, vegetated shoreline that provides a natural buffer and habitat for wildlife and aquatic life (oysters, crustaceans, invertebrates and fish).

In the scenarios below, in Map 1, as water levels rise, new marsh forms inland behind seawalls. In Map 2, existing marsh moves farther inland as land becomes wetter. In Map 3, the marsh has no room to migrate because of existing impervious areas, such as roads, that act as barriers. In Map 4, sea level rises and crosses those impervious areas such as roads, resulting in isolated wetlands forming inland, sometimes in yards of residential areas.

Evaluating Sea Level Rise and Wetland Migration - 2040 Scenario



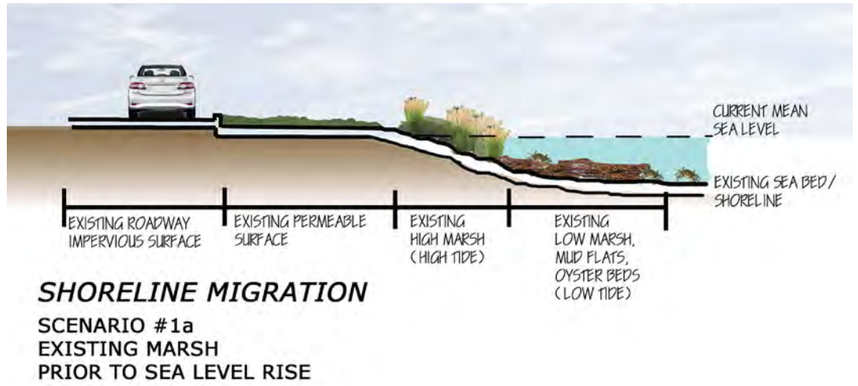
Map 1: Sea level rise into areas where no wetland currently exists.

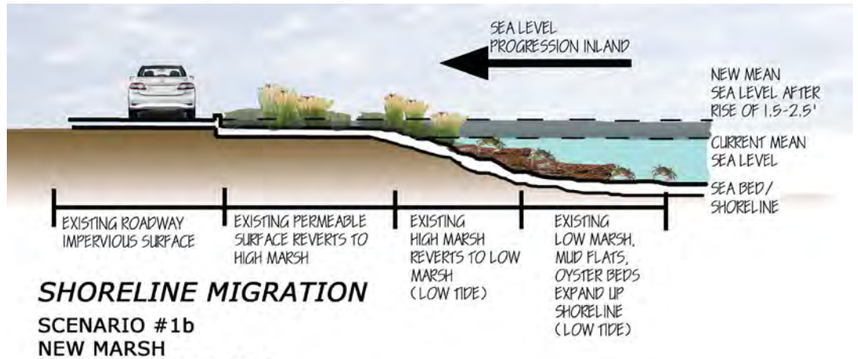
Map 2: Sea level rise over existing wetland resulting in migration of wetland.

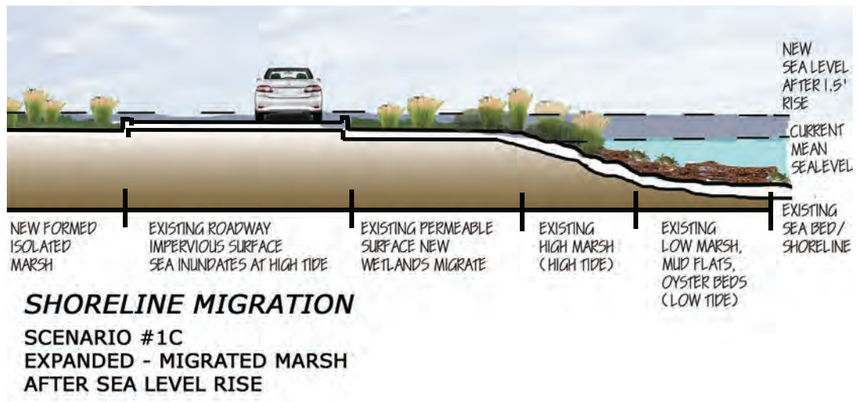
Map 3: Marsh has no room to migrate.

Map 4: Sea level rises over existing wetland and across impervious surface resulting in isolated wetland.

As this graphic series shows, scenario 1a is current, but as sea level rises, marsh may move inland (scenario 1b). If water crosses the road (scenario 1c) during high tides or storms, water becomes trapped behind the road forming new wetlands. This water may stagnate and invasive species (e.g. phragmites[5]) may overtake native vegetation and wildlife over time as the marsh is disconnected. In some cases, barriers may be built to protect the road.

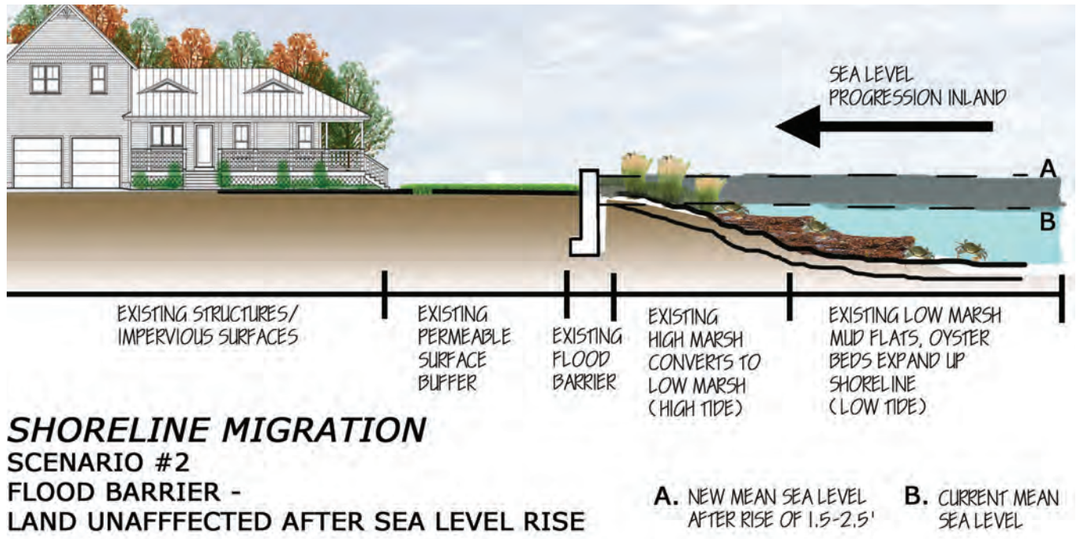


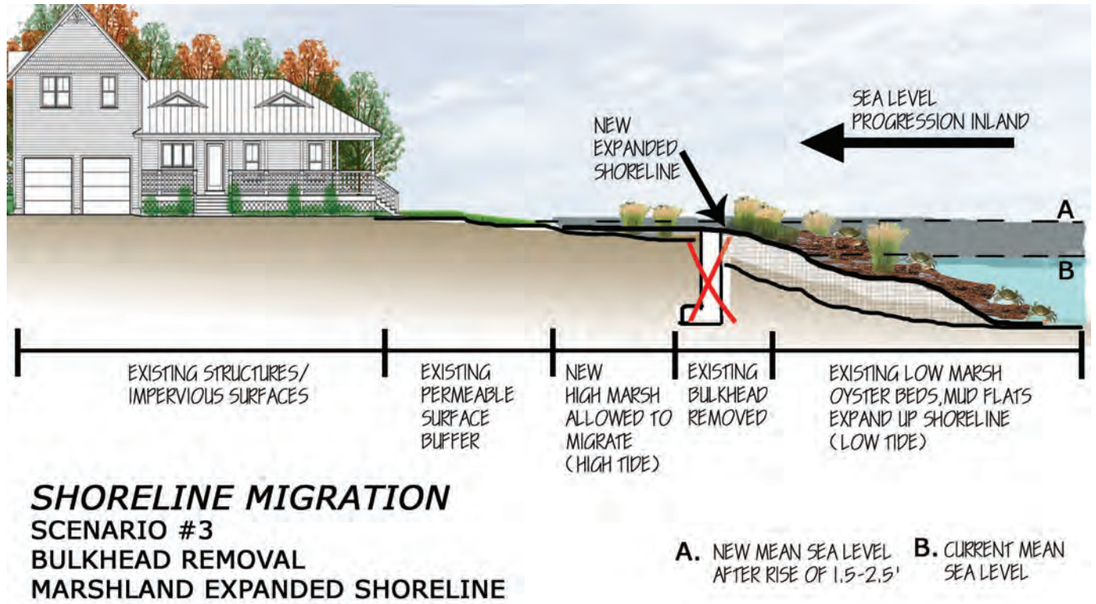




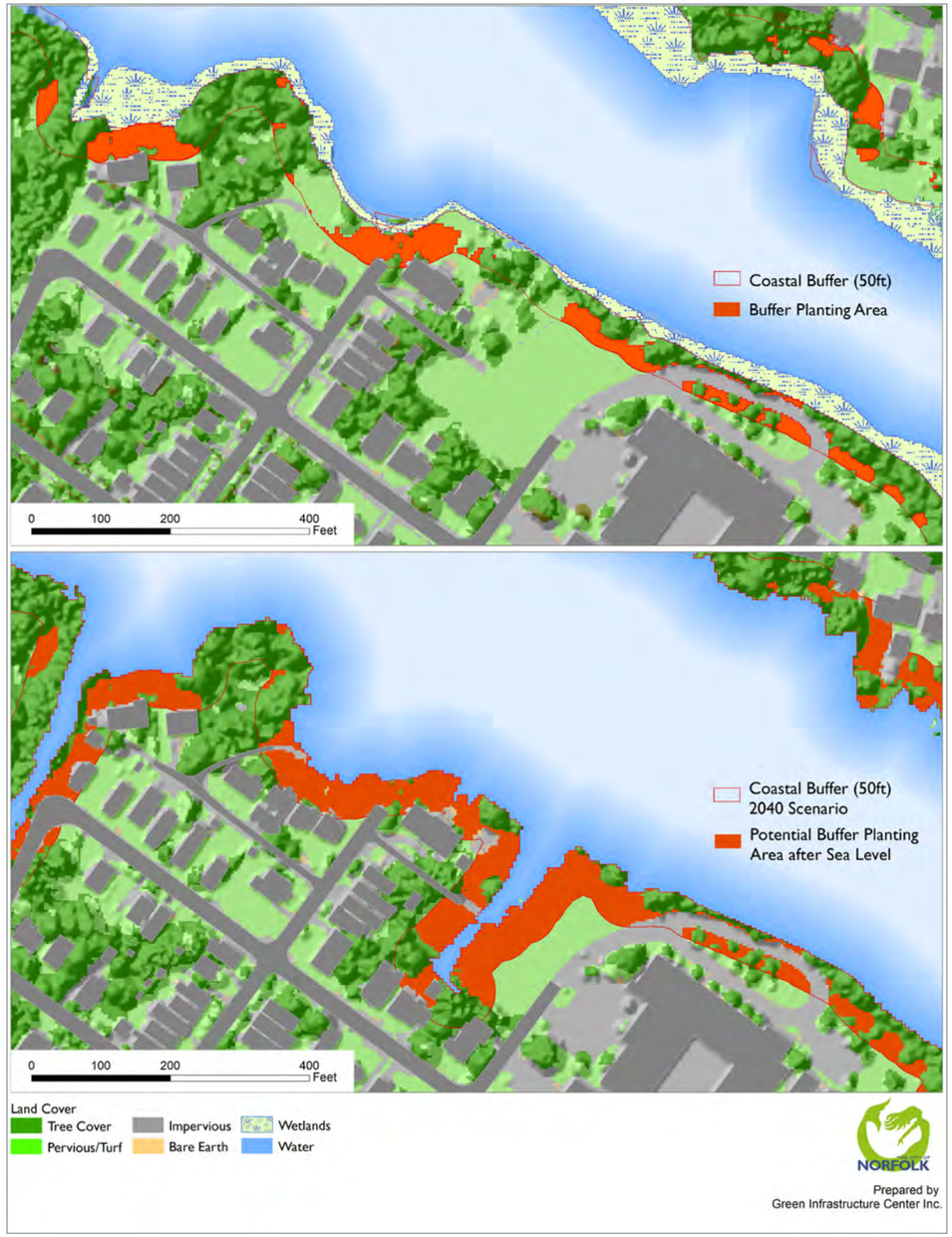
[5] *Phragmites is a perennial grass that are outcompetes native vegetation and lowers the local plant biodiversity. Phragmites forms dense thickets of vegetation that are unsuitable habitat for native fauna*

As these diagrams show, barriers can be effective with rising sea levels, but they may fail as sea level rises over time. Instead of continually repairing them, seas may be allowed to migrate inland by removing a failing barrier and rebuilding the marsh





Shoreline Buffer Planting



As this image shows (top), currently there are places within a 50-foot vegetated buffer where trees can be planted (red areas). As sea level rises, buffers may migrate inland as inundated areas become inhospitable for trees and convert to marsh. This second map (lower) shows the new buffer in the year 2040 with 1.5 to 2-foot rise of sea level. This is important to map because, if Norfolk is to have vegetated shoreline buffers in the future, areas may need to be preserved to become new shoreline buffers. In other words, today's upland areas just behind the shoreline are the shoreline buffers of the future.

*Opportunities to convert hard shoreline to soft account for **34.7 miles** of the **192 miles** of coastline, or approximately **18%** could be naturalized.*

HOWEVER, 29.7 MILES WILL BE IMPACTED BY SEA LEVEL RISE SO ONLY 5 MILES REMAIN VIABLE FOR RESTORATION.

In addition to restoring the shoreline, vegetated buffers landward of the mean high water lines can be planted to:

1) *Resist wave and wind energy from storm surges*
2) *Filter pollutants such as nitrogen, phosphorus, and sediment from reaching the water*
3) *Provide habitat for birds and other wildlife*
4) *Protect shorelines from erosion*
5) *Provide natural beauty*

Many 'buffers' in Norfolk are just 'one salt bush wide.' A buffer of only 3-5 feet does little to provide protection against wind and waves or to filter land runoff.

Currently there are 1,695 acres alongside the city's shore that can form a vegetated zone to buffer the water from land runoff and protect the land from wave and wind damage. This area is known as the shoreline buffer zone. The standard is for a minimum width of 50 feet of vegetation that forms the Chesapeake Bay Preservation Area coastal buffer. Thickening shorelines with buffer plantings is a key strategy in creating a more resilient city.

Today there are 378 acres (22%) of the 50 foot buffer area that are possible for planting (no obvious obstructions such as roads). However, taking into account rising seas, an additional 69 of those acres will be lost, leaving just 309 acres possible to plant. Fortunately, in some cases, there is room for the buffer to move inland (see graphic on prior page) because there are no existing barriers to inward migration, such as parking lots or buildings. As the movement of the buffer inland is taken into account, 1,402 acres fall within a transition zone that will eventually become part of the Chesapeake Bay Preservation Area.

A buffer that is too thin does little to resist winds and waves that cause erosion or to filter overland runoff.

Restoration plantings can restore wetlands and buffer shorelines. Photo credit: The Hermitage Foundation

Dunes should replanted with native vegetation to provide habitat and storm buffering.

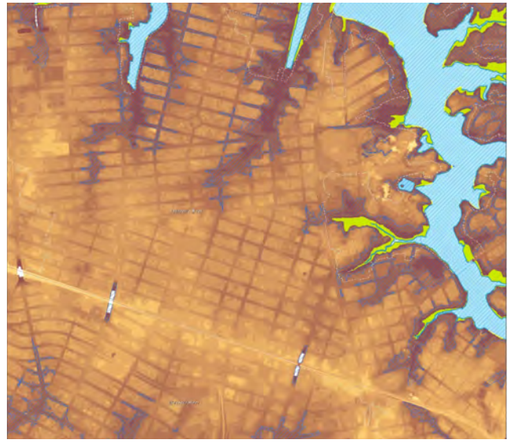
REDUCING FLOODING FROM IMPERVIOUSNESS

Neighborhood flooding was identified as a key concern by participants at community meetings as well as by city staff. Many areas flood near the coast and there are several reasons for this. First, those areas are affected by high tides, such as spring tides or periodic high tides (often occurring during a new or full moon, sometimes referred to as 'king tides') which cause higher than normal water levels. Coastal storms further exacerbate these tidal flooding events.

As storms and high tides push water through stormwater pipes and up onto city streets, even areas further from the waterfront may be impacted by tidal flooding. Thus, stormwater runoff adds a further layer of complexity when assessing flooding. Additional coastal flooding is caused by flows of stormwater from upland impervious areas. While Norfolk may appear relatively flat, there are higher areas of the city. Some of these areas have been heavily developed in the past or are identified for future development, precisely because they are high enough to avoid existing flooding and impacts from SLR. However, many of these areas are also highly impervious, with a combination of commercial districts, railroads or major transportation corridors crossing most of them and adding to impervious area.

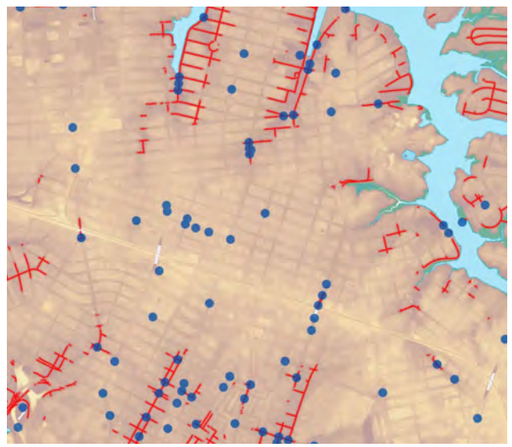
Further adding to flooding frequency is the fact that the stormwater pipes in some areas suffer from a lack of capacity. With increased development over time, some pipes are simply undersized for the amount of water draining into them, while others are permanently at least partially filled as SLR has caused them to be below the groundwater table or average tide level.

The city hired the Timmons Group to analyze the capacity of city storm pipes to carry stormwater now and in the future. They considered whether any pipes facing capacity challenges could be modified to expand their capacity. This study was added to the analysis for this plan, resulting in the composite map (page 40) that shows which areas have high imperviousness, where runoff volumes are higher and where the city should focus on infiltrative practices or water storage.

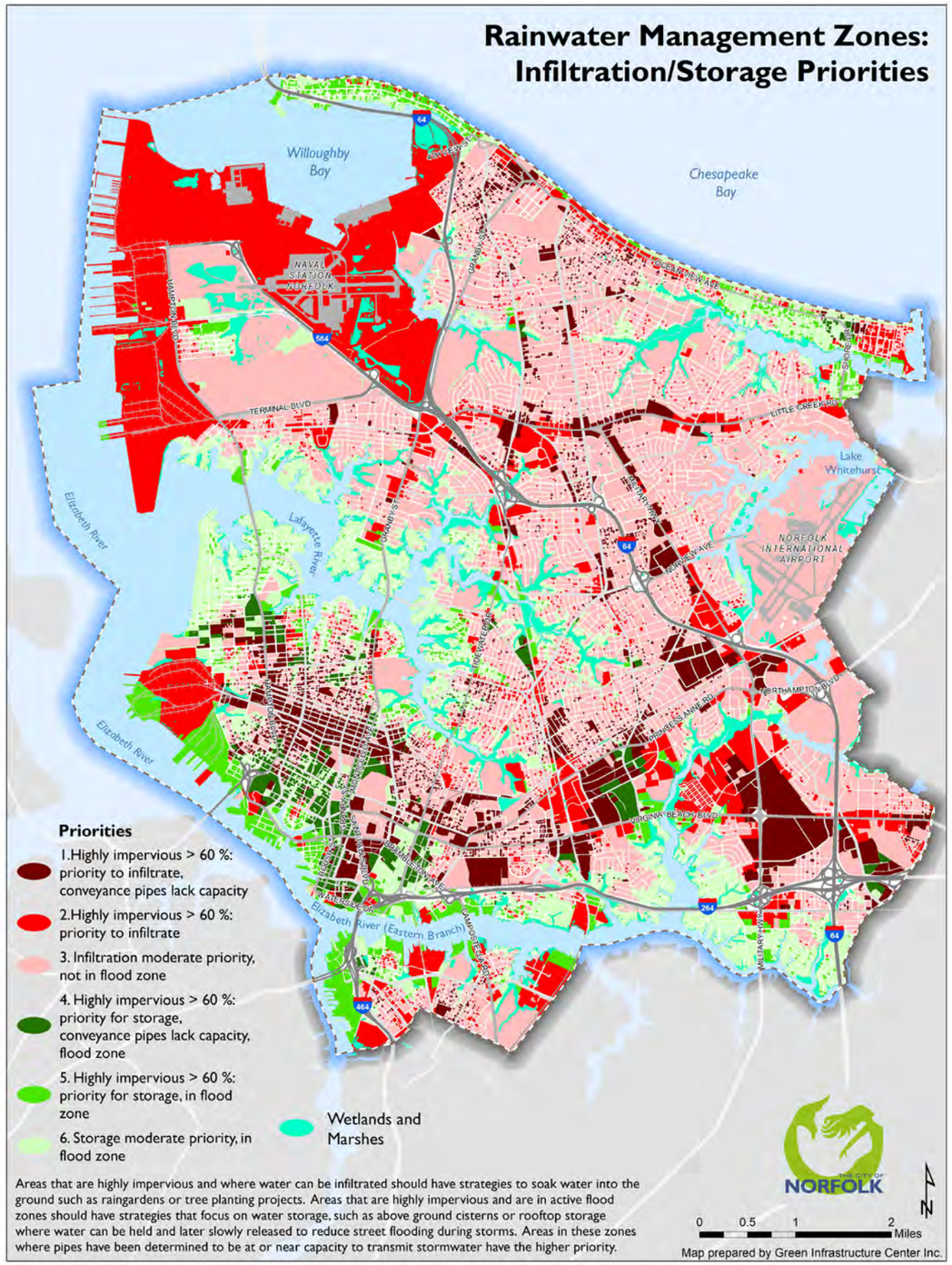


Light colored areas in this map (above) show high elevation in lighter colors. These areas are often very impervious leading to flooding downslope/downstream. Piped streams are seen in dark colors lacking blue lines. While more flooding issues are found on the coast, solutions may lie upslope.

Below, flooding complaints are shown in blue along with streets shown in red where streets are likely to be flooded during a storm event (modeled using Hurricane Joaquin). Both pipe survey data and complaint data are used to identify areas where problems are occurring. However, solutions may lie upslope at the locations where impervious areas are causing excessive runoff.



Rainwater infiltration is a high priority focus for areas where imperviousness is high and pipes lack capacity, whereas storage is a key strategy for areas that are highly impervious and are also in a flood zone.



The Rainwater Management Zones map can be used to inform strategies for stormwater management and even urban design. In areas where water storage is paramount, cisterns, rooftop water storage or green rooftops may be employed, while in areas where infiltration is indicated as a priority, site designs should incorporate rain gardens, bioswales, pervious pavers, and dry wells. Trees and other vegetation should be prioritized in both zones, to help absorb and filter water. The city's new zoning ordinance already utilizes a creative resilience quotient to require additional best management practices that focus on infiltration and storage.

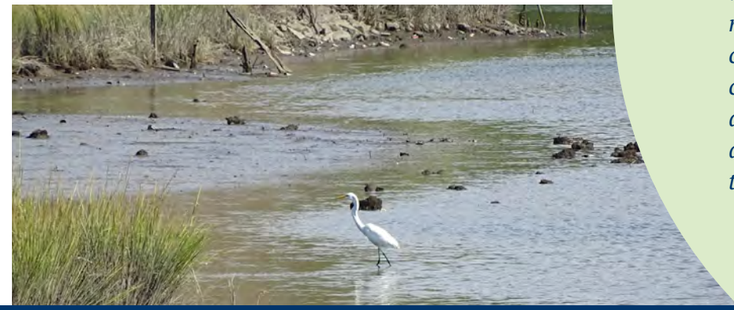
There are many best management practice technologies for rainwater storage, such as cisterns, that hold water temporarily and release it later to be used for landscaping or grey water uses in a building. This reduces peak flows and demands on storm drain systems. Some storage technologies are designed to both hold and release water through transpiration and evaporation, such as a green roof top. Currently, Norfolk only has four known green roofs: the Hanbury Building on Atlantic Street next to the Slover Library; a building at the Naval Station; one residential; and a small sloped roof at the Norfolk Botanical Garden.

This roof on the Hanbury Building as seen from the Slover Library is an example of an extensive green roof. Green roofs can often be added to older buildings because they have the structural capacity to support the additional weight.

As this wall on the Paris Museum shows, green walls add an attractive and interesting aspect to urban architecture. Green walls can also absorb water channeled from a roof and down the green wall. Plants intercept and clean the water, while also insulating interior walls for energy savings. Green walls and rooftops also provide habitat for birds and butterflies.

Norfolk's Strategic Focus on Becoming a Resilient City

While the alterations made to Norfolk's landscape are typical of a modern coastal city, Norfolk is now planning, designing, and building in a new way – one that recognizes the need to plan with nature in mind. As Norfolk plans for its future, it has recognized the importance of its natural landscape for absorbing and cleaning water; filtering the air; providing access to outdoor recreation, such as fishing and boating; and sheltering and buffering residents from heat, wind, and storms. Today, the city is thinking of its natural landscape features– its marshes, forests, meadows, and creeks, – as its green infrastructure, allowing the city to become more resilient. As the following programs and initiatives demonstrate, Norfolk is building resilience every day.



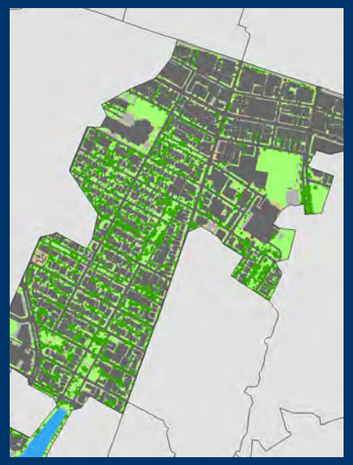
Resilience...

refers to the amount of change a system can undergo and still retain the same controls on structure and function. Resilient systems are self-organizing and adaptive. 'Systems' can refer to both natural or human communities. A resilient city has the capacity at the individual, community and system level to survive, adapt, and grow in the face of stresses and potential shock and when required, to transform itself.

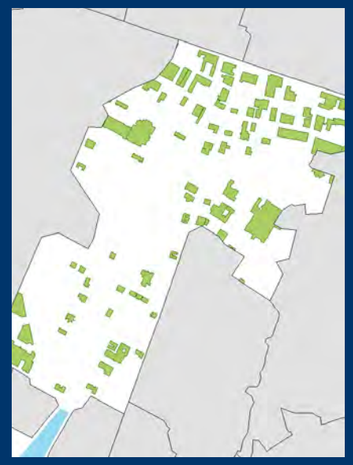
GREEN ROOFS AND GREEN WALLS

A green roof costs about twice as much per square foot as a conventional roof. However, it tends to last two to three times longer than a conventional roof. They also can save on heating and cooling costs by insulating the roof from heat and cooling losses. A green roof captures about the same amount of water as a forested land cover over the same area – that is because densely planted sedums soak up a tremendous amount of water and excess water can be stored in the growing medium as well. The city's Retain Your Rain website has more information on green roofs, see:

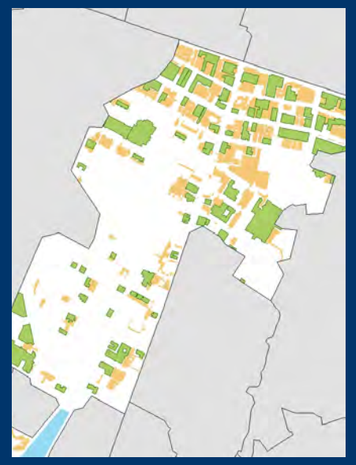
https://www.norfolk.gov/retainyourrain



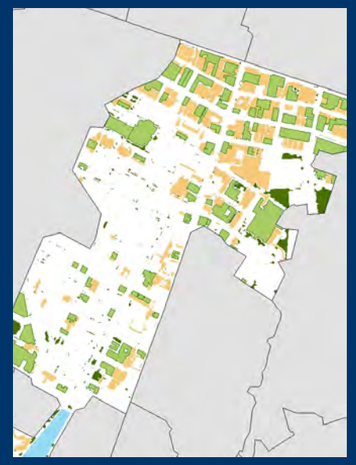
This watershed is 64% impervious and drains to the Hague. Dark green shows vegetation while grey shows impervious.



Select all buildings with more than 2,000 sq. ft. of flat rooftop space for green roofs.



Add trees over impervious possible planting areas (e.g. parking lots)



Plant trees in pervious possible planting area.

ARE MORE GREEN ROOFS POSSIBLE?

Certainly.

Norfolk could support more than four green roofs. The City of Chicago has 509 vegetated roofs covering 5,564,412 square feet of green roof coverage! In the example scenario at left, green roof benefits are calculated for a small city watershed.

Results from the scenario at left, are that green roofs reduce runoff from rooftops by 21 million gallons annually (assuming 70% capture). And, if 50% of parking is covered by shade trees – an additional 700,000 gallons could be intercepted annually. This results in less runoff, less pollution and less flooding.

Marsh Restoration at ODU Sailing Facility.

RESILIENCE STRATEGY

In the fall of 2015, Norfolk was selected to join a network of '100 Resilient Cities' by the Rockefeller Foundation. Selection as a resilient city included support to hire a Chief Resilience Officer for a new Office of Resilience, along with technical and networking support to collaborate with other resilient cities around the world. The focus on resilience helps the city prepare better for storms, rising seas, infrastructure needs, community cohesion and economic stability and growth. Norfolk's resilience strategy includes four essential dimensions of urban resilience:

- Health and Wellbeing
- Economy and Society
- Infrastructure and Environment
- Leadership and Strategy

The city has identified three goals for becoming resilient:

Goal 1: *Design the coastal community of the future.*

Goal 2: *Create economic opportunity by advancing efforts to grow existing and new sectors.*

Goal 3: *Advance initiatives to connect communities, deconcentrate poverty, and strengthen neighborhoods.*

A key to becoming resilient is being continuously adaptive. The city is developing new methods and technologies to live with water, finding new ways to help infiltrate or store stormwater, and restoring natural shorelines that provide habitat and buffers from storms. This plan helps the city 'design the coastal community of the future' by using the city's natural assets to improve environmental and community health and structures. For example, mapping and replanting marshes can absorb wave and storm impacts while also cleaning the water and providing access to recreation and natural beauty.

Central to Norfolk's approach to building its resilience is identifying, orienting, and leveraging new public and private partnerships. The city is partnering across sectors (federal, state, local and private) to achieve the city's resilience goals. For example, partnerships with local conservation groups allow the city to leverage private sector funds to invest in public projects, such as improving water quality in the Lafayette River or providing more trail and bike routes near the Elizabeth River (See section Partnerships Make It Possible on page 48). This partnership approach is very much in keeping with this green infrastructure plan since such partnerships are needed for fulfillment of identified strategies.

BUILDING RESILIENCE THROUGH GREEN INFRASTRUCTURE

A key way to build resilience is to protect the city's natural assets and restore them where they have been lost. This plan can help Norfolk be more resilient in the following ways:

- ☑ *It identifies areas of significant tree canopy, wetlands, and marshes that should be protected.*
- ☑ *It maps where new vegetation – more tree canopy and more natural shorelines – can be installed to soak up excess water, buffer areas from storms and provide habitat and scenic vistas.*
- ☑ *It promotes a more connected landscape increasing walkability and community health through enhanced access to open space and waterways.*
- ☑ *It protects the city's heritage and culture by identifying key features, including some that have not been mapped previously.*
- ☑ *It provides a tool to plan where to focus water infiltration and retention efforts.*
- ☑ *It promotes education and engagement of the community in creating livable communities.*
- ☑ *It recommends new data collection for more strategic decision making.*

There are many ways to design urban habitats to increase resilience. For example, rather than using concrete and bulkheads to stabilize shorelines, waterfront property can be restored by adding natural vegetation and a healthy coastal marsh to buffer communities from wave and wind impacts, while also filtering runoff from the land to protect water quality.

Norfolk Larchmont Branch Library restored wetland.

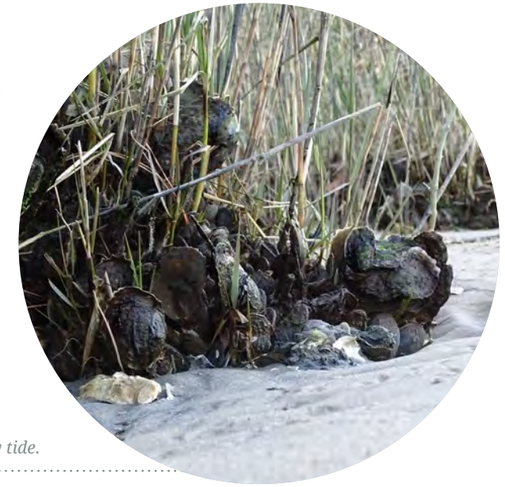
The city recently completed stabilization of 0.35 acres of marsh shoreline on Knitting Mill Creek in the Colonial Place neighborhood and it expanded marsh habitat such as the 15,500 sq. ft. marsh restoration at Myrtle Park, which included a boardwalk. In the past ten years, the city has constructed four miles of restored shoreline and has improved stormwater management by adding or upgrading more than 20 best management practices on public lands to infiltrate and filter stormwater runoff.

Boardwalk in Myrtle Park allows the public to enjoy the restored marsh.

In the fall of 2017, the city restored 1.44 acres of oyster reef off the southern shoreline of the Hermitage Museum. The Lafayette river will become the first tributary in the Chesapeake Bay Watershed on track to fully meet its oyster restoration goal by achieving 80 acres of newly functioning oyster reef. This has happened though city and federally initiated projects and partnerships with many nonprofit and civic groups. In June 2016, the Virginia Department of Environmental Quality (DEQ) removed the Lafayette River from its list of rivers contaminated by bacteria. So, the city's restoration efforts are paying off with great results!

THE CITY'S RESTORATION EFFORTS ARE PAYING OFF!

In June 2016, the Virginia Department of Environmental Quality (DEQ) removed the Lafayette River from its list of rivers contaminated by bacteria.



Healthy oysters along the Lafayette River at low tide.

plaNorfolk2030

The city's comprehensive plan, known as plaNorfolk2030, is guiding growth and development over the next 20 years. This green infrastructure plan supplements the plaNorfolk2030 with additional initiatives and goals that will help in its implementation. Below are some examples of how the green infrastructure plan facilitates implementation of city goals. To create this plan, new analysis was conducted that has resulted in new goals and objectives for city implementation to address identified needs, best practices and innovative ways to achieve the city's strategic directions.

Example actions from plaNorfolk 2030 that are supported by this plan:

- ☑ ***Action ES1.1.6.*** *Encourage the use of Best Management Practices (BMPs) reflective of Norfolk's urban character in order to reduce and filter stormwater runoff.*
- ☑ ***Action ES2.1.7.*** *Continue to implement wetland design changes, such as the use of living shorelines that allow for the landward migration of wetlands, for resilience to sea level rise.*
- ☑ ***Action ES1.1.11.*** *Develop criteria for defining environmentally sensitive areas that can be mapped to assist in selecting locations for shoreline restoration projects.*
- ☑ ***Action ES1.3.6.*** *Encourage connections of open green spaces throughout the City through the development of pedestrian and bicycle corridors.*
- ☑ ***Action ES1.3.1.*** *Increase the quantity, density, and diversity of trees to achieve a goal of 40% tree canopy cover through a combination of regulatory actions and city provided trees.*[6]

[6] *The plaNorfoplk2030 lists canopy at 35% and a goal to reach 40%. Since canopy is now actually 25.8% and there is not 14% of open space available to plant, the new recommended goal is 30%. See page 22 for discussion.*

Actions and Goals Related to Green Infrastructure Plan Focus

plaNorfolk2030 Goals and Actions	Neighborhood Goal 3:	Transportation Goal 1.	Environmental Sustainability Goal 1.	Daily Life Goal 1.
	Enhance neighborhood character, design and visual density and related action to revitalize commercial corridors. Partnerships, public spaces. (Actions N1.1.5, N2.2.2.)	Connect residents and visitors with business, employment, shopping, educational, and activity centers through a safe and efficient multi-modal regional transportation system. Transportation: Complete streets, bicycle facilities, trails etc. (T1, 3,1 and 3.3, 3.7, 3.16)	Ensure high quality natural resources. Partnerships with environmental groups and schools, stormwater planning, criteria for project sites, complete streets, increase canopy, native species, (Actions ES1.1.13, ES1.1.16, ES1.1.10, ES1.2.2., ES1.3.1, ES1.3.3, ES2.1.7.) **Environmental Sustainability Goal 2:** Prepare for the consequences of natural hazards. Restoring living shorelines, mitigating natural hazards, CRS rating. (Actions ES2.1.6, ES2.1.5, ES2.1.7, ES2.1.8.)	Provide Norfolk residents with a rich variety of parks and recreational opportunities. Access to recreation, access to the water, pedestrian and bike travel. (Actions DL1.1.6, DL1.1.17, DL3.1.7.)

VISION 2100

As part of the city's focus on resilience to create a coastal community of the future, the city initiated Vision 2100. It builds on plaNorfolk2030, the city's comprehensive plan, by taking a long-term view and imagining the changes needed today to adapt to a city that is changing physically, socially, and economically.

Vision 2100 is a citywide strategy to create a vision for Norfolk's long-term future that 'looks at the entire city, not just those areas at risk due to sea level rise, but also those that could bear the burden of redevelopment and all of the areas in between.' City leaders identified where flood protection strategies could be employed and how and where to replicate the best elements of the city on higher ground. It recommends taking proactive steps today to create the future desired by all city stakeholders. Most importantly, a key theme of the vision is to learn to live better with water. Finding ways to better manage and accommodate water can reduce stresses on city infrastructure while creating a safer, more attractive, and healthful environment for people, while also sustaining wildlife.

Vision 2100's overall concept provides rough geographic boundaries within which its different strategies could apply. Areas of the city were grouped by location according to elevation and the collection of city assets they have now, or might have in the future. These groupings resulted in four vision areas, identified by color on the Vision 2100 map as 'Red' areas rich in assets and at higher natural risk – much of that risk accounted for by existing or planned flood control structures. 'Yellow' areas have fewer key assets and higher risk, where existing communities would have to slowly adapt to flood threats. 'Green' areas had lower risk locations with great potential for transformation – a potential home for many new assets. Finally, 'Purple' areas had lower risk locations without many key assets, and these places might become the future primary residential areas of the city.

This green infrastructure plan directly supports Citywide Action 3 of Vision 2100 which states:

CITYWIDE ACTION 3: BE A MODEL FOR RESPONSIBLY ADDRESSING RESILIENCE - It is imperative that every Norfolk resident, business, and organization implement innovative strategies to prevent flooding, whether or not an individual property is directly impacted by sea level rise. Even those living and working in areas at less risk for flooding should embrace responsible development practices such as enhanced stormwater reduction, green building techniques and green infrastructure development in support of overall city needs and goals. Data generated through this plan will help identify key locations to target for pilot programs or projects to promote such activities and will provide information on potential options for every parcel or right-of-way throughout the city.

Improving the Affordability of Flood Insurance

This green infrastructure plan can also be tied to the city's participation in the National Flood Insurance Program's (NFIP) Community Rating System (CRS). The CRS is a voluntary incentive program local governments join to earn flood insurance premium discounts for policyholders in the community. Local governments receive points for actions and/or policies that reduce flooding and flood damage; these points earn premium discounts as high as 45%. The City of Norfolk participates in the CRS at a Class 7, effective May 1, 2018, which earns policyholders a 15% discount each year.

Many creditable actions help accomplish the three goals of the CRS:

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

Many recommended strategies in this report for incorporating additional green infrastructure in Norfolk are creditable through the CRS program. Examples of creditable actions include: preserving land located in the 100 year floodplain as open space, preserving shorelines and channels in their natural state, stormwater management, erosion and sediment control regulations, riparian buffers, Low Impact Development best management practices[7], low density zoning, local drainage protection, maintenance of drainage systems, and including various flood related information on maps and GIS databases.

Additionally, communities can earn credit for community adopted management plans that protect the critical natural functions of floodplains and native species in the floodplain, while implementing habitat restoration projects. This plan itself could earn points in the CRS program if certain CRS requirements are met; these requirements include an inventory of all species in the plan's geographic purview, action items for protecting one or more of the identified species of interest and natural floodplain functions, and the review and update of the plan every 10 years.

[7] *Low Impact Development is a design strategy with a goal of maintaining or replicating the pre-development hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic site design.*

NEW ZONING ORDINANCE

Norfolk's new zoning ordinance went into effect on March 1, 2018. It focuses on the city's commitment to vibrant neighborhoods, economic diversity, and coastal resilience and it supports a streamlined development process. The new zoning ordinance contains a number of pioneering approaches in response to the long-term challenges posed by sea level rise, one of which requires all development within the city to meet a resilience quotient. The requirement is built around addressing three separate resilience elements: risk reduction, stormwater management, and energy resilience. The resilience quotient includes an innovative points system ensures that new development will be more resilient and environmentally-friendly while providing flexibility to builders by allowing them to choose which measures to include in the development. Additionally, new or expanding development must meet minimum requirements for first floor elevations 1.5 – 3 feet above flood level, limiting future structures that will be directly threatened by flooding. This will be increasingly important as monthly tidal flooding increases with sea level rise.

Ohio Creek Watershed Demonstration Project

A living example of the city's resilience strategy is demonstrated by the Ohio Creek Watershed Project. In March 2017, Norfolk received a sub-recipient agreement award for $112 million from the Commonwealth of Virginia for the Ohio Creek Watershed project, which is funded under the Department of Housing and Urban Development (HUD) National Disaster Resilience Competition (NDRC) grant. The project explored various landscape and hardscape options to reduce flooding, and improve public access to the waterway and connections to the rest of the city such as construction of flood walls, living shorelines, raised roads, and other infrastructure improvements.

Other funds from the NDRC award went to a "Coastal Resilience Laboratory and Accelerator Center" called RISE. RISE is a non-profit organization establishing a series of strategic initiatives in the resilience field. RISE's vision is to position Hampton Roads as the global leader in addressing the impacts of sea level rise, recurrent flooding, and extreme weather events by developing strategies, policies, and products that allow the region to continue to grow.

Norfolk's Adopt A Spot Program provides a way for residents and businesses to help the city care for its landscape.

PARTNERSHIPS MAKE IT POSSIBLE

As the following examples illustrate, the city has tremendous opportunities to enlist many partners in carrying out collaborative strategies needed to implement this green infrastructure plan. The city routinely engages in partnerships that foster civic engagement. These partnerships will be essential for carrying out the strategies of this green infrastructure plan.

While city programs such as those described earlier and others including street sweeping, storm sewer pump outs, ditch cleaning, and best management practice (BMP) inspections play major roles in managing water quality and quantity issues, the City of Norfolk knows that it takes partnerships to tackle the restoration of city watersheds and landscapes. The city has a great civic spirit and both paid and volunteer groups do their part to build a resilient city. The city manages programs and commissions such as **Keep Norfolk Beautiful**, the **Norfolk Environmental Commission**, and the **Norfolk Tree Commission** to educate and facilitate these partnerships.

The cities *Retain Your Rain* https://www.norfolk.gov/retainyourrain program works with businesses and homeowners to discover and install projects to infiltrate or store rainwater on site, thereby reducing runoff, filtering pollutants, and lessening stresses on city storm drains. Workshops teach residents best practices and the stormwater calculator app allows anyone to learn how much runoff from their own rooftops needs to be captured.

Citizens can also sign up with the city's program to become a Bay Star Home: https://askhrgreen.org/programs/bay-star-homes . Adopters are asked to pick eight environmentally-friendly actions and then register to receive a Bay Star Homes yard flag, a welcome packet and notice of opportunities to start making a difference. The city also has a stormwater utility fee and ways to lower the fee by reducing runoff are specified in the city's manual: https://www.norfolk.gov/DocumentCenter/View/28851

Many groups work in partnership with Norfolk to achieve environmental goals. Organizations such as **Elizabeth River Project (ERP), Lafayette Wetlands Partnership (LWP), Wetlands Watch (WW), the Chesapeake Bay Foundation (CBF), Friends of Norfolk' Environment (FONE)**, and many civic leagues and organizations have donated time, resources, and ideas to re-create a resilient city.

For example, CBF, ERP, and others have worked with the City of Norfolk to restore the oyster population in the Lafayette River. Since 2009, CBF has planted 40 million oysters in this urban waterway. Many of these oysters are grown on the hundreds of bushels of recycled oyster shells CBF collects every year from restaurants across Norfolk and shell recycling bins, in partnership with Keep Norfolk Beautiful, Waste Management, and Larchmont Library. By summer 2018, ERP will have constructed its 12th oyster reef in the Lafayette River, achieving the goal for the 80 acres of functioning oyster reef prescribed by a workgroup of Chesapeake Bay Program scientists. Similar work to restore oysters has also begun in both Little Creek and the Eastern Branch of the Elizabeth River. CBF also supports the city in many legislative efforts, such as seeking state grants to construct water quality projects.

Partners help to restore oyster beds.

ERP's Watershed Action Teams have set and achieved many goals for Elizabeth River restoration and cleanup in the past 20 years and have launched an ambitious action plan to carry forward into 2025. For example, the Elizabeth River Project has been the catalyst for dozens of wetland restorations and hundreds of other shoreline plantings on the Elizabeth since constructing the first voluntary wetland restoration in Virginia in 1997 at Larchmont Public Library. The project, Birdsong Wetland, a partnership with the City of Norfolk and Old Dominion University, won the international Clearwater Award. They also engage residents in reducing yard runoff through the River Star Homes program which covers homes and businesses in the Elizabeth River watershed. ERP's Dominion Energy Learning Barge is the world's first floating wetland classroom and 'America's Greenest Vessel.' According to ERP it's

Lafayette Wetlands Partnership volunteers remove invasive phragmites. Credit: Lafayette Wetlands Partnership

a 'steward ship,' teaching the children of the river environmental stewardship actions. Over 70,000 people have been educated on the barge since its 2009 launch.

The LWP is a citizen-based initiative that mentors individuals and groups who want to restore wetland habitat along the Lafayette River. It has worked with civic leagues, churches, schools, and numerous neighborhood leaders in completing ten Phragmites control and shoreline stabilization projects since its inception in 2007. In addition, it has collaborated with the Elizabeth River Project on the installation of several 'oysterberg' reefs based on a design by one of LWP's members.

Through partnerships with ERP, the City of Norfolk, Virginia Sea Grant, and students from several Virginia universities, **WW** is working with Norfolk communities to improve resiliency to sea level rise and address recurrent flooding with sustainable landscapes and green infrastructure practices. WW has worked with many partners to increase the use of riparian buffers, raingardens, living shorelines, and other sustainable landscape and nature-based practices that increase wetlands protection and resiliency. As the Virginia Coordinator for the Chesapeake Bay Landscape Professional (CBLP) Certification Program, Wetlands Watch and partners are building a network of certified professionals prepared to be better green infrastructure partners.

The CBLP is a voluntary credential system for professionals who design, install, and maintain sustainable landscapes in the Chesapeake Bay watershed with two levels available. Level 1 CBLPs can provide basic sustainable landscape services with a particular focus on maintenance of green infrastructure practices and conservation landscaping with native plants. Level 2 CBLPs go through an intensive sustainable landscape seminar and assessment process for design and installation of conservation landscaping and residential scale stewardship practices. WW also offers Certified Floodplain Managers to advise localities and communities on how to restore natural floodplain functions and open space to improve community ratings and reduce flood insurance premiums (see Community Rating System text box).

Old Dominion University has been a strong partner in education and student-led design projects. Over the Fall 2016, Spring 2017, Fall 2017 semesters, Old Dominion University's Engineering Technology Department hosted an introductory training course on green infrastructure. Class participants received a twenty-hour training course, and green infrastructure tour and participated in a hands-on implementation project. Training topics included site selection/design, Science of Green Infrastructure, plant selection, site maintenance, and implementation.

The desired result of the course was to ensure that students understood what green infrastructure is, how it is different from grey infrastructure, how it improves water quality in nearby receiving waters, and potential career opportunities in this field. Implementation projects were chosen in coordination with the City of Norfolk at Norview Elementary School and Norfolk Wellness and Fitness Center. Both implementation projects were successful and utilized 140 volunteer hours for installation. ODU hopes to continue to offer these training courses.

A restored upland area following restoration by Lafayette Wetlands Partnership volunteers. Credit: Lafayette Wetlands Partnership

Norview Elementary School:

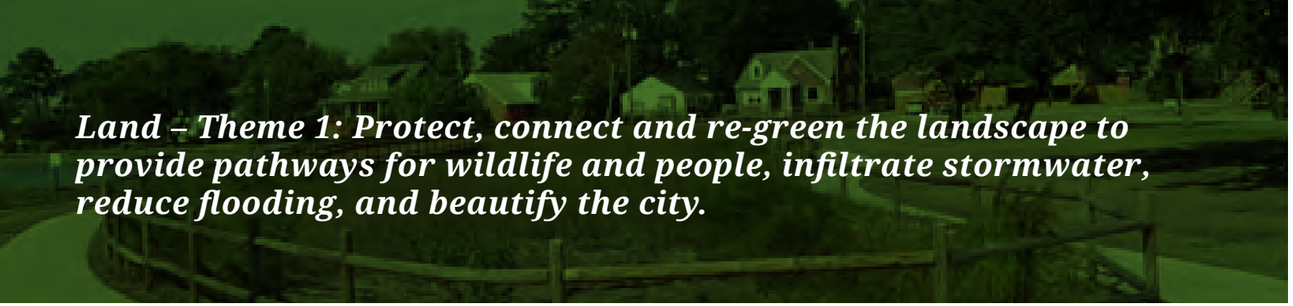
During the fall 2016 class, participants installed a rain garden behind the elementary school, rerouting the gutter system from the roof to the raingarden where plants and trees provide filtration. Volunteers performed site maintenance to remove grassy overgrowth and re-mulching of the entire area.

Norfolk Wellness and Fitness Center:

The site design was implemented over two phases in 2017 to restore a wetlands buffer zone between the parking lot and creek. Phases 1 and 2 both required significant effort to remove overgrowth and invasive vines. After the phase 1 planting, a maintenance day was held to remove the weeds and grasses, and during phase 2, additional plants and trees were installed along the edge of the wetlands. Both sites will require ongoing maintenance to remove invasives.

Plan Strategies

The following strategies were proposed to address the analyzed needs and will serve as guidance for early implementation, with new strategies added over time to continue green infrastructure improvements. In addition to these strategies, the maps and data created should be used for everyday planning; for stormwater designs, site plan analysis, park and open space planting, area plans, informing Vision 2100 and plaNorfolk2030 updates, resilience planning and planning for restoration projects for shorelines, open spaces and urban forestry.



Land – Theme 1: Protect, connect and re-green the landscape to provide pathways for wildlife and people, infiltrate stormwater, reduce flooding, and beautify the city.

LAND GOALS & OBJECTIVES

Land Goal 1: Increase and maintain natural green infrastructure – urban forest, shrub and meadow habitats – to support wildlife, infiltrate and clean water, improve air quality, reduce high temperatures, and provide scenic beauty.

Obj. 1: Create a planting goal for tree canopy to achieve 30% canopy coverage (a 4% increase).

Action 1: Target current city tree planting efforts to city neighborhoods where canopy is less than 30 percent (tree adoptions and right-of-way plantings).

BEFORE

AFTER

Action 2: Hold community tree adoption/planting events in priority neighborhoods and track addresses of where trees are donated.

(Note:Achievement of this goal within the next 20 years requires planting of 5,200 trees annually.)

Action 3: Restore trees and vegetation to upland areas where there is adequate space to plant trees. Use the possible planting areas (PPA) map of highest opportunity planting zones.

Obj. 2: Create incentives for tree planting by citizens and businesses.

Action 1: Create tree planting credit program (a treebate) through public-private partnerships or city programs to reward those who plant trees on private property.

Action 2: Expand existing recognition programs for community tree planting projects to include categories for businesses, churches, schools, and others.

Action 3: Create a tree map for crowdsourcing and tracking trees planted in yards and other private properties.

Action 4: Seek new community partners to provide guidance, support, and grant cost-sharing to private property owners in areas of the city not served by current community environmental organizations, such as Little Creek, Ocean View, Willoughby, Mason Creek, and Lake Whitehurst.

Action 5: Review options for encouraging or requiring the retention of trees on private property.

Obj. 3: Protect intact habitat patches in the city and connect or reconnect them with green pathways to support people, plants, and animals. (See future green infrastructure map).

Action 1: Plant street trees on key connection routes between civic spaces such as parks, schools and cultural sites for streets having low canopy (See map of street by street analysis, walk zones for parks and schools and the base green infrastructure network map).

Action 2: Partner with local nonprofit groups to encourage residents to plant '3Bs' (birds, bees, butterflies) pathways and add more information to the city website about the importance of habitat.

https://www.norfolk.gov/documentcenter/view/28756

Action 3: Create a map of current community habitat projects and areas that need projects.

Action 4: Develop policy requiring replacement or transplant of all trees impacted by roadway or utility infrastructure improvements, where preservation is not possible.

Obj. 4: Encourage the use of native plantings.

Action 1: Create a suggested planting list for the city that includes appropriate species for near shore areas (salt and water tolerant), street trees and open space trees. Consider whether species recommended for planting should change as climate becomes warmer.

Action 2: Choose resilient species for plantings (consider southern species/changes in species due to climate change/salt tolerant species).

Action 3: Promote the use of low maintenance native grasses to improve infiltration and habitat in highly visible areas such as rain gardens, medians, ditches, and edges of restoration areas.

Action 4: Develop an education campaign through Bay Star Homes to promote use of natives, emphasizing species similar in appearance and function to commonly used non-natives.

Action 5: Enlist more local plant sellers and nurseries in the Southeastern Virginia plant natives campaign to provide numerous alternatives to common non-native landscape selections.

https://www.plantvirginianatives.org/plant-southeast-virginia-natives

Obj. 5: Improve the city's data on trees to ensure good management and longevity.

Action 1: Update the canopy map every five years.

Action 2: Implement a citizen tree survey and train community members in tree survey to track tree diversity, coverage and health.

Action 3: Institute street and park tree risk assessments in areas most at risk from storm damage and track responses.

Action 4: Utilize existing software tools and research to track co-benefits of green infrastructure enhancements, including carbon sequestration, air quality improvements, and heat island reduction.

Obj. 6: Promote urban food production for healthful communities and permeable landscapes.

Action 1: Create media campaign about grow local/eat local.

Action 2: Plant orchards or food forests in city parks.

Action 3: Establish community gardens on vacant lots.

Action 4: Consider establishing community farms on larger open spaces and use these to promote healthy eating and education about how to establish gardens.

Obj. 7: Daylight (re-surface) creeks that have been buried to expand channel capacity and provide natural amenities for communities.

Action 1: Identify filled creeks which could be daylit as part of future development and resilience plans (see city data for possible sites).

Action 2: Engage the community in creating a design for a new creek or wetland park(s), and in helping plan the site.

Land Goal 2: Install and maintain constructed green infrastructure to detain and retain stormwater and beautify areas where natural green infrastructure practices are less suitable.

Obj. 1: Use schools and parks as demonstration sites for low impact development – constructed and natural green infrastructure – and continue to engage students as designers.

Action 1: Develop policy requiring green infrastructure practices be included in designs for all new city and Norfolk Public School facilities.

Action 2: Implement the green infrastructure training modules developed by Old Dominion University (ODU) for use by Earth Science classes during hydrology lessons. (Course offerings started in January 2018.)

Action 3: Engage students to design and install new infiltrative practices (including how to budget and plan for them).

Obj. 2: Retrofit existing parking lots to create room for bioswales and other best management practices to infiltrate or store water.

Action 1: Identify parking lots for retrofitting, beginning with city-owned lots that may need resurfacing or where medians can be depressed, or water storage may be added.

Action 2: Promote parking lot retrofits as an option to reduce (not eliminate) the stormwater fee.

Action 3: Promote improved variable space parking.

Obj. 3: Encourage building owners to retrofit existing roofs for stormwater treatment.

Action 1: Publicize the benefits of green roofs; consider a web site with case examples of how they work and why they help Norfolk.

Action 2: Create a roof top retrofit opportunity zone for areas of the city where imperviousness is high and green space is low. Analyze rooftops (using flat roof tops and year built <1975) to show where green rooftops might work based on the infiltration and storage map on page 40.

Action 3: Consider whether the city could provide a tax incentive or fee reduction for those businesses that install a rooftop retrofit to hold stormwater (in addition to reduction in stormwater utility fees).

Action 4: Promote the use of other methods to slow, capture or treat roof runoff such as green walls, downspout planter boxes, cisterns and other methods on the city's Retain Your Rain website.

Obj. 4: Create an annual innovation award for those developments that use the greatest creativity in instituting and maximizing the use of low impact development strategies.

Action 1: Partner with existing awards programs to create standards for receiving the award; publicize the program and recognition elements.

Action 2: Raise funds to provide incentives for participation.

Obj. 5: Create and promote stormwater education through parks to demonstrate low impact development practices.

Action 1: Consider sites to retrofit as a stormwater learning park, ideally impervious areas to convert as a demonstration site. Create grant proposal to fund the park as well as seeking sponsors (e.g. a company could install a certain practice with credit in the park). This park can demonstrate key considerations for coastal best management practices. (Review the Cincinnati green stormwater learning park for how it was developed and funded.

http://www.civicgardencenter.org/green-learning-station/explore-the-gls/?view=gls?view=gls?view=gls)

Action 2: Review and promote the green infrastructure walking tour at ODU. Consider whether a similar tour could be created for other locations such as the Norfolk Botanical Gardens and the Virginia Zoo.

Action 3: Design a stormwater playground to allow wet parks to function for stormwater management during wet weather and as playgrounds and open space other times. Identify how parks that currently face inundation could be modified.
(See **Appendix B** for examples.)

Obj. 6: Expand or create volunteer programs to maintain the aesthetics and health of green infrastructure projects.

Action 1: Promote the beautification theme of Adopt-a-Spot program and expand adoptable areas to include rain gardens, community food production plots, buffer areas, tree groves, and other locations that may require enhanced maintenance for aesthetics.

https://www.norfolk.gov/index.aspx?nid=2626&PREVIEW=YES

Action 2: Encourage local businesses to adopt green infrastructure areas and review creative signage options.
(See an example at *http://go-sage.com/the-program/*)

Action 3: Develop maintenance agreements for adopted locations that allow adequate maintenance by volunteers, including use of approved power tools and pesticides.

Action 4: Launch education campaigns with local groups to manage expectations for the varied aesthetics of green infrastructure at different times of year and at different ages after installation (i.e. initial appearance versus after five years).

Action 5: Identify community partners to assist with monitoring of sites which require less routine maintenance, such as tidal marshes and forested buffers.

Obj. 7: Increase knowledge about the infiltration capacity of the city's soils to ensure projects account for local soil conditions when designing stormwater projects or land development plans.

Action 1: For areas where there are poorly drained or low organic matter soils, encourage landowners to increase infiltration by adding organic soil amendments, aerating turf areas and converting lawns to shrubs and trees.

Action 2: Develop standards for soil and infiltration testing and require application of these standards for retrofit projects (similar to requirements for development projects in the Norfolk Stormwater Design and Construction Manual).

Action 3: Develop database of soil borings for past and future projects to improve knowledge about the condition and types of soils and house the data at the Public Works Department.

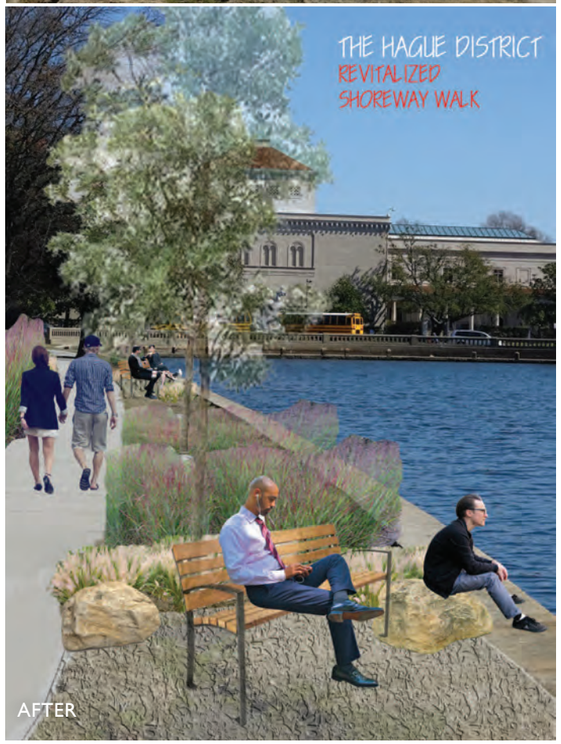
Land Goal 3: Provide adequate open space access to ensure a healthful city for residents and visitors.

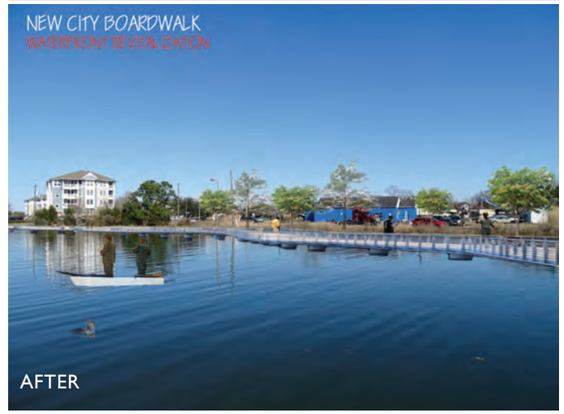
Obj. 1: Increase access to parks and natural areas to support community health and wellbeing by ensuring that all residences are within ¼ mile of a park *(see map of areas in gap zones where access is lacking, currently 52 percent of city is within walking distance of ¼ mile)*

Action 1: Put new parks in communities that have a lack of open space (see map of park access) and replace parkland that will be lost due to sea level rise and repetitive storm surge.

Action 2: For parks that will be somewhat inundated by sea level rise, consider ways to utilize inundated areas by adding boardwalks or boating access points.

Action 3: Develop policy requiring review of all newly vacant city properties for open space potential prior to sale for development, with special priority given to areas lacking existing open space within ¼ mile.





Obj. 2: Create or modify trails to provide more opportunities for recreation and alternative transportation options for pedestrians of all abilities.

Action 1: Continue to work with the Elizabeth River Trail Foundation, city agencies and others to plan new trails or trail modifications.

Action 2: Plan to reroute or convert land trails to boardwalk trails that will be lost to sea level rise or face repetitive, damaging storm surge.

Action 3: When seeking new park or water access, consider whether there are paper streets or undevelopable parcels that could be used for public right of way access.

Obj. 3: Target streets for conversion to complete green streets to soak up stormwater, improve aesthetic values, increase safety and provide more opportunities for alternative transportation. (e.g. bike lane streets and entry corridors.)

Action 1: Set goal to make all city bike corridors 'complete green streets.'

Action 2: When designing new streets or improvements, recess all planting medians and right of way plantings to absorb and temporarily store water (see illustration of recessed planting for green streets).

Action 3: Plant trees near bus stops lacking shade (see map of bus stops with planting areas available).

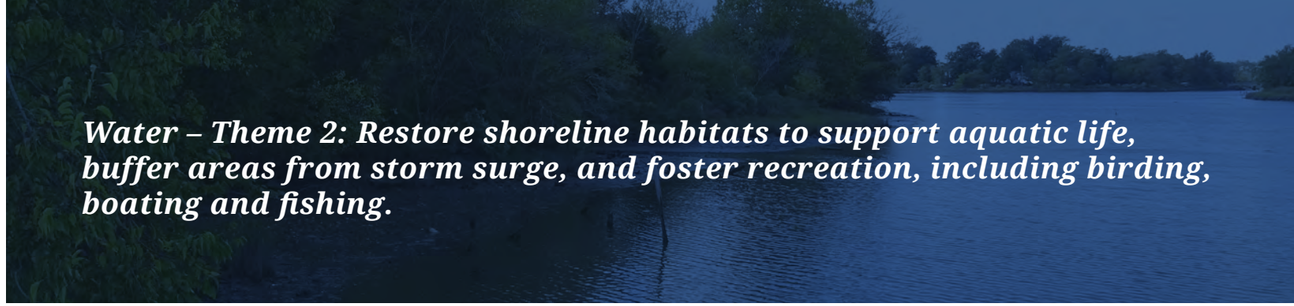
Obj. 4: Protect or enhance landscapes and buffers around and near key historic and cultural sites (see history and culture map).

Action 1: Retain historic landscapes by requiring a 1:1 replacement for private property trees removed in designated city historic districts.

Action 2: Fund signage and small pocket parks to recognize more historic sites in the city, such as unrecognized African American or Native American sites, as well as interesting stories to expand the walking tours available currently.

https://www.visitnorfolk.com/things-to-do/self-guided-tours/

View of the Lafayette River from the Hermitage Museum. Many projects have been done to restore the buffers on the grounds of this historic estate.



Water – Theme 2: Restore shoreline habitats to support aquatic life, buffer areas from storm surge, and foster recreation, including birding, boating and fishing.

WATER GOALS AND OBJECTIVES

Water Goal 1: Protect and restore natural shorelines to support healthy aquatic life, storm buffering, and water filtration.

Obj. 1: Restore and expand wetlands to protect shorelines from storm surges, prevent erosion, and filter pollutants (refer to city map of candidate areas).

Action 1: Develop master plan of sites on city-owned land to restore and prioritize based on site condition and location.

Action 2: Develop inventory of existing oyster resources and potential reef restoration sites in all tidal waterbodies, similar to recent work in the Lafayette River.

Action 3: Add areas for oyster habitat creation to shoreline restoration projects where possible.

Action 4: Encourage residents and businesses to work with local nonprofit groups to protect or expand wetlands on private property.

Action 5: Assess the ability of residents to make use of the tax credit for those properties where lands have been inundated (as authorized by S 58.1-3666 Code of Virginia).

Obj. 2: Restore vegetated buffers around the city's lakes, ponds, reservoirs, wetlands and shorelines to protect water quality and allow inland migration of wetlands as sea level rises.

Action 1: Conduct buffer outreach campaigns to residents and businesses through the city's Bay Star and Lake Star Homes programs and community programs such as ERP's River Star and Friends of Norfolk Environment programs.

Action 2: Highlight pilot projects in highly visible areas where property owners can see different styles of buffers.

Action 3: Restore forested buffers on public property in areas where it is deficient in the current Chesapeake Bay Preservation Area and in areas where the CBPA may extend by the year 2040.

Action 4: Implement or incentivize restoration of meadow or forested buffers around city reservoirs, lakes, and stormwater ponds.

Obj. 3: Expand programs to engage private property owners in planning for change on those properties where inundation from sea level rise may occur.

Action 1: Promote participation in the Elizabeth River Living River Trust to conserve open spaces.

Action 2: Create a campaign similar to 'Retain Your Rain' with strategies for management of shoreline properties.

Obj. 4: Remove non-native invasive species and encourage removal campaigns through partnerships with residents, the military, nonprofit groups and local businesses.

Action 1: Coordinate with the military to implement a phragmites removal program around the naval base.

Action 2: Develop resources and partnership programs to remove phragmites.

Action 3: Review the development of potential programs to utilize volunteers for removal or management of non-native invasive species in shoreline buffers and dunes. Consider a citizen monitoring protocol to track the problem.

Water Goal 2: Expand water access for boaters, fishermen, birders and walkers of all abilities.

Obj. 1: Provide new boat ramps for motorized and non-motorized boats, including adequate parking and staging areas. (See map of existing and needed areas).

Action 1: Select areas to prioritize new ramps and repair failing ramps. Seek community input for where ramps are desired.

Action 2: Review options for small neighborhood "put-ins" on paper streets or right-of-way for kayaks, canoes, and paddleboards, to be adopted and maintained by the community.

Obj. 2: Provide access and views of the water by creating new pocket parks, passive green spaces or vistas, especially for those areas which will lose open spaces due to future sea level rise.

Action 1: Develop an appendix to Parks and Recreation Master Plan to identify park or open space areas where water viewsheds are limited.

Action 2: Expand Adopt-a-Spot to include adoptions and maintenance of small parks and vistas, including agreements on which vegetation can be pruned to maintain desired viewsheds.

Obj. 3: Provide fishing access (piers, docks, cleaning stations) for residents and visitors of all abilities throughout the city.

Action 1: Expand Adopt-a-Spot to include boat launches and fishing areas to keep sites clean and ensure timely reporting of problems.

Action 2: Build new fishing facilities in neighborhoods where access or facilities are lacking.

TIMEFRAME FOR ACHIEVEMENT

This plan will likely take a decade or longer to achieve. However, the best use of this plan is for everyday decision making. This plan should be used to change the way the city plans – by considering its natural and green connected network as part of everyday decision making.

This plan will be overseen by the Watershed Management Task Force. They will establish key benchmarks, review process for updating the data and plan. Most importantly, they will establish partnerships and seek funds to carry out objectives.

Each year, the WMTF will evaluate the plan and prioritize actions to tackle. If some actions are not being taken, they may consider whether objectives or actions need to be modified or whether more urgent action is needed to carry them forward. City agencies will also need to review the plan (they are also on the WMTF) and consider action items that can be accomplished through their existing or upcoming work plans.

Conclusion

The City of Norfolk is well on its way to becoming the ***coastal community of the future.***

With the talent, innovation, progressive planning, zoning and mapping underway, the city has new tools to build resiliency. Most importantly, the city has a long history of partnership and being willing to listen to new ideas, even when they represent an entirely different way of thinking. Norfolk has shown time and time again that it can and will adapt to meet community needs today and in the future.

The implementation of this green infrastructure plan will help the city make tremendous progress in managing and connecting its green spaces thereby creating a more walkable, infiltrative, attractive and livable city. The city is on a journey of learning to live with water in a whole new way. This plan represents creative ideas and analysis for how to implement the city's resilience strategy.

This plan should be updated to reflect new ideas, innovations and needs. It should be seen as a living document that can be modified as needed. The data created for this plan (land cover, tree canopy, shoreline migration, infiltration, walkability) should be used to inform everyday planning and management decisions by city agencies and partner organizations. Maps are available on the city's website to download and use.

Many of the actions in this plan such as tree planting, shoreline restoration or seeking grants will require partnerships amongst city agencies and stakeholder groups to make them possible. An implementation schedule for this plan will be developed and overseen by the City's Watershed Management Task Force (WMTF). The WMTF will establish implementation strategies and schedule and will review the plan annually to update its progress and develop new approaches for implementation. The WMTF will also establish annual benchmarks to track strategies' progress.

The appendixes provide examples of related strategies and list of grant sources that may be applied to fund this plan. Some of the work in this plan will need to be funded out of the city's budget, while other work will require a new way of doing business, with more frequent and creative collaboration between agencies and their partners.

Sunset over Lake Whitehurst

Appendixes

APPENDIX A: RESOURCES FOR FUNDING AND PROJECT DEVELOPMENT

This plan's implementation will be managed by the Department of Public Works and overseen by the city's Watershed Management Task Force. However, there are several objectives for which other agencies should take the lead. For example, Norfolk Public Schools may want to lead applications for safe routes to school, while Norfolk's Dept. of Recreation, Parks and Open Space may take the lead on projects to install butterfly gardens at city parks or new street tree plantings.

There are many interrelated ideas for how to fund actions listed in this plan. Some ideas do not require new funding to implement. Rather, they need a change in coordination or planning for existing programs. As shown in the report section Partnerships Make It Possible, groups already collaborate quite a lot – but there is always room to collaborate even more! This section covers ideas and examples for how funds can be obtained and creative ways to finance new actions. These resources and links were current as of the date of this plan (July 2018).

Some funds for this plan could be obtained by putting projects into the city's Capital Improvements Program (CIP) (*https://www.norfolk.gov/index.aspx?NID=191*)

For example, if the city is resurfacing a city lot in a highly impervious zone where water infiltration is important, why not make it a permeable pavement or permeable concrete surface? If a school needs a new roof or if a new school is being planned, could it have a green roof instead of a conventional roof?

Getting projects done may just take a creative approach. Here is one example: a stream restoration project was completed entirely for free. Here's how. VDOT volunteered to supply the backhoe to re-slope the stream channel, planting materials were obtained by calling USDA to request end-of-year plant materials that were left over and materials were harvested from nearby open lands, labor was donated from volunteers, erosion control fencing, gloves and other materials were also donated and boy scouts built a fence to protect the young plantings. Of course, such projects take coordination. This was donated by staff from the Virginia Department of Forestry and the Department of Conservation. Cash needed for the project: $0.

Some projects can be planned and installed entirely by volunteers. Eagle Scouts have installed gardens, footbridges, stream buffers, trails, benches, removal of invasive species and many more design build projects. The oldest continuously chartered scout troop in Virginia is in the Ghent Neighborhood. See *https://norfolk1.mytroop.us/*

Similarly, neighborhood groups and collaborative efforts, such as the Lafayette Wetlands Partnership have installed projects across the city.

Maintenance is a key concern and a maintenance agreement is needed for any project constructed or maintained by volunteers. If maintenance requirements will be high, consider whether the project could be designed to have lower maintenance. These details should be worked out in advance. If the project needs trained people to do the work, having people take a certification course may be a good idea so that the project is cared for properly. Consider the Chesapeake Bay Landscape Professional Certification Program, see: *https://cblpro.org/get-certified/*

The best approach for funding is to prioritize objectives in the attached plan and form partnerships to go after funding. Many funding topics are interrelated. For example, goals for walkability and green streets can be combined by planting street trees to provide shaded walks to school and recessing the planting beds can allow them to provide stormwater treatment along designated safe routes to schools. Some grants will require a nonprofit corporation to be the applicant while others (such as Virginia Department of Forestry) allow the local governments to apply. Following are examples of technical support and project funding.

Water Access

Paddling Grants for Water Trail and Facilities (apply in March):

Ivan Levin, Senior Director Programs + Outdoor Nation
Outdoor foundation, 419 7th Street NW, Suite 401,
Washington, DC 20004
https://outdoorindustry.org/participation/outdoor-foundation-grants-management/

Water Trails Guidance

American Rivers Blue Trails Guide:
http://www.bluetrailsguide.org

River Network River Voices on Water Trails
https://www.rivernetwork.org/wp-content/uploads/2016/04/River-Voices-v16n2-2006_What-is-a-Water-Trail.pdf

Guidelines for Paddling Trail Development
http://myfwc.com/boating/waterway/paddling-trails/

Chesapeake Bay Gateways Network: Water Trail Toolbox
http://www.baygateways.net/watertrailtools.cfm


Ship Yards

Low Impact Development and Stormwater Management

Grants for Low Impact Development, Habitat Restoration and More (they funded this plan)
National Fish and Wildlife Foundation
http://www.nfwf.org/whatwedo/grants/pages/home.aspx

Urban Waters Small Grants from U.S. EPA (usually release RFP in the fall, check to see if program funded each year)
https://www.epa.gov/urbanwaters/urban-waters-small-grants

Virginia Environmental Endowment: Funds planning for climate adaptation and coastal resiliency.
http://www.vee.org/grant-programs-application/general-grants/

Habitats and Tree Planting

Backyard and School Butterfly Gardens (apply by Oct. 15)

The WildOnes
Cash grants of $500 for plants and seeds, and prefer students and teachers apply for school projects.
http://www.wildones.org/seeds-for-education/sfe/

Alliance for Community Trees Program, Arbor Day Foundation (ability to network and to apply for tree planting grants for those who join the group (fee is $125.00)
http://actrees.org/what-we-do/grants-and-awards/planting-trees/

Virginia Department of Forestry, Urban and Community Forestry Program: Funds for the tree planting if educational, also for open space master plan / tree planting plans /landscaping plans. Virginia's Urban & Community Forestry Program.
http://www.dof.virginia.gov/forestry/community/index.htm

Dominion Charitable Foundation: They have supported many community tree planting projects.
https://www.dominionenergy.com/community/dominion-energy-charitable-foundation/email-dominion-foundation

Walkabilty

Transportation Enhancement Grants/Transportation Alternatives:

This funds multi-modal, trails, depends on Congressional allocation. This could be used to plant trees for safe routes to school, pedestrian bridges, traffic calming/green streets.

Link to the grant application page – usually for November deadline:
http://www.virginiadot.org/business/prenhancegrants.asp

Virginia Profile:
http://trade.railstotrails.org/state_profile?state_id=51

About the program – funding eligibility:
http://trade.railstotrails.org/10_definitions

Rails to Trails Conservancy: Funding links for converting rail lines into trails.
http://www.railstotrails.org/build-trails/trail-building-toolbox/acquisition/financing-and-funding/

In addition, visit the Foundation Center:
http://foundationcenter.org/

APPENDIX B: CASE EXAMPLE OF STORMWATER PLAYGROUNDS –

A Fun Way to Treat Rain Water and People

By Janie Whitworth and Karen Firehock

This case example describes the green infrastructure strategy for implementing stormwater playgrounds. Stormwater playgrounds are a form of constructed green infrastructure that may treat stormwater on site as well as from nearby surroundings. These interventions act like sponges, soaking up wastewater and slowly releasing filtered water into the ground. Each stormwater playground, depending on acreage can collect hundreds of thousands gallons of water each year. These playgrounds often collect not only the first inch of rainfall from the particular site, but from the surrounding impervious areas as well. The playground and its subsurface infrastructure then manage runoff at its original location rather than letting it flow off-site and to a river or stream. This Low Impact Design allows the site to remain as close to its pre-playground and settlement state as possible, filtering water and avoiding potential flooding.

Conventional stormwater treatment such as detention basins, take up a great deal of useable land. In dense urban areas, stormwater detention basins may be located in areas where open space is scarce. The ability to change these spaces into useable play areas while also meeting goals for stormwater management is a tremendous opportunity. Even an existing playground could be retrofitted to become a stormwater playground.

Construction of the basketball court at Clark Park shows the installation of material to allow water to percolate through with a liner to trap finer materials.

A secondary opportunity is to take existing surfaces used for sports, such as basketball courts, and convert them to permeable spaces. The surface of the playground is the most vital element to creating and maintaining a stormwater playground. The subsurface infiltration systems protect the surface layer and allow the playground to collect an even greater volume of water. These systems can hold a large amount of water while the water is slowly percolating into the ground below. The subsurface infiltration systems incorporated in these play spaces remove a high percentage of suspended solids and organic compounds from runoff. This results in a reduction in the volume of stormwater runoff and amount of pollution entering water systems. Using systems like these to replace aging playgrounds and infrastructure will reduce the frequency and amount of combined sewer systems' overflows that often occur with aged infrastructure.

A subsurface infiltration bed beneath a new basketball court at Clark Park in Philadelphia manages stormwater runoff from the basketball court, as well as from an adjacent street and parking lot. The system has been designed to capture about 1.5" of rainfall from the contributing drainage area, but with well-drained soil, it is anticipated that actual stormwater capture will be much greater.

Stormwater playgrounds are applicable anywhere there are people who will use them and especially in areas lacking stormwater treatment. They are especially helpful interventions in the urban setting where imperviousness is high and where more open space is desired. They also can be installed as part of redesigning an existing park as shown on the next page.

The Trust for Public Land and New York City's Department of Environmental Protection formed a partnership to turn 40 asphalt-covered play spaces across the city into stormwater management systems. Above is one of these many playgrounds in Harlem. The Trust for Public Land has developed 189 playgrounds in New York City that are also open to the public outside of school hours.

Transformed Stormwater Playground at School 154M in Harlem in New York City

The Herron Playground, pictured below, is a city-owned facility managed by Philadelphia's Parks and Recreation Division and is located in a neighborhood with a combined sewer system. Philadelphia Water, Philadelphia Parks and Recreation, and the City's Capital Program Office designed and constructed this infiltration system as a reconstruction of the playground to manage on and off-site runoff from adjacent streets.

The basketball court was reconstructed and resurfaced with porous asphalt and a subsurface infiltration system was installed beneath the basketball court area to manage stormwater runoff from portions of the adjacent streets. A new infiltration trench with a perforated pipe laid in gravel replaced a traditional concrete drain, allowing stormwater to soak into the soil beneath the porous play surface while ensuring proper drainage.

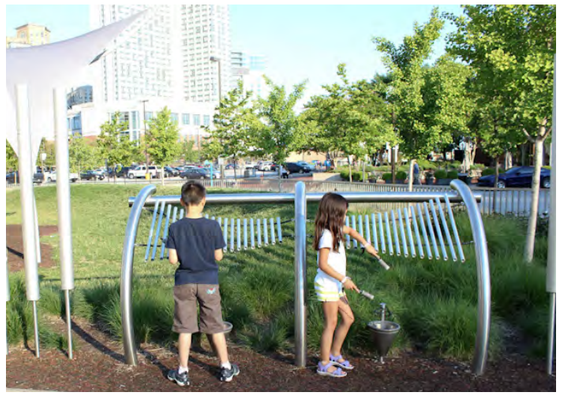
The Trust for Public Land (TPL) in New York receives public funding from the Departments of Education and Environmental Protection, the School Construction Authority, the City Council, and the Manhattan Borough President, the Queens Borough President, and the Bronx Borough President. New York Road Runner also

Herron Playground, Image Credit: Trust for Public Land

contributed an initial $1 million to help fund the design and construction of playgrounds at three school campuses, serving six schools, and plans to continue funding to support the construction of stormwater playgrounds in all five boroughs of New York.

Incorporating stormwater management practices in the construction of playgrounds reduces the amount of maintenance required to ensure a long lifespan for the playground. The cost of the Herron Park design and construction was $1.1 million, but maintenance costs will be lower, due to less cracking from freeze thaw caused by standing water. These structural changes improve drainage, reduce erosion, and eliminate standing water, all of which extend the lifetime of the playground and reduce the amount of required maintenance. Permeable pavement is low maintenance, but requires occasional vacuum sweeping.

The TPL reports that each playground absorbs hundreds of thousands of gallons of water annually and includes 30 new trees that provide benefits in shade and water pollution absorption. The 1.12 acre Herron Park now retains the first inch of rainfall from the site itself as well as runoff from 1.17 acres of adjacent, impervious land.



Pierce's Park in Baltimore Maryland creates a beautiful urban space that now infiltrates water too.

Baltimore City's redevelopment along its waterfront includes Pierce's Park is a multifunctional green space that combines play, stormwater management, and environmental education into a one-acre urban oasis. Designed by landscape architecture firm Mahan Rykiel Associates, the park incorporates rain gardens and recycled material into an artful space that doubles as a playground.

Additional signage may be needed to advise areas are off limits during rainstorms, however well-draining areas should not hold standing water. Existing structures such as buildings can also be retrofitted with cisterns to hold stormwater and release it later for landscaping needs. As these examples show, stormwater playgrounds can be functional open space that also address the need to retrofit stormwater management practices into existing landscapes that lacked treatment of surface runoff previously.

Examples of Stormwater Playgrounds

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APPENDIX C: MAPPING RULES FOR MARSH MIGRATION, SHORELINE RESTORATION, AND BUFFER PLANTING

Marsh Migration

This analysis shows three scenarios this plan utilized to evaluate effects of sea level rise (SLR) on marsh migration and formation. The following three scenarios created were created

1) Where existing marsh might have room to migrate with the rising sea level but will be blocked by existing roads.
2) Where isolated marsh might form if sea level rise crosses over a road or other impervious surface.
3) Where there is currently no marsh, but one could form as seal level rises.

Following are the mapping rules applied.

COASTAL MARSH FORMATION

1. Located adjacent to coast
2. Inundated by SLR year 2040
3. Has pervious surface or tree cover
4. Does not cross road.

EXISTING MARSH MIGRATION

1. Adjacent to existing marsh or wetland
2. Within a distance of 5 ft. to nearby marsh
3. Can jump to further adjacent features no more than 5 ft. away
4. Inundated by SLR year 2040
5. Pervious or tree cover
6. Does not cross road.

ISOLATED MARSH FORMATION

1. Adjacent to existing marsh or wetland
2. Inundated by SLR year 2040
3. Pervious or tree cover

The year 2040 was modeled for between 1.5 to 2.5 feet of sea level rise.

Shoreline Restoration

This analysis reviewed where hard shoreline might be converted to a natural state. This analyses considered parcel by parcel where there are areas below 4-ft, elevation that are at least 30 feet from a road or building. If an area does not fit this (30 feet from road or building) criteria but most likely lost to sea level rise, then it was not included.

HARDENED SHORELINE

1. Select all land less than 4ft elevation adjacent to hardened shoreline (initially in)
2. If parcel has building (> 500 square feet) lost to SLR but meets rule 1 then keep (keep)
3. If parcel does not have a Tax ID (public land) but meets rule 1 (keep)
4. If parcel has building within 30 feet of 4ft zone then drop (drop)
5. If parcel has road within 30 feet of 4ft zone then drop (drop)
6. Visual inspection: If parcel is highly impervious along major city scape then identify but do not count in final number.

This analysis considers where soft shorelines could be (if necessary) rehabilitated to a more natural state. A 40-foot buffer was used from the inland side of existing wetlands and along natural shorelines (Not hardened). This analyses considered parcel by parcel where areas below 4-ft. elevation was more than 30 feet from a road or building. If an area does not fit this (30 feet from road or building) criteria but most likely lost to sea level rise, then it was included.

SOFT SHORELINE

1. Select all land within 5ft buffer of soft shoreline. i.e.: Not hardened. (initially in)
2. If parcel has building (> 500 square feet) lost to SLR but meets rule 1 then keep (keep)
3. If parcel does not have a Tax ID (public land) but meets rule 1 (keep)
4. If parcel has building within 30 feet of 40 ft. buffer zone, then drop (drop)
5. If parcel has road within 30 feet of 40 ft. buffer zone, then drop (drop)
6. Visual inspection: If parcel is highly impervious along major city scape then identify but do not count in final number.

Shoreline/Buffer Planting

This analysis used a 50-foot buffer from both the existing and future (2040) coastlines. Where pervious land cover was within the buffer it was considered to have potential for planting.

Note this analysis identified wetland vs coastal planting; if the current shoreline was going to be lost to SLR then it was dropped from the map.

CURRENT

1. 50 ft. buffer from coast (where wetlands exist coastline is defined as inland boundary of wetland.)
2. Areas that are currently pervious

FUTURE

1. A 50 ft. buffer marked from the estimated 2040 coastline. i.e.: after projected sea level rise
2. Areas that are currently pervious

NOTES

1. The tree planting strategy included 20 and 40-foot diameter trees, with a 20% overlap.

APPENDIX D: REFERENCES

Direct download links have been provided when possible.

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Native Plants For Wetland Restoration and Enhancement: https://www.norfolk.gov/DocumentCenter/View/3827

NOAA Sea Level Rise Viewer: https://coast.noaa.gov/digitalcoast/tools/slr

Land Use and Sea Level Rise: Practice Tips for Land Use Practitioners in the Wake of Changing Regulatory Schemes: Tips for how to plan for and deal with flooding and flood prone areas, especially sea level rise. https://www.americanbar.org/publications/probate_property_magazine_2012/2015/july_august_2015/2015_aba_rpte_pp_v29_3_article_negro_land_use_and_sea_level_rise.html

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USDA Forest Service. https://www.fs.fed.us/psw/topics/urban_forestry/products/cufr_511_large_tree_argument.pdf

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Sustainable Urban Forest Guide: http://www.itreetools.org/resources/content/Sustainable_Urban_Forest_Guide_14Nov2016.pdf

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Data

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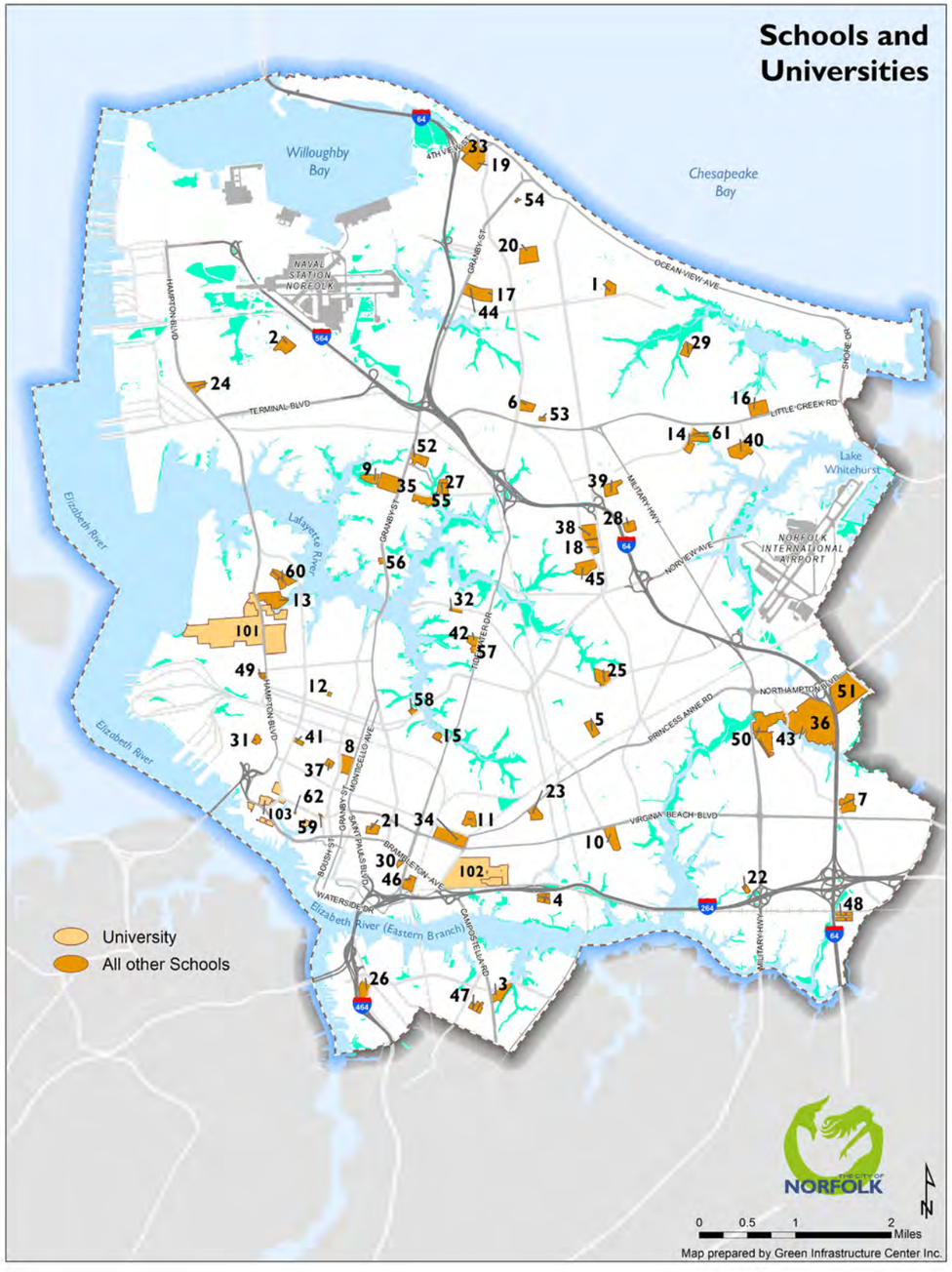
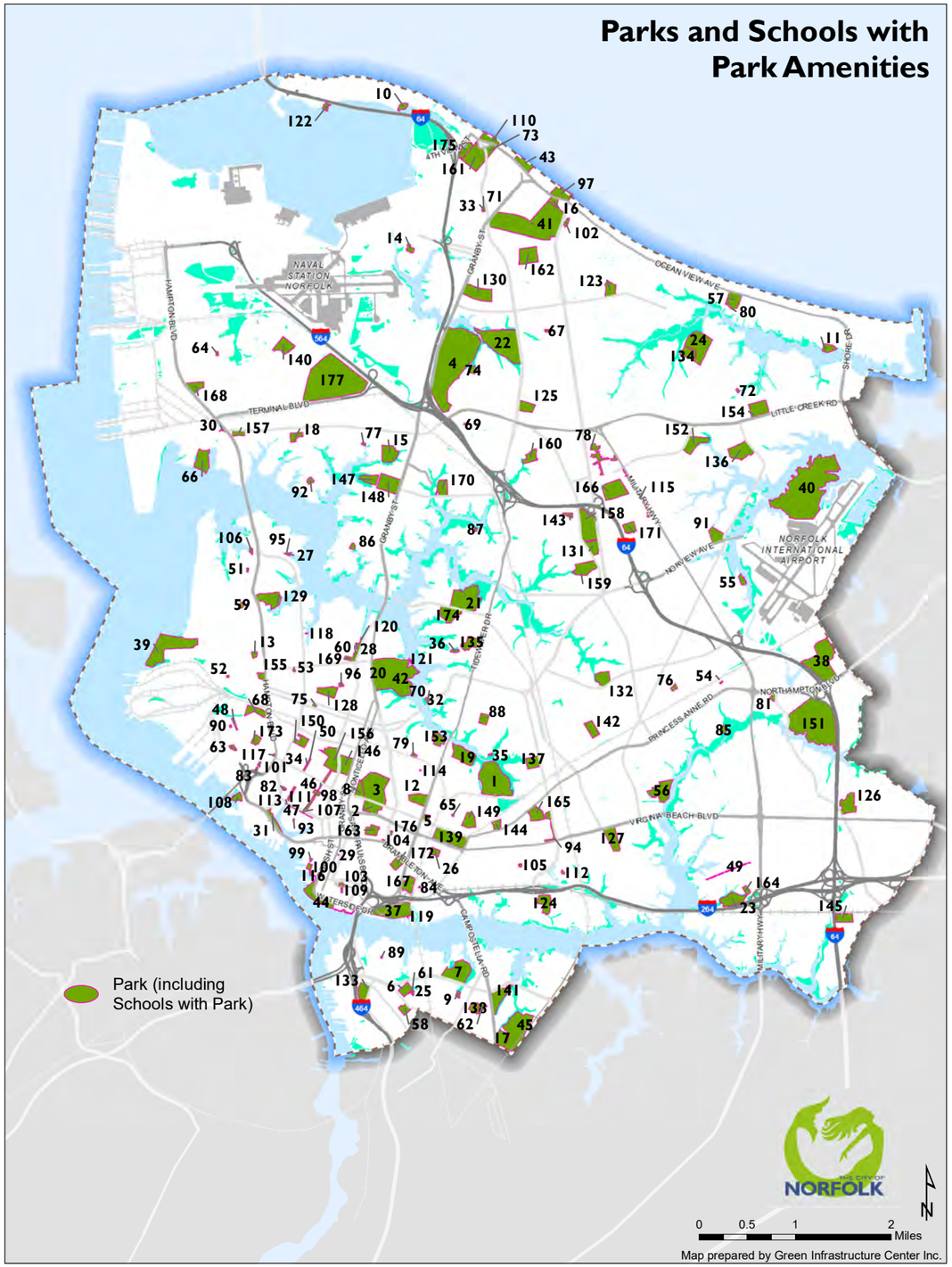
APPENDIX E: REFERENCES FOR MAP LOCATIONS



SCHOOLS & UNIVERSITIES

Label	School Name	Grade Level	Public/Private
101	Old Dominion University	University	Public
102	Norfolk State University		
103	Eastern Virginia Medical School		
1	Bay View ES	Elementary School	
2	Camp Allen ES		
3	Campostella ES		
4	Chesterfield Academy		
5	Coleman Place ES		
6	Crossroads ES		
7	Fairlawn ES		
8	Ghent ES		
9	Granby ES		
10	Ingleside ES		
11	Jacox ES		
12	James Monroe ES		
13	Larchmont ES		
14	Larrymore ES		
15	Lindenwood ES		
16	Little Creek ES		
17	Mary Calcott ES		
18	Norview ES		
19	Ocean View ES		
20	Oceanair ES		
21	PB Young, Sr ES		
22	Poplar Halls ES		
23	Richard Bowling ES		
24	Sewells Point ES		
25	Sherwood Forest ES		
26	St. Helena ES		
27	Suburban Park ES		
28	Tanners Creek ES		
29	Tarrallton ES		
30	Tidewater Park ES		
31	W.H. Taylor ES		
32	Willard Model School		
33	Willoughby ES		
34	Booker T. Washington HS	High School	
35	Granby HS		
36	Lake Taylor HS		
37	Maury HS		
38	Norview HS		
39	Academy of International Studies	Middle School	
40	Azalea Gardens MS		
41	Blair MS		
42	Lafayette-Winona MS		
43	Lake Taylor MS		
44	Northside MS		
45	Norview MS		
46	Ruffner Academy		
47	Berkley/Campostella ECC	Preschool	
48	Easton Preschool		
49	Madison Career Center	Special Purpose	
50	Norfolk Technicall Center		
51	Norfolk Academy	K-12	Private
52	Norfolk Collegiate		
53	Ryan Academy of Norfolk		
54	Ocean View Christian Academy	PK-10	
55	Norfolk Christian Schools	PK-12	
56	Trinity Lutheran School	PK-5	
57	Christ the King Catholic School	PK-8	
58	Faith Academy School		
59	Ghent Montessori		
60	St. Patricks Catholic School		
61	St. Pius X Catholic School		
62	The Williams School		

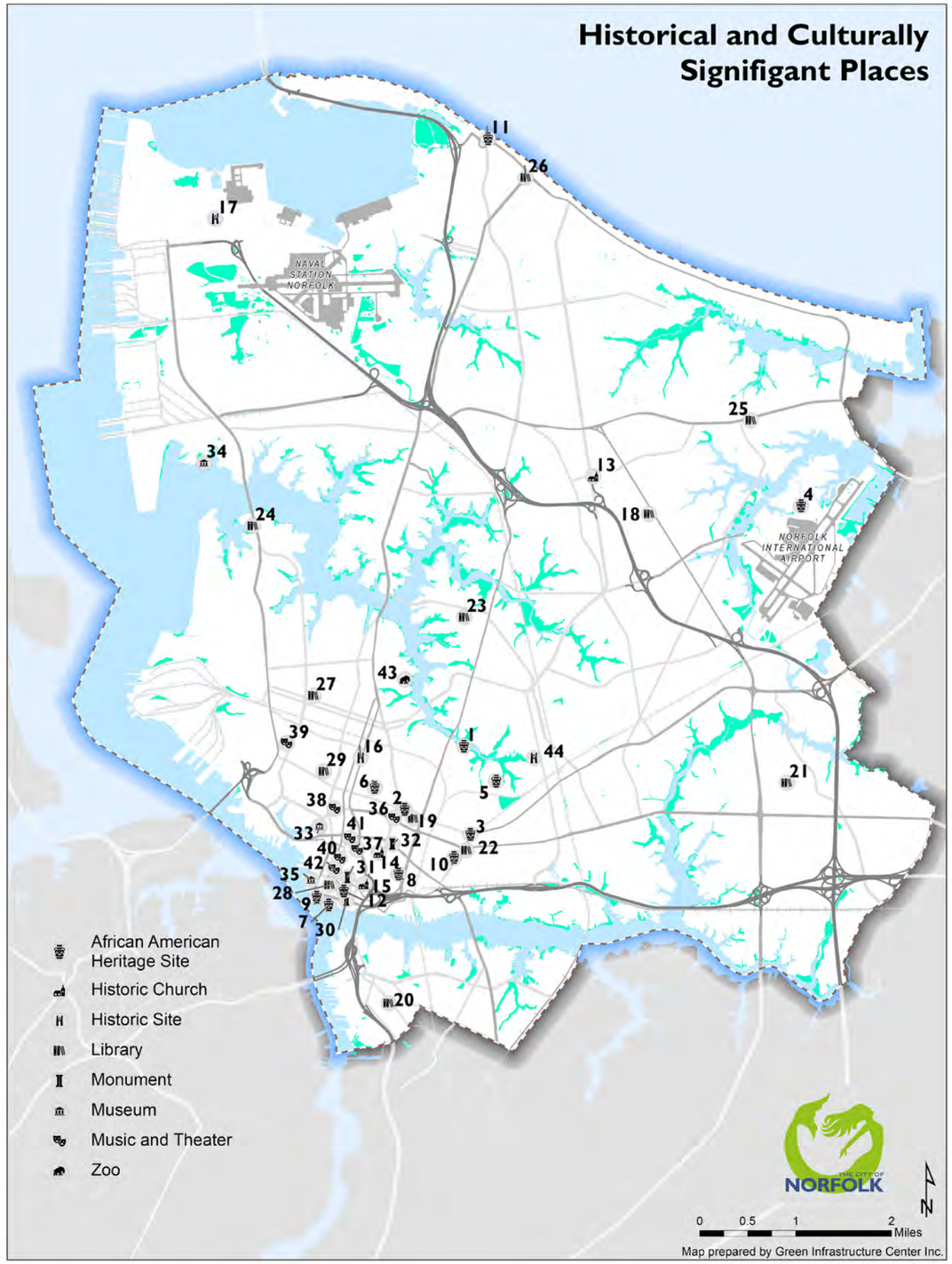


PARKS & SCHOOLS WITH PARK AMENITIES

Label	Park Name
Cemetery	
1	Calvary Cemetery
2	Cedar Grove Cemetery
3	Elmwood Cemetery
4	Forest Lawn Cemetery
5	Hebrew Cemetery
6	Magnolia Cemetery
7	Riverside Cemetery
8	West Point Cemetery
City Centers with Active Park Amenities	
9	Campostella Center
10	Captain's Quarters Park
11	East Ocean View Community Center
12	Huntersville Community Center
13	Lamberts Point Community Center
14	Merrimack Landing Recreation Center
15	Norfolk Fitness and Wellness Center
16	Ocean View Community Center
17	Southside Aquatic Center
18	Titustown Visual Arts Center
Community Park	
19	Barraud Park
20	Lafayette Park
21	Lakewood Park
22	Northside Park
23	Poplar Hall Park
24	Tarrallton Park
Dog Park	
25	Berkley Dog Park
26	Brambleton Dog Park
27	Cambridge Crescent Dog Park
28	Colonial Greenway Dog Park
29	Downtown Dog Park
30	Gleneagles Dog Park
31	Hague Dog Park
32	Lafayette Dog Park
33	Maple Avenue Dog Park
34	Stockley Garden Dog Park
35	Tait Terrace Dog Park
36	Winona Dog Park
Fee Based Open Space	
37	Harbor Park
38	Lake Wright Golf Course
39	Lamberts Point Golf Course
40	Norfolk Botanical Garden
41	Ocean View Golf Course
42	Virginia Zoological Park
Festival Park	
43	Ocean View Park
44	Town Point Park
Known/Future Potential Sites	
45	Campostella Landfill Park
Medians/Greenspace Used as Open Space	
46	Botetourt Gardens- North Blocks
47	Botetourt Gardens- South Blocks
48	Graydon Place
49	Poplar Halls
50	Stockley Garden- North Blocks
51	Virginia Park
Neighborhood Active Park	
52	37th Street Park
53	38th Street Playground
54	Ashby Street Park
55	Azalea Acres Playground
56	Azalea Little League Park
57	Bay Oaks Park
58	Berkley Park
59	Bluestone Playground
60	Colonial Greenway
61	Craig Street Playground
62	Diggs Town Park
63	Fergis Reid Tennis Courts
64	Glennwood Park
65	Goff and Maltby Mini Park
66	Hermitage Museum Playground
67	Hyde Park
68	Jeff Robertson Park
69	Kaboom Playground
70	Lafayette Residence Park
71	Maple Avenue Playground
72	Mona Avenue Park
73	Monkey Bottom Park
74	Monticello Village Park
75	Munson Park
76	North Fox Hall Playground
77	North Shore Road Playground
78	Oakmont North Playgrounds
79	Pollard Street Playground
80	Pretty Lake Playground
81	Princess Anne Park
82	Raleigh Avenue Playground
83	Redgate Playground
84	Reservior Avenue Mini Park
85	River Oaks Park
86	Riverpoint Playground
87	Roland Park Playground
88	Shoop Park
89	South Main Street Playground
90	Westover Memorial Park
Neighborhood Passive Park	
91	Airport Gateway Park
92	Algonquin Park
93	Beechwood Park
94	Broad Creek Park
95	Cambridge Park
96	Colonial Avenue Park
97	Community Beach
98	Fred Huette Center
99	Freemason Green
100	Friendship Park
101	Greenway Court Park
102	Lake Modoc
103	MacArthur Memorial Plaza
104	Martin Luther King Memorial Plaza
105	Middletown Arch
106	Myrtle Park
107	Olney Road Parks
108	Plum Point Park
109	Plume Fountain
110	Sarah Constance Park
111	Stockley Garden- South Blocks
112	Stone Bridge Park
113	Stone Park
114	Sutton Street Park

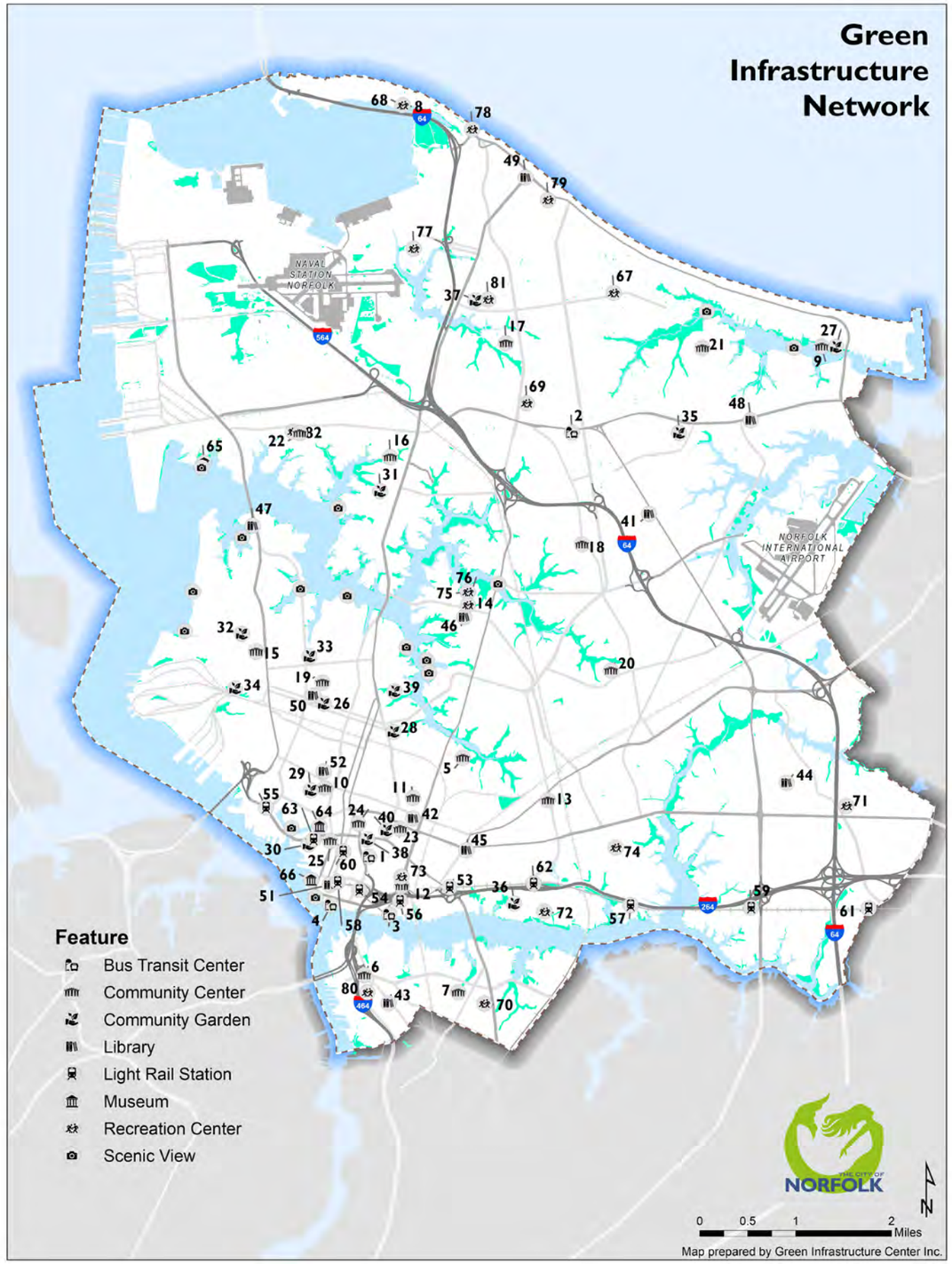
115	Tanners Creek
116	Wisconsin Plaza
117	Yellow Fever Park
Public Boat Ramp	
118	45th Street Boat Ramp
119	Harbor Park Canoe/Kayak Launch
120	Haven Creek Boat Ramp
121	Lafayette City Park Boat Ramp
122	Willoughby Boat Ramp
School & City Shared Sites with Active Park Amenities	
123	Bayview Elementary and Recreation Center
124	Chesterfield Elementary and Community Pool
125	Crossroads Elementary School and Recreation Center
126	Fairlawn Elementary and Recreation Center
127	Ingleside Elementary and Recreation Center
128	James Monroe Elementary and Park Place Recreation
129	Larchmont Elementary and Recreation Center
130	Northside Middle Mary Calcott Elementary THRC
131	Norview Elementary Norview Community Center
132	Sherwood Forest Elementary and Community Center
133	St Helena Elementary Berkley Community Center
134	Tarrallton Elementary and Community Center
School Sites with Active Park Amenities	
135	Academy for Discovery at Lakewood
136	Azalea Garden Middle School
137	Ballentine School
138	Berkley Campostella Early Childhood Center
139	Booker T Washington High School
140	Camp Allen Elementary School
141	Campostella Elementary School
142	Coleman Place Elementary School
143	Coronado School
144	Dreamkeepers Academy (Retired)
145	Easton PreSchool
146	Ghent Elementary School
147	Granby Elementary School
148	Granby High School
149	Jacox Elementary School
150	James Blair Middle School
151	Lake Taylor Middle and High School
152	Larrymore Elementary School
153	Lindenwood Elementary School
154	Little Creek Elementary School and Primary School
155	Madison Career Center
156	Maury High School
157	Meadowbrook Elementary
158	Norview High School
159	Norview Middle School
160	Oakwood Elementary School
161	Ocean View Elementary School
162	Oceanair Elementary School
163	PB Young Elementary School
164	Poplar Hall Elementary School
165	Richard Bowling Elementary School
166	Rosemont Middle School
167	Ruffner Middle School
168	Sewells Point Elementary School
169	Stuart Early Childhood Center
170	Suburban Park Elementary School
171	Tanners Creek Elementary School
172	Tidewater Park Elementary School
173	WH Taylor Elementary School
174	Willard Model School
175	Willoughby Elementary School
176	Vivian C Mason Center
177	Sewells Point Golf Course

Natural marsh



HISTORICAL & CULTURALLY SIGNIFICANT PLACES

ID	Name
African American Heritage Site	
1	Barraud Park (Site of Segregated Boxing School)
2	Blyden Branch Library (First Black Library - 1921)
3	Booker T. Washington (First Accredited Black High School in VA)
4	Botanical Garden planted by African American Workers
5	Calvary Cemetery (Only Black Cemetary Until 1970s)
6	Elmwood Cemetery (Section for Black Union Soldiers)
7	Former Ferry Crossing for Slaves (1829)
8	Hunton YMCA (Formaly a segragated YMCA)
9	Norfolk-Portsmouth Ferry
10	Phyllis Wheatley Hall (Former YWCA for Black Women)
11	Sarah Constant Beach Park (Former Segregated Beach)
12	Site of Slave Market
Historic Church	
13	Bank Street Memorial Baptist Church
14	St John's Church
15	St. Pauls Ep. Church
Historic Site	
16	Doumars
17	Jamestown Exposition
44	Capt John Smith Marker
Library	
18	Barron F Black Branch Library
19	Blyden Branch Library
20	Horace C Downing Branch Library
21	Janaf Branch Library
22	Jordan-Newby Branch Library
23	Lafayette Branch Library
24	Larchmont Branch Library
25	Little Creek Branch Library
26	Mary D Pretlow Branch Library
27	Park Place Branch Library
28	Slover Library
29	Van Wyck Branch Library
Monument	
30	Confederate Monument
31	MacArthur Memorial
32	Martin Luther King Memorial
33	Chrysler Museum Of Art
34	Heritage Museum and Gardens
35	Nauticus
Music and Theater	
36	Attucks Theater
37	Chrysler Hall
38	Harrison Opera House
39	Nero Expanded Cinema
40	NorVa
41	Scope
42	Wells Theatre
Zoo	
43	Virginia Zoological Park



GREEN INFRASTRUCTURE NETWORK

ID	Name
Bus Transit Center	
1	Downtown Norfolk Transit Center
2	Evelyn Butts and Avenue J Bus Stop
3	Game Day Ferry
4	Waterside Ferry
Community Center	
5	Barraud Park
6	Berkley Community Center (Sr. Center,Pool,Clinic)
7	Campostella Center
8	Captains Quarters
9	East Ocean View Community Center
10	Fred Heutte Center
11	Huntersville Community Center
12	Hunton YMCA
13	KROC Center
14	Lakewood Park & Athletics (Dance & Music)
15	Lamberts Point Community Center
16	Norfolk Fitness & Wellness Center
17	Northside Community Center
18	Norview Community Center
19	Park Place Community Center
20	Sherwood Forest Community Center
21	Tarrallton Community Center
22	Titustown Visual Arts Center
23	Vivian C Mason Center
24	Young Terrace Community Center
25	Youth Resource Center
Community Garden	
26	29th Street "Peace Garden"
27	East Ocean View Community Center
28	Fawn Street Community Garden
29	Fred Heutte Center
30	Freemason Free Garden
31	Granby Elementary School
32	Kaplan Orchid Conservatory
33	Knitting Mill Creek Community Garden
34	Lamberts Point Micro Farm
35	Larrymore Lawns Pool
36	Norfolk Stanhope House
37	Northside food forest (community garden layer)
38	P.B. Young Sr Elementary School
39	Virginia Zoological Park
40	Vivian C Mason Art & Tech Center
Library	
41	Barron F Black Branch Library
42	Blyden Branch Library
43	Horace C Downing Branch Library
44	Janaf Branch Library
45	Jordan-Newby Branch Library
46	Lafayette Branch Library
47	Larchmont Branch Library
48	Little Creek Branch Library
49	Mary D Pretlow Branch Library
50	Park Place Branch Library
51	Slover Library
52	Van Wyck Branch Library
Light Rail Station	
53	Ballentine/Broad Creek Station
54	Civic Plaza Station
55	EVMC/Ft. Norfolk Station
56	Harbor Park Station
57	Ingleside Road Station
58	MacArthur Square Station
59	Military Highway Station
60	Monticello Station
61	Newtown Road Station
62	NSU Station
63	York Street/Freemason Station
Museum	
64	Chrysler Museum Of Art
65	Heritage Museum and Gardens
66	Nauticus
Recreation Center	
67	Bayview Recreation Center
68	Captains Quarters
69	Crossroads Recreation Center
70	Diggs Town Recreation Center
71	Fairlawn Recreation Center
72	Grandy Village Recreation Center
73	Hunton YMCA
74	Ingleside Recreation Center
75	Lakewood Dance & Music
76	Lakewood Park & Athletics
77	Merrimac Landing Recreation Cent
78	Ocean View Fishing Pier
79	Ocean View Recreation Center
80	Southside Senior Center
81	Therapeutic Recreation Center
82	Titustown Recreation /A&C Center