ROUTE 114
RESILIENCE PLAN

EXISTING + FUTURE CONDITIONS SUMMARY

February 2024

FUSS & O'NEILL

PROJECT TEAM + PARTNERS

PROJECT MANAGEMENT TEAM

TOWN OF BARRINGTON

Karlo Berger

Teresa Crean

TOWN OF BRISTOL

Diane Williamson

TOWN OF WARREN

Herb Durfee

RHODE ISLAND DIVISION OF STATEWIDE PLANNING (RIDSP)

Caitlin Greeley

Roberta Groch, AICP

RHODE ISLAND DEPARTMENT OF TRANSPORTATION (RIDOT)

Pamela Cotter

RHODE ISLAND PUBLIC TRANSIT AUTHORITY (RIPTA)

Zachary Agush

CONSULTANT TEAM

FUSS & O'NEILL

CONTENTS

CONTENTS (CONTINUED)

1. PLAN OVERVIEW

Purpose of the Plan
Planning Goals
Planning Approach

PURPOSE OF THE PLAN

Rhode Island (RI) State Route 114 is a key north-south regional connector in the State's East Bay transportation network that serves as the central main street for the communities of Barrington, Bristol, and Warren, providing important connections between commercial, educational, and residential land uses. Several local and state plans recognize that Route 114 also serves as a critical evacuation route (see "Existing Plans and Studies Assessment" section), yet the use and long-term functionality of Route 114 are vulnerable to the current and future impacts of a changing climate, as the road runs through several low-lying areas along the RI shoreline. As recently as December 2022, several segments of the Route 114 corridor road were under water during a storm surge event (see Figure 1), and these conditions are only expected to worsen in the future with the increasing rise in sea levels and greater intensity of coastal storms (CRMC, 2018).

Even temporary disruptions to the use of this state-owned collector road can result in dramatic community impacts, ranging from disconnecting neighborhoods from emergency services to the loss of economic production and damage to critical infrastructure (URI, 2013). With support from the Rhode Island Division of Statewide Planning and the Towns of Barrington, Bristol, and Warren, the *Route 114 Resilience Plan* is being developed to: (1) assess the current and future vulnerability of the Route 114 corridor through Barrington, Bristol, and Warren and (2) establish conceptual alternatives for reducing coastal flood risks and improving overall resilience in key areas of vulnerability (AOVs) throughout the region.

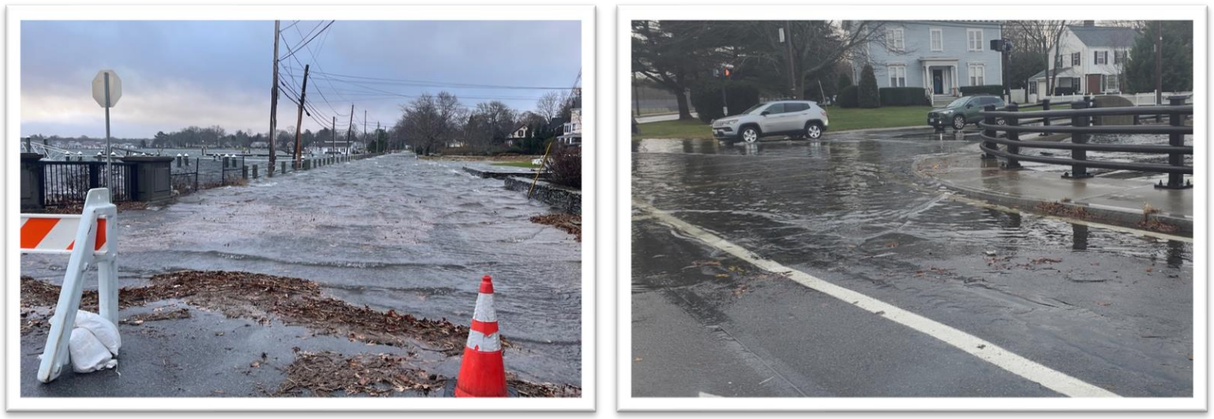
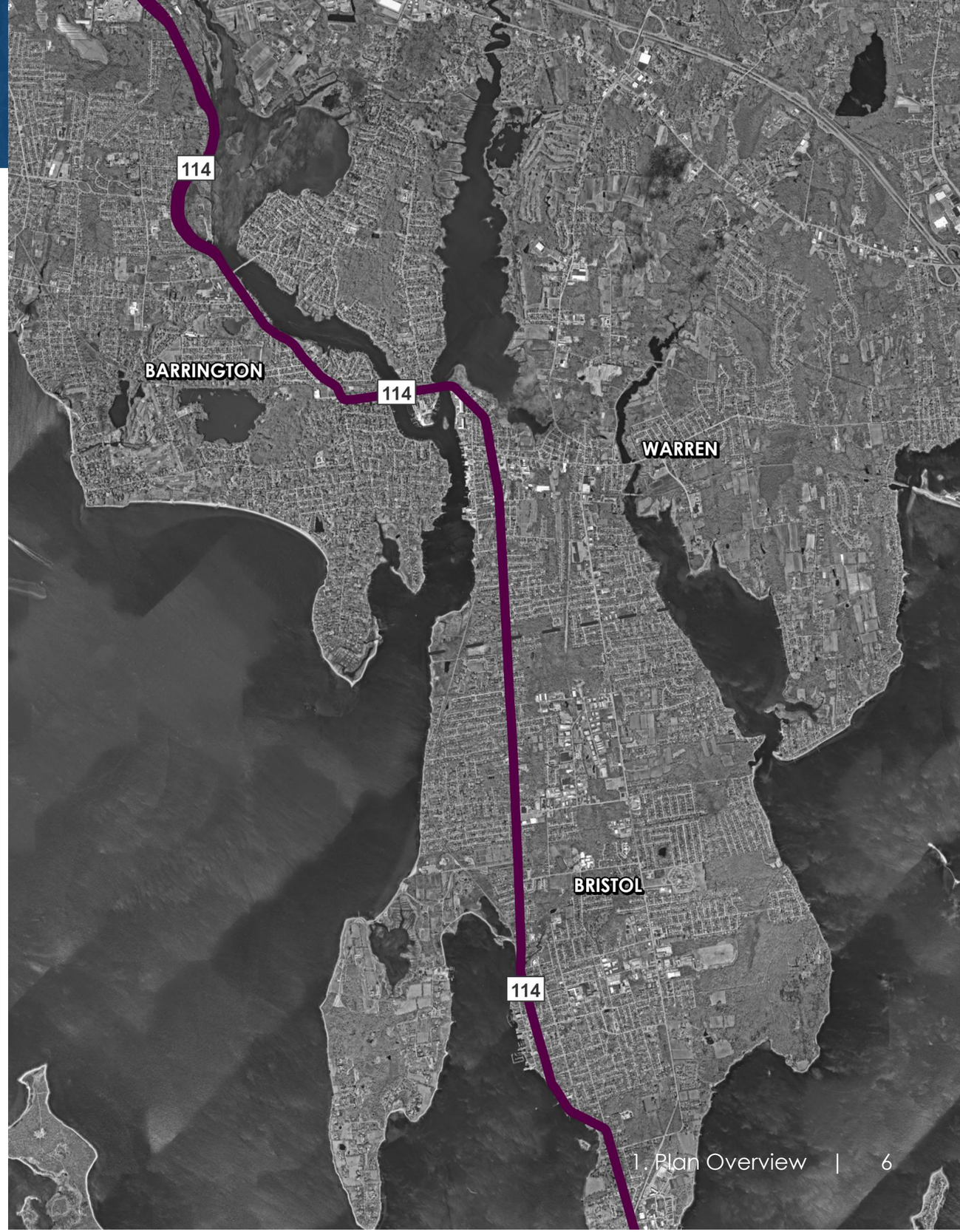


Figure 1: Route 114 flooding in Barrington during the December 23, 2022 storm



PLANNING GOALS

The primary goal of this plan is to engage local, regional, and state stakeholders in developing a purposeful and actionable plan that positions the Barrington, Bristol, and Warren communities to maximize the value of future investments that will be required to make the Route 114 corridor more resilient to future flooding. Recognizing the growing scale of funding opportunities that are now available for taking action on addressing climate-related impacts, the focus of this plan is to prioritize actions that support long-term community goals and balance flood risk reduction with potential project costs to generate benefits that create value beyond coastal flood resilience.

Image showing coastal flooding along Route 114 corridor in Barrington on December 23, 2022

PLANNING APPROACH

The planning process began in September 2023 with a kickoff meeting where the project team met with several members from the Project Management Team, which is comprised of representatives from the Rhode Island Division of Statewide Planning (RIDSP), Rhode Island Department of Transportation (RIDOT), Rhode Island Public Transit Authority (RIPTA), and the Towns of Barrington, Bristol, and Warren. During the meeting, attendees were introduced to the project and the following phased approach to the *Route 114 Resilience Plan* was established (see Figure 2).

(PAST) PHASE 1: EXISTING + FUTURE CONDITIONS ASSESSMENT
The purpose of this initial phase was to collect and utilize existing sources of data to develop an understanding of existing and future conditions related to flood risks within the Route 114 corridor through Barrington, Bristol, and Warren. As part of this assessment, the project team reviewed existing local and state plans, studies, programs, and Geographic Information System (GIS) datasets related to Route 114 and established several key areas of vulnerability (AOVs) for further examination during the vulnerability assessment.

(FUTURE) PHASE 2: VULNERABILITY ASSESSMENT
During the second phase of the project, the project team will identify and assess the vulnerability of key infrastructure to both current and future flooding. This assessment will consist of developing a composite risk score for each AOV that will allow for the prioritization of actions with inputs for community stakeholders.

(FUTURE) PHASE 3: ALTERNATIVE ROUTES ANALYSIS
Building upon the results of the vulnerability assessment, an alternative routes analysis will be conducted to determine scenarios and specific locations where Route 114 may become impassable due to flooding. The analysis will also assess where and how to divert traffic should it become necessary. Both short-term and long-term recommendations will be developed to highlight where temporary diversions of traffic may be a feasible response and where more permanent alternative routes or adaptations may be needed in the future.

(FUTURE) PHASE 4: CONCEPTUAL ALTERNATIVES ANALYSIS
After completing the alternative route analysis, a series of two conceptual alternatives will be developed for each AOV that identify important strategies for addressing coastal flood vulnerabilities. Alternatives will be coupled with approximate scales of costs – along with qualitative summaries of potential benefits and challenges (or barriers) to implementation for the actions identified in the analysis.

(FUTURE) PHASE 5: RECOMMENDED ACTION PLAN
Lastly, based on the results of the existing and future conditions assessment, vulnerability assessment, alternative route analysis, and conceptual alternatives analysis, the *Route 114 Resilience Plan* will be established as the recommended action plan for use by the Towns of Barrington, Bristol, and Warren – along with other state agencies – to improve the long-term resilience of the Route 114 corridor.

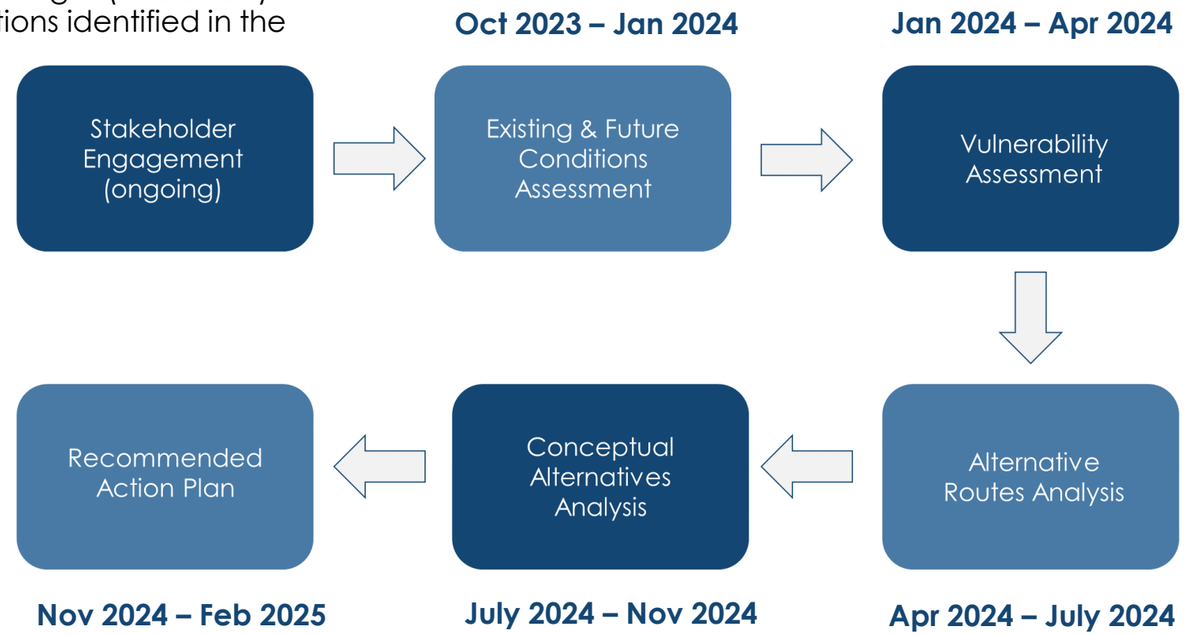


Figure 2: Approach and timeline for plan development

2. EXISTING + FUTURE CONDITIONS ASSESSMENT

Desktop Dataset Review
Existing Plans + Studies Assessment
Site Visits + Staff Meetings
Coastal Flood Assessment

DESKTOP DATASET REVIEW

During the first phase of the project, the project team started by collecting and reviewing mapping data from datasets provided by the Division of Statewide Planning and the Towns of Barrington, Bristol, and Warren related to utilities, buildings, roadways, open space, zoning, historic properties, and land use. Additionally, important geographic climate and transportation modeling was gathered from key state resources, including:

- *STORMTOOLS* – a mapping database that illustrates the extent and depth of flooding from sea level rise (see Figure 3) and coastal storms (CMRC & URI, 2023)
- *Sea Level Affecting Marsh Migration Model (SLAMM)* – a geographic model that shows how coastal wetlands will likely transition and migrate onto adjacent upland areas under projected sea level rise scenarios of 1, 3, and 5 feet in the coming decades (CMRC, 2016)

The data collected was then combined into a geodatabase using geographic information systems (GIS) and used to generate existing and future conditions basemaps highlighting key areas of vulnerability as part of a desktop site analysis. These maps are shown later in this section (see "Coastal Flood Assessment").

Importantly, this geodatabase will also be used in subsequent phases of the project (e.g., the vulnerability assessment) where more granular analysis is needed to develop, examine, and prioritize alternative solutions.

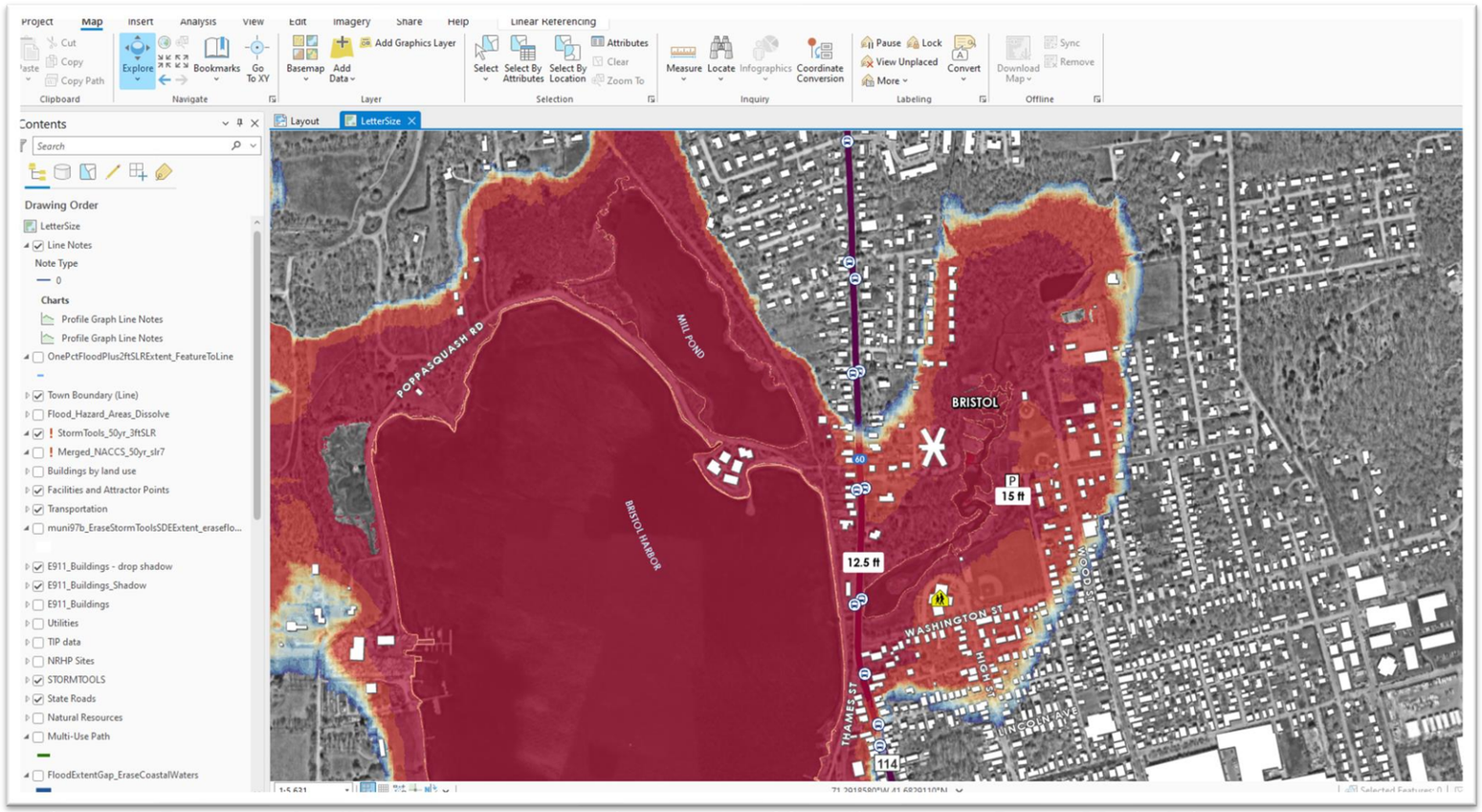


Figure 3: Example ArcGIS screenshot showing depth of flooding along Route 114 in Bristol

EXISTING PLANS + STUDIES ASSESSMENT

As a complement to the desktop dataset analysis, a plan review was conducted. This plan review involved the examination of existing plans, studies, maps, and reports from the Towns of Barrington, Bristol, and Warren (see Figure 4) and identified elements of those documents that mentioned actions, policies, priorities, and strategies related to Route 114 – especially those that focused on improving the overall resilience of the Route 114 corridor. The planning documents reviewed included:

- Past vulnerability assessments and community resilience reports
- Sea level rise reports
- Town hazard mitigation and flood management plans
- Town comprehensive plans
- Transportation fact sheets and parking studies

A summary of the complete list of planning documentation reviewed – in addition to the data reviewed as part of the desktop dataset review – is included in Appendix A. Additionally, key findings were summarized in the memoranda included in Appendix B, which were then used in the evaluation of existing and future conditions for key areas of vulnerability (AOVs) in each town.

Figure 4: Examples of plans reviewed from the Towns of Barrington, Bristol, and Warren as part of the Existing Plans and Studies Assessment

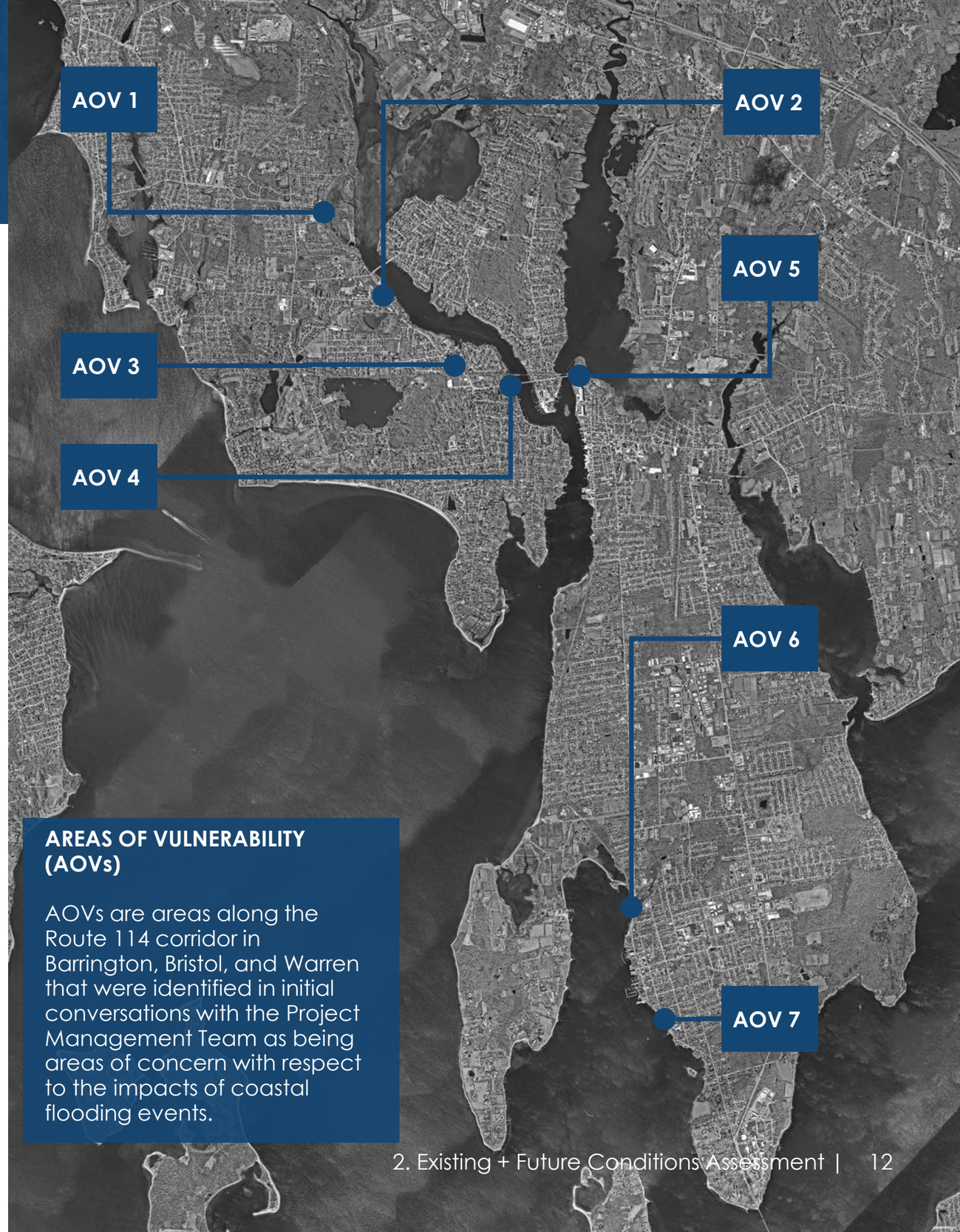
SITE VISITS + STAFF MEETINGS

Over the course of November and December 2023, a series of site visits and interviews with planners from the Towns of Barrington, Bristol, and Warren were conducted to:

- Photo document (see Figure 5) existing conditions at each of the preliminary areas of vulnerability (AOVs) and visually confirm the conditions highlighted in the desktop dataset review
- Understand concerns – as well as short- and long-term visions – regarding the future of Route 114
- Ideate on possible approaches to improving coastal flood resilience, including nature-based solutions, road raisings, hardened infrastructure, and other strategies

Additionally, a meeting was held with staff from the Rhode Island Department of Transportation (RIDOT) to learn about the Department's plans for upcoming projects in the Route 114 corridor and approaches to evaluating and planning for resilience.

Figure 5: Images from site visits to AOV 2 (left), AOV 6 (middle), and AOV 7 (right)



AREAS OF VULNERABILITY (AOVs)

AOVs are areas along the Route 114 corridor in Barrington, Bristol, and Warren that were identified in initial conversations with the Project Management Team as being areas of concern with respect to the impacts of coastal flooding events.

COASTAL FLOOD ASSESSMENT

While conducting site visits and meeting with town staff and State agencies, the project team also reviewed the existing and future projected sea level and coastal storm scenarios for the State of Rhode Island. This included mapping the 10% and 1% annual exceedance probability (AEP) flood events (also sometimes referred to as the "10-year" and "100-year" flood events) for both the current and future 2-foot sea level rise (SLR) scenarios using data collected from STORMTOOLS.

WHAT IS ANNUAL EXCEEDANCE PROBABILITY (AEP)?

AEP is the probability (or "chance") that a flood event of that magnitude will be met or exceeded within a given year. A storm causing coastal flooding with an AEP of 50% has a 1 in 2 chance of occurring at any point within a given year. With the likelihood that storms will become more intense and more frequent over time in Rhode Island as a result of climate change (State of Rhode Island, 2018), it will become more common for storms to result in higher water surface elevations.

TYPES OF COASTAL FLOOD RISK

SEA LEVEL RISE & TIDAL FLOODING (Chronic/Nuisance Flooding)

Sea level rise (SLR) is an important climate-related hazard that will impact shorelines, estuaries, bays, and tidal rivers across Rhode Island. As the sea and mean tide levels rise, low points across the Rhode Island shoreline that were once above the intertidal zone will become inundated with tidal flood waters more frequently. To start, these nuisance tidal flooding events may only happen a few times per year. However, as SLR increases, these events will be more likely to occur monthly or even daily.

STORM SURGE (Periodic Flooding)

Storm surge flooding is a result of coastal storms that generate winds that push coastal waters towards land, which leads to a "surge" that increases the water surface elevations (WSEs) above normal tides. When coupled with the tide, the maximum WSE reached during a storm event is often referred to as a "storm tide." In Rhode Island, some of the most common types of storms include nor'easters and hurricanes. As SLR increases, a weaker storm in the future may still lead to the same (or greater) amounts of coastal flooding as a more powerful storm today.

COASTAL FLOOD ASSESSMENT

As shown in the following sections, flood maps were prepared for each AOV, highlighting the extent and depth of flooding, infrastructure and natural resources at risk of flooding, and an initial assessment of key challenges and opportunities for addressing mapped vulnerabilities.

WHAT ABOUT FEMA FLOOD MAPS?

The Federal Emergency Management Agency (FEMA) flood maps are an important component of the National Flood Insurance Program (NFIP), as they serve as the foundation for establishing regulations and insurance requirements. However, FEMA flood maps are designed to assign insurance rates and rely on historic events (as opposed to future projected conditions). This makes it difficult to compare these maps with other types of flood maps like the coastal flood maps generated using STORMTOOLS in this assessment.

WHEN DOES IT FLOOD?

DAILY HIGH TIDE FLOODING

Daily high tide flooding is the daily inundation of low-lying areas from high tide events. In Rhode Island, tides occur on a semidiurnal cycle, which means that the coastline experiences two high tides and two low tides of roughly equal size each day. (Note: Mean higher high water (MHHW) refers to the average of the higher of the two high tides that occur in a given day.)

10% ANNUAL EXCEEDANCE CHANCE FLOOD

The 10% annual exceedance chance flood is a flood event that has a 10% chance of being equaled or exceeded each year.

1% ANNUAL EXCEEDANCE CHANCE FLOOD

The 1% annual exceedance chance flood is a flood event that has a 1% chance of being equaled or exceeded each year.

AOV 1

EXISTING + FUTURE CONDITIONS

The area that defines AOV 1 extends from the East Providence-Barrington border to an area south of the East Bay Health Center. This area contains natural resources of significance that offer ecological and community services to the Town of Barrington. This includes walking trails, shoreline areas, and bird sanctuaries in Osamequin Park and Walker Farm, which are also located in existing FEMA flood zones and areas at risk of exposure to a Category 1 hurricane, as indicated in the Town's Hazard Mitigation Plan (Jacobs, 2022). Similar flood risks are projected to impact low-lying vulnerable areas in this AOV, such as the portion of Route 114 adjacent to the Barrington Community Garden.

Future projections estimate that 3 feet of SLR will inundate the road with 12 feet of water in areas during a 1% annual chance flood event. Such an event would have major implications on public safety, disruption of services, and potential economic loss. The Hazard Mitigation Plan also identified at-risk critical facilities, including the Barrington Christian Academy, Primrose Hill School, and the East Bay Health Center, each of which is vulnerable to intense hurricanes (Category 3 and 4).

PRESENT COASTAL FLOOD RISK: AOV 1

Under current conditions, the 10% annual chance flood event threatens natural resources, residential properties, and evacuation routes along Route 114 in AOV 1.

CURRENT CONDITIONS (2023)

Current flooding conditions in AOV 1 present flood risks to various portions of Route 114. Tidal flooding drives coastal flooding and inundation along the shoreline areas, including valuable natural resources (e.g., Walker Farm).

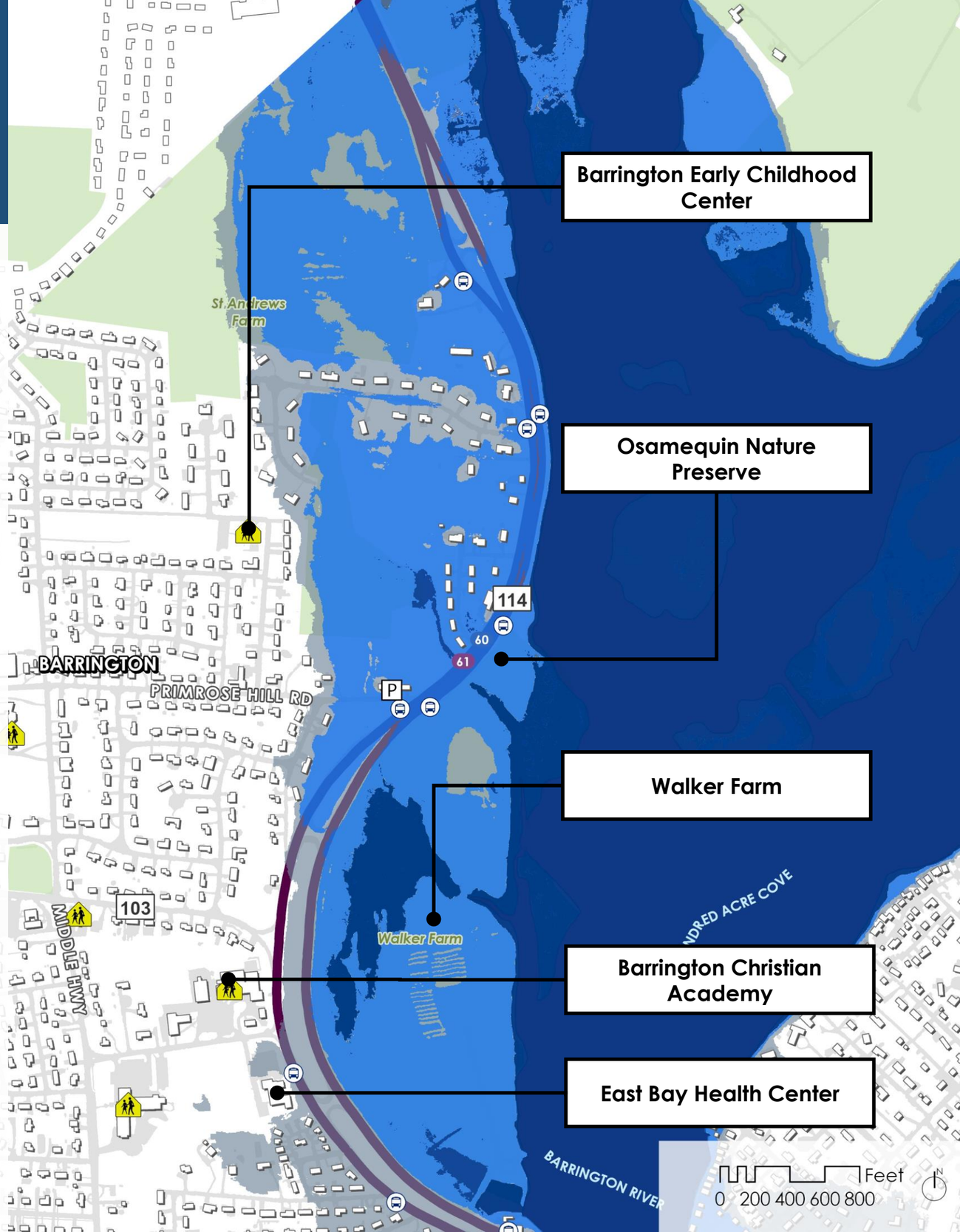
Areas vulnerable to nuisance flooding (i.e., tidal flooding events) extend from St. Andrews Farm south beyond Primrose Hill Road. Within this area, flood waters have the potential to reach and impact numerous residential properties, as well as a sewer pump station.

During a 1% annual chance flood, the flood extents spread westward and are likely to impact more residential properties and critical services such as the East Bay Health Center and RIPTA bus stops. Furthermore, increased portions of Route 114 become impacted by flooding and could become impassable depending on the depth and duration of flooding.

LEGEND

- Tidal Flooding (MHHW) in 2023
- 10% Annual Chance Flood in 2023
- 1% Annual Chance Flood in 2023

Sources: RIGIS, CRMC, Town of Barrington



FUTURE COASTAL FLOOD RISK: AOV 1

By 2050, several Barrington schools and health centers in AOV 1 may be vulnerable to flooding impacts during a 1% annual chance flood event, while the extent of a 10% annual chance event will impact more residential areas.

2 FEET OF SEA LEVEL RISE (2050s)

According to the NOAA Sea Level Rise Viewer (NOAA, 2023), the Town of Barrington is projected to face 2 feet of SLR by the 2050s. The anticipated impacts of sea level rise on coastal flood events will increase flood-related risks in AOV 1.

By the 2050s, the entirety of Walker Farm will be impacted by nuisance flooding. Future nuisance flooding will inundate a majority of the coastal area in AOV 1, with tidal flood waters extending close to Route 114.

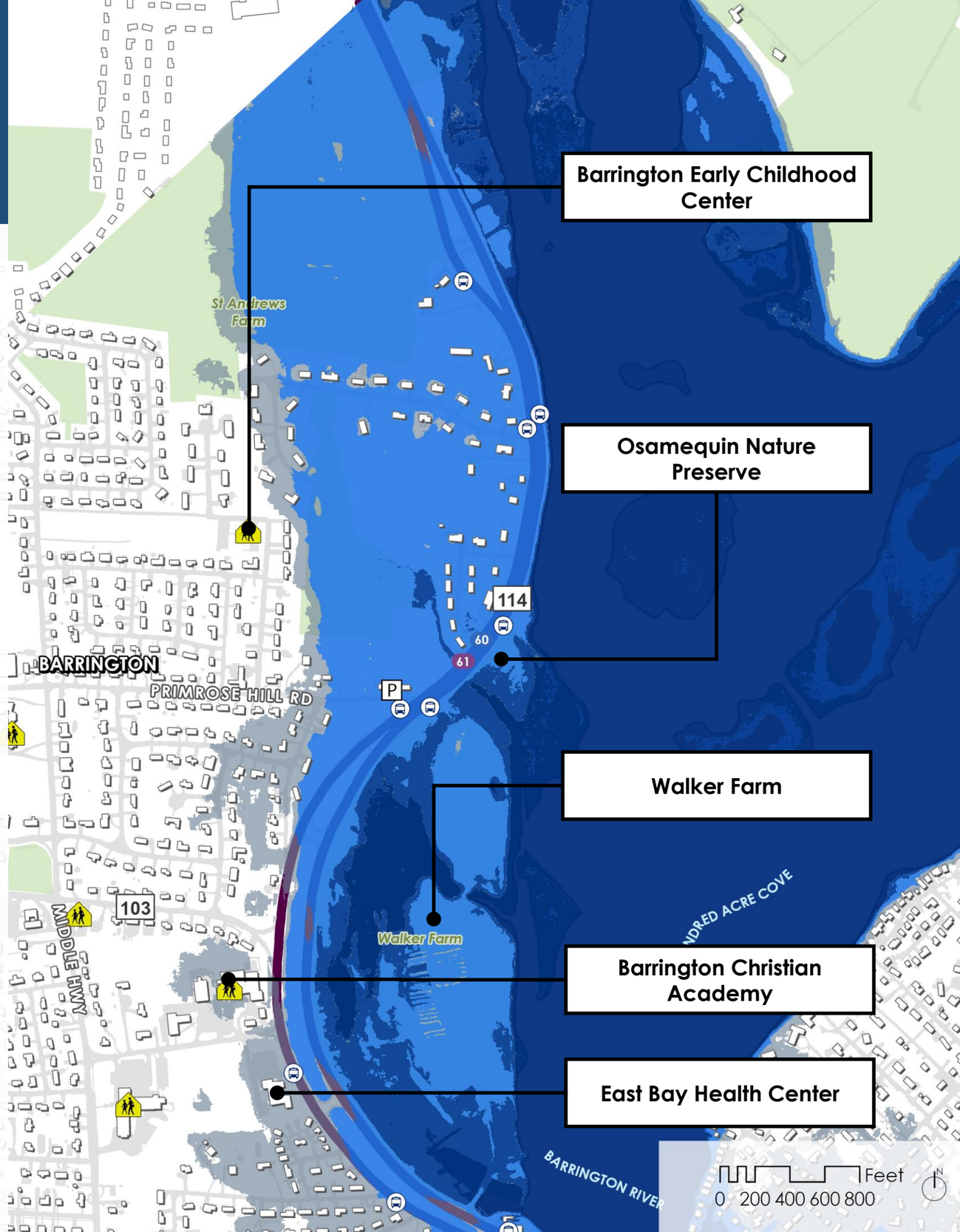
During the future 10% annual chance flood event, nearly all of Route 114 within AOV 1 will be impacted by flooding. Additionally, the flood extents will cover St. Andrews Farm, the residential properties on Pinetop Road, and all of Walker Farm to the south.

During the future 1% annual chance flood event, the flooding extent will expand to include parts of the Primrose Hill neighborhood and the area around the Barrington Christian Academy.

LEGEND

- Tidal Flooding (MHHW) + 2 Feet of SLR
- 10% Annual Chance Flood + 2 Feet of SLR
- 1% Annual Chance Flood + 2 Feet of SLR

Sources: RIGIS, CRMC, Town of Barrington



COASTAL FLOOD DEPTH: AOV 1

Based on current SLR predictions, coastal water depths in AOV 1 are predicted to cause up to 12 feet of flooding along portions of Route 114 during a future 1% annual chance flood event.

DESIGN FLOOD ELEVATION (1% ANNUAL CHANCE FLOOD + 2 FT OF SLR)

The 1% annual chance flood + 2 feet of SLR has been recommended by Spaulding et al. (2018) as the STORMTOOLS design elevation (SDE) for use in assessing the impact of future sea level rise and climate action planning. Based on the projected water depths for this scenario, many key services in AOV 1 will be inaccessible due to coastal flooding.

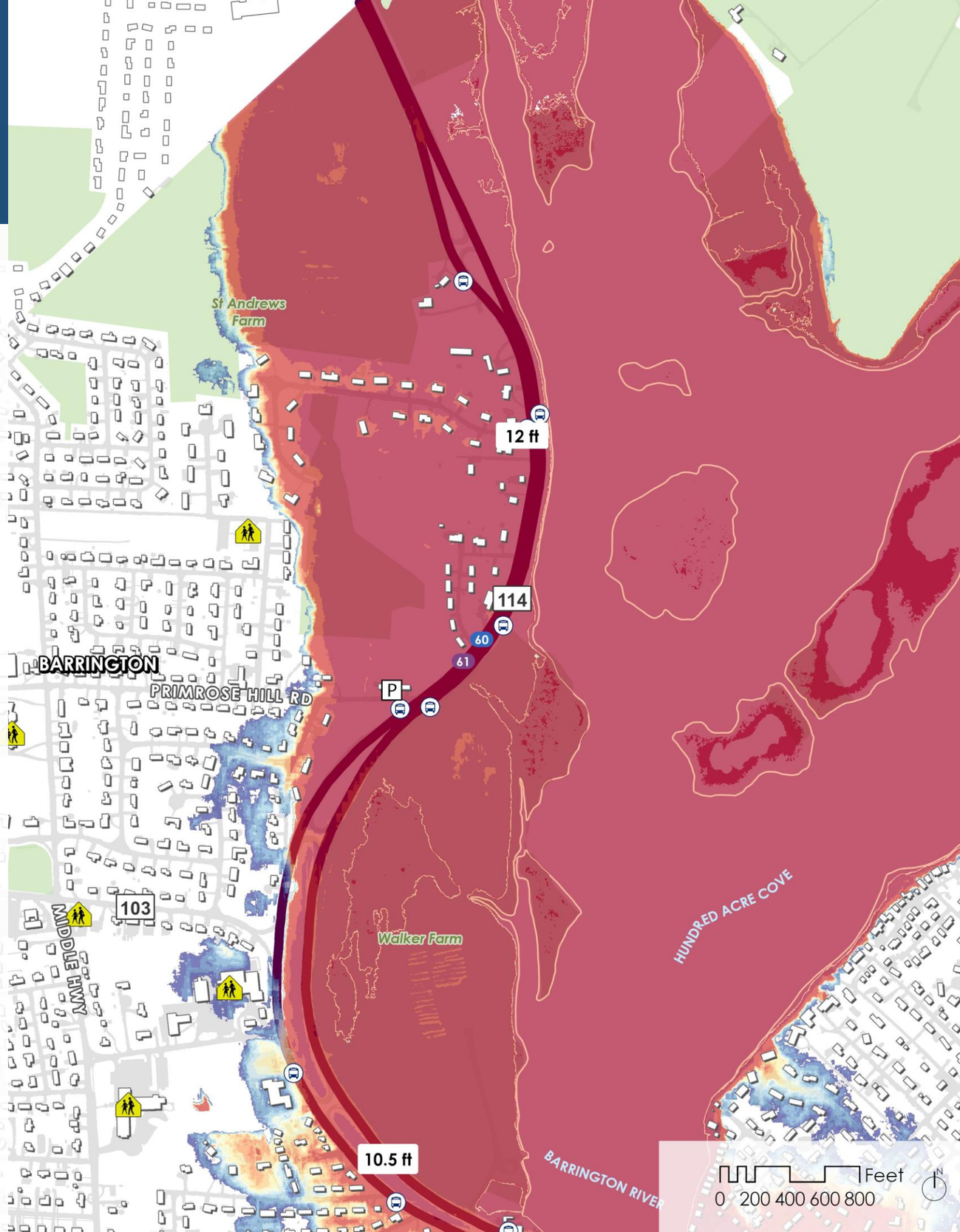
The Osamequin Nature Preserve and Walker Farm, situated directly on the Barrington River shoreline, will likely be inundated by more than 10 feet of water.

On the upgradient side of Route 114, the Barrington Christian Academy and East Bay Health Center will see some coastal flooding, with a few feet of water flooding the property. While not as significant as the flooding experienced elsewhere in AOV 1, these flood depths may still make it challenging for pedestrian and vehicular traffic to retreat from these locations. Additionally, access to both buildings via Route 114 will not be possible due to the depth of flooding (>10 feet) in the surrounding area. The Barrington Early Childhood Center and Primrose Hill School will not be impacted by coastal flooding in this scenario, but they would face similar challenges with roadway access from Route 114. Similarly, several RIPTA bus stops would not be serviceable, and RIPTA would likely need to reroute buses from Route 114.

LEGEND

- 0 – 0.5 FT
- 0.5 – 1 FT
- 1 – 1.5 FT
- 1.5 – 2 FT
- 2 – 2.5 FT
- 2.5 – 3 FT
- 3 – 3.5 FT
- 3.5 – 4 FT
- 4 – 4.5 FT
- 4.5 – 5 FT
- 5 – 10 FT
- >10 FT

Sources: RIGIS, CRMC, Town of Barrington



NATURAL RESOURCES AT RISK: AOV 1

AOV 1 contains a large complex of mapped freshwater and estuarine/marine wetlands surrounding the Route 114 corridor based on geographic data provided by the Rhode Island Department of Environmental Management (RI DEM) and the National Wetlands Inventory (NWI). The majority of the Route 114 corridor in the AOV also falls within mapped natural heritage areas. Projected conditions indicate that flood depths in these areas could reach greater than 10 feet during the 1% annual chance flood event with 2 feet of SLR. This would have a significant impact on the natural resources present. The ability of natural resources to help mitigate flood risks in this area is likely to decrease over time as the projected amount of inundation increases and outpaces the rate at which the natural resources can adapt.

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Freshwater Wetland
- Estuarine/Marine Wetland
- Natural Heritage Areas

Sources: RIGIS, RIDEM, CRMC

BUILDINGS AT RISK: AOV 1

By the 2050s, it is projected that 129 buildings within AOV 1 will be at risk of inundation during a 1% annual chance flood event + 2 feet of SLR. Most of the buildings at risk of flood-related impacts are residential properties located on side streets adjacent to Route 114. Fortunately, many of these neighborhoods have secondary egress routes, which could be used in the event of an evacuation without leaving residents stranded. The exception to this would be the homes on Peck Lane, which rely on Route 114 for access.

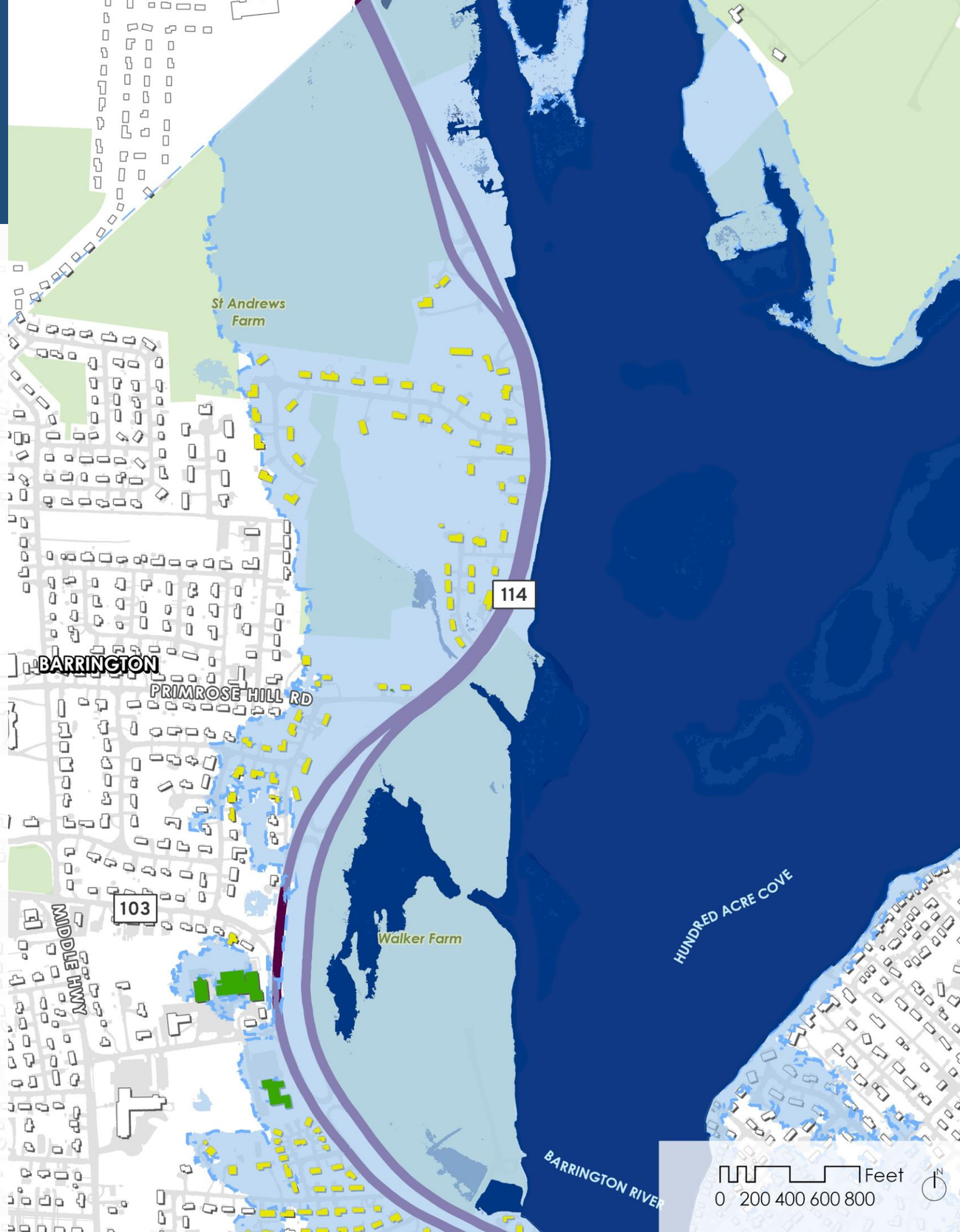
Of additional concern are the institutional buildings vulnerable to a 1% annual chance flood event with 2 feet of sea level rise, which includes the Barrington Christian Academy and East Bay Health Center (Figure 6). While both structures will be impacted by flood waters, secondary egress via Old County Road would allow safe access by emergency vehicles during flooding events.

Figure 6: Existing conditions at the East Bay Health Center, with adjacent RIPTA bus stop, on Route 114 in Barrington

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Commercial (0 buildings)
- Commercial/Residential Mixed (0 buildings)
- Residential (125 buildings)
- Manufacturing/Light Industrial (0 buildings)
- Municipal/Institutional (4 buildings)

Sources: RIGIS, CRMC



KEY CHALLENGES + OPPORTUNITIES: AOV 1

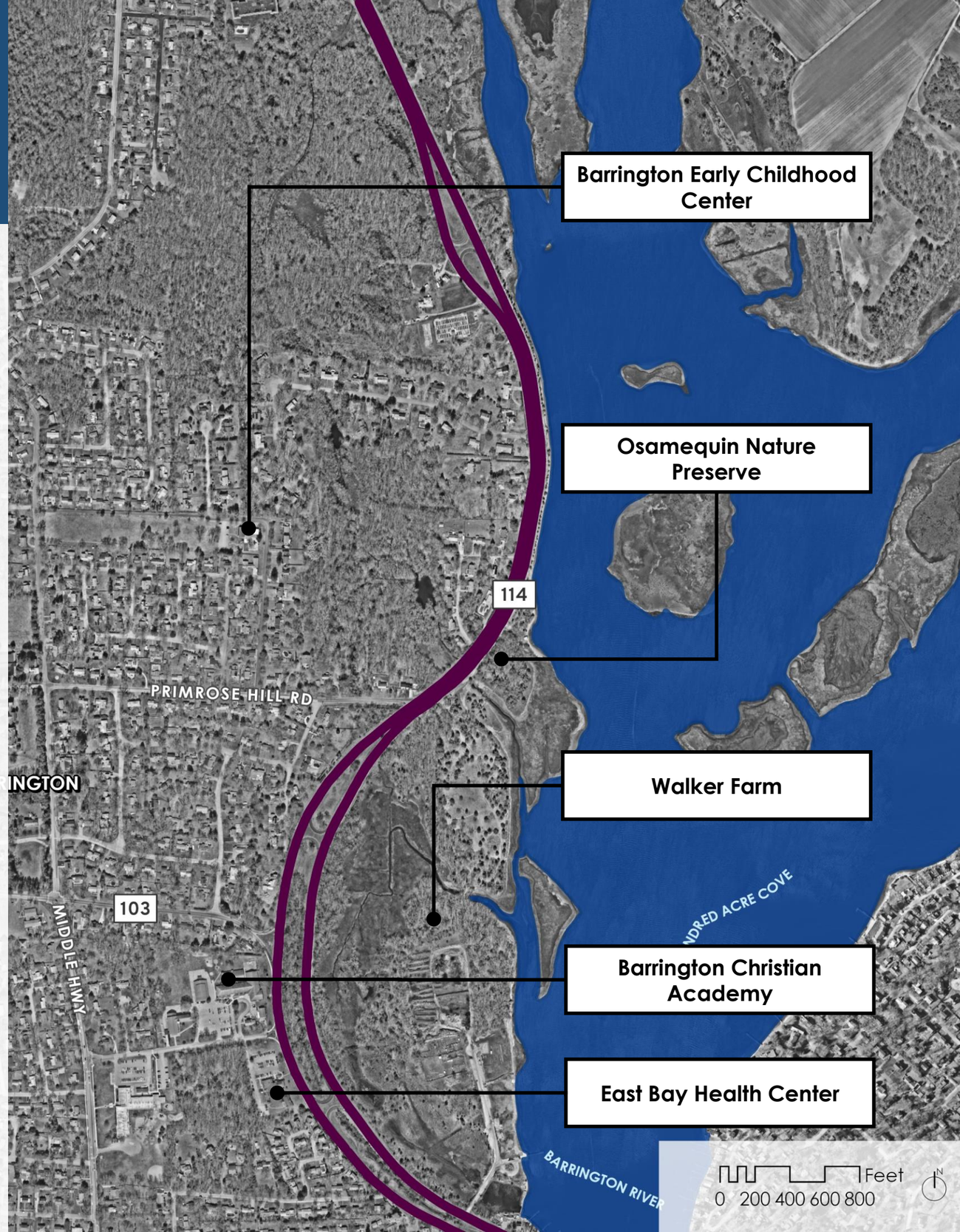
CHALLENGES

One of the key challenges in AOV 1 is the extent of inundation under current and future conditions. By the 2050s, nearly the entirety of Route 114 within this AOV is likely to be inundated by flood depths of up to 10 feet during a 1% annual chance flood event. These conditions would limit safe vehicular or pedestrian travel and make it difficult to elevate Route 114 to heights necessary to avoid overtopping. Additionally, valuable natural resources in this area (e.g., the Osamequin Nature Preserve – see Figure 7) are likely to lose their ability to provide natural flood risk mitigation and protect sensitive coastal ecosystems over time due to coastal inundation.

OPPORTUNITIES

Existing natural resources and parks within AOV 1 present the opportunity to use nature-based solutions and floodplain restoration methods to reduce near-term flooding concerns along the Barrington River shoreline in the Hundred Acre Cove. Implementing nature-based solutions aimed at reducing coastal erosion, reducing/buffering tidal and event-based wave energy, and improving floodplain storage may reduce the impacts on residential and institutional infrastructure west of Route 114 (e.g., the Barrington Early Childhood Center). The Town could also consider rerouting Route 114 (as needed) to a higher elevation roadway (e.g., Middle Highway), which ties into other major roadways in Barrington and provides numerous alternative routes in the case of an emergency.

Figure 7: Existing shoreline conditions at the Osamequin Nature Preserve, located between the Barrington River and Route 114 in Barrington



AOV 2

EXISTING + FUTURE CONDITIONS

As outlined in the Barrington Hazard Mitigation Plan (HMP) (Jacobs, 2022), AOV 2 contains several critical services and facilities, including the RIDOT Park & Ride at White Church, sanitary sewer pump station near Prince Pond, public/private schools, and religious institutions. The majority of Route 114 in AOV 2 is located within a FEMA flood zone and is considered an area subject to inundation by a 1% annual chance flood event.

This AOV also includes the portion of Route 114 that spans from Winsor Avenue to the area near Sullivan Terrace. In Barrington's HMP, the Park & Ride was identified as being at risk of a Category 1 hurricane, while the pump station is at risk of a Category 3 hurricane. Barrington High School, St. Andrew's School, and Tot's Nursing School were identified as being at risk of Category 2, 3, and 1 hurricanes, respectively. Each of these institutions services vulnerable populations (i.e., children) that are less able to evacuate on their own during an emergency flood event.

PRESENT COASTAL FLOOD RISK: AOV 2

Current flooding conditions in AOV 2 leave a key junction of Route 114 vulnerable to flooding during the 10% and 1% annual chance flood events, putting residences, roadway infrastructure, and critical services at risk.

CURRENT CONDITIONS (2023)

Current flooding conditions in AOV 2 present a flood risk to various portions of Route 114. Nuisance flooding causes coastal inundation along the shoreline areas and poses a risk to residential properties along the Barrington River.

The extent of the 10% annual chance flood event in AOV 2 extends from north of Massasoit Avenue south to the Barrington Presbyterian Church and Prince Pond area. Within this area, flooding has the potential to impact numerous residential properties, churches (i.e., Barrington Presbyterian and Barrington Congregational), small businesses (e.g., In Full Bloom Flowers), the RIDOT Park & Ride, and numerous RIPTA bus stops.

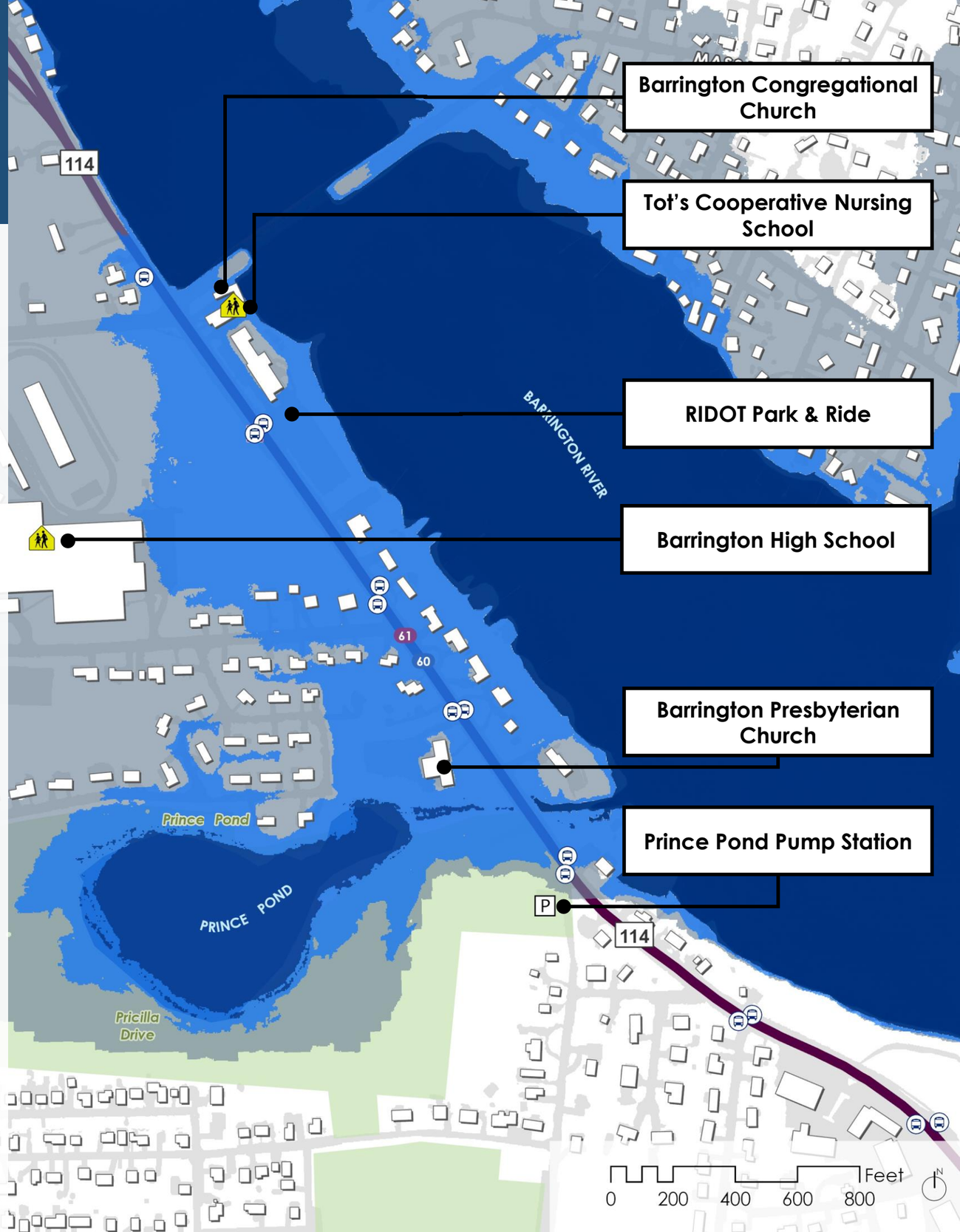
During a 1% annual chance flood event, potential flooding extends upland and impacts Barrington High School, St. Andrew's School, and more residential properties. Northern portions of Route 114, from Massasoit Avenue to Windsor Drive, will become vulnerable to flood risks. This will increase the number of residential properties at risk and further isolate portions of the Town if water depths become unsafe to pass.

In all present flood scenarios evaluated, flood waters have the potential to impact Prince Pond through increased saltwater intrusion. Under the 10% or 1% annual chance flood scenarios, it is possible that Prince Pond may maintain connectivity to the Barrington River. This may have larger ecological impacts on the pond's freshwater plant and animal species.

LEGEND

- Tidal Flooding (MHHW) in 2023
- 10% Annual Chance Flood in 2023
- 1% Annual Chance Flood in 2023

Sources: RIGIS, CRMC, Town of Barrington



FUTURE COASTAL FLOOD RISK: AOV 2

Future sea level rise predictions for AOV 2 will place schools and residences at risk of flooding during the 10% annual chance flooding event and increase the risk of nuisance flooding to riverine properties.

2 FEET OF SEA LEVEL RISE (2050s)

The anticipated impacts of sea level rise in the future will increase Route 114's vulnerability to flooding in AOV2.

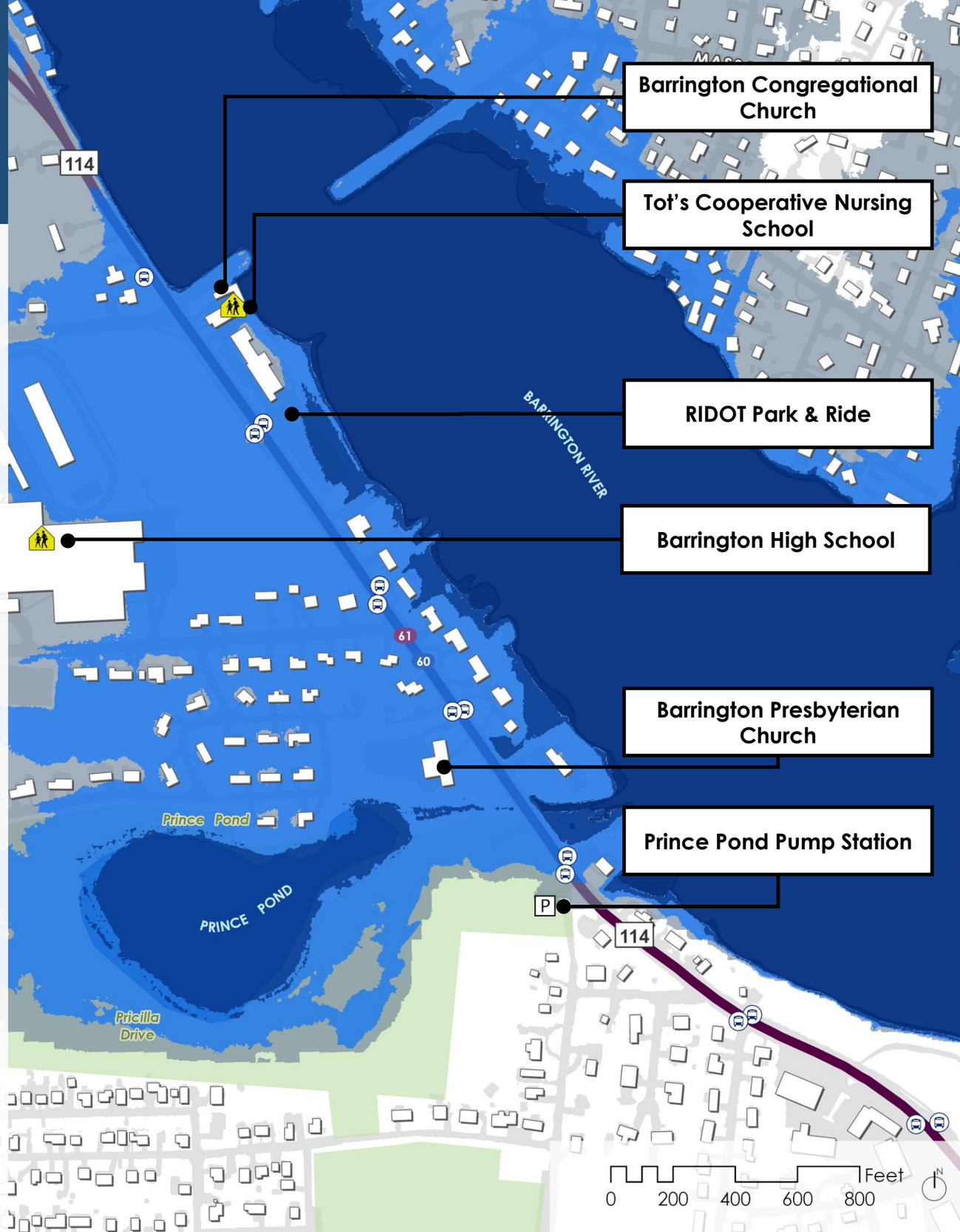
By the 2050s, the impacts of nuisance flooding will extend into the RIDOT Park & Ride and encroach on the residential properties located on the Barrington River. A 10% annual chance flooding event would threaten the Barrington High School (and the surrounding property) and more residential homes in the Prince Pond neighborhood.

During a 1% annual chance event, flooding extents will be largely unchanged except for the area near the Prince Pond pump station. The pump station is located on slightly higher ground in comparison to Route 114; however, it is likely to have floodwater encroaching onto the property during the 1% annual chance flood event.

LEGEND

- Tidal Flooding (MHHW) + 2 Feet of SLR
- 10% Annual Chance Flood + 2 Feet of SLR
- 1% Annual Chance Flood + 2 Feet of SLR

Sources: RIGIS, CRMC, Town of Barrington



COASTAL FLOOD DEPTH: AOV 2

Based on current SLR projections, coastal flood depths in AOV 2 are predicted to cause 5-10 feet of flooding at critical community assets (e.g., churches and schools) and up to 13 feet of flooding along Route 114.

DESIGN FLOOD ELEVATION (1% ANNUAL CHANCE FLOOD + 2 FT OF SLR)

The coastal flood depths projected for the 1% annual chance flood event + 2 feet of SLR will cause many critical services in AOV 2 to become inaccessible.

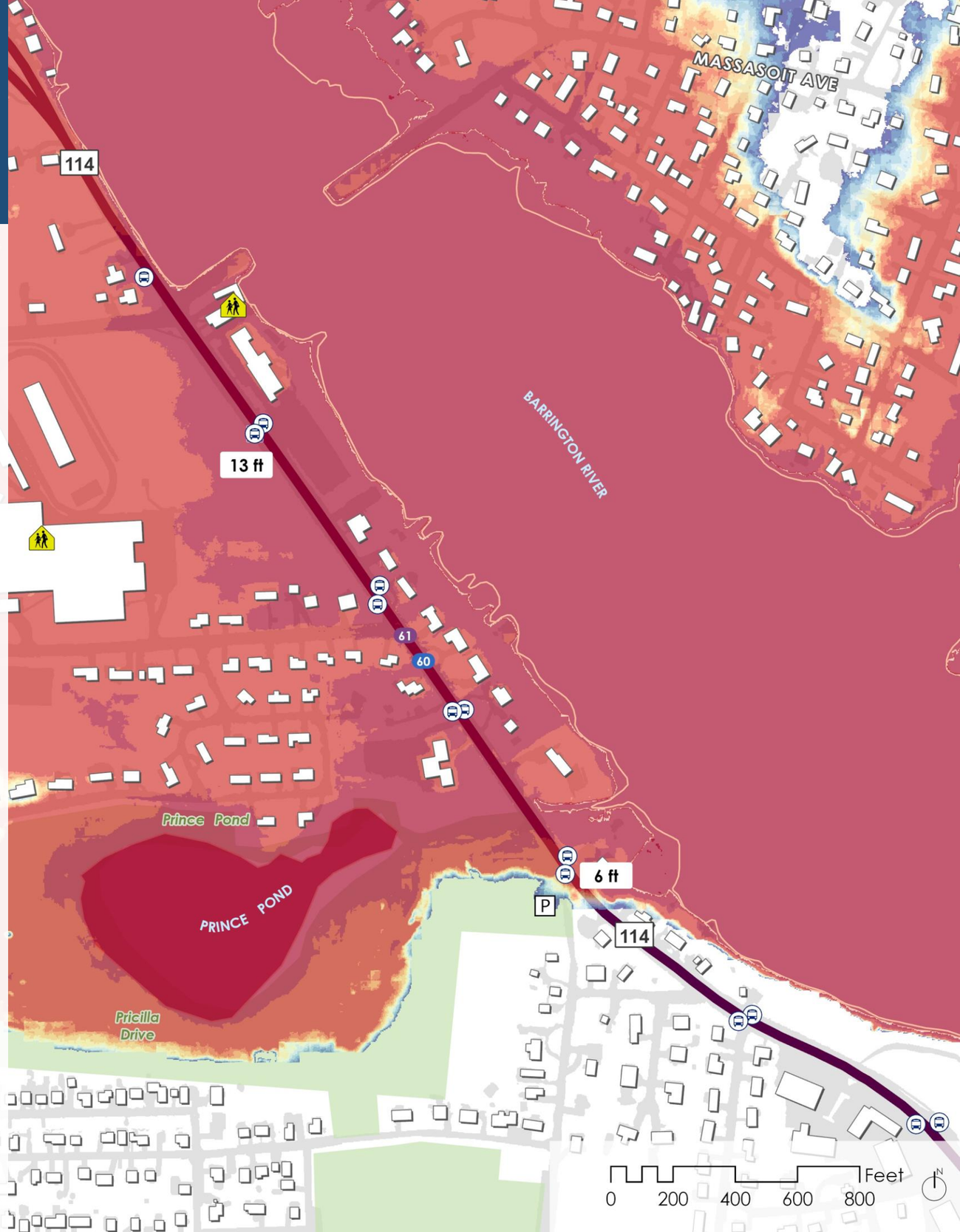
Specifically, the St. Andrew's School and Barrington High School are predicted to be flooded with 4.5 to 5 feet of water. Critical transportation infrastructure (i.e., RIDOT Park & Ride and RIPTA bus stops) along the Barrington River will face some of the worst flooding impacts, as flood depths are projected to reach 13 feet in these areas.

Other vulnerable services include the Tot's Nursing School and Barrington Presbyterian Church. Both buildings are projected to be flooded with 4.5 and 5 feet of floodwater, respectively.

LEGEND

- 0 – 0.5 FT
- 0.5 – 1 FT
- 1 – 1.5 FT
- 1.5 – 2 FT
- 2 – 2.5 FT
- 2.5 – 3 FT
- 3 – 3.5 FT
- 3.5 – 4 FT
- 4 – 4.5 FT
- 4.5 – 5 FT
- 5 – 10 FT
- >10 FT

Sources: RIGIS, CRMC, Town of Barrington



NATURAL RESOURCES AT RISK: AOV 2

RI DEM and NWI mapping indicate the presence of estuarine emergent wetlands, Prince Pond, and associated freshwater wetlands within AOV 2. Natural heritage areas are also present within the northern portion of Route 114 in this AOV. Projected conditions indicate natural resources will be inundated with between 5 feet and greater than 10 feet of coastal flooding during the 1% annual chance flood with 2 feet of SLR. There is some potential for these natural resources to migrate and adapt to SLR; however, the rate of inundation is likely to outpace the adaptive capabilities of the natural resources by the 2050s, and ecosystem function and flood risk reduction capabilities of the wetlands in this area will decrease over time.

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Freshwater Wetland
- Estuarine/Marine Wetland
- Natural Heritage Areas

Sources: RIGIS, RIDEM, CRMC

BUILDINGS AT RISK: AOV 2

By the 2050s, it is projected that 84 buildings within AOV 2 will be at risk of inundation during the 1% annual chance flood. Most of the buildings at risk of flood-related impacts are residential buildings located on side streets adjacent to Route 114. Additionally, many of these homes are located in neighborhoods bordering Prince Pond, which is likely to further exacerbate future flood risks where overland flooding connects the pond with the Barrington River. Other buildings at risk include 11 municipal and institutional structures, such as the Barrington Congregational Church (Figure 8) and the RIDOT Park & Ride.

Fortunately, many of the buildings in the AOV 2 neighborhoods have secondary egress routes that could be used in the event of an evacuation without leaving residents stranded.

Figure 8: Existing conditions at the Barrington Congregational Church at the intersection of Route 114 and Massasoit Avenue in Barrington

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Commercial (0 buildings)
- Commercial/Residential Mixed (0 buildings)
- Residential (73 buildings)
- Manufacturing/Light Industrial (0 buildings)
- Municipal/Institutional (11 buildings)

Sources: RIGIS, CRMC

KEY CHALLENGES + OPPORTUNITIES: AOV 2

CHALLENGES

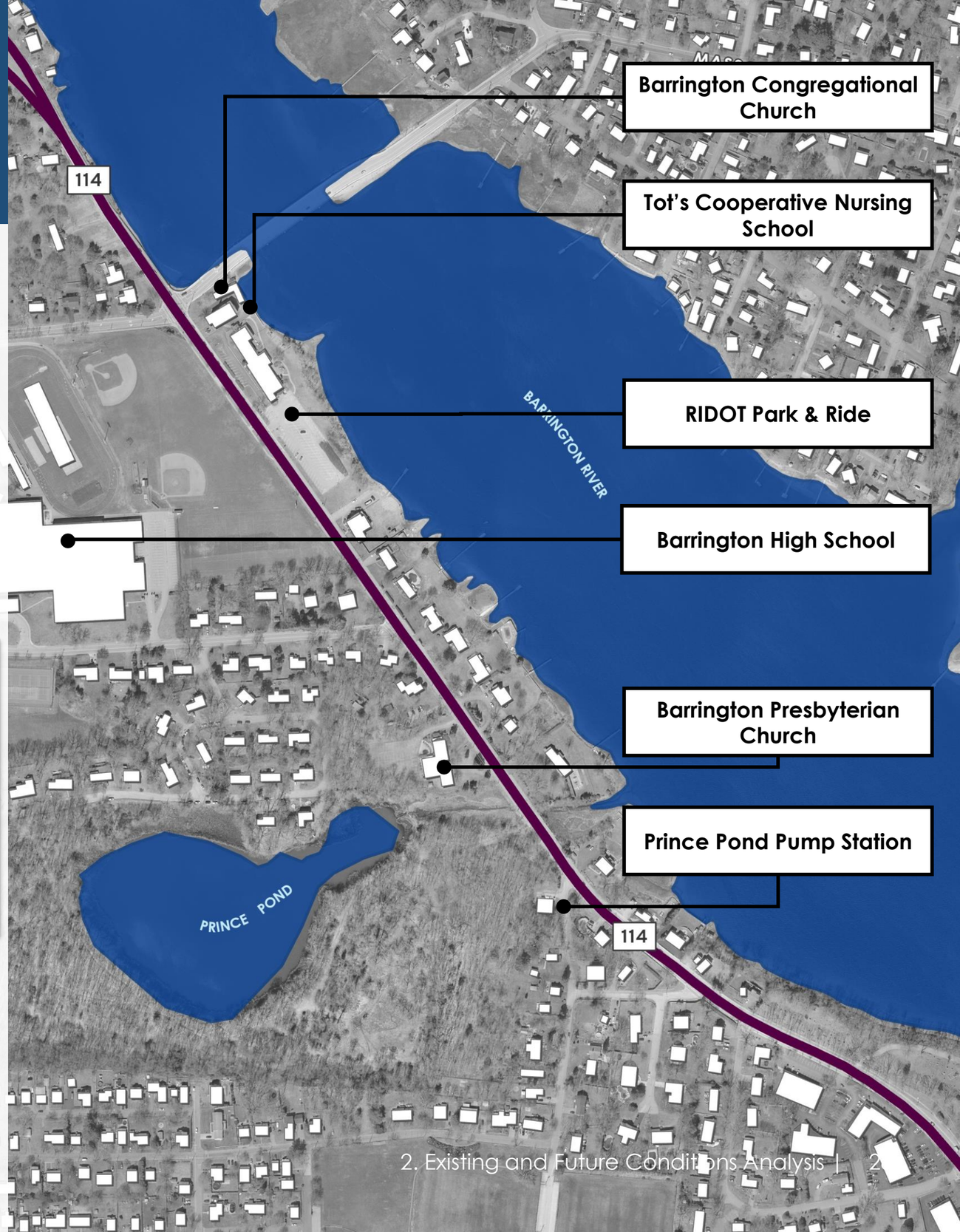
Currently, the 10% annual chance coastal flood event restricts entry to the Barrington Veterans Memorial Bridge on Massasoit Ave and threatens access to local schools, churches, the RIDOT Park & Ride (see Figure 9), the Town-owned Prince Pond pump station, and local residences. By the 2050s, flood depths associated with the 1% annual chance flood will cause water depths along Route 114 to reach 5-10 feet, making this stretch of road impassable.

Raising Route 114 in this area would enable the road to act as a berm, reducing flooding on Route 114 and the vulnerability of the structures on the landward side of the road. However, the Barrington Veterans Memorial Bridge would also need to be raised to correct the grade and angle of approach connecting Massasoit Avenue to Route 114. Similar considerations would need to be made for the properties, businesses, and services on the riverside of Route 114.

OPPORTUNITIES

Resilience opportunities for this stretch of Route 114 are limited due to the projected flood water depths and limited available space for implementation of flood control measures. One opportunity for the Town to consider would be the future acquisition of the institutional and residential parcels between Route 114 and the Barrington River. Subsequent efforts could be made to remove the existing structures on these parcels and restore the floodplain. The Town might also consider partnering with RIDOT to relocate the Park & Ride to a less vulnerable location and restore the impervious area to a more natural marsh habitat to help buffer near-term flooding impacts in the lowest lying portion of AOV 2.

Figure 9: Existing conditions at the RIDOT Park & Ride on Route 114, highlighting a large area of impervious cover abutting riverine wetland habitat



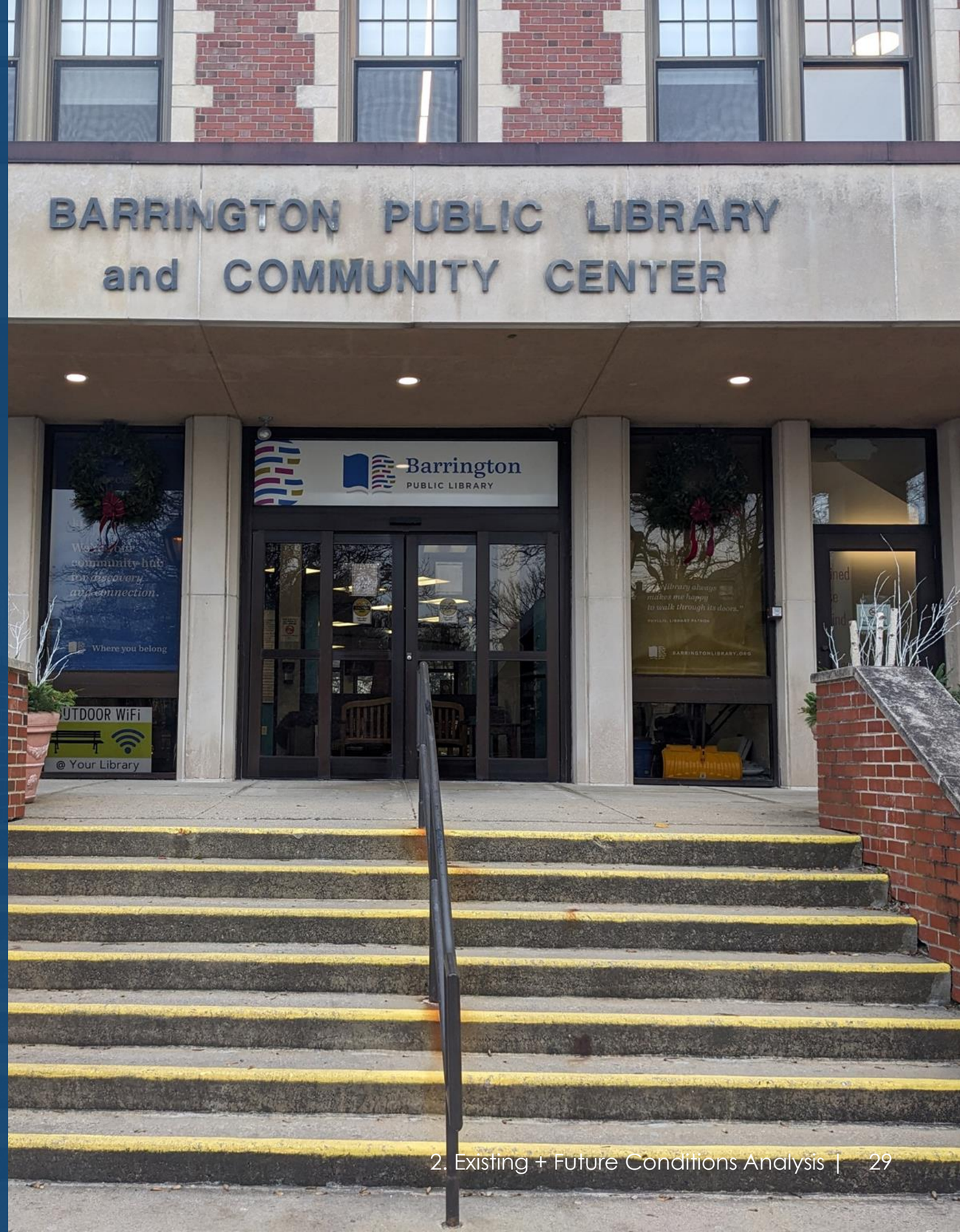
AOV 3

EXISTING + FUTURE CONDITIONS

AOV 3 extends from Cady Road to Joyce Street and includes portions of the Town that are critical to the residents of Barrington – specifically, the Barrington Shopping Center and Barrington Civic Center.

In addition to the important economic and civic assets located within AOV 3, this area also contains Town-owned properties of cultural and historic significance, as indicated in the Barrington Community Comprehensive Plan (Town of Barrington, 2015). The Barrington Civic Center and Jennys Lane Historic Districts (between Mathewson and Rumstick Road) are both listed in the National Register of Historic Places. The Civic Center Historic District is considered locally significant as it contains the historic Town Hall building (built in 1888), as well as the Peck Center (Library/Senior Center), Prince's Hill Burial Ground, and Wood Pond.

Of greatest concern is the risk to the Barrington Shopping Center, which is located in a FEMA flood zone and is at risk of sea level rise and Category 2 hurricanes. The Barrington Shopping Center provides access to food (Shaw's grocery store), home supplies (Ace Hardware), pharmaceuticals (CVS Pharmacy), financial institutions (e.g., banks), and is a major economic hub for the Town.



PRESENT COASTAL FLOOD RISK: AOV 3

In AOV 3, the extent of the current 1% annual chance flood event threatens large portions of Route 114, including the Barrington Shopping Center.

CURRENT CONDITIONS (2023)

Current modeled flooding conditions in AOV 3 show limited vulnerability to nuisance flooding. Nuisance flooding causes coastal flooding along the shoreline areas. Flooding extent in this area impacts private homes and properties, predominantly those situated on the Barrington River.

The extent of the 10% annual chance event in AOV 3 is mostly limited to residential homes in the Markwood Drive and Riverside Drive neighborhoods. These neighborhoods are particularly vulnerable as they are located at lower elevations than Route 114 and other areas of the Town.

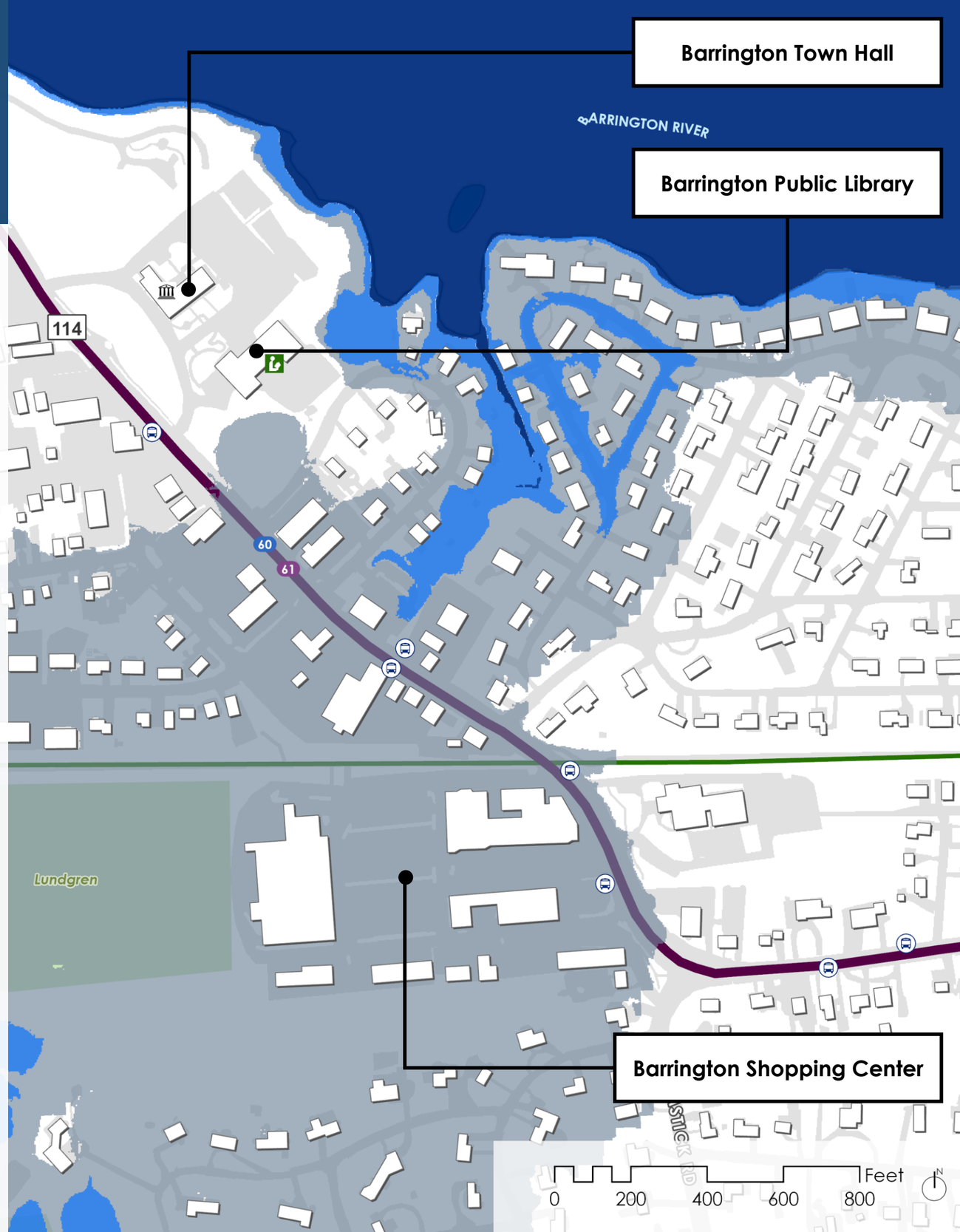
During the current 1% annual chance flood event, a large portion of Route 114 becomes vulnerable to flooding impacts. In this scenario, floodwaters may extend from Markwood Drive to the intersection of Rumstick Road and Route 114. This area houses the "downtown" core of Barrington, including many businesses and services that are integral to the Town. Of note, is the Barrington Shopping Center, which includes a Shaw's grocery store, CVS Pharmacy, Ace Hardware, several restaurants, and banks.

Additionally, State-maintained infrastructure, such as the East Bay Bike Path and RIPTA bus stops, are located in the flood zone. Critical municipal buildings, such as Barrington Town Hall and the Public Library, are unlikely to be impacted by flood waters. However, accessibility will become an issue during flood events considering the potential roadway inundation during the 1% annual chance event.

LEGEND

- Tidal Flooding (MHHW) in 2023
- 10% Annual Chance Flood in 2023
- 1% Annual Chance Flood in 2023

Sources: RIGIS, CRMC, Town of Barrington



FUTURE COASTAL FLOOD RISK: AOV 3

Based on future sea level rise projections, portions of Route 114 and the Barrington Shopping Center will be vulnerable to the 1% and 10% annual chance flood event scenarios.

2 FEET OF SEA LEVEL RISE (2050s)

By the 2050s, the impact of sea level rise on future flood event scenarios is projected to have extensive impacts on residential, commercial, and municipal facilities servicing the Town.

The impacts of nuisance flooding will cause tidal waters to extend further into the tidal channel behind Markwood Drive and Riverside Drive, terminating behind the TD Bank on Route 114. Flooding during the 10% annual chance flood event will extend further upgradient into the residential areas of Riverside Drive and Markwood Drive, as well as in the Barrington Shopping Center.

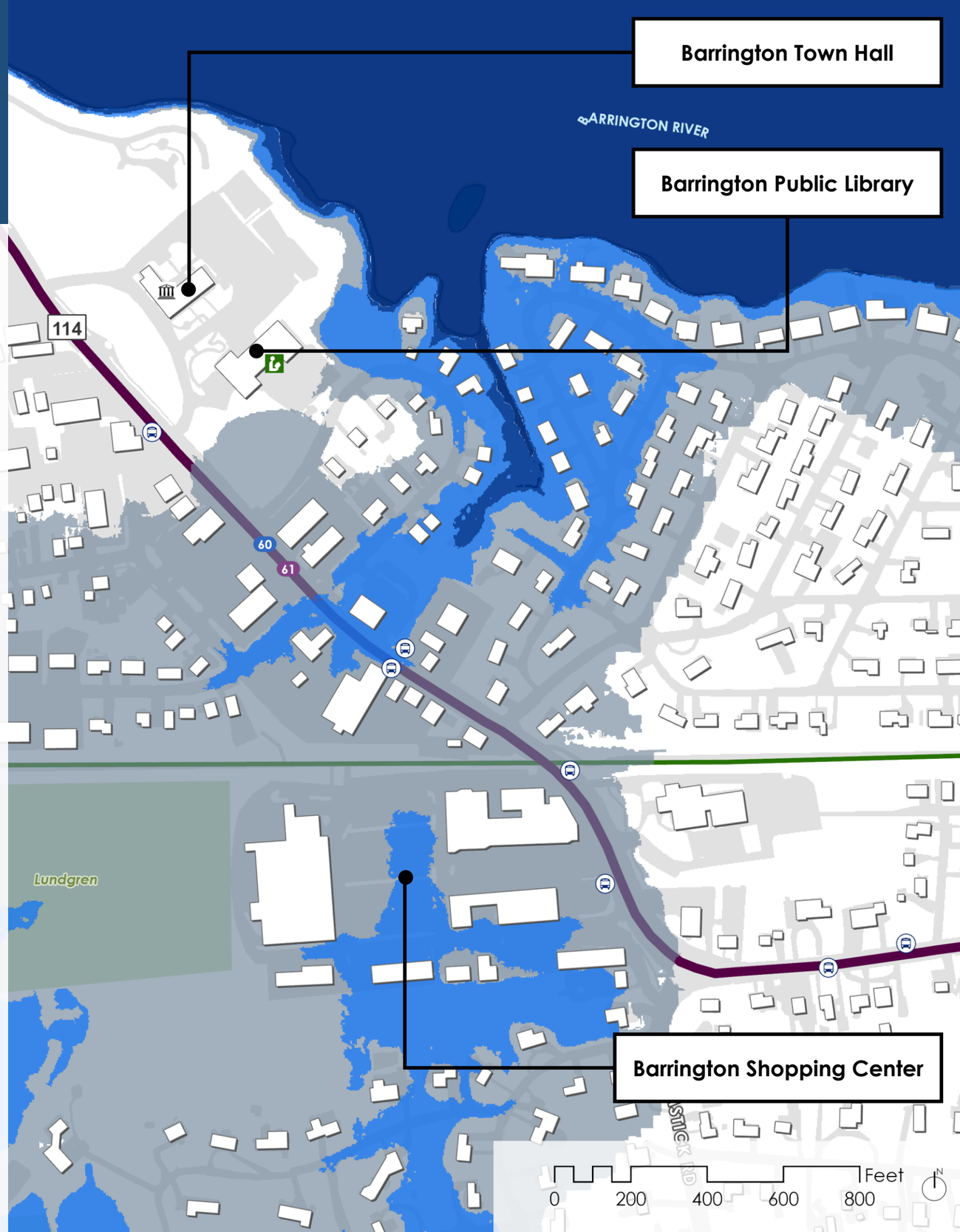
The intersection of Route 114 and Markwood Drive/Waseca Avenue will also become vulnerable to nuisance flooding.

During the future 1% annual chance flood event, flooding will extend further onto portions of Rumstick Road. Similarly, a higher number of residential homes on Stratford Road and Fairway Drive will be at risk of flooding impacts.

LEGEND

- Tidal Flooding (MHHW) + 2 Feet of SLR
- 10% Annual Chance Flood + 2 Feet of SLR
- 1% Annual Chance Flood + 2 Feet of SLR

Sources: RIGIS, CRMC, Town of Barrington



COASTAL FLOOD DEPTH: AOV 3

Based on current SLR predictions, the Barrington Shopping Center will be inaccessible by the 2050s, with 5-10 feet of coastal flooding preventing access to critical services.

DESIGN FLOOD ELEVATION (1% ANNUAL CHANCE FLOOD + 2 FT OF SLR)

AOV 3 contains key services of social and economic value to the greater community. Coastal flood depths projected during the 1% annual chance flood event + 2 feet of SLR will prevent safe access to these services – namely, the Barrington Shopping Center.

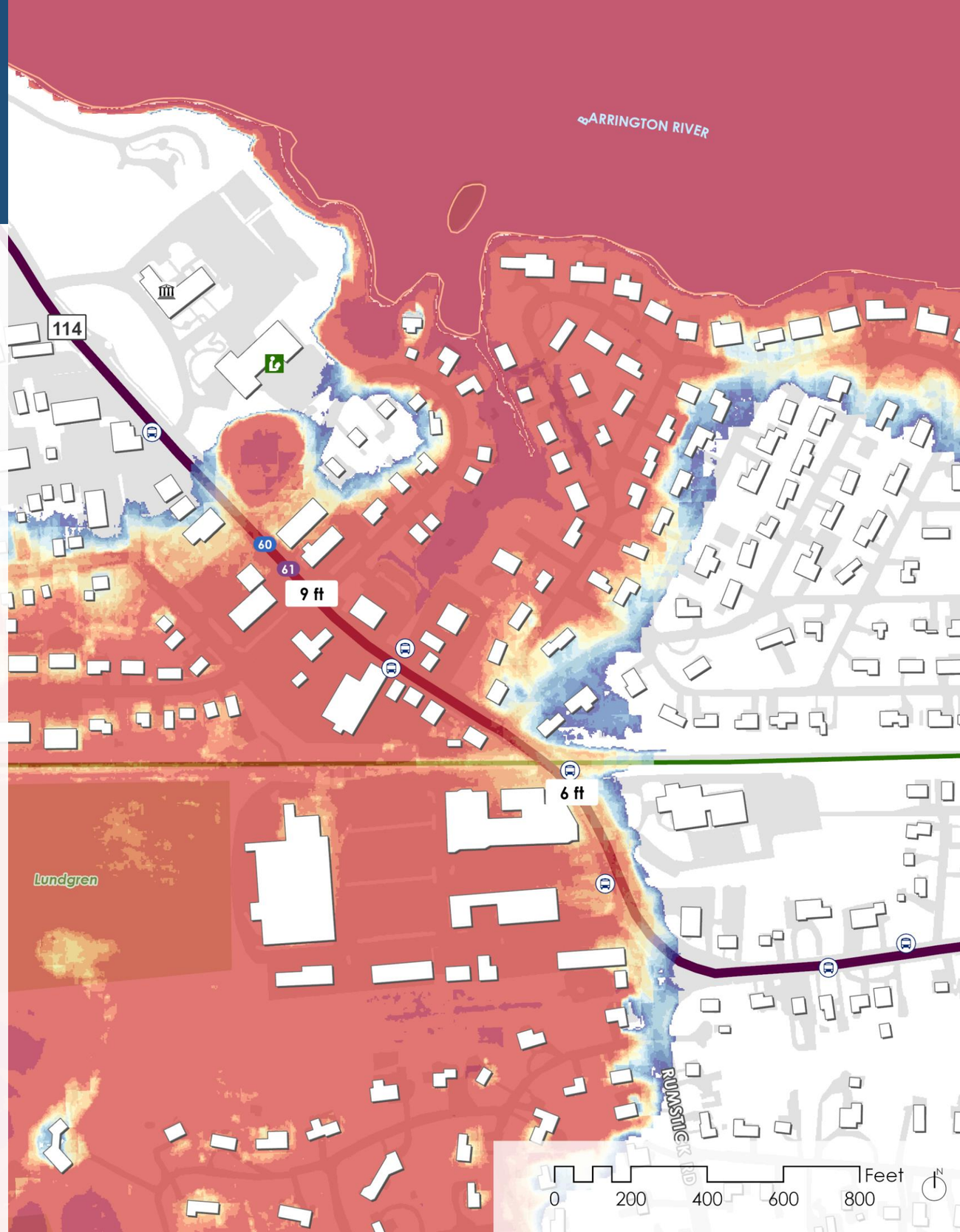
The Barrington Shopping Center includes businesses (e.g., grocery store and hardware store) and services (i.e., banking) that will be integral to residents immediately preceding a flooding event. The Barrington Shopping Center is projected to have over 10 feet of water inundating the parking lot and businesses, with access points from Route 114 being impassable due to high water depths (6-9 feet).

Critical Town-owned buildings located in AOV 3 are not projected to experience direct coastal flooding impacts due to their location in higher elevation areas. However, flooding of the adjacent roadway with up to 9 feet of water will prevent access to the Town Hall and Public Library. As with other portions of Route 114, RIPTA bus stops will not be serviceable due to the flood depths exceeding more than 1 foot, and RIPTA will likely need to reroute busses from this area of Town.

LEGEND

- 0 – 0.5 FT
- 0.5 – 1 FT
- 1 – 1.5 FT
- 1.5 – 2 FT
- 2 – 2.5 FT
- 2.5 – 3 FT
- 3 – 3.5 FT
- 3.5 – 4 FT
- 4 – 4.5 FT
- 4.5 – 5 FT
- 5 – 10 FT
- >10 FT

Sources: RIGIS, CRMC, Town of Barrington



NATURAL RESOURCES AT RISK: AOV 3

Several freshwater wetlands are mapped near Route 114 within AOV 3 by RI DEM and NWI (see Figure 10). Projected conditions indicate that 5 to 10 feet of coastal flooding are likely during a 1% annual chance flood with 2 feet of SLR by the 2050s. Natural resources and the built environment are closely intertwined within this AOV. The developed areas surrounding the natural resources present a physical barrier to wetland migration. The rate of inundation and the surrounding development will result in reduced ecosystem function and reduced adaptive capacity over time.

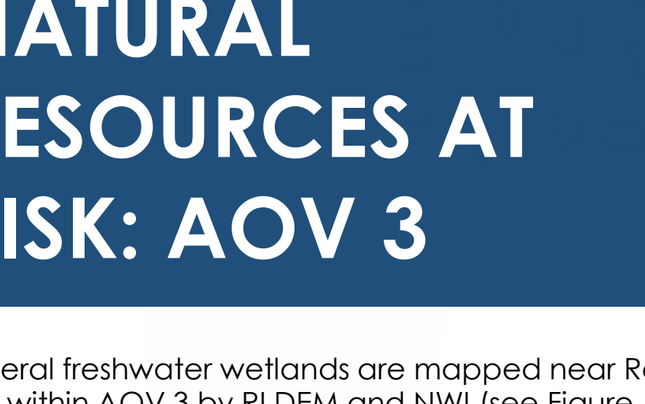


Figure 10 – Image of marine wetlands in AOV 3

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Freshwater Wetland
- Estuarine/Marine Wetland
- Natural Heritage Areas

Sources: RIGIS, RIDEM, CRMC

BUILDINGS AT RISK: AOV 3

By the 2050s, it is projected that 234 buildings within AOV 3 will be at risk of inundation during the 1% annual chance flood. Similar to the other AOVs, the primary at-risk buildings are residential homes. The at-risk residential properties are primarily located in shoreline neighborhoods that are dependent on access to Route 114 for safe egress during a flooding event (e.g., Riverside Drive).

Notably, this AOV has the greatest number of commercial properties, as it features the Barrington Shopping Center. The Barrington Shopping Center contains commercial businesses key to local residents such as the Shaw's grocery store, Ace Hardware, and the CVS Pharmacy (Figures 11 & 12). Many of these buildings are located directly on, or adjacent to, Route 114, and depend on this major roadway for customer traffic. With 9 feet of floodwater projected along Route 114 during flood events in this AOV, flood damages to these commercial properties could have serious economic impacts.

Figures 11 & 12: Existing conditions at the Ace Hardware (left) and CVS Pharmacy in the Barrington Shopping Center

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Commercial (44 buildings)
- Commercial/Residential Mixed (0 buildings)
- Residential (185 buildings)
- Manufacturing/Light Industrial (0 buildings)
- Municipal/Institutional (5 buildings)

Sources: RIGIS, CRMC

KEY CHALLENGES + OPPORTUNITIES: AOV 3

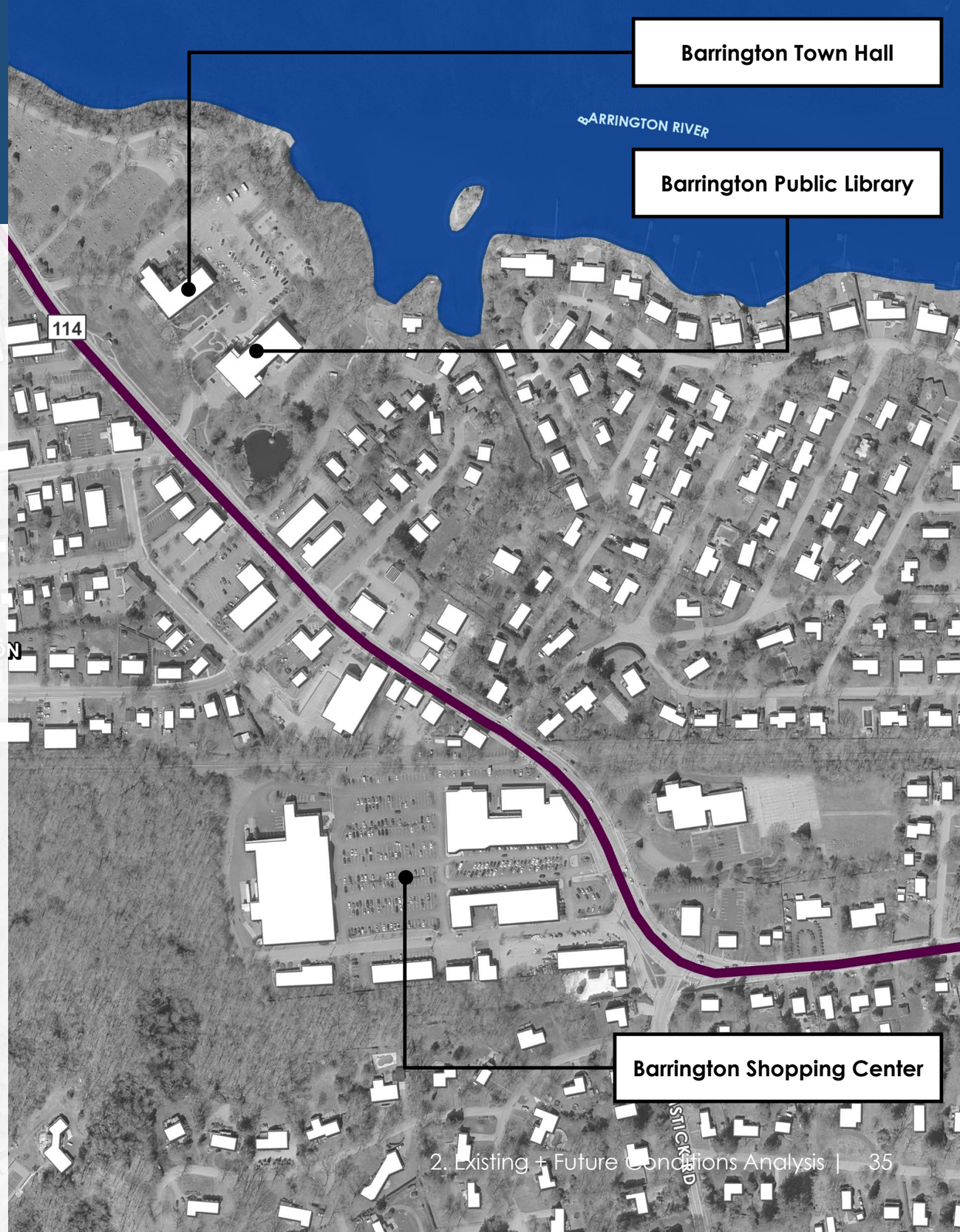
CHALLENGES

AOV 3 represents one of the most vulnerable and challenging AOVs in the Town of Barrington. The 6 feet of projected water depth on Route 114 during the 10% annual chance flood event + 2 feet of SLR will prevent access to the Barrington Shopping Center. Additionally, many of the commercial buildings in this area lack the floodproofing needed to reduce the risk from future coastal flood events or flooding from nearby Brickyard Pond.

OPPORTUNITIES

Within AOV 3, there are limited opportunities to address the key challenges identified above due to dense development along Route 114. One opportunity the Town could explore is the feasibility of constructing a flood gate, or similar flood control structure, in the ravine that conveys flood waters from the Barrington River to Route 114 (behind the Riverside Drive neighborhood). For long-term planning, the Town may also want to engage in conversations with local business owners about floodproofing their structures (see Figure 13) and establishing post-flooding recovery plans. Additionally, the Town could investigate constructing a secondary egress from the Shopping Center on the western side of the property (a route less likely to be impacted by future flooding events) and discuss the possible future relocation of key businesses that comprise the Barrington Shopping Center.

Figure 13: The front doors of the CVS in the Barrington Shopping Center, serving as an example of a vulnerable entry point where floodwater may infiltrate a critical building during a flooding event



AOV 4

EXISTING + FUTURE CONDITIONS

AOV 4 extends from Joyce Street to the Warren Bridge and includes vital transportation infrastructure that is critical to the Town in an emergency. Regular high tide flooding currently causes flooding in this AOV in areas such as New Meadow Road and Sowams Road (Jacobs, 2022). Heavy rain events have also caused flooding to occur in areas around the Warren/Barrington border.

Critical services of concern in AOV 4 include the Barrington Bridge, the Warren Bridge, and the Police Cove pump station. Each of these services is currently located in a FEMA flood zone and is vulnerable to a 1% annual chance flood event. The Police Cove sanitary sewage pump station has also been assessed as being at risk of a Category 2 hurricane event. Based on a State-wide assessment of at-risk bridges under State jurisdiction, the Barrington Bridge was ranked #1 as most vulnerable to sea level rise (RIDSP, 2015).

PRESENT COASTAL FLOOD RISK: AOV 4

Existing flooding conditions in AOV 4 place waterfront properties, pump stations, and critical transportation infrastructure at risk of flooding during the 10% and 1% annual chance flood events.

CURRENT CONDITIONS (2023)

Current flooding conditions in AOV 4 present a flood risk to one of the key routes entering/exiting the Town. Currently, nuisance flooding does not cause tidal inundation onshore, and impacts are limited to the riverbanks.

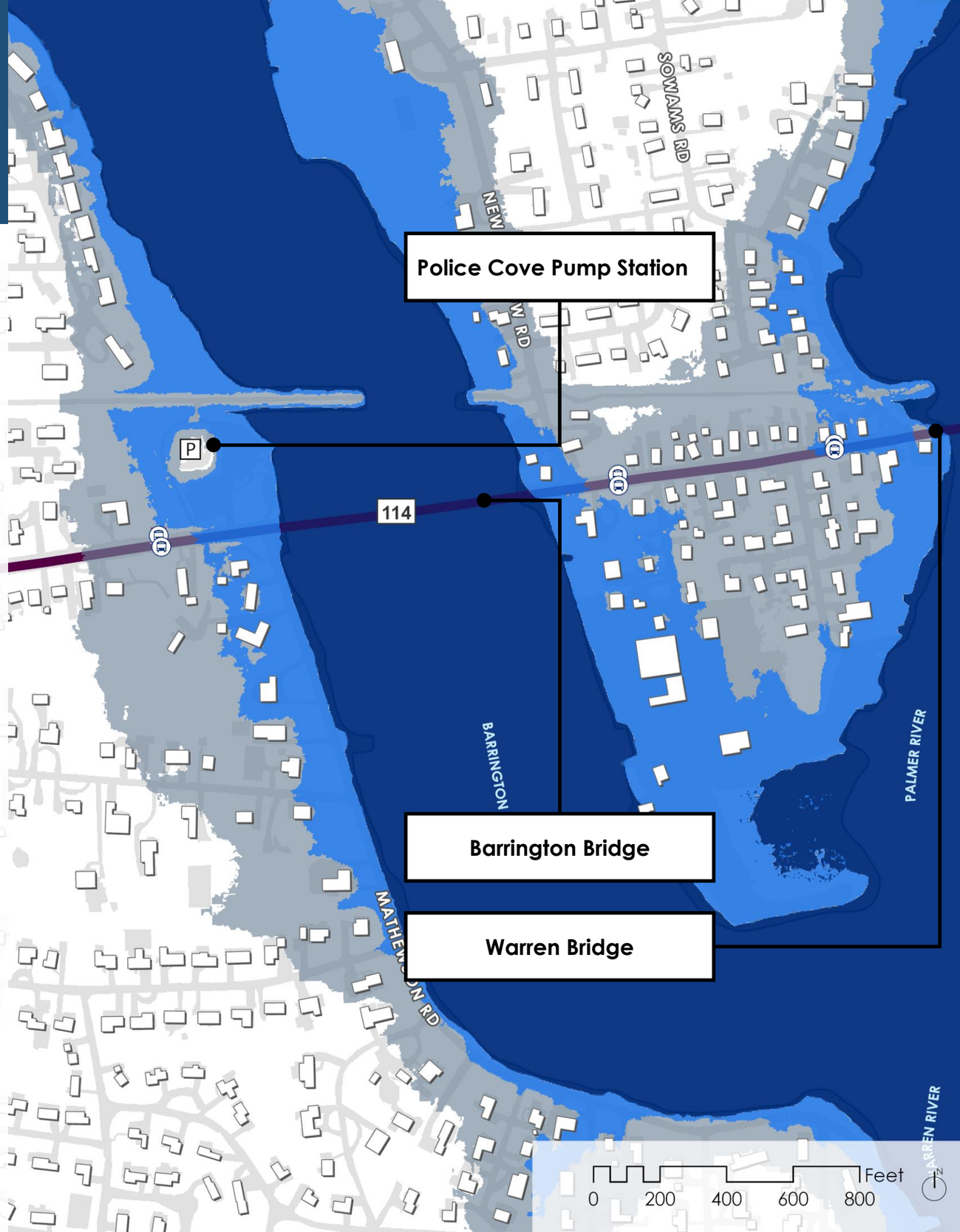
During the current 10% annual chance flood event, flood extents in AOV 4 extend upgradient and impact residential properties on Route 114 and Jennys Lane. Mathewson Road may become impassable, depending on the depth of floodwaters inundating the roadway. Furthermore, the extent of flooding may impact portions of Route 114 that convey traffic across the Barrington and Warren Bridges, which would impact residents commuting between Warren and Barrington. Additional Town-owned services will be impacted by the 10% annual chance event, including the Police Cove area and associated sewer pump station. While the pump station is elevated on higher ground, accessing the structure during a flooding event for repair or maintenance will be difficult.

During the 1% annual chance flood event, potential flooding impacts extend upland and impact more residential properties in the Jennys Lane and Riverside Drive neighborhoods. Four RIPTA bus stops are vulnerable to flooding under this flood scenario.

LEGEND

- Tidal Flooding (MHHW) in 2023
- 10% Annual Chance Flood in 2023
- 1% Annual Chance Flood in 2023

Sources: RIGIS, CRMC, Town of Barrington



FUTURE COASTAL FLOOD RISK: AOV 4

By the 2050s, sea level rise will increase the number of residential homes at risk from the 1% annual chance flood event, as well increasing the vulnerability of RIPTA bus stops from a 10% annual chance flood event.

2 FEET OF SEA LEVEL RISE (2050s)

The anticipated impacts of sea level rise on flooding event scenarios will expand flooding vulnerability to residential buildings in AOV4.

By the 2050s, the impacts of nuisance flooding will cause tidal waters to extend further into the Police Cove area and onto private residential property.

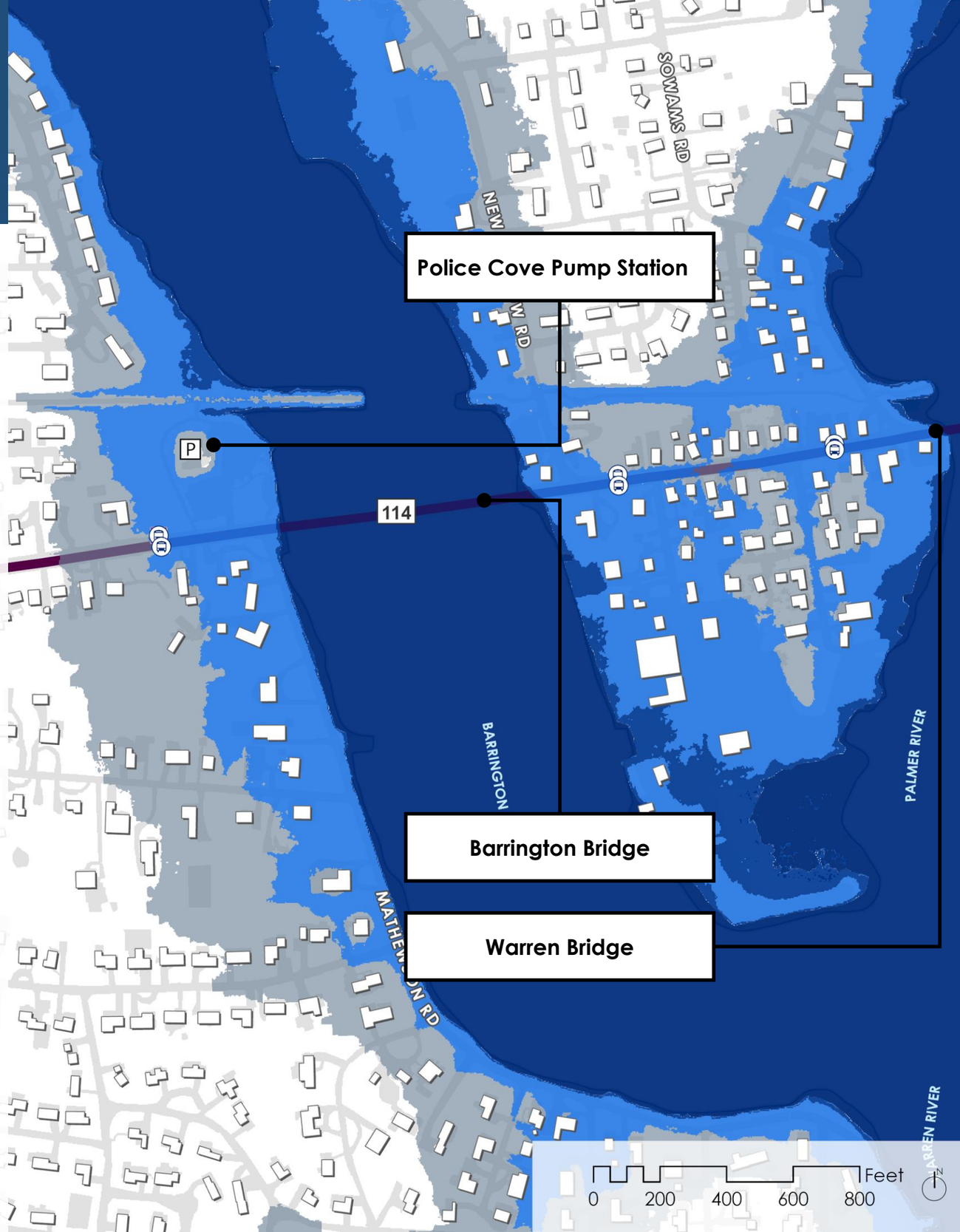
A 10% annual chance flooding event in the 2050s is projected to impact properties on Riverside Drive and inundate greater portions of Route 114 westward of the Barrington Bridge.

A 1% chance flooding event in the 2050s will isolate a greater proportion of residential areas. Flooding extents will impact more residential homes in the Jennys Lane and Chapin Road neighborhoods, more portions of Riverside Drive, and extend along Route 114 westward towards the Shopping Center. The Barrington Bridge, Warren Bridge, and Police Cove pump station will be inaccessible during the 10% or a 1% annual chance flooding event.

LEGEND

- Tidal Flooding (MHHW) + 2 Feet of SLR
- 10% Annual Chance Flood + 2 Feet of SLR
- 1% Annual Chance Flood + 2 Feet of SLR

Sources: RIGIS, CRMC, Town of Barrington



COASTAL FLOOD DEPTH: AOV 4

In AOV 4, the 5-10 feet of coastal flooding projected due to sea level rise would cut off access to critical services, including a pump station and Town bridges.

DESIGN FLOOD ELEVATION (1% ANNUAL CHANCE FLOOD + 2 FT OF SLR)

Future resilience planning in AOV 4, based on the 1% annual chance flood event + 2 feet of SLR, will need to focus on three key services: the Barrington Bridge, the Warren Bridge, and the Police Cove sanitary sewage pump station. The projected water depths under this scenario will make these services inaccessible due to coastal flooding.

The Barrington and Warren Bridges, which connect the Towns of Barrington and Warren, will be inaccessible with more than 10 feet of water at the base of both bridges in the future. This will have major impacts on Town safety and evacuation routes. Additionally, the Police Cove sanitary sewage pump station will not be accessible in the event of failure during a flooding event, as Route 114 will be inundated with over 7 feet of water at the entry point.

Along Mathewson Road, residential homes may have water depths as deep as 5-10 feet. This will prevent safe egress from the properties and may result in damages to personal property.

LEGEND

- 0 – 0.5 FT
- 0.5 – 1 FT
- 1 – 1.5 FT
- 1.5 – 2 FT
- 2 – 2.5 FT
- 2.5 – 3 FT
- 3 – 3.5 FT
- 3.5 – 4 FT
- 4 – 4.5 FT
- 4.5 – 5 FT
- 5 – 10 FT
- >10 FT

Sources: RIGIS, CRMC, Town of Barrington

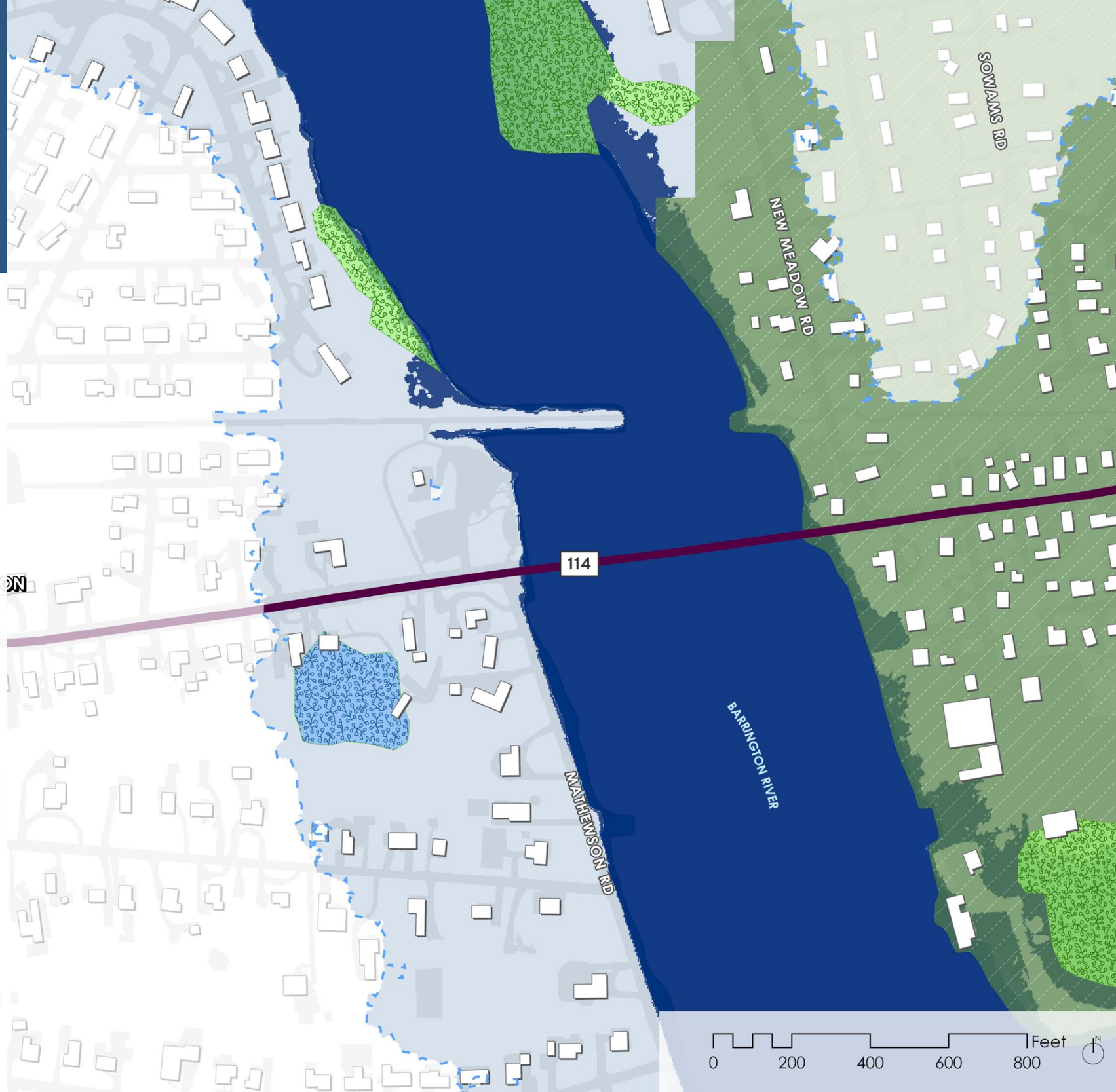
NATURAL RESOURCES AT RISK: AOV 4

RI DEM and NWI have mapped one freshwater wetland south of Route 114 in AOV 4. The area of Route 114 to the east of the Barrington River is also mapped as a natural heritage area. Future flood projections indicate that the freshwater wetland will likely be inundated with 3 to 10 feet of coastal flooding during the 1% annual chance flood with 2 feet of SLR. The freshwater wetland is surrounded by residential properties, which will further limit its ecosystem function, adaptive capacity, and flood risk reduction capacity by limiting the potential for wetland migration.

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Freshwater Wetland
- Estuarine/Marine Wetland
- Natural Heritage Areas

Sources: RIGIS, RIDEM, CRMC



BUILDINGS AT RISK: AOV 4

In AOV 4, 183 buildings are likely to be impacted by the 1% chance flood with 2 feet of SLR, as coastal inundation will extend throughout the Police Cove area (Figure 14). The majority of these buildings are residential, with some commercial buildings and one municipal structure (Police Cove sanitary sewage pump station) in the area (see Figure 15). The number of residential buildings vulnerable to flooding impacts raises concern, as the closest evacuation route during an emergency would be the Barrington and Warren Bridges. However, these bridges will be impassable at a flood water depth of 1 foot or greater on Route 114. The alternative evacuation routes will still require residents to traverse inundated portions of Route 114 in other AOVs.

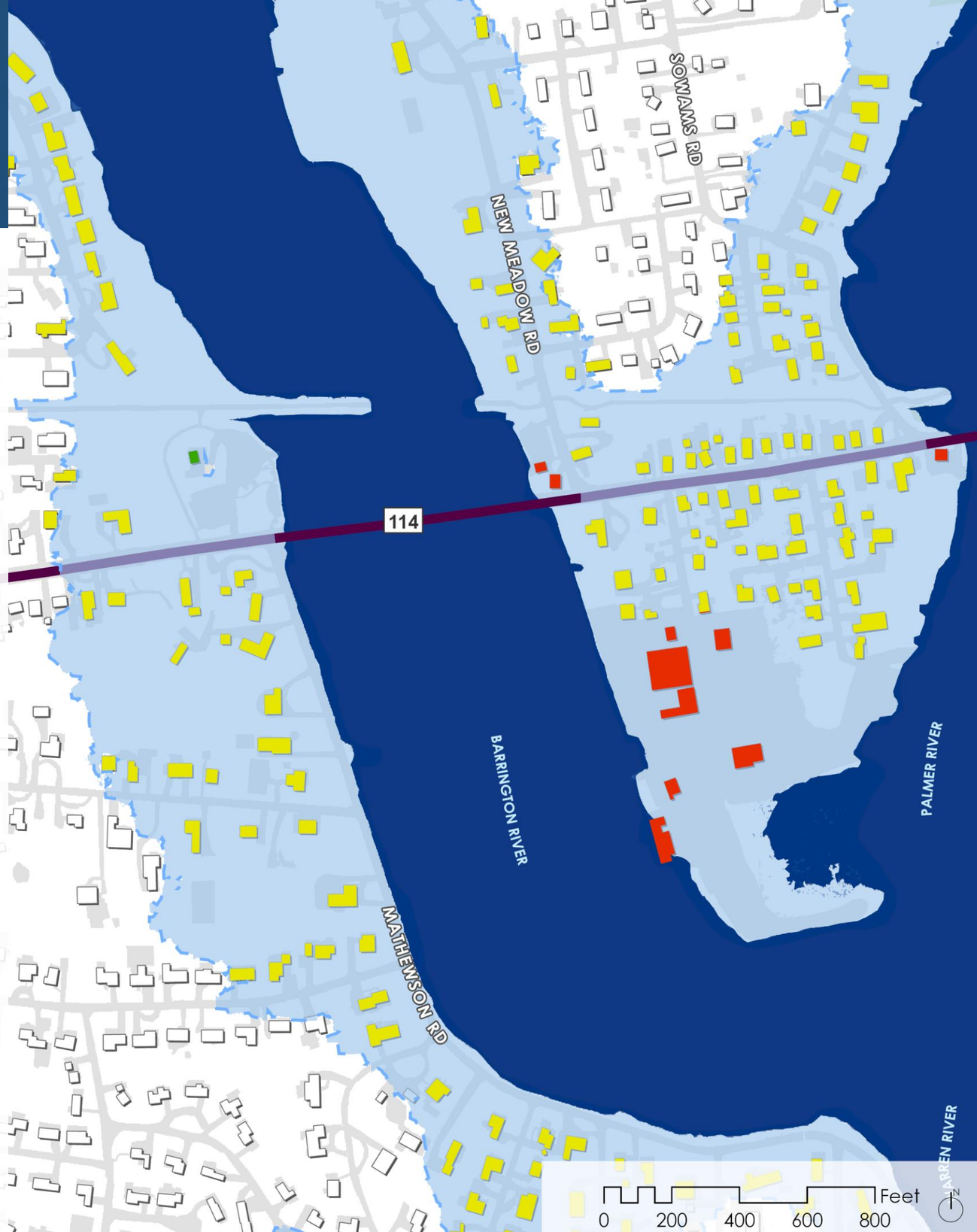
Figure 14: Existing conditions at Police Cove Beach on Route 114 in Barrington

Figure 15: Existing conditions at the Police Cove Beach sanitary pump station on Route 114 in Barrington

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Commercial (11 buildings)
- Commercial/Residential Mixed (0 buildings)
- Residential (171 buildings)
- Manufacturing/Light Industrial (0 buildings)
- Municipal/Institutional (1 building)

Sources: RIGIS, CRMC



KEY CHALLENGES + OPPORTUNITIES: AOV 4

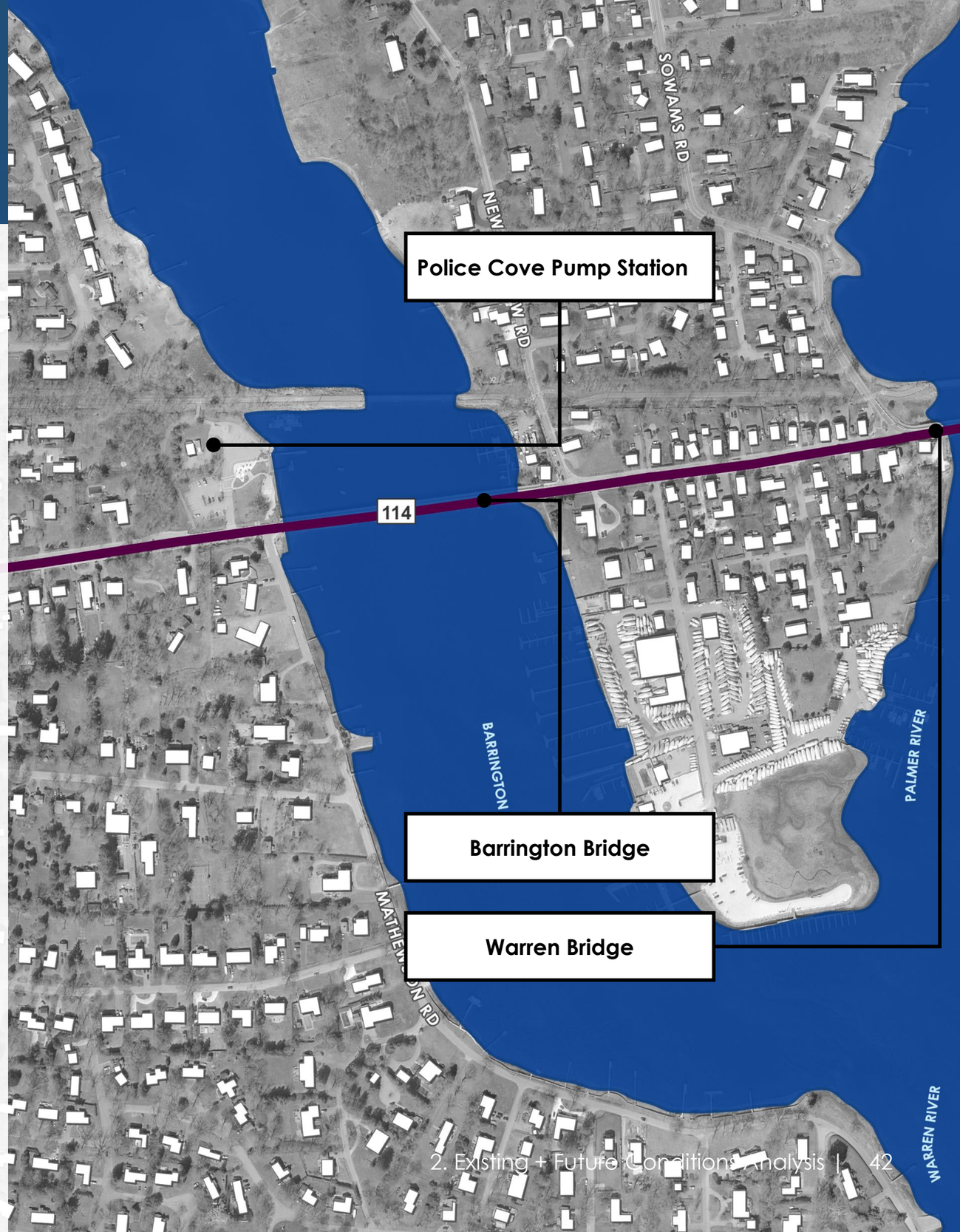
CHALLENGES

With projected flood depths of 7.5 feet and 9.5 feet on either side of the Barrington Bridge during the future 10% annual chance flood event + 2 feet of SLR, one of the greatest challenges for AOV 4 will be egress through the southern portion of Town and reducing the vulnerability of residential properties along the Barrington River.

OPPORTUNITIES

One of the few opportunities available to the Town in this AOV would involve improved communication with the public prior to a flooding event. For example, the Town could install signage along Route 114 that directs evacuees to the nearest alternative emergency route (e.g., Route 295) to avoid confusion during an evacuation. This opportunity could be a collaborative effort with the Town of Warren to ensure consistent messaging.

Additionally, the Town could consider raising portions of Route 114 in this AOV, including the Barrington Bridge. Raising Route 114 in this area would reduce floodwaters on the roadway and enable safe passage from the peninsula to the rest of Barrington. However, depending on the extent of road raising, this alternative presents several additional challenges. First, this solution would not completely address the projected future coastal flooding events likely to be faced by many of the residences along Mathewson Road, Riverside Drive, Tyler Point Road, and Barton Avenue. Additionally, raising the road in this area would require the regrading of many intersections, adjoining streets, and driveways to meet new grades established by the elevated roadway.



AOV 5

EXISTING + FUTURE CONDITIONS

AOV 5 is bound in the north by the Warren-Barrington Bridge that transverses Palmer River, and in the south by the intersection of Route 114 and Hope Street. The Tourister Mill, which is a large apartment complex, is located near the northern boundary of the AOV. Some critical facilities located in this AOV include a school, the Warren Fire Department Rescue Station, Bierman Autism Center, and The Corliss Institute. The RIPTA 60 and 61 bus routes run along the portion of Route 114 daily with multiple stops in this AOV.

Route 114 in Warren was ranked number one in the top 10 road assets in the Town of Warren vulnerable to SLR in the *Warren, RI Coastal Sea Level Rise and Storm Surge: Transportation Fact Sheet* (RISPP, 2016).

Downtown Warren is a Historic District and includes several properties along Main Street that were recommended for National Register of Historic Places status to the RI Historical Preservation & Heritage Commission. Water and sewer lines currently run under portions of Route 114 and are vulnerable to flooding.

PRESENT COASTAL FLOOD RISK: AOV 5

Under present-day conditions, tidal flooding is less of an issue in this section of Route 114 when compared to the effects of modeled storm surge.

CURRENT CONDITIONS (2023)

Historically, during heavy storms and rain events, flooding has occurred in this area, especially when paired with high winds. These storms can make Route 114 impassable due to flooding. In discussions with members of the community, the areas of Route 114 that have historically experienced flooding align with the flooding modeled in STORMTOOLS and shown in this map.

According to the modeling from STORMTOOLS, during the 10% annual chance flood, two RIPTA bus stops are affected by coastal flooding, along with several buildings (including the Autism Center).

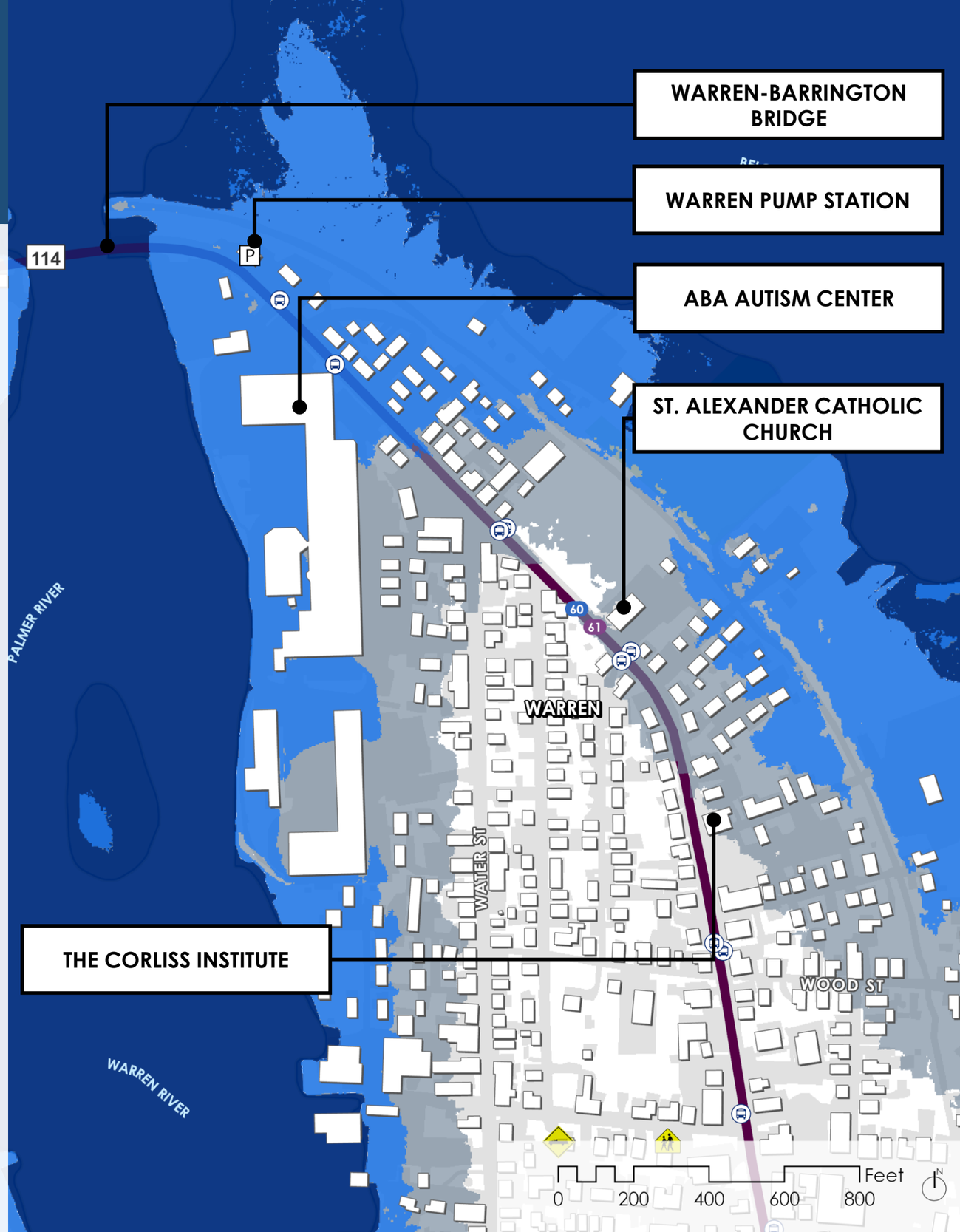
LEGEND

- Tidal Flooding (MHHW) in 2023
- 10% Annual Chance Flood in 2023
- 1% Annual Chance Flood in 2023

Sources: RIGIS, CRMC, Town of Warren

Route 114 is flooded from the Warren-Barrington Bridge to the intersection of 114 and Thompson Street.

During the 1% annual chance flood, a total of 6 RIPTA bus stops are likely to be impacted by coastal flooding, and Route 114 would be flooded from the Warren-Barrington Bridge to the intersection of 114 and Union Street. There is a high point on Route 114 just north of St. Alexander Catholic Church at the cemetery, at approximately elevation 14 feet (NAVD 88), but the road continues to be exposed to coastal flooding during the modeled 1% annual chance flood further south between St. Alexander Catholic Church and Park Street. The Autism Center, along with The Corliss Institute, would also likely experience flooding under these conditions.



FUTURE COASTAL FLOOD RISK: AOV 5

Under projected sea level rise conditions, the extent of flooding along Route 114 in AOV 5 reaches farther south, increasing the length of road that would experience flooding.

2 FEET OF SEA LEVEL RISE (2050s)

Projected modeling shows that under future conditions, MHHW will cause nuisance flooding of Route 114 near the Warren-Barrington Bridge.

The extent of flooding for the 10% and 1% annual chance flood increase under projected future conditions. Under the 10% annual chance flood, flooding is projected to occur from the Warren-Barrington Bridge to the intersection of 114 and Kelly Street.

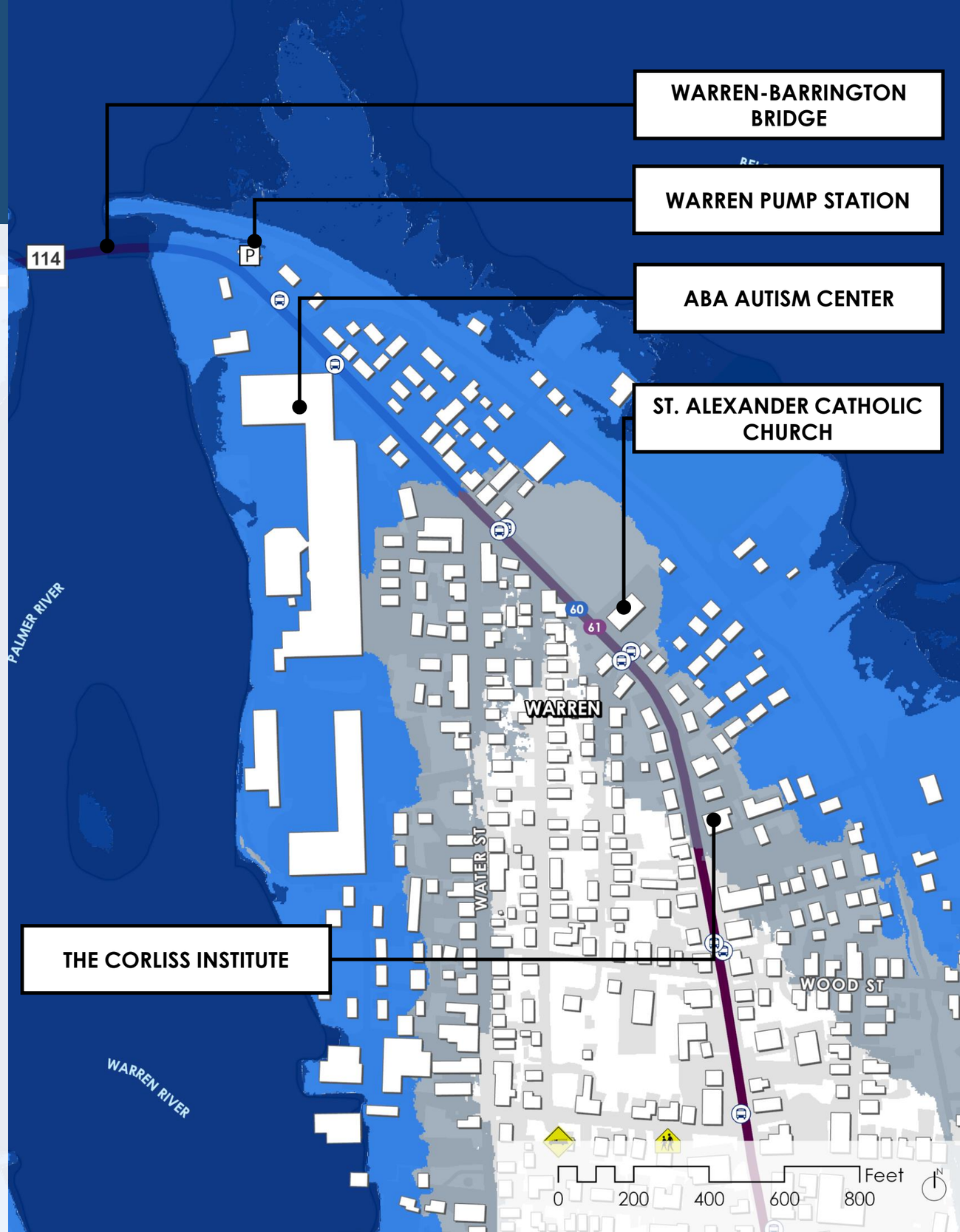
During the future 1% annual chance flood, flooding is projected to occur from the Warren-Barrington Bridge and reach Norbert Street. The Corliss Institute sits on the corner of Route 114 and Norbert Street and is projected to be affected by flooding during these flood conditions.

Under these conditions, the entirety of Route 114 would experience flooding, including the high point at the St. Alexander Catholic Church Cemetery. Under present-day conditions, this portion of Route 114 does not experience flooding impacts.

LEGEND

- Tidal Flooding (MHHW) + 2 Feet of SLR
- 10% Annual Chance Flood + 2 Feet of SLR
- 1% Annual Chance Flood + 2 Feet of SLR

Sources: RIGIS, CRMC, Town of Warren



COASTAL FLOOD DEPTH: AOV 5

Route 114 is projected to experience the deepest flood depth (around 14 feet) in the future in the area south of the Warren-Barrington Bridge near the Tourister Mill.

DESIGN FLOOD ELEVATION (1% ANNUAL CHANCE FLOOD + 2 FT OF SLR)

In the future, the deepest areas of flooding (14 feet) are projected to occur near the northern boundary of AOV 5 at the Warren-Barrington Bridge. The bike path that runs parallel to Route 114 would also become unusable in these conditions. As Route 114 runs south, the amount of flooding is projected to decrease until it reaches a high point in the road between Union Street and Warren Avenue where flooding would decrease to a few feet. Flooding impacts are then expected to worsen as the road continues south and flooding depth increases to 7 feet.

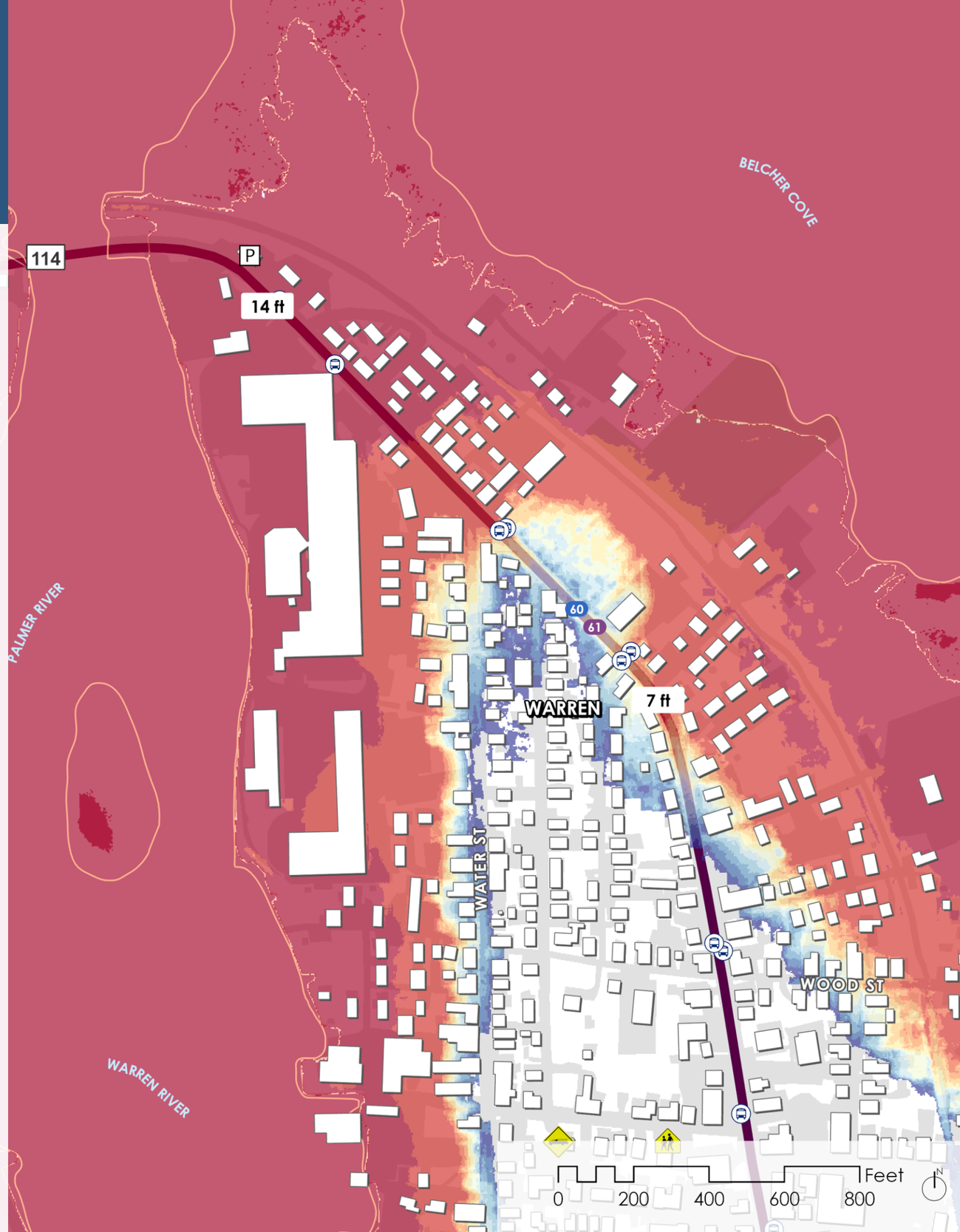
Flooding then decreases to only a few inches near The Corliss Institute, as the road elevation continues to increase to the south.

Under these conditions, a total of 5 bus stops would experience significant flooding, with the northernmost bus stop in this AOV experiencing the worst flooding impacts, with over 10 feet of flooding. The Autism Center is also expected to experience major flooding under these conditions at around 14 feet of flooding, and The Corliss Institute would experience a range of flood depths up to 3 feet.

LEGEND

0 – 0.5 FT	3 – 3.5 FT
0.5 – 1 FT	3.5 – 4 FT
1 – 1.5 FT	4 – 4.5 FT
1.5 – 2 FT	4.5 – 5 FT
2 – 2.5 FT	5 – 10 FT
2.5 – 3 FT	>10 FT

Sources: RIGIS, CRMC, Town of Warren



NATURAL RESOURCES AT RISK: AOV 5

Estuarine emergent wetlands are mapped to the north of Route 114 in AOV 5 by RI DEM and NWI. The majority of Route 114 in this area also transects an urbanized, mapped natural heritage area. Projected coastal flood conditions indicate the wetlands in AOV 5 will likely be inundated with greater than 10 feet of coastal flooding during a 1% annual chance flood with 2 feet of SLR, which will have significant impacts on the ecosystem function of the wetlands. In addition, the built environment along Route 114 (including the East Bay Bike Path) will act as a barrier for marsh migration and adaptation. The projected rate of tidal flooding and the existing built environment will prohibit the ability of natural resources to adapt.

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Freshwater Wetland
- Estuarine/Marine Wetland
- Natural Heritage Areas

Sources: RIGIS, RIDEM, CRMC

BUILDINGS AT RISK: AOV 5

A total of 221 buildings are likely to be impacted during the future 1% annual chance flood with 2 feet of SLR. These buildings include a wide variety of uses; however, most of the impacted buildings are residential. The large number of vulnerable residential buildings raises concern, as several residential properties, including the Tourister Mill Apartments (see Figure 16), lack an evacuation route that is not impacted by the future 1% annual chance flood. For several of these houses, there is only one major evacuation route, which is Route 114.

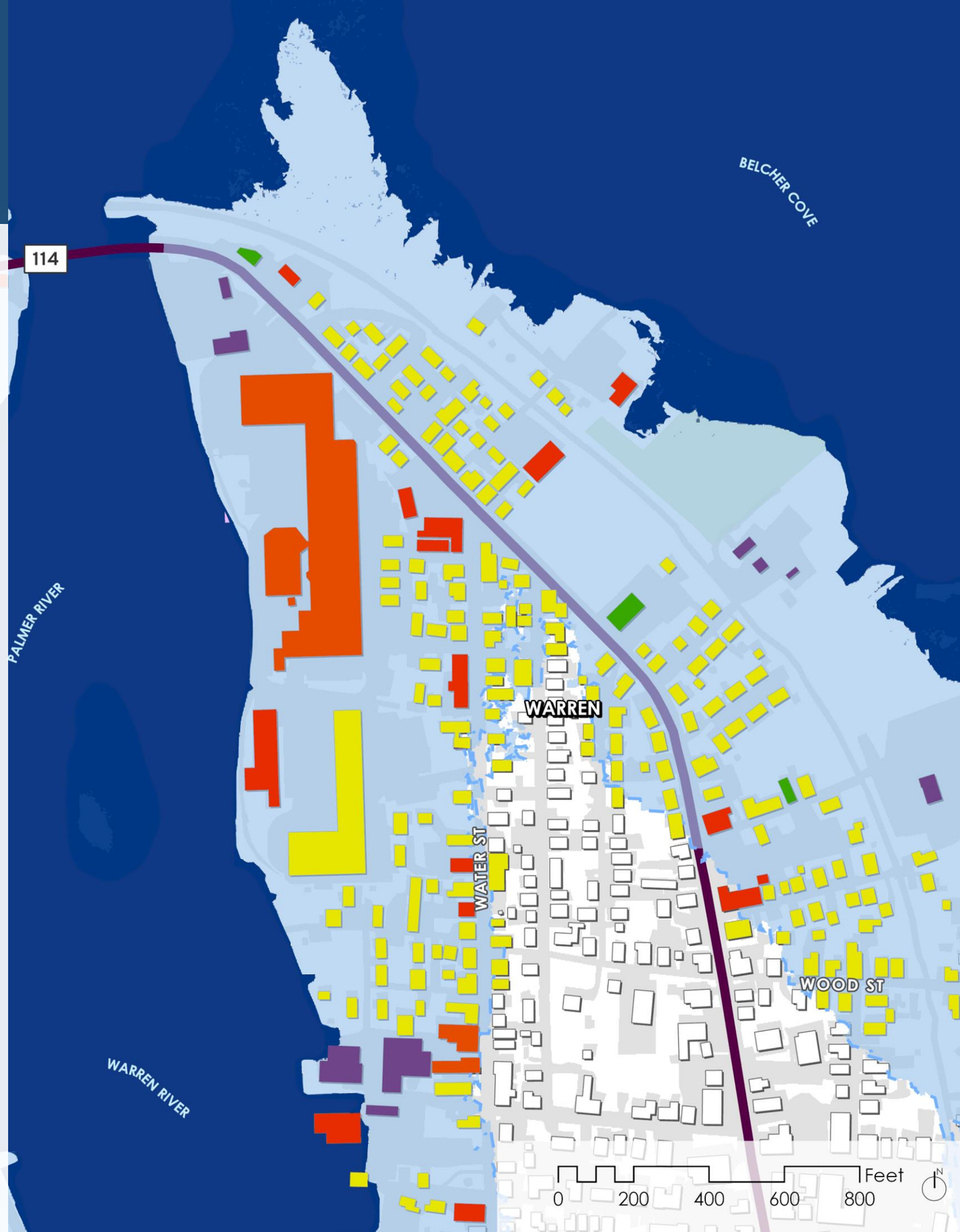
For some buildings in the area that are at risk of inundation by up to 14 feet of water during a future 1% annual chance flood, the cost of impacts from flooding could be irreparable. This type of flooding also poses a safety risk if residents are not able to evacuate to safety in time to avoid becoming trapped in their homes. As flooding depths decrease, like at St. Alexander Catholic Church, damages tend to be less costly and potentially easier to avoid through the implementation of adaptive measures.

Figure 16: Image of the Tourister Mill Apartments

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Commercial (14 buildings)
- Commercial/Residential Mixed (4 buildings)
- Residential (189 buildings)
- Manufacturing/Light Industrial (11 buildings)
- Municipal/Institutional (3 buildings)

Sources: RIGIS, CRMC



KEY CHALLENGES + OPPORTUNITIES: AOV 5

CHALLENGES

The northern part of Route 114 in this AOV is projected to be under 14 feet of water during the 1% annual chance flood event with 2 feet of SLR. Due to the proximity of buildings on Route 114, road raising may not be a viable option. This is due to the necessary widening of the road footprint often required to elevate roadways. The Warren-Barrington Bridge would also need to be raised to accommodate the raised road. This would alter the overall aesthetics of the bridge, potentially impacting the look and feel of the area.

Flooding in this AOV is projected to occur from all directions except from the south. This creates a challenge because evacuation routes during flooding events are limited to Route 114 heading south. Modeling shows that the alternate north-south route of Water Street may also be impacted during the present-day 1% annual chance flood event.

OPPORTUNITIES

One opportunity for improving the resilience of the Route 114 corridor in AOV 5 is to make Route 114 resilient to projected future nuisance flooding and focus on implementing an efficient early warning system for evacuation before flooding occurs. Notifying residents that they reside in a floodplain would be key to this early warning system so that residents can be ready to evacuate if needed.

During tidal flooding events, a small section of the bridge approach in the northern portion of the AOV could be raised to keep it out of the projected future MHHW flooding. Engineered or hybrid infrastructure solutions (e.g., elevated walls) could potentially be used in this area to prevent water from coming onto the road.

Additionally, as suggested by some community stakeholders, emergency ferries could be considered in the future to aid in evacuations and emergency responses. Daily ferries to replace RIPTA bus routes could also be utilized to mitigate the impact flooding may have on local bus routes.

AOV 6

EXISTING + FUTURE CONDITIONS

AOV 6 is bound by the intersection between Route 114 and Chestnut Street in the north and Franklin Street in the south. This area is a vital artery to downtown Bristol from the north that contains many restaurants and small businesses. This section of Route 114 is designated as a State Scenic Roadway.

Guiteras Elementary School, the Silver Creek Rehab and Healthcare Center, and Bristol VFW Post 237 are all critical facilities that are located in this AOV. Other critical services, such as the Bristol Senior Center and Benjamin Church Manor, are also within this AOV but not at risk of flooding from current or future flooding events.

AOV 6 also contains the Silver Creek Bridge, which is a particularly vulnerable area due to the occasional flooding of the Silver Creek that runs underneath the bridge and discharges to Bristol Harbor. According to a study titled 'Vulnerability of Transportation Assets to Sea Level Rise' (RIDSP, 2015), the Silver Creek Bridge was rated one of the most vulnerable bridges under state jurisdiction. This portion of the road is also on Bristol's Fourth of July Parade route – an important cultural, historical, and economic development event.

PRESENT COASTAL FLOOD RISK: AOV 6

Coastal flooding across the Silver Creek Bridge is a present-day issue during heavy rainstorms combined with high tides.

CURRENT CONDITIONS (2023)

The Silver Creek Bridge, which is the section of Route 114 that spans across Silver Creek, experiences frequent flooding during major storm events. This causes the road to become dangerous to pass.

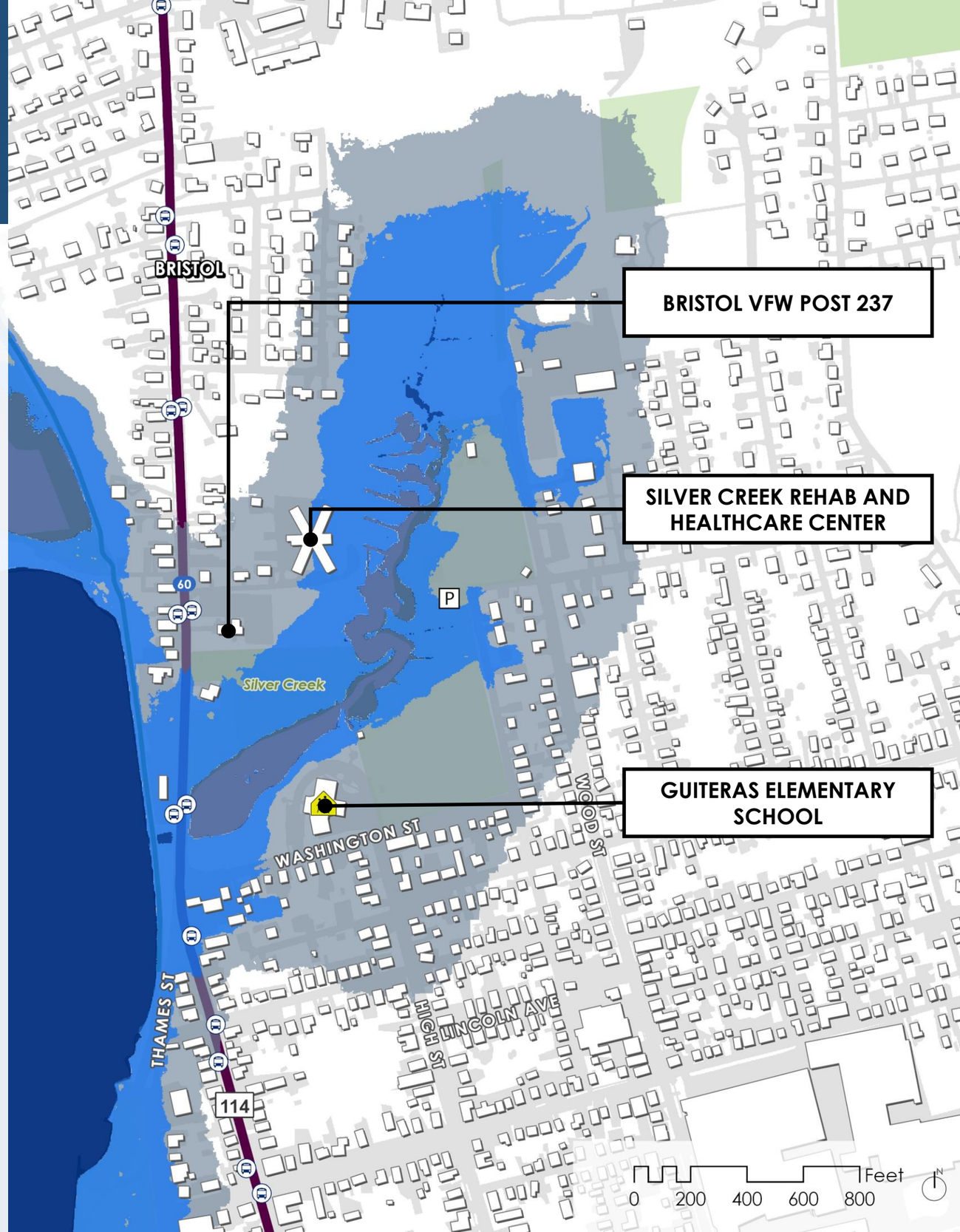
Tidal flooding does not affect Route 114 under present-day conditions; however, under present-day conditions, it is projected that a 10% annual chance flood event would flood a large section of Route 114 spanning from the Beach House Restaurant to Oliver Street. This flooding would affect three RIPTA bus stops and limit access to the Guiteras Elementary School from the north and the Silver Creek Healthcare Center from the south.

Under a 1% annual chance flood, Route 114 would experience flooding from north of Poppasquash Road to Oliver Street. The number of bus stops affected by flooding would increase to seven, and Route 114 would become impassable, forcing traffic to be rerouted to Sherry Ave, which is a narrow roadway that may not be able to handle the additional traffic flow. This would also cause 12 bus stops to be taken out of service due to the detour. Guiteras Elementary School and the Silver Creek Healthcare Center would also be inaccessible due to the flooding under these projected conditions.

LEGEND

- Tidal Flooding (MHHW) in 2023
- 10% Annual Chance Flood in 2023
- 1% Annual Chance Flood in 2023

Sources: RIGIS, CRMC, Town of Bristol



FUTURE COASTAL FLOOD RISK: AOV 6

Under future, projected conditions, Route 114 is at risk of more frequent nuisance and is likely to experience larger areas of coastal flooding during the 10% and 1% annual chance flood.

2 FEET OF SEA LEVEL RISE (2050s)

Silver Creek Bridge is projected to experience flooding under future conditions during tidal flooding events. This would affect the ability of north-south travel through Bristol on a frequent basis, and traffic would be forced to reroute to Sherry Ave.

During the future 10% annual chance flood, Route 114 could see flooding span from south of Creek Lane to south of Oliver Street. This would impact the Silver Creek Rehab and Healthcare Center, and it would cause Guiteras Elementary to become isolated due to flooding. Five RIPTA stops would also be impacted by flooding.

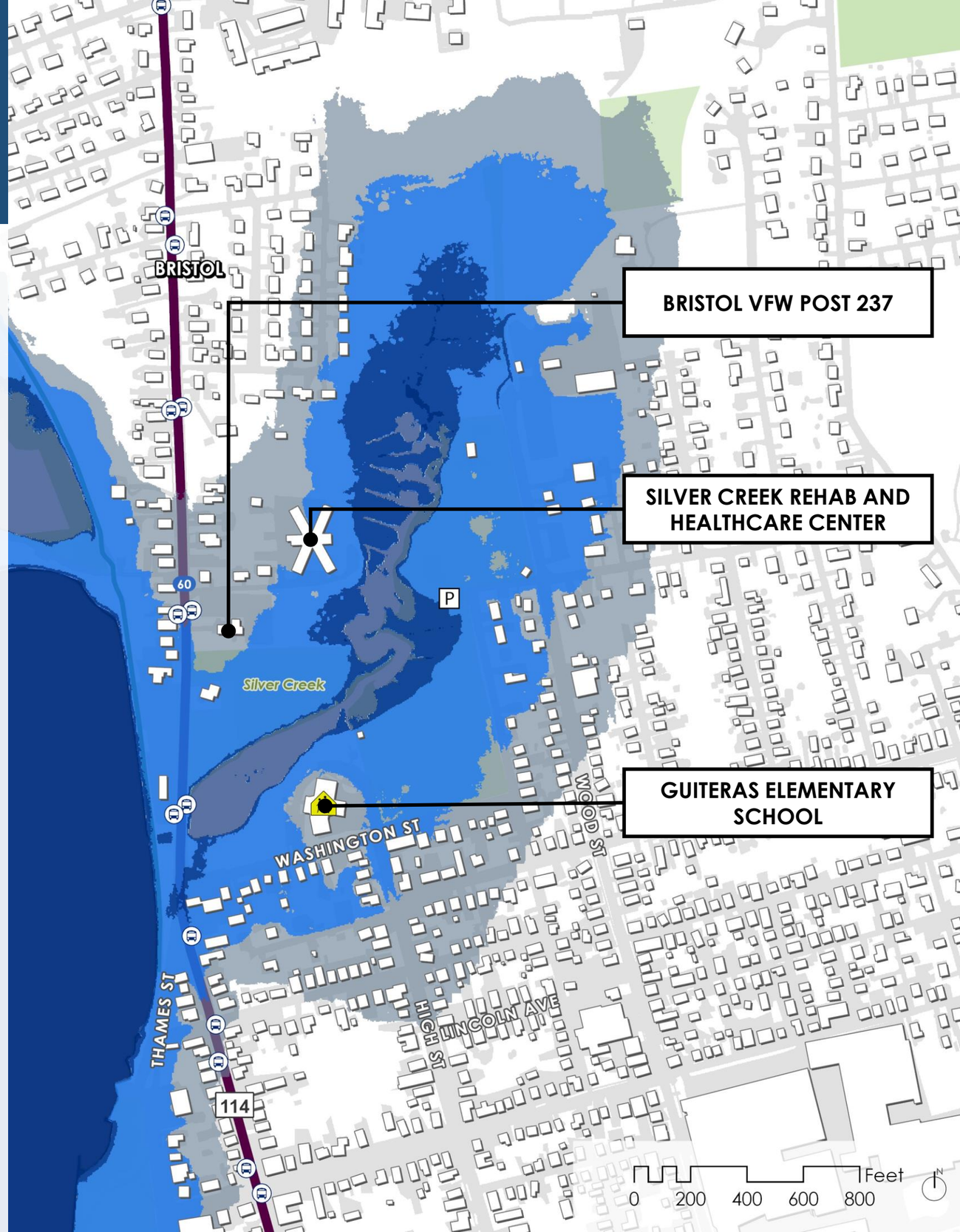
During the future 1% annual chance flood, flooding along Route 114 could reach as far north as the area between Hillside Road and Poppasquash Road and as far south as Oliver Street. Seven RIPTA stops would be impacted by flooding, and the Guiteras Elementary School and the Silver Creek Rehab and Healthcare Center would become inaccessible.

For both the 10% and 1% annual chance flood, Route 114 would not be able to convey north-south traffic, and all traffic would have to be routed to Sherry Ave.

LEGEND

- Tidal Flooding (MHHW) + 2 Feet of SLR
- 10% Annual Chance Flood + 2 Feet of SLR
- 1% Annual Chance Flood + 2 Feet of SLR

Sources: RIGIS, CRMC, Town of Bristol



COASTAL FLOOD DEPTH: AOV 6

Route 114 could be under as much as 12.5 feet of flooding at its peak during the future projected 1% annual chance flood.

DESIGN FLOOD ELEVATION (1% ANNUAL CHANCE FLOOD + 2 FT OF SLR)

At its deepest, flooding could be up to 12.5 feet north of the Silver Creek Bridge during the future 1% annual chance flood. The Silver Creek Bridge is a low point in this AOV, and as Route 114 stretches north and south, flooding decreases as the road increases in elevation.

North of the Silver Creek Bridge, flood depths range from under 4.5 feet to greater than 10 feet of water prior to a rise in the roadway elevation between Creek Lane and Hillside Road where there are only a few inches of projected flooding.

South of Silver Creek Bridge, the elevation of Route 114 is relatively flat compared to the north, with elevation increasing quickly beyond Oliver Street.

Also of concern in this area, the Silver Creek Healthcare Center and Guiteras Elementary School could be under 4.5 to 10 feet of flooding during the future 1% annual chance flood, which could potentially cause significant damage to these buildings. Major damage could also be caused to the utilities that run through Silver Creek Bridge under these future flood conditions.

LEGEND

- 0 – 0.5 FT
- 0.5 – 1 FT
- 1 – 1.5 FT
- 1.5 – 2 FT
- 2 – 2.5 FT
- 2.5 – 3 FT
- 3 – 3.5 FT
- 3.5 – 4 FT
- 4 – 4.5 FT
- 4.5 – 5 FT
- 5 – 10 FT
- >10 FT

Sources: RIGIS, CRMC, Town of Bristol

NATURAL RESOURCES AT RISK: AOV 6

Mapped estuarine emergent wetlands are in close proximity to Route 114 within AOV 6. The entirety of Route 114 in this area occurs within mapped natural heritage areas. Future flood projections indicate natural resources will be inundated by coastal flood waters with greater than 10 feet of water during the 1% annual chance flood with 2 feet of SLR, reducing the ecological function of the wetlands in this area. However, the restriction of flow from the Silver Creek Bridge will help slow the inundation of natural resources; therefore, there is potential for the wetlands to adapt and migrate into adjacent upland habitats if unimpeded by urban development in the area.

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Freshwater Wetland
- Estuarine/Marine Wetland
- Natural Heritage Areas

Sources: RIGIS, RIDEM, CRMC

BUILDINGS AT RISK: AOV 6

A total of 220 structures are likely to be impacted during the future 1% annual chance flood, most of which are residential. However, the Guiteras Elementary School (see Figure 17), Silver Creek Rehab and Healthcare Center, and Bristol VFW Post 237 are also likely to be impacted by these projected flood conditions.

The structures that are closest to Silver Creek, which will most likely experience the greatest amount of flooding in the future, would also be at risk of more extensive flood-related damages. These damages could be substantial, especially if the future flooding reaches more than 3 feet above the first-floor elevation. This is the elevation at which many of the easier flood mitigation options (e.g., dry floodproofing) become infeasible due to the cost of implementation and/or safety concerns of being able to evacuate from buildings/properties with high barriers.

Figure 17: Image of the Guiteras Elementary School

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Commercial (9 buildings)
- Commercial/Residential Mixed (0 buildings)
- Residential (197 buildings)
- Manufacturing/Light Industrial (6 buildings)
- Municipal/Institutional (8 buildings)

Sources: RIGIS, CRMC

KEY CHALLENGES + OPPORTUNITIES: AOV 6

CHALLENGES

There is currently a lack of north-south connectors through Bristol, with the main connectors being Route 114 and Metacom Avenue. As future projected depths during coastal flooding events increase in the area, Route 114 will no longer be able to serve as one of the primary north-south connectors, and mitigation measures (e.g., road raising) become less feasible. Additionally, the gas and sewer utilities that run under Route 114 pose a challenge in the future, as they will likely need to be relocated or protected to reduce their risk from the impacts of more severe coastal flooding events. Inland flooding is another challenge that this section of Route 114 faces via Silver Creek. Because Route 114 experiences flooding from both the coastal and inland sides, any coastal flooding mitigation actions must also consider inland flooding mitigation actions.

OPPORTUNITIES

One opportunity for addressing future flood risks could be to raise the lower elevation portions of Route 114 in this area to meet the higher elevations to the north and south of the Silver Creek Bridge area (see Figure 18) to reduce the risk of impacts from future nuisance flooding. This could also reduce upstream flood risk because the raised road could serve as a berm. This would allow Route 114 to become more usable as a north-south connector road in the future during non-storm events. Route 114 could also be redesigned to better withstand overtopping to allow for a quicker return to service when flood waters recede following a storm event. Additionally, the Town could also consider constructing a berm between Route 114 and Bristol Harbor for added flood risk reduction. The berm could also then create an opportunity for improved public access to the waterfront.

Widening of Sherry Avenue in the future may make it more viable as an alternate route during coastal storm events. This could help support a retreat route where High Street slowly starts to become the new Main Street, and the existing Route 114 corridor in this AOV become a walkable waterfront space. Extending Wood Street to connect north to Chestnut Street provides another alternative north-south route.

Figure 18: Image of the Silver Creek Bridge

AOV 7

EXISTING + FUTURE CONDITIONS

AOV 7 is bound in the north by Constitution Street and the south by Griswold Avenue. A particularly vulnerable area of Route 114 in this AOV is the section of road above Tanyard Brook and the Burton Street Bridge. This section of the road is prone to flooding. This section of Route 114 is also designated as a State Scenic Roadway and contains the Bristol Water Pollution Control and Bristol Sewer Plant.

This AOV provides access to Bristol's downtown area from the south and is also on Bristol's Fourth of July Parade path.

PRESENT COASTAL FLOOD RISK: AOV 7

Under current conditions, the 1% and 10% annual chance flood events are more of a concern compared to more frequent tidal flooding.

CURRENT CONDITIONS (2023)

Under current conditions, tidal flooding is not a primary concern, as it does not affect Route 114 in this area.

However, for the 10% annual chance flood, the section of Route 114 between the Lobster Pot Restaurant and the intersection with Wood Street is expected to experience significant amounts of flooding. Three RIPTA bus stops in this area would be prone to flooding under these conditions, and traffic would need to be rerouted through nearby Wood Street and Walley Street.

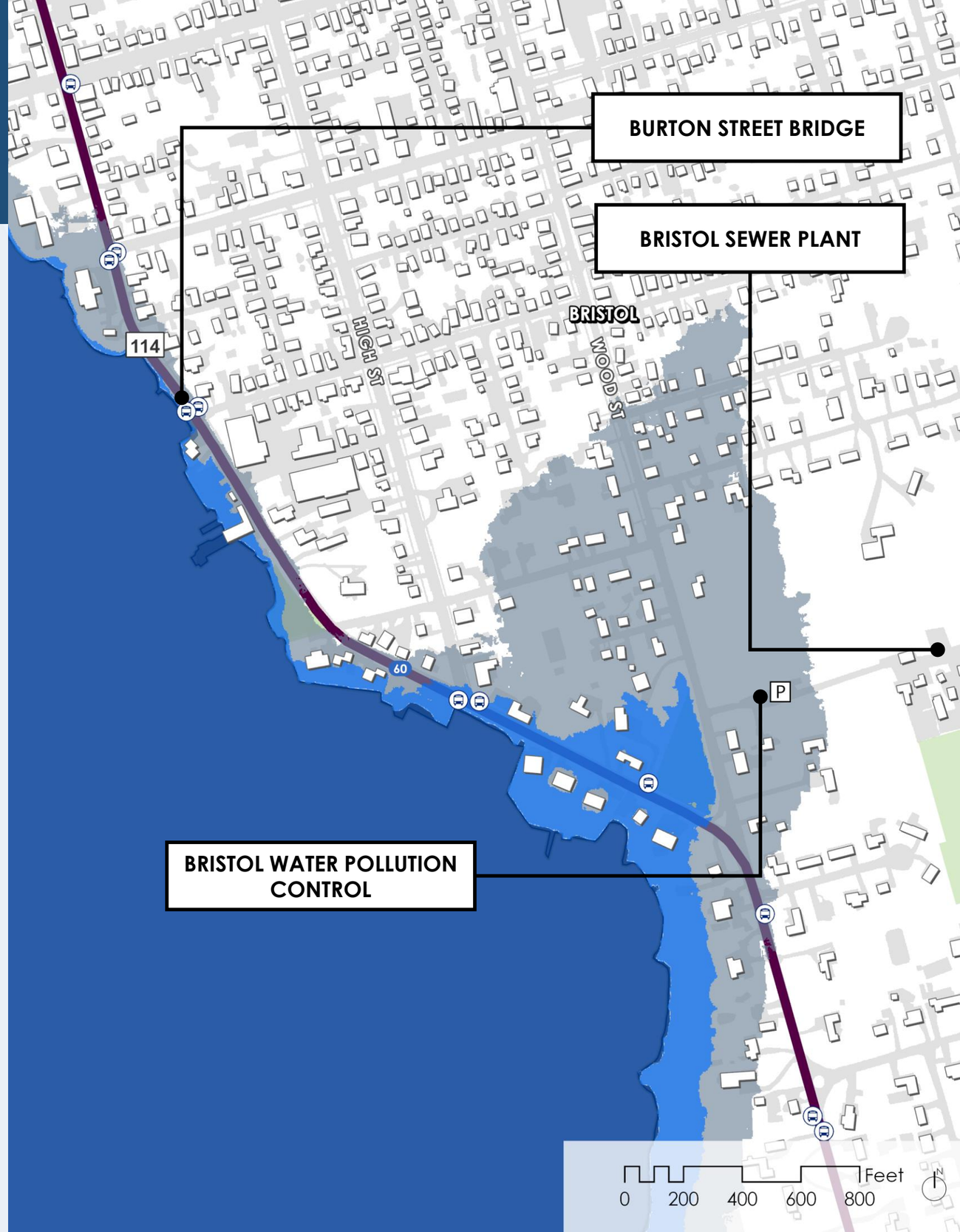
During the 1% annual chance flood, a larger portion of Route 114 would experience flooding, ranging from Union Street in the north to just south of Fairview Drive in the south. Eight RIPTA bus stops would likely be impacted by flooding under these conditions, and a major reroute would be needed to avoid flooding in this area, as vehicles would need to use Griswold Ave to get to Metacom Ave. Additionally, access to the Bristol Water Pollution Control and Bristol Sewer Plant would be affected during the 1% annual chance flood.

The Burton Street Bridge is also a key area of concern in this AOV, as the road in this area is supported by a retaining wall that is in poor condition. This poor condition allows for undermining of the road that could be worsened by coastal flooding and would further threaten the structural integrity of the road.

LEGEND

- Tidal Flooding (MHHW) in 2023
- 10% Annual Chance Flood in 2023
- 1% Annual Chance Flood in 2023

Sources: RIGIS, CRMC, Town of Bristol



FUTURE COASTAL FLOOD RISK: AOV 7

Compared to present conditions, the extent of flooding in AOV 7 only increases under future, projected conditions.

2 FEET OF SEA LEVEL RISE (2050s)

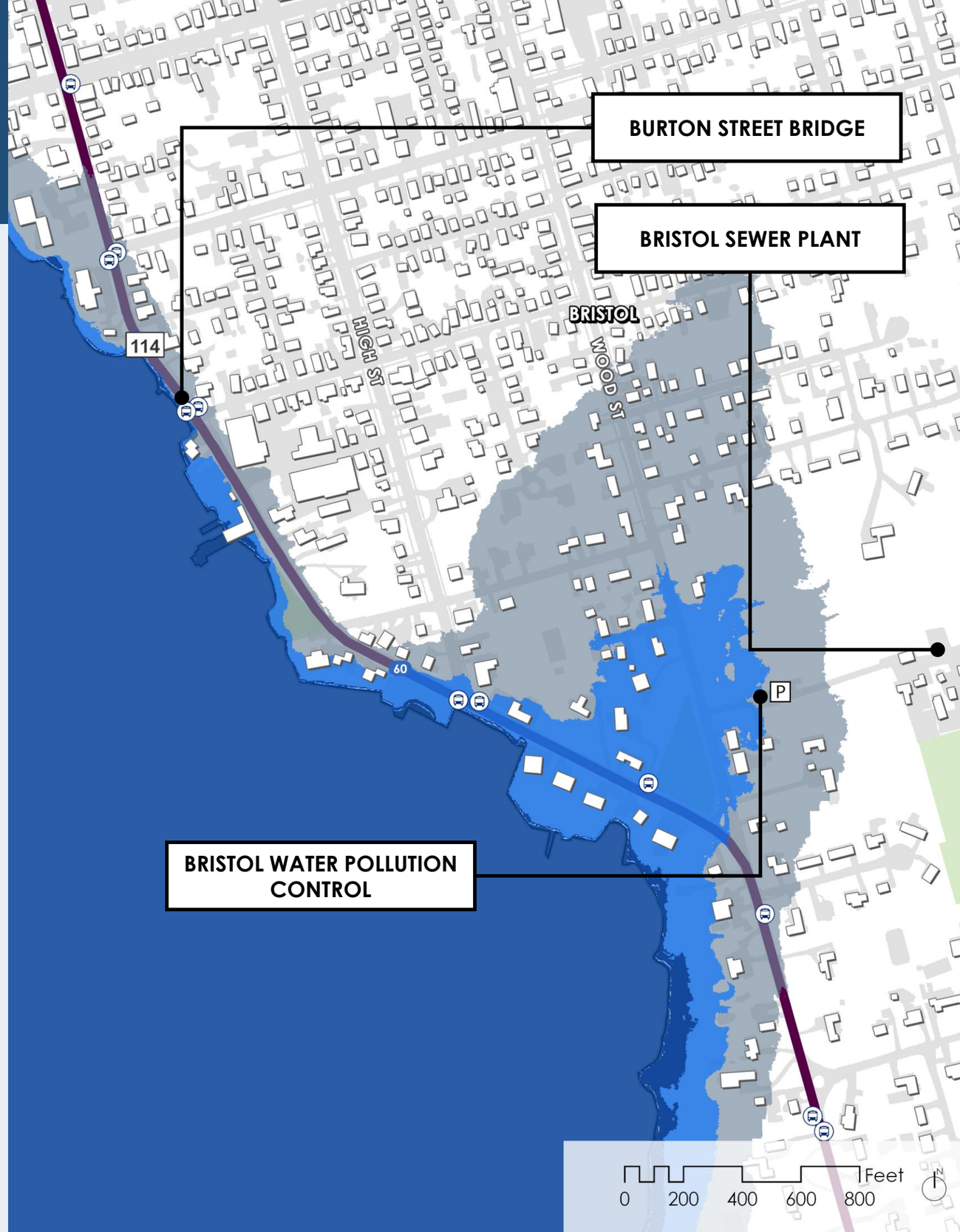
Under future, projected conditions, tidal flooding still does not affect Route 114 in this AOV. However, the extent of the 10% annual chance flood spans to the north of the Lobster Pot Restaurant and closer to the intersection of Wood Street. Two RIPTA stops would still be affected under these future conditions, and the same detour as was mentioned in the previous page (under current conditions) would be needed during the 10% annual chance flood event.

Similarly, during the future 1% annual chance flood, the mapped flood extents also increase. In the north, the flooding is projected to reach between Pleasant Street and Constitution Street. In the south, flooding is projected to extend between Fairview Drive and Griswold Avenue. The same number of RIPTA stops would be affected by the future 1% as the present 1% annual chance flood events, and the Bristol Water Pollution Control and access to the Bristol Sewer Plant would still be affected.

LEGEND

- Tidal Flooding (MHHW) + 2 Feet of SLR
- 10% Annual Chance Flood + 2 Feet of SLR
- 1% Annual Chance Flood + 2 Feet of SLR

Sources: RIGIS, CRMC, Town of Bristol



COASTAL FLOOD DEPTH: AOV 7

A large section of Route 114 is projected to be flooded by over 10 feet of water during the future projected 1% annual chance flood.

DESIGN FLOOD ELEVATION (1% ANNUAL CHANCE FLOOD + 2 FT OF SLR)

The highest flood depth along this section of Route 114 is projected to be around 13 feet. This depth decreases to 11 feet as the road travels north; however, as Route 114 continues along the coastline to the north, the flood depths remain significant in this portion of the low-lying road until it reaches higher elevations between Pleasant Street and Constitution Street.

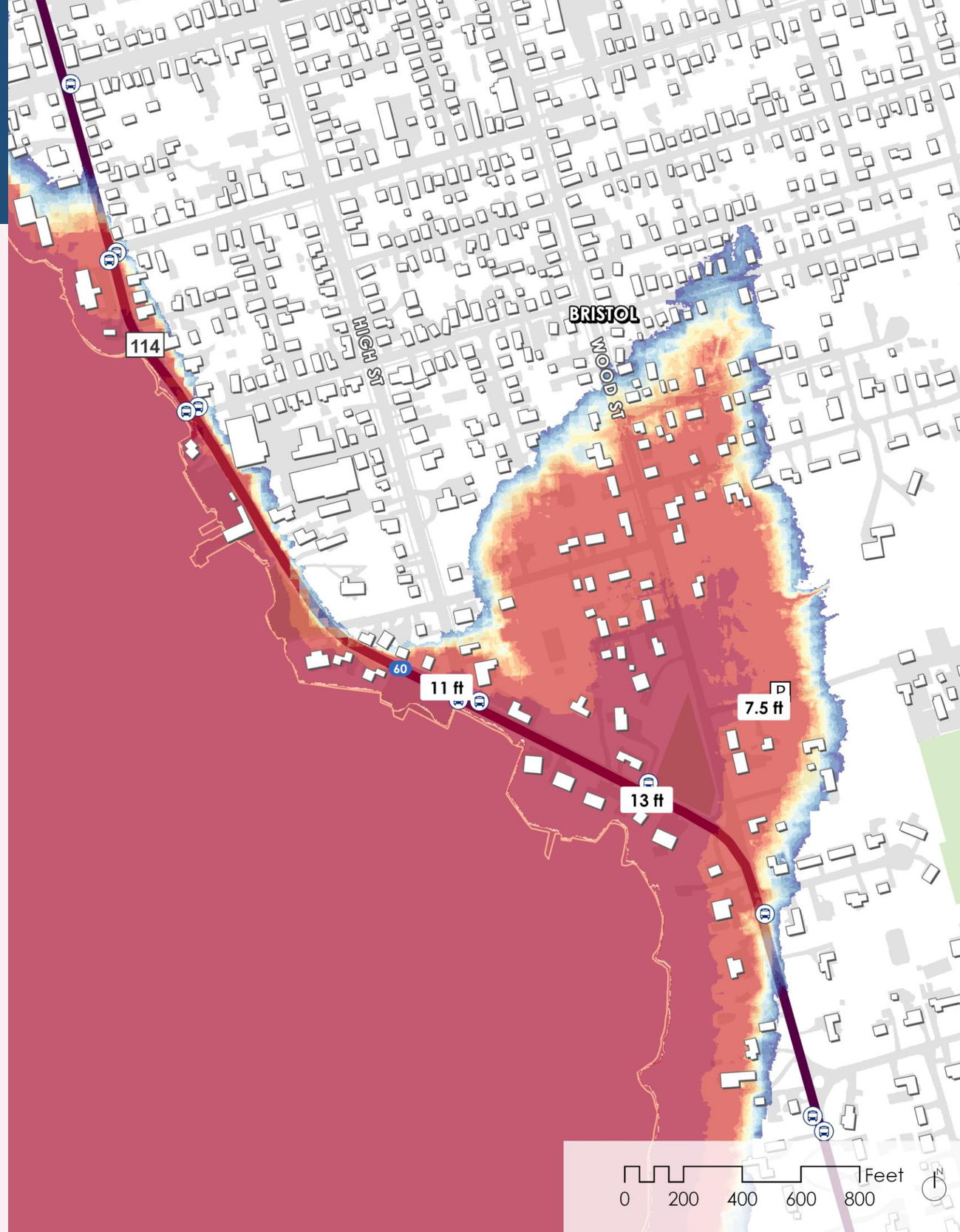
Under the future 1% annual chance flood scenario, projected flood depths on Route 114 would limit access to the Bristol Water Pollution Control Plant and Bristol Sewer Plant. Flood depths could reach up to 7.5 feet, which would cut off the only access road. This makes this area more vulnerable and raises the need to examine alternatives that would maintain access to these important community facilities. The Water Pollution Control plant presents a future opportunity for additional floodproofing measures, where needed.

Importantly, eight of the RIPTA bus stops in this AOV would become inaccessible under future 1% annual chance flood events, as the depth of flood water would make the road impassible by bus.

LEGEND

- 0 – 0.5 FT
- 0.5 – 1 FT
- 1 – 1.5 FT
- 1.5 – 2 FT
- 2 – 2.5 FT
- 2.5 – 3 FT
- 3 – 3.5 FT
- 3.5 – 4 FT
- 4 – 4.5 FT
- 4.5 – 5 FT
- 5 – 10 FT
- >10 FT

Sources: RIGIS, CRMC, Town of Bristol



NATURAL RESOURCES AT RISK: AOV 7

There are no mapped wetlands in close proximity to Route 114 within AOV 7. NWI identified a small estuarine wetland, and RI DEM identified an unconsolidated shoreline and rocky shore habitat south of Route 114 (see Figure 19). These mapped natural resources are separated from the Route 114 corridor by the built environment and have limited risk reduction and adaptation capabilities. The majority of Route 114 within AOV 7 occurs within a mapped natural heritage area.

Figure 19: Image of natural resource in AOV 7

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Freshwater Wetland
- Estuarine/Marine Wetland
- Natural Heritage Areas

Sources: RIGIS, RIDEM, CRMC

BUILDINGS AT RISK: AOV 7

A total of 111 structures would be impacted during the future, projected 1% annual chance flood event. Most of the structures impacted by flooding under these conditions would be residential, though there are also several restaurants, small businesses, museums, and key access roads in the flood extents. Damage to critical infrastructure, such as the Bristol Water Pollution Control facility (see Figure 20), could be significant if mitigation measures are not in place to protect this structure from coastal flood inundation.

Figure 20: Image of the Bristol Water Pollution Control Facility

LEGEND

- 1% Annual Chance Flood + 2 feet of SLR
- Commercial (3 buildings)
- Commercial/Residential Mixed (0 buildings)
- Residential (106 buildings)
- Manufacturing/Light Industrial (1 building)
- Municipal/Institutional (1 building)

Sources: RIGIS, CRMC

KEY CHALLENGES + OPPORTUNITIES: AOV 7

CHALLENGES

The length and location of Route 114 along the coastline in this area (see Figure 21) present a major challenge to coastal flood resilience, as most of the road has an elevation below 15 feet. Additionally, there is limited space between the road and Bristol Harbor to implement flood risk mitigation alternatives (e.g., road raising or elevated walls) that may require larger road footprints. Access to the Bristol Water Pollution Control Facility during a storm is also a challenge, as this is a critical Town facility.

OPPORTUNITIES

Because of the low risk of tidal flooding, there is an opportunity to focus flood mitigation measures in this area on evacuations during storm events. For example, Wood Street – which sits at a higher elevation than nearby Route 114 – could be used in the future to effectively reroute traffic from a portion of Route 114 during coastal storm events. Route 114 could also be made resilient to overtopping and saltwater exposure and increase the ability of the road to be useable after flooding has subsided.

Adding signage of where flooding is predicted to occur in the future may also help inform the public of the flood risk in this area. Similar to AOV 6, there is also the opportunity in this area to make Wood Street the permanent north-south route in the future and convert Route 114 into a walkable coastal area.

Figure 21: Image of the low-lying section of Route 114 in AOV 7

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4. APPENDICES

Appendix A: Data Collection + Plan Review References
Appendix B: Plan Review Technical Memorandums
Appendix C: Additional AOV Zoning Maps

Appendix A: Data Collection + Plan Review References

DATA COLLECTION REFERENCES

Sea Level Rise and Vulnerable Infrastructure References:

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Appendix B: Plan Review Technical Memorandums

FUSS & O'NEILL

MEMORANDUM

TO: Roberta Groch, AICP - Assistant Chief, RI Division of Statewide Planning
Caitlin Greeley, Principal Planner, RI Division of Statewide Planning

CC: Teresa Crean, AICP, Director of Planning, Building and Resilience, Town of Barrington

FROM: Arnold Robinson, AICP, NCI, WEDG
Shawna Little, PhD

DATE: February 13, 2024

RE: Resilient Route 114 Project, Task 3
Review Town of Barrington Existing Documents

Purpose of Plan Review

Fuss & O'Neill reviewed the Town of Barrington's plans, studies, maps, and reports to identify elements of these planning documents that mention actions, policies, priorities, and strategies related to Route 114, especially those that focus on improving the overall resilience of the Route 114 corridor. The existing plans, studies, maps, and reports reviewed included:

- Town of Barrington Comprehensive Community Plan, 2015 Update (BCCP, 2015)
- Town of Barrington Comprehensive Community Plan Maps, 2015 Update (BCCP Maps, 2015)
- Town of Barrington Hazard Mitigation and Flood Management Plan, 2022 (BHMP, 2022)
- Town of Barrington Village Center Parking Study, 2016 (BVCPS, 2016)
- Town of Barrington Community Resilience Building Workshop Summary of Findings Report, 2019 (CRB, 2019)
- University of Rhode Island Preparing for Resilience, Barrington, and Warren Mixed-Use Climate Response Demonstration Site, Fall 2019 (URI, 2019)
- University of Rhode Island Preparing for Resilience, Barrington and Warren Mixed-Use Climate Response Demonstration Site, Accomplishments, December 2021 (URI, 2021)
- Rhode Island Statewide Planning Program Vulnerability of Municipal Transportation Assets to Sea Level Rise, January 2015 (RISPP, 2015)
- Rhode Island Statewide Planning Program Vulnerability of Municipal Transportation Assets to Sea Level Rise and Storm Surge: Transportation Fact Sheet, September 2016 (RISPP, 2016)

Summary and Major Takeaways

Currently, the Barrington Comprehensive Community Plan does not specifically address climate resiliency as it relates to natural, historic, or cultural resources along Route 114. However, the Town did include resilience improvements as a general theme in the BCCP Implementation Plan (page 149), and

the Town set goals to improve resilience via the preservation of the natural environment under Natural Hazards (Goal NH-2; BCCP, page 131).

Route 114 (Wampanoag Trail, County Road) was identified as a particular area of concern in the Town's Community Resilience Building Workshop (CRB, 2019, page 4) due to potential impacts related to extreme weather events (e.g., hurricanes, Nor'Easters, etc.), sea level rise (SLR), and coastal inundation, which threatens numerous sections of Route 114 (BHMP, 2022). For example, regular high tide flooding occurs on Route 114 near the High School and Prince Pond, as well as sections of New Meadow Road and Sowams Road near the Barrington and Palmer Rivers (BHMP, 2022, page 4-76; BCCP, 2015, page 123). Recent flooding events on Route 114 have resulted in extensive flooding in vulnerable, low-lying areas. One such example occurred on August 1st, 2012 when heavy rains caused portions of Route 114 to flood with 1.5 feet of water, specifically the area along the Warren/Barrington Border (BHMP, 2022). Similarly, in July of 2015, a flooding event caused New Meadow Road at Route 114 to flood with 6 inches of water along the Warren/Barrington Border (BHMP, 2022).

Future flooding projections assessing flood vulnerability for Route 114 have identified specific assets and portions of roadway that would be inundated by sea level rise. Based on the RIDSP vulnerability assessment of State transportation assets, three of the ten most vulnerable segments of roadway under state jurisdiction at risk of inundation by sea level rise, are located in Barrington: 1) County Road, 2) Massasoit Ave, and 3) Wampanoag Trail (RISPP, 2015, page 12; BHMP, 2022, pages 4-93 to 4-94). All three of these roads are part of the Army Corps of Engineers Hurricane Evacuation Route and are principal arteries for the Town. **Table 1** below provides the linear feet of roadway projected to be inundated under 3 different scenarios of SLR. The Wampanoag Trail and County Road are principal arteries and local emergency routes, with an overall vulnerability score of 7.3 and 8.8, respectively (RISPP, 2015, page 12). This is in line with an assessment by URI which ranked Wampanoag Trail, north of White Church and County Road bridges (Barrington bridge and Warren bridge, as some of the highest priority transportation areas of concern in the Town (URI, 2019, page 14).

Table 1. The top-rated road segments in Barrington, under state jurisdiction, most vulnerable to inundation due to sea level rise with state ranking and the total linear feet of roadway that would be flooded under three different SLR scenarios (1, 3, and 5-ft). Adapted from the Vulnerability of Transportation Assets to Sea Level Rise (RIDSP, 2015, page 12).

Road Name	Ranking under State Jurisdiction	Linear Feet Flooded at:		
		1-ft SLR	3-ft SLR	5-ft SLR
County Road	#1	31	248	2888
Massasoit Ave	#4	15	59	630
Wampanoag Trail	#5	0	141	6368

Additional assets vulnerable to sea level rise include two major bridges along Route 114, the Barrington Bridge and Warren Bridge. The Barrington Bridge (carrying Route 114) is ranked #1 in the list of top 10

bridges under state jurisdiction most vulnerable to sea level rise (RISPP, 2015, page 21). The bridge was built in 2009 with an annual average daily traffic (AADT) load of 26,000 vehicles per day, and it has only 10 inches of freeboard relative to 7 feet of SLR predicted to impact Barrington (RISPP, 2016). The Warren Bridge (carrying Route 114), ranked #2 in the same list, was built in 1914 with an AADT load of 19,900 vehicles per day, and has 14 inches of freeboard relative to the projected 7 feet of SLR in Barrington (RISPP, 2016).

Based on the Vulnerability Analysis Summary of the BHMP, there is an elevational low point on Route 114 adjacent to the current Barrington Community Garden, which is located in a FEMA flood zone. This low-lying area is at risk of flooding due to Category 1 hurricanes, winter storms, and earthquakes (BHMP, 2022, Appendix 4-2 and 4-3). Additionally, it will be inundated by 3 feet of SLR, with a flood depth of 12.2 feet during a 100-year storm event. Anticipated impacts include public safety, disruption of services, infrastructure damage, and economic loss.

Floodwaters on the road surface (in feet) of the intersection of Primrose Hill Road and Wampanoag Trail (Route 114) were projected as follows by the URI-CI internship program (**Table 2**; URI, 2021, page 18):

Table 2. Depth of floodwater inundating the intersection of Primrose Hill Road and Wampanoag Trail under four different SLR scenarios and storm surge. Reproduced from the Preparing For Resilience Barrington, Warren, and Bristol Mixed-Use Climate Response Demonstration Site, Accomplishments (URI, 2021).

Sea-level Rise Scenario	Mean Higher High Water (ft)	1 Year Storm Return Period (ft)	25 Year Storm Return Period (ft)	100 Year Storm Return Period (ft)
2 feet	-----	0.73	8.91	12.66
5 feet	0.58	3.73	11.91	15.90
7 feet	2.58	5.73	13.91	18.00
10 feet	5.58	8.73	16.91	24.57

Services and Facilities

Aside from vulnerabilities to the Route 114 roadway itself, existing planning documents identified numerous services and facilities throughout the Route 114 corridor that are vulnerable to flooding, sea level rise, coastal inundation, and extreme weather events.

The BCCP identified multiple critical transportation assets, such as the Barrington River Bridge, Warren River Bridge, Warren River Bike path, and Barrington River Bike Path Bridge, as being primarily threatened by flooding, located in the 100-year flood zone (AE), and vulnerable to Category 1 hurricane storm surge. Other critical facilities identified by the vulnerability analysis included (BHMP, 2022, pages 473 to 74):

- **Schools**: Barrington Christian Academy (private), Primrose Hill School (public), St. Andrews School (Private), and Barrington High School (Public)
- **Day care/early learning**: Tot's Cooperative Nursery School (private)
- **Government/emergency centers**: Town Hall/School Administration and Barrington Public Library (public)
- **Institutional/commercial**: East Bay Health Center (Private) and Barrington Shopping Center (private)
- **Natural resources**: Osamequin Nature preserve (public) and Walker Farm (public)

The vulnerabilities for each critical facility were identified in the BHMP (2022; Appendix 4-3) and are listed below:

- Barrington Christian Academy – services a vulnerable population, is in a FEMA Flood Zone (X) and at risk to a Category 4 hurricane, winter storms, and earthquakes.
- Barrington High School (Public) – services a vulnerable population, is in a FEMA Flood Zone (AE) and at risk of a Category 2 hurricane and earthquakes. The school will be inundated by 7 feet of sea level rise with a flood depth of 4.6 feet during a 100-year storm event.
- Primrose Hill School (public) – services a vulnerable population, is in a FEMA Flood Zone (X) and at risk of earthquakes.
- St. Andrews School (Private) – services a vulnerable population, is in a FEMA Flood Zone (X) and at risk to a Category 3 hurricane and earthquakes. The school will be inundated by 12 feet of sea level rise with a flood depth of 1.9 feet during a 100-year storm event.
- Tot's Cooperative Nursery School services a vulnerable population, is in a FEMA Flood Zone (AE) and at risk of a Category 1 hurricane and earthquakes.
    - The building will be inundated by 3 feet of sea level rise with a flood depth of 10.6 feet during a 100-year storm event.
- Town Hall/School Administration building is in a FEMA Flood Zone (X) and at risk of earthquakes.
- Barrington Public Library – is in a FEMA Flood Zone (X) and at risk of earthquakes.
- East Bay Health Center is in a FEMA Flood Zone (X) and at risk of a Category 3 hurricane and earthquakes.
- Barrington Shopping Center is in a FEMA Flood Zone (AE) and at risk of a Category 2 hurricane, winter storms, and earthquakes.
    - The building will be inundated by 10 feet of sea level rise with a flood depth of 5.7 feet during a 100-year storm event.
- Osamequin Nature preserve is in a FEMA Flood Zone (AE) and at risk of a Category 1 hurricane, drought, and brush fires.
    - Primary effects of problems will include property damage, disruption of access, coastal erosion, wetland, and habitat damage, mosquito, and tick-borne diseases.

Flood-related impacts to each of these facilities will impact public safety, property damage, disruption of services, and economic losses. The Barrington Public Library also serves as an emergency warming/cooling center for the public.

Other notable services include the Walker Farm off Route 114, the Park & Ride at White Church on Route 114, and several sanitary sewerage pump stations (BHMP, 2022, Appendix 4-3). The vulnerabilities for each critical facility were identified in the BHMP (2022; Appendix 4-3) and are listed below:

- Walker Farm is in a FEMA Flood Zone (AE) and at risk of a Category 1 hurricane, extreme heat, and earthquakes.
- The Park & Ride at White Church on Route 114 is in the AE FEMA Flood Zone and at risk of a Category 1 hurricane and winter storms.
    - It will be inundated by 2 feet of sea level rise with a flood depth of 11.4 feet during a 100-year storm event.
- Sanitary sewerage pump stations (public), including the Police Cove Pump Station along Route 114 is in the AE FEMA Flood Zone and at risk of a Category 2 hurricane.
    - It will be inundated with a flood depth of 0.7 feet during a 100-year storm event.
- Sanitary sewerage pump stations (public), including the Prince Pond Pump Station along Route 114 is in the X FEMA Flood Zone and at risk of a Category 3 hurricane.
    - It will be inundated by 7 feet of a sea level rise with a flood depth of 5.7 feet during a 100-year storm event.

Primary impacts will include disruption of services/access, public health risks, infrastructure damage, property damage, economic loss, coastal erosion, wetland and habitat damage, and no shade structures.

Implementation Actions from Existing Planning Documents

Each of the existing planning documents reviewed here by Fuss & O'Neill identify the need for alternatives for adaptation to future flooding and identify challenges regarding Wampanoag Trail. This included road improvements such as re-angle for drainage, elevate, or building a causeway to keep the roadway as a main thoroughfare (URI, 2019, page 14). The following includes a list of recommended actions or strategies for Route 114, and related roadways or facilities, aimed at improving the resilience of the Route 114 corridor:

- Immediate corrective action should be taken on evacuation routes, including Route 114, by working with RIDOT to complete drainage improvements on roadways under their jurisdiction through the installation of innovative water technology in areas subject to severe flooding (BHMP, 2022, page 6-10).
- Coordinate with RIDOT/RIDSP on Route 114 Corridor Study to assess existing and future vulnerabilities and options to reduce risk, including rerouting and raising (BHMP, 2022, page 6-

12). Similarly, coordinate with RIDOT to ensure timely and adequate repairs and upgrades for the existing Barrington River Bridge (CRB, 2019, page 10).
    - RIDOT engagement on repairs and upgrades to the Barrington River Bridge was categorized as a higher priority action item in the Town's CRB Summary of Findings Report (CRB, 2019).
- Complete a neighborhood scale flood, storm surge, and SLR impact assessment using the mapping and data generated from a previous SLR exposure assessment of buildings and roadways town-wide, developed in partnership with the URI Coastal Institute. The assessment will include the impact on publicly and privately owned buildings and sites, roads, stormwater drainage system, sewer system, and other utilities (BHMP, 2022, page 6-14).
    - Scope will involve generating cost estimates for mitigation projects, establishing project priorities, and identifying the intersection of residential homes in current and projected future flood zones to proactively educate the community on potential future remediation strategies such as home elevation, voluntary buyouts, and/or relocation (BHMP, 2022, page 6-14).
    - Other potential priority projects include areas adjacent to Route 114 including the vicinity of the High School on Lincoln Ave, the vicinity of the Public Safety Building on Federal Road, Massasoit Ave neighborhoods,
- Accommodate marsh migration at Walker Farm on the west side of Route 114 in the area adjacent to Barrington Community Garden's parking lot and further north at Osamequin Nature Preserve (BHMP, 2022, page 6-16).
    - Note: This was also identified as a prioritized actions & projects in the Comprehensive Plan to Restore Water Quality in the Hundred Acre Cove (2021) (BHMP, 2022, Appendix 6-1).
- Complete a comprehensive assessment of the existing and future vulnerabilities and options to reduce risk for Route 114 including rerouting and raising, amongst others (BHMP, 2022, Appendix 4-2 and 6-1; CRB, 2019, page 11).
    - This was categorized as a high priority action item in the Town's CRB Summary of Findings Report (CRB, 2019).
- Complete an assessment of the local alternative routes for residents to access during an emergency flooding event, specifically evacuation routes across and out of the municipality (CRB, 2019, page 13).
    - This was categorized as a moderate priority action item in the Town's CRB Summary of Findings Report (CRB, 2019).
- Under a modest 3-ft rise in sea level, portions of Route 114 will need to be reinforced (elevated), bridges along Route 114 and bridges and roads that provide access to Route 114 will need to be elevated. With 5-7 feet of sea level rise, the report suggests retreat from portions of Wampanoag Trail will be necessary and roadways realigned throughout Barrington and Warren to maintain routine transportation corridors and emergency routes. Abandoned roads will be restored to natural habitats (URI, 2019, page 18).

- Convene a second Transportation Workshop to engage RIDOT and the RI Division of Statewide Planning in transportation resilience discussions. Specifically, identify the need for site-specific transportation resilience planning studies and identify transportation projects to be considered for federal funding through the State Transportation Improvement Program (BHMP, 2022, Appendix 4-2 and 6-1).
- Promote increased awareness regarding the Town's evacuation plans and designated evacuation routes, enhanced by more prominent signage during emergency events to better direct residents evacuating from the Town (CRB, 2019, page 10).
    - This was categorized as a higher priority action item in the Town's CRB Summary of Findings Report (CRB, 2019).

The Town has already undertaken several projects to improve the natural environment and increase the resilience of areas subject to flooding along Route 114. This includes converting portions of the former "Vitullo Farm" property, specifically the farm fields nearest Wampanoag Trail, into the Barrington Community Garden (BCCP, 2015, page 32). Similarly, the Town completed the Walker Farm marsh restoration project in 2005, converting property previously used as farmland into marsh habitat. This included increasing the size of the marsh habitat to 15 acres and addressing problems on the site caused by historic alterations, including roads and dam structures. This property separates Route 103/114 from the Barrington River and 100-Acre Cove, and is vital for storing flood waters (BCCP, 2015, page 121). In 2022, the Town continued efforts to improve the Walker Farm shoreline area by beginning construction on initiatives to restore coastal habitat along the Walker Farm beach with intended benefits to the broader Hundred Acre Cove ecosystem. This project involved implementing a salt marsh migration corridor, planting salt marsh vegetation with the intent of allowing natural inland migration to expand marsh habitat in the area. Ultimately, the goal of the project is to buffer coastal wave action during coastal flooding and storm events, while providing increased aesthetic and recreational value for local residents. The project was successfully completed before the end of 2023.

Public Opinion on Route 114 Resilience

As part of the Barrington Hazard Mitigation Plan (2022, Appendix 6-1), the Town conducted a survey of the public opinion related to hazard mitigation and flood management. Excerpts from the survey respondents related to Route 114 are listed below:

- #40 – "There needs to be a plan to address possible flooding of rt 114. I do not technically live in the floods zones, but the property behind me is in one - in a neighborhood off 114. The town needs a long-range plan of what to do if 114 cannot be used as a safe evacuation route. Also, the go to place for me to find info about things going on is the Barrington Community Facebook group. I do not think this is the best, because many people might not know about it, and it relies on people reposting the town's news. I follow the town on Facebook but the algorithm doesn't ever show me updates. You can see how information doesn't get disseminated

effectively by noting how many people put their trash out incorrectly when there has been a change to the collection schedule."

- #86 – "The town should consider proactively planning for managed retreat in Hampden Meadows and in other areas that are especially vulnerable to SLR. Hampden Meadows in particular is locked in by transportation infrastructure that will be inundated by SLR. However other sub areas are also vulnerable. RT 114 endangers the entire town with its bridges among the most endangered in the state (DOT analysis) and Wampanoag Trail likely to last until the 30s or 40s at the latest. The Town needs to be creative in identifying the high ground and ensuring that all critical infrastructure is resilient and can operate in a high (12 ft by 2100) SLR scenario. Any new Town infrastructure needs to be built so that it has resilient power designed (including geothermal, battery, solar) and that it can withstand SLR."
- #120 – "Alternate routes out of town besides 114. Flood escape routes. Do NOT communicate to the community via Facebook and Twitter only. It forces people to be on platforms they otherwise would not want to be on."
- #144 – "Evacuation routes, such as Route 114, be maintained above the predicted flood levels; We will need new bridges to get out of town and to airport; Ensure that roads and evacuation routes can remain functional if an evacuation were needed for flooding, hurricane, etc.; make a better plan for evacuation."
- #174 – "Address the "wall" on Mathewson Lane. Build higher to mitigate/prevent flood water from washing over. Plan for erosion on rt 114 coming into town from E.P. (raise level of the road, think about a bridge in the future?)"
- #197 – "Raising and regrading the Mathewson Rd.- Ferry Lane corner area which floods on many Spring tides. Paving the road would also be a good idea. The paving of roads in RI no longer seems a priority for Towns and the State. Rt. 114 from Providence to Newport is an embarrassment."
- #222 – "Urge state to ensure escape paths for hurricanes are viable and available. We shouldn't have to worry if 114 is going to be flooded."
- #226 – "More to mitigate flooding on Hampden Meadows Road along the water during Lunar Tide. Additional work should be done to protect Rte. 114 along Hundred Acre Cove. Lastly, the area around the Yacht Club needs to be either rezoned for elevated structures or shored up."
- #8 – "Continuous monitoring and planning; repair of bridges over Barrington and Warren rivers"
- #19 – "Get ahead of concerns TODAY. Make smart investments TODAY along the shoreline to mitigate flood risk especially investing in public roads, bridges, and utilities. Have a PLAN for evacuation."
- #114 – "We will need new bridges to get out of town and to airport."
- #217 – "Trim trees along power lines Bolster bridges, embankments on rivers Improve upon sewer systems nearest rivers."

Additional Findings

Considering the importance of Route 114 as the main thoroughfare and emergency evacuation route for the Town, there are numerous references to Route 114 throughout each of the planning documents reviewed, although not directly related to resilience. Many of these references pertain to future planning decisions/goals concerning land use, economic development, and natural resources. These references include:

- A 2005 RIDOT traffic safety study found that two Wampanoag Trail intersections were at or over capacity — at County Road (or the junction of Routes 114 and 103) and just to the south at Old County Road. Based on 2000-2004 data, these locations had the highest number of accidents per year. Suggestions included improvements for pedestrian access to bus stops along Wampanoag Trail (BCCP, 2015).
- The Town has an existing Village Center along Route 114 that has been the focus of revitalization since the 1990's (BCCP, 2015, page 25; BVCPS, 2016). The Town has been working towards restoring the character of the area and creating a space that is more walkable and aesthetically pleasing in an otherwise car-dominated landscape. Specifically, the Town is focused on current and future planning efforts related to preserving the historic character of the community, mitigating the impacts of sea level rise along Town shores and beaches, and protecting local environmental areas of concern.
- Collaborate with private property owners to create a new shared Village Center parking lot that can be accessed from County Road and create publicly accessible parking lots within a short walk of most Village Center destinations (BVCPS, 2016).
    - Including redesigning County Road to accommodate on-street parking and securing additional public parking (on and off street) in the Village Center for the Town Hall/Library along Route 114. This is included in recommendations for broader streetscape improvements (BCCP, 2015, page 33).
- Partner with the State to provide safe access to bus stops on Route 114 north of White Church Bridge (BCCP, 2015, page 53).
    - Route 114 is one of RIPTA's most successful bus routes with 14 bus stops between Massasoit Avenue and Warren Bridge (BHMP, 2022, page 4-93).
    - This was identified as being a medium priority of no cost with a mid-term timeframe and the responsibility of the Planning Board.
- Expand additional park and ride capacity or introduce joint utilization of parking lots located near bus stops preferably focusing on Route 114, specifically for the commercial and church lots in the vicinity of County Road (BCCP, 2015, page 53).

Additional valuable resources along Route 114 that may be vulnerable to flooding include wetland areas, surface water bodies (e.g., Prince Pond), groundwater resources, Rhode Island Natural Heritage Program identified rare or endangered species habitats areas, and scenic views (BCCP, 2015, pages 69-71). Identification of natural resources along Route 114 included: the Barrington River, Palmer River,

wetland area near shores of Hundred Acre Cove, wetland area between the Barrington Shopping center off of Route 114 and westward to Brickyard Pond (BCCP, 2015, page 69).

Identification of Town owned properties of natural significance along Route 114 including areas used for conservation (i.e., Divine Vargas and Palmer River), trails, community use/access, and bird sanctuaries, such as the former "Vitullo Farm", Osamequin Park, and Walker's Farm. This also includes scenic views such as Hundred Acre Cove which can be seen from Wampanoag Trail (BCCP, 2015, page 69).

Identification of two Town-owned properties of cultural significance along Route 114, as listed with the National Register of Historic Places: The Barrington Civic Center on County Road and Jennys Lane Historic District on Jennys Lane between Mathewson and Rumstick Roads (BCCP, 2015, pages 69-74). The Civic Center Historic District, which is located directly on Route 114, is listed as a locally significant district, and includes key Town services including Town Hall (built in 1988), the Peck Center (Library/Senior Center), Princes Hill Cemetery, and Wood Pond (BCCP, 2015, pages 69-74). The roadway stormwater system maintained along State and local roads includes total of 521 catch basins and 347 manholes. Most of this drainage infrastructure is along major roadways such as Wampanoag Trail/County Road and the mixed-use sections of Maple Avenue (BCCP, 2015, page 61).

Conclusion

The Town of Barrington has consistently undertaken efforts to better understand the current and potential future vulnerabilities of the Town, and more specifically Route 114, as part of the community's greater vision of the future. The Town has identified the need for continued implementation of infrastructure improvements to wastewater systems, stormwater management systems, and roads and bridges. As part of this, the Town has also prioritized emergency preparedness, continuation of services, and continuing to strengthen the integration of resilience into future projects.

Many existing strengths set the Town ahead when it comes to future development, including Town staff who are experienced in driving local resilience projects and working with the local residents and businesses to build a strong support network. The Town strives to keep climate change, sea level rise, and coastal flooding at the forefront of future planning efforts. Understanding where the Town is now, in terms of goals and actions, will allow us to create concepts for Route 114 that are in line with the community's vision and addresses potential existing and future flooding conditions.

FUSS & O'NEILL

MEMORANDUM

TO: Ms. Roberta Groch, Assistant Chief, AICP
Ms. Caitlin Greely, Principal Planner

CC: Ms. Diane Williamson, Community Development Director

FROM: Arnold Robinson, AICP, NCI, WEDG
Rebecca Meyers, EIT, MS

DATE: December 28, 2023

RE: Resilient Route 114 Project, Task 3 –
Review Town of Bristol Existing Planning Documents

Background and Methodology

Fuss & O'Neill reviewed the Town of Bristol's existing plans, studies, maps, and reports to identify elements of these planning documents that mention actions, policies, priorities, and strategies related to Route 114 – especially those that focus on improving the overall resilience of the Route 114 corridor. The existing plans, studies, maps, and reports reviewed included:

- Town of Bristol 2016 Comprehensive Community Plan, 2016 [BCCP, 2016]
- Natural Hazard Mitigation Plan of the Town of Bristol, Rhode Island, June 2009 [BNHMP, 2009]
- Natural Hazard Mitigation Plan Bristol, Rhode Island, July 2016 [BNHMP, 2016]
- Town of Bristol Municipal Resilience Program: Community Resilience Building Workshop Summary of Findings, August 2020 [BMRP, 2020]
- Bristol, RI Coastal Sea Level Rise and Storm Surge: Transportation Fact Sheet [BCSLRSS, 2016]
- Vulnerability of Transportation Assets to Sea Level Rise, January 2015 [VTA, 2015]

KEY FINDINGS

The following actions, policies, priorities, and strategies related to improving the resilience of the Route 114 corridor were identified during the plan review:

- **Revisit the construction of the Silver Creek Bridge with a focus on long-term sea level rise** (SLR) and how it is built into the design and engineering solutions [BCCP, 2016, page 11 & BMRP, 2020, page 11].
- **Complete the Tanyard Brook flood mitigation project and continue the Silver Creek stormwater plan** [BMRP, 2020, page 10].
- **Create a plan to help aid and restart businesses after storm events** [BMRP, 2020, page 11].
- **Bury electrical wires and other suspended cables along Route 114** [BMRP, 2020, page 23].

For Tanyard Brook, a project received permits in 2009 from the Rhode Island Department of Environmental Management and the RI Coastal Resources Management Council to enlarge the culvert, install a tide gate at the outfall, and remove sewer lines that constrict the flow through the culvert under Hope Street. The **Town also adopted an ordinance that regulates storm water runoff from new development in Tanyard Brook watershed as part of the area improvement process** [BNHMP, 2009, page 18].

Additionally, several of the planning documents also identified key existing vulnerabilities and past climate-related events that helped highlight the need for improving the resilience of the Route 114 corridor:

- **Route 114 is vulnerable to flooding and SLR under both existing and future modeled conditions.**
    - **Silver Creek Area** – In the area of Hope Street where the Silver Creek (a tidal inlet) discharges into Bristol Harbor. This **area floods frequently during heavy rainstorm events, particularly when combined with high tides** [BNHMP, 2016, page 36], and is a key watershed [BMRP, 2020, page 6]. This area, along with the Tanyard Brook area, has historically experienced the highest damages from flooding throughout the Town [BNHMP, 2016, page 36].
    - **Tanyard Brook Area** – In the area where Tanyard Brook runs under Route 114. This **section of Route 114 has water and sewer lines** [BNHMP, 2009, page 28], and it is a **key watershed and is prone to flooding** [BMRP, 2020, page 6]. This area, along with the Silver Creek area, has historically experienced the highest damages from flooding throughout the Town [BNHMP, 2016, page 36]. During the March 2010 storm event, this area was closed due to flooding [BNHMP, 2009, page 28].
    - **The Town has the fourth most vulnerable bridges in the State to SLR.** The Silver Creek Bridge was rated the most vulnerable to SLR in the Town, and the Mount Hope Bridge was rated the 4th most vulnerable in the Town [BCSLRSS, 2016, page 3]. Under 7 feet of SLR, Silver Creek Bridge has -20 inches of freeboard. The Mount Hope Bridge was flagged as requiring further investigation to determine its amount of freeboard. [BCSLRSS, 2016, page 3]
    - **Silver Creek Bridge has been rated the most vulnerable to SLR plus 100-year storm surge event in the Town**, and the Mount Hope Bridge was rated the 5th most vulnerable in the Town [BCSLRSS, 2016, page 3]. Under 7 feet of SLR plus 100-year storm surge event, Silver Creek Bridge has -185 inches of freeboard. The Mount Hope Bridge was flagged as requiring further investigation to determine its amount of freeboard. [BCSLRSS, 2016, page 5]
    - **Route 114 was ranked the most vulnerable road to SLR in the State** [BCSLRSS, 2016, page 2]. For 100-year surge events, it is the most vulnerable road in Bristol, and the 5th most vulnerable in the State [BCSLRSS, 2016, page 4].
- **Critical areas along Route 114 are located in mapped FEMA flood zones.** The intersection of Route 114/Ferry Road, which also serves as a part of a primary evacuation route, is located

in the VE/Velocity Zone [BNHMP, 2016, page 42] and the AE/100-year Flood Zone [BNHMP, 2016, page 43].

- **Several parts of the Town's circulation and transportation are vulnerable to flooding.**
  - Bristol has the 5th most vulnerable RIPTA stops to SLR in the State [VTA, 2015, page 15].
  - Bristol has the 3rd most vulnerable intermodal hubs inundated by SLR in the State [VTA, 2015, page 16].
  - Bristol's commercial ferry, fishing, and government ports are affected by SLR, including the Prudence Island Ferry Terminal and USCG Bristol [VTA, 2015, page 18].
- **Historically, flooding along Route 114 in Bristol has caused repetitive damages.** During the December 12, 2008 flood event, $3,000 in property damages resulted from 3-5 inches of flooding from Silver Creek [BNHMP, 2009, page 25].

Importantly, existing planning documents highlighted the **community's concerns over the existing and future vulnerability of Route 114**. The **isolation of local residents and visitors due to compromised/limited access and egress due to flooding is a major concern**, as Route 114 is a low-lying coastal road, near riverine systems, and is subjected to erosion and routine flooding from storm surge and stormwater run-off [BMRP, 2020, page 7]. In 2013, a forum was attended by 140 volunteers as part of the Comprehensive Community Plan to generate ideas and visions for the future development and growth of Bristol. **Infrastructure and traffic along Route 114 were one of the top six themes and concerns** of the forum [BCCP, 2016, page ix].

Despite these concerns, **several improvements are being made in Bristol to address key vulnerabilities**, including:

- The **paving of Route 114 in Downtown Bristol** through the Rhode Island Transportation Improvement Program [BCCP, 2016, page 151]
- The Rhode Island Department of Transportation completed **drainage improvements along Route 114** that are also expected to help mitigate the flooding [BNHMP, 2009, page 20]
- **For Silver Creek, large rip rap stones that had fallen, and were blocking the outfall, were removed, and a foot bridge that was creating a restriction further up in the marsh was raised**. However, more work is needed to improve the flood storage capacity of the marsh by removing sediment from the area [BNHMP, 2009, page 20].

<u>Additional Findings</u>

Route 114 was also mentioned in the following ways throughout the planning documents reviewed:

The **Comprehensive Community Plan noted several key goals related to Route 114**:

- **Provide more alternatives for residents to move about** within Bristol without using Metacom Avenue or Hope Street (Route 114) [BCCP, 2016, page 14].

- **Encourage sidewalks in new developments** that will connect with other sidewalks and trails. Encourage a greater focus on sidewalks on Hope Street (Route 114), Ferry Road, and Metacom Avenue [BCCP, 2016, page 155].

The Comprehensive Master Plan notes a key goal related to Route 114:

- **Provide pedestrian safety on Bradford Street between Hope and Central Street** (between the two elementary schools). Due to the limited space available on Route 114, there is no place to drop off or pick up school children without blocking traffic on Route 114 [BCCP, 2016, page 47].
- **Maintain the residential character of the east side of Hope Street** [BCCP, 2016, page 190].
- **Complete large scale plant materials inventory** along Route 114 [BCCP, 2016, page 218].

Route 114 is an integral avenue to many features of the Town, including **William B. White "Stoney Hedge Farm."** This farm is located along Route 114 and is used for agricultural fields, crops, and horses [BBCP, 2016, page 140].

The Town has many **natural, historical, and cultural resources** and strong interest in protecting these resources.

- The community has a desire to **retain Bristol's small town character and natural beauty**. Conservation development techniques are planned to be implemented for future developments as part of the strategy to retain the Town's rural character [BCCP, 2016, page 48].
- The **entire length of Route 114 (from Warren to the Mount Hope Bridge) was designated as a State Scenic Roadway**. This designation triggers a State permit that requires a review from the State's Scenic Roadways Board for projects involving Route 114 [BCCP, 2016, page 118]. Following this designation, a **Scenic Roadway Corridor Management Plan was prepared in 2005 to provide recommendations for preservation of the visual qualities and enhancements to those areas that are in need of improvements along the roadway** [BCCP, 2016, page 48].
- For the past 17 years, **Bristol has been recognized as a "Tree City USA."** The Town's Tree Commission works through the Conservation Commission to inventory public tree resources and improve the "urban forest." Volunteer organizations, such as Bristol Blooms Organization, work on continuous improvements including planting and maintaining the hanging flower baskets along Hope Street [BCCP, 2016 pages 120-121].
- **Along Route 114, there are a number of National Register Historic Candidate Sites, National Register and Bristol Local Historic Districts, and Historic Site Property/Local Individually Listed Historic Properties** [BCCP, 2016, page 127]. Many of these historic resources and sites are located in the FEMA floodplains [BMRP, 2020, page 7].
    - National Register Historical District Sites along Route 114 include: Poppasquash Farms Historic District, Bristol Waterfront Historic District, and Mount Hope Bridge [BCCP, 2016, page 127].

- National Register Historic Candidate Sites along Route 114 include: Bristol Highlands Neighborhood, Sam Whites Corner Historic District, North Hope Street Historic District, Yacht Spartan, and Ferry Road Historic District [BCCP, 2016, page 127].

The **Town has several parks along Route 114** [BCCP, 2016, pages 139] that are important in providing open recreation space for the community.

Several recent improvements have been made to the existing infrastructure related to Route 114. Granite curbs and sidewalks from the Thames Street intersection to Constitution Street that were installed as part of the Hope Street sidewalk projected completed by RIDOT in 2012 – as well as new decorative streetlights, benches, bike racks, trash and recycling bins. To help incorporate public art and place into the project, the Steel Yard was commissioned to create the street furniture [BCCP, 2016, page 95].

The Town also has noted several **key transportation-related goals related to Route 114 as a Town-maintained street**, which include [BCCP, 2016, page 149]:

- **Work with RIPTA to establish a designated park-and-ride lot at the Corner of Gooding Avenue and Hope Street**, provide protected bus stops that match the surrounding environment, provide safe access for boarding at the stops, and to allow for the ability for a bus to pull closer to the curb so as not to disrupt the flow of traffic along Route 114. This goal of this would be to help promote public transportation through RIPTA [BCCP, 2016, page 152].
- **Determine the feasibility of providing access for most neighborhoods through Route 114** via an existing signalized intersection [BCCP, 2016, page 15].
- **Work with Warren and Barrington to determine more efficient alternatives for transportation between the Towns** [BCCP, 2016, page 15].

The Town currently has **plans in place for infiltration and inflow reduction projects like the Hope Street (Route 114) Sewer Rehabilitation**, which were included in the Wastewater Facilities Plan that was adopted in 2000 [BCCP, 2016, page 169].

Additionally, **future plans for improving local infrastructure** in Bristol, include:

- Implementing the access and use of an **advanced fiber optic network that runs down Hope Street** [BCCP, 2016, page 211]
- A planned project for the **Ferry Road Pump Station improvements** [BCCP, 2016, page 169]

Conclusion

The plan review revealed several specific actions related to improving the resilience of Route 114 – along with planning documents that highlighted current and future vulnerabilities related to the Route 114 corridor in Bristol. Additionally, the plan review captured several other mentions of Route 114 in existing planning documents, which included notes related to comprehensive community planning goals,

transportation and infrastructure improvements, historic district sites, and existing natural resources. These findings will be used as a complement to the review of existing datasets to develop a more comprehensive existing conditions assessment – and ultimately inform the development of future strategies and plans for improving the resilience of Route 114 in Bristol.

FUSS & O'NEILL

MEMORANDUM

TO: Ms. Roberta Groch, Assistant Chief, AICP
Ms. Caitlin Greely, Principal Planner

CC: Mr. Herbert Durfee, Town Planner

FROM: Arnold Robinson, AICP, NCI, WEDG
Rebecca Meyers, EIT, MS

DATE: December 28, 2023

RE: Resilient Route 114 Project, Task 3 –
Review Town of Warren Existing Planning Documents

Background and Methodology

Fuss & O'Neill reviewed the Town of Warren's existing plans, studies, maps, and reports to identify elements of these planning documents that mention actions, policies, priorities, or strategies related to Route 114 – especially those that focus on improving the overall resilience of the Route 114 corridor. The existing plans, studies, maps, and reports reviewed included:

- Draft Town of Warren Comprehensive Plan (Town of Warren, 2023), including the following plan elements:
    - Land Use [WCPLU, 2023]
    - Historic District Map [WCPHM, 2023]
    - Water Supply Map [WCPWSM, 2023]
    - Natural Resources Map [WCPNRM, 2023]
    - Sewer Service Map [WCPSM, 2023]
    - Natural Hazard Map [WCPNHM, 2023]
    - Transportation [WCPT, 2023]
    - Economic Development [WCPED, 2023]
    - Natural Hazards & Climate Change [WCPCC, 2023]
    - Historic and Cultural Resources [WCPHC, 2023]
    - Services and Facilities [WCPSF, 2023]
- Town of Warren Hazard Mitigation & Flood Management Plan (Town of Warren, 2022) [WHMP, 2022]
- Town of Warren Municipal Resilience Program: Community Resilience Building Workshop Summary of Findings October 2019 (Town of Warren, 2019) [WMRP, 2019]
- Town of Warren Downtown Parking Study: Summary of Parking Utilization Data Collection (McMahon, 2022) [WPS, 2022]
- Warren, RI Coastal Sea Level Rise and Storm Surge: Transportation Fact Sheet (RI DSP, 2016) [WCSLRSS, 2016]
- Vulnerability of Transportation Assets to Sea Level Rise (RI DSP, 2015) [VTA, 2015]

KEY FINDINGS

The following actions, policies, priorities, and strategies related to improving the resilience of the Route 114 corridor were identified during the plan review:

- **Improve awareness by implementing a high-water mark program.** This program would increase public awareness of flooding risk and sea level rise (SLR). A consideration for part of this program is to install SLR gauges and provide local data and signage demarcating high water levels associated with significant storm events, projected SLR, and flood zones related to bridges on Main Street (i.e., Route 114) [WHMP, 2022, page 6-9]. Similarly, the Summary of Findings from the Town of Warren's recent Community Resilience Building Workshop also recommended "developing and installing signage demarcating flood zones related to bridges on Main Street" as a "Moderate Priority Action" [WMRP, 2019, page 12].
- **Encourage RIDOT to address resilient transportation system needs that incorporate sea level rise projections** [WMRP, 2019, page 10].

Additionally, several of the planning documents also identified key existing vulnerabilities and past climate-related events that helped highlight the need for improving the resilience of the Route 114 corridor:

- **Route 114 is a key evacuation route** for the Town and was identified as an area of concern during the Community Resilience Building Workshop [WMRP, 2019, page 4].
- **Route 114 is vulnerable to flooding and SLR under both existing and future modeled conditions.**
    - **Route 114 was noted as one of the most vulnerable roadways in the State** [WCPT, 2023, page 5], with portions of the road located in Zone AE and 0.2% annual change flood hazard zone in Warren [WCPNHM, 2023, page 1].
    - **Route 114 was also ranked number one in the top 10 road assets in the Town of Warren vulnerable to SLR** [WCSLRSS, 2016, page 2], and it was **ranked number one in top 10 road assets vulnerable to the 100-year surge event** [WCSLRSS, 2016, page 4].
    - It has also been projected that 13 linear feet of Route 114 will be impacted with 1 foot of SLR, and 343 liner feet will be affected by 3 feet of SLR [WCPCC, 2023, page 6]. Similarly, 491 linear feet of roadway were projected to be compromised under a 1-year storm return, not including SLR [WHMP, 2022, page 4-85].
    - According to the Statewide Planning Vulnerability Assessment, the **Warren Bridge is the 3rd most vulnerable bridge to sea level rise in the State** [WHMP, 2022, page 4-85], and the Warren Bridge and evacuation routes of low areas of Route 114 were included in the 2022 Critical Asset list under the Transportation section of Warren's Hazard Mitigation Plan [WHMP, 2022, page 247]. Both assets would be affected by a Category 1 hurricane, with the primary effects or problems of flooding including public

safety, disruption of services, disruption of access, and economic loss [WHMP, 2022, page 52]. Similarly, it was noted that flash flooding may also occur along 114 near the Warren Bridge [WHMP, 2022, page 4-2].

- **Historically, Route 114 has been affected during heavy storms and rain events.**
    - On August 10, 2013, heavy rain, thunderstorms, and strong winds caused Route 114 on the Town of Warren/Town of Barrington line to be flooded with 1.5 feet of water [WHMP, 2022, page 4-24].
    - On August 9, 2013, heavy rain of 2-2.25 inches, thunderstorms, and high atmospheric moisture content resulted in torrential downpours across much of the region, which led to flash flooding in some areas [WHMP, 2022, page 4-24].
    - On September 3, 2013, heavy rain, thunderstorms, and damaging winds in some areas caused Route 114 to become flooded and impassable [WHMP, 2022, page 4-24].
- **Water and sewer lines currently run under portions of Route 114 that are vulnerable to flooding** and have the potential to cause major disruptions to water supply and wastewater services in the Town if compromised [WCPWSM, 2023, page 1].

Additional Findings

Route 114 was also mentioned in the following ways throughout the planning documents reviewed:

- Warren has an **existing Village Business District and Special District on Route 114** [WCPLU, 2023, page 2], which includes:
    - **Hope & Main** – a food hub that offers a variety of amenities, including an affordable kitchen space and mentoring for aspiring chefs, farmers, fishermen, and food professionals. Hope & Main contributes to a more resilient economy and increased food security for residents [WCPED, 2023, page 6].
    - **Warren Commercial and Industrial Ports** – ports that are vulnerable to SLR and include commercial fishing, fish processing, general berthing, and ship building and repair businesses [VTA, 2015, page 18].
    - **Bierman ABA Autism Center** – included in the 2022 Critical Asset list under Schools [WHMP, 2022, page 247], Bierman would be affected by a Category 1 hurricane and is in FEMA Flood Zone A [WHMP, 2022, page 249].
    - **Head Start Program from the Mary V. Quirk School** – included in the 2022 Critical Asset list under Schools [WHMP, 2022, page 247], the Head Start is in FEMA Flood Zone X [WHMP, 2022, page 249].
    - **Community Center Mary V. Quirk School** – included in the 2022 Critical Asset list under Government/Emergency Centers [WHMP, 2022, page 247], the Community Center is located in a FEMA Flood Zone X [WHMP, 2022, page 250].
    - **Town Hall** – included in the 2022 Critical Asset list under Government/Emergency Centers [WHMP, 2022, page 247], the Town Hall would be affected by a Category 4 hurricane and is located in FEMA Flood Zone X [WHMP, 2022, page 250].

    - **Life Incorporated** – included in the 2022 Critical Asset list under Special Population Centers [WHMP, 2022, page 247], Life Incorporated would be affected by a Category 4 hurricane and is located in FEMA Flood Zone X [WHMP, 2022, page 252].
    - **Corliss Institute** – included in the 2022 Critical Asset list under Special Population Centers [WHMP, 2022, page 247], Corliss would be affected by a Category 1 hurricane and is located in FEMA Flood Zone X [WHMP, 2022, page 252].
    - **Main Street Group Home (Public-RI State)** – included in the 2022 Critical Asset list under Special Population Centers [WHMP, 2022, page 247], primary effects or challenge with the group home experiencing flooding include public safety, disruption of services, and disruption of access [WHMP, 2022, page 252]
- **RIPTA line runs daily along Route 114** with a stop in Warren [WCPT, 2023, page 8].
- **Route 114 is utilized for street parking**, with around 198 cars per day typically parked along Main Street [WPS, 2022, Excel Data].
- The **Warren Waterfront Historic District** encompasses almost half a square mile and is bounded by Route 114 to the east. This district has over 300 documented historic buildings [WCPHC, 2023, page 4]. Additionally, the Town is interested in establishing south Main Street (i.e., Route 114) with new historic districts to preserve other areas of Warren of special historic and cultural significance [WCPHC, 2023, page 2]. And, a number of properties along Main Street and the Main Street Commercial District were recommended for National Register of Historic Places status to the Rhode Island Historical Preservation Commission [WCPHC, 2023, page 5], including:
    - George Hatch House
    - L.B. Hatch House
    - Louis R. Seymour House
    - Captain Benjamin Usher House
- **Natural resources along Route 114** include:
    - Estuarine and Marine **Wetlands** to the north end of Route 114, near the Warren Bridge [WCPNRM, 2023, page 1]
    - Estuarine and Marine **Deepwater** to the north end of Route 114, near the Warren Bridge, and running underneath Route 114 south of the intersection of 114 and Beach Street and near the intersection of 114 and Jacobs Point Road [WCPNRM, 2023, page 1]
    - **Salt marsh** habitat to the to the north end of Route 114, near the Warren Bridge [WCPNRM, 2023, page 3]
    - **Plantation and ruderal forest** spanning on the west side of Route 114 between the intersections of Route 114 and Oyster Point and Jacobs Point Road [WCPNRM, 2023, page 3]

Conclusion

The plan review revealed several specific actions related to improving the resilience of Route 114 – along with planning documents that highlighted current and future vulnerabilities related to the Route 114

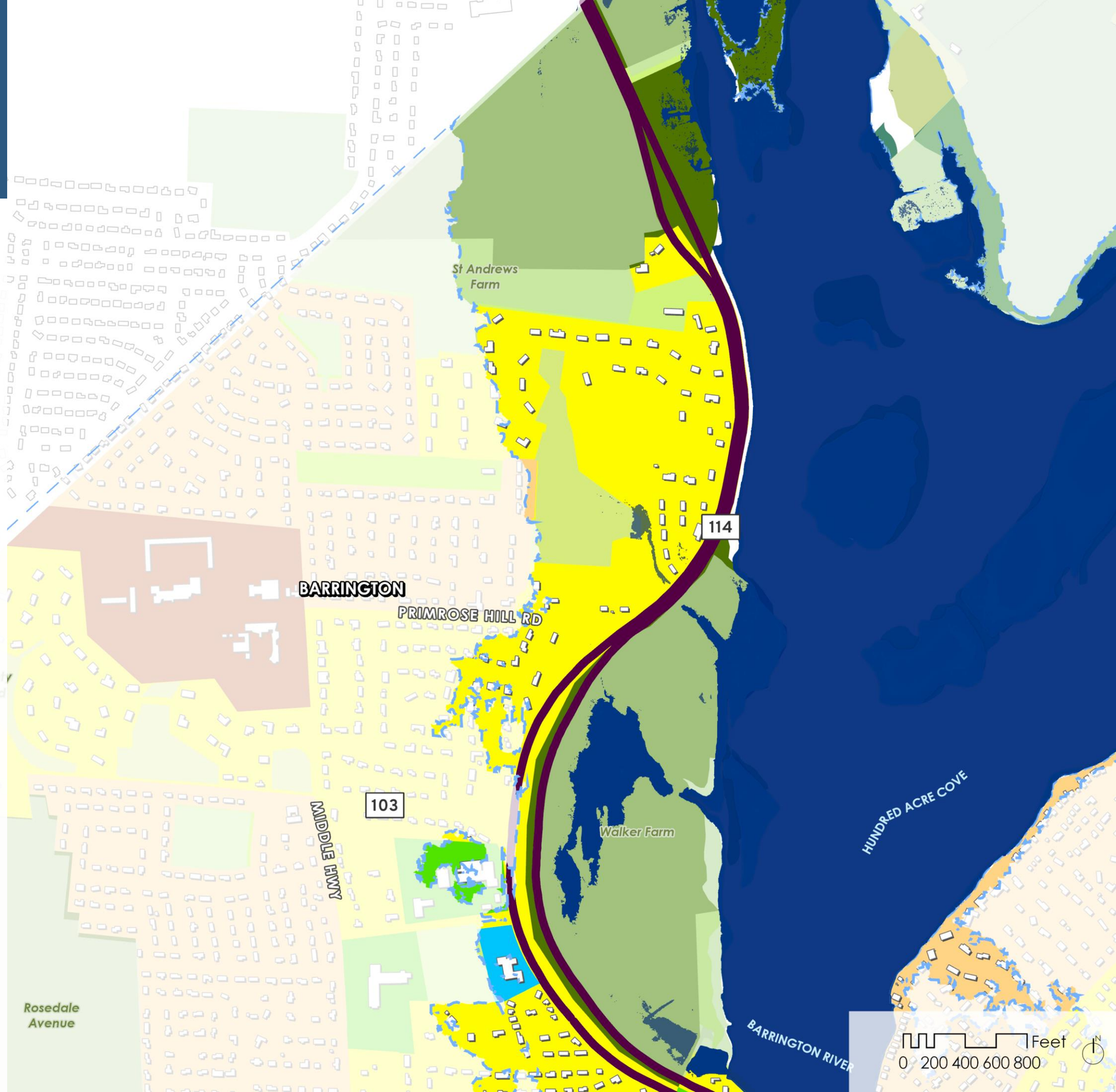
corridor in Warren. Additionally, the plan review captured several other mentions of Route 114 in existing planning documents, which included notes related to the Village Business District and Special District, RIPTA routes and existing street parking conditions, the Waterfront Historic District, and existing natural resources. These findings will be used as a complement to the review of existing datasets to develop a more comprehensive existing conditions assessment – and ultimately inform the development of future strategies and plans for improving the resilience of Route 114 in Warren.

Appendix C: Additional AOV Zoning Maps

EXISTING ZONING MAPPING: AOV 1

LEGEND

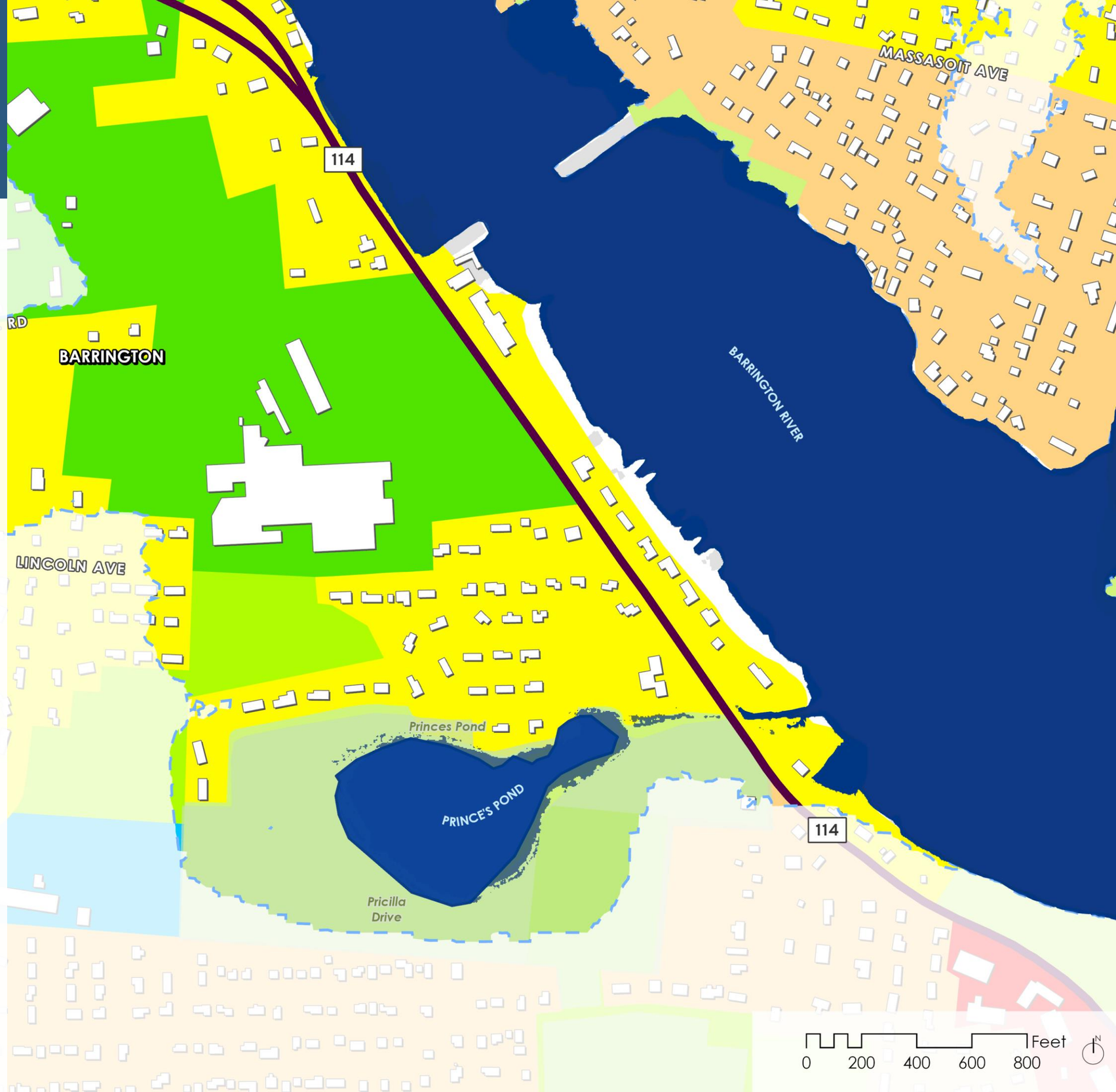
- 1% Annual Chance Flood with 2 Feet of SLR
- Agricultural - Rural
- Business
- Conservation
- Government and Institutional
- Open Space - Active Recreation
- Open Space - Passive Recreation
- Residence 10
- Residence 25
- Residence and Education
- Senior Residential Village
- Waterfront Business
- Wildlife Refuge



EXISTING ZONING MAPPING: AOV 2

LEGEND

- 1% Annual Chance Flood with 2 Feet of SLR
- Business
- Government and Institutional
- Open Space - Active Recreation
- Open Space - Passive Recreation
- Residence 10
- Residence 25
- Residence and Education



EXISTING ZONING MAPPING: AOV 3

LEGEND

- 1% Annual Chance Flood with 2 Feet of SLR
- Business
- Conservation
- Government and Institutional
- Neighborhood Business
- Open Space - Active Recreation
- Open Space - Passive Recreation
- Residence 10
- Residence 25
- Residence and Education

EXISTING ZONING MAPPING: AOV 4

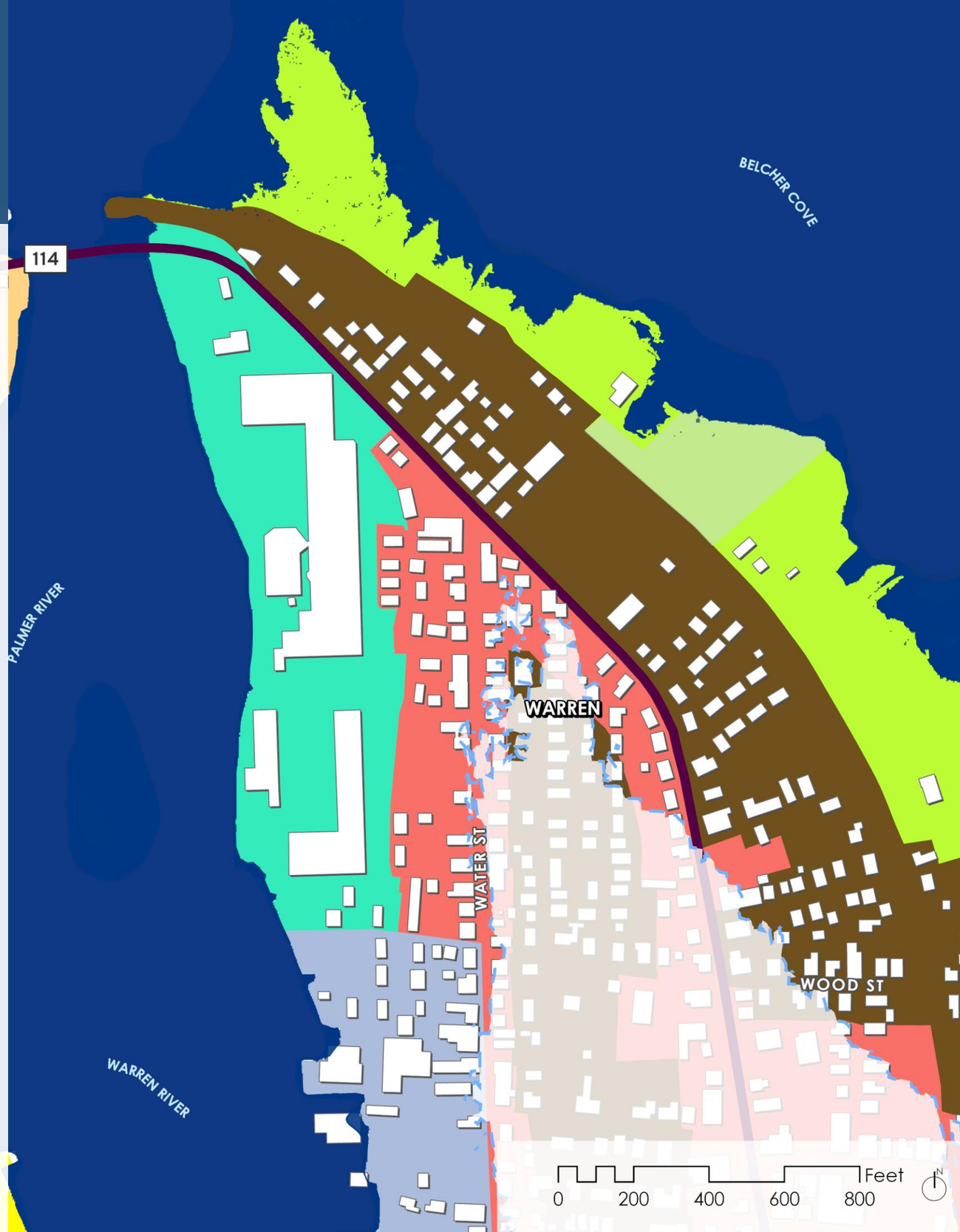
LEGEND

- 1% Annual Chance Flood with 2 Feet of SLR
- Business
- Conservation
- Government and Institutional
- Neighborhood Business
- Open Space - Active Recreation
- Open Space - Passive Recreation
- Residence 10
- Residence 25
- Residence 25 Cluster
- Residence and Education
- Waterfront Business

EXISTING ZONING MAPPING: AOV 5

LEGEND

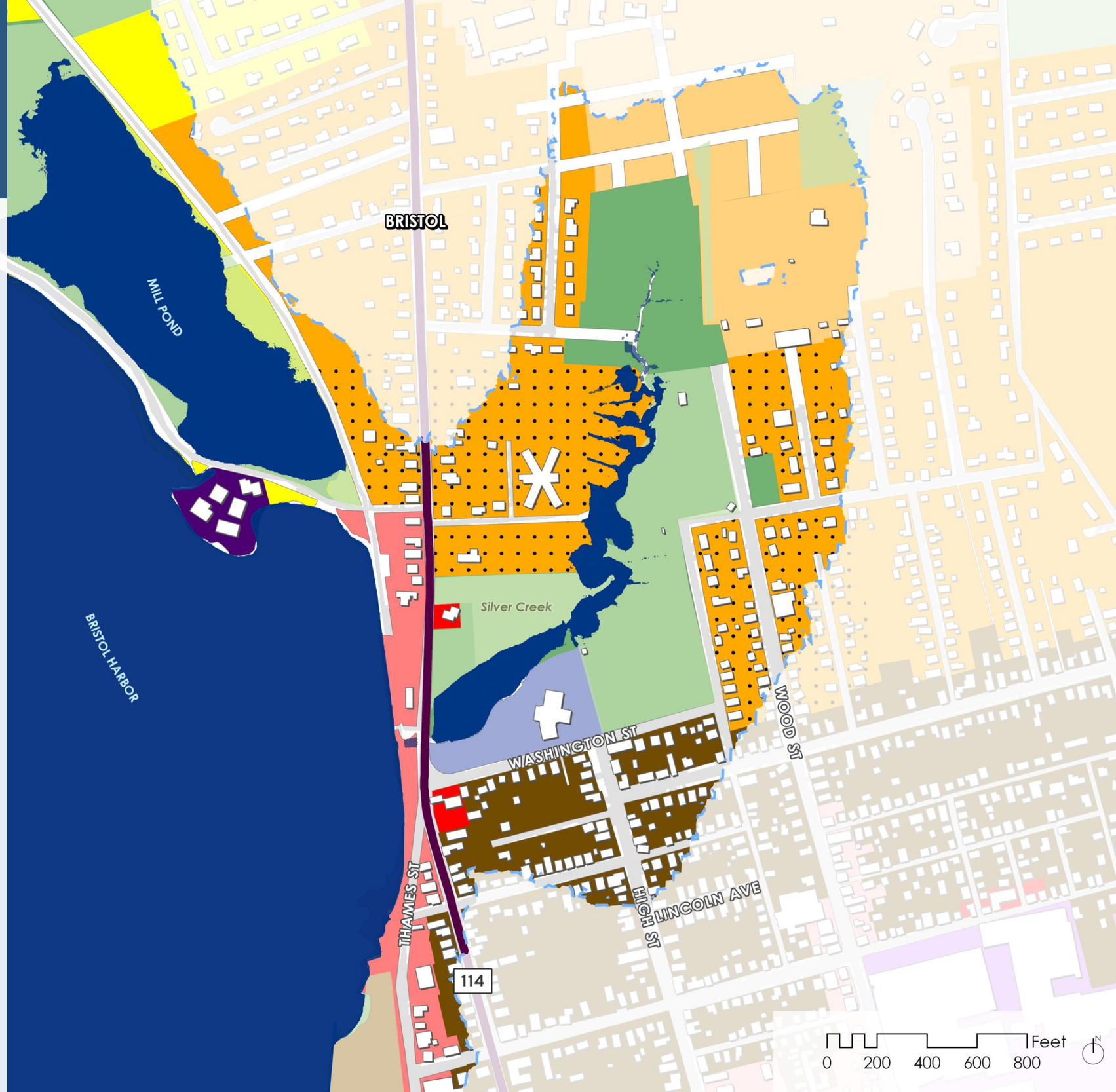
- 1% Annual Chance Flood with 2 Feet of SLR
- (C) Conservation District
- (R6) R-6 Residential District
- (S) Special District
- (VB) Village Business District
- (W) Waterfront District



EXISTING ZONING MAPPING: AOV 6

LEGEND

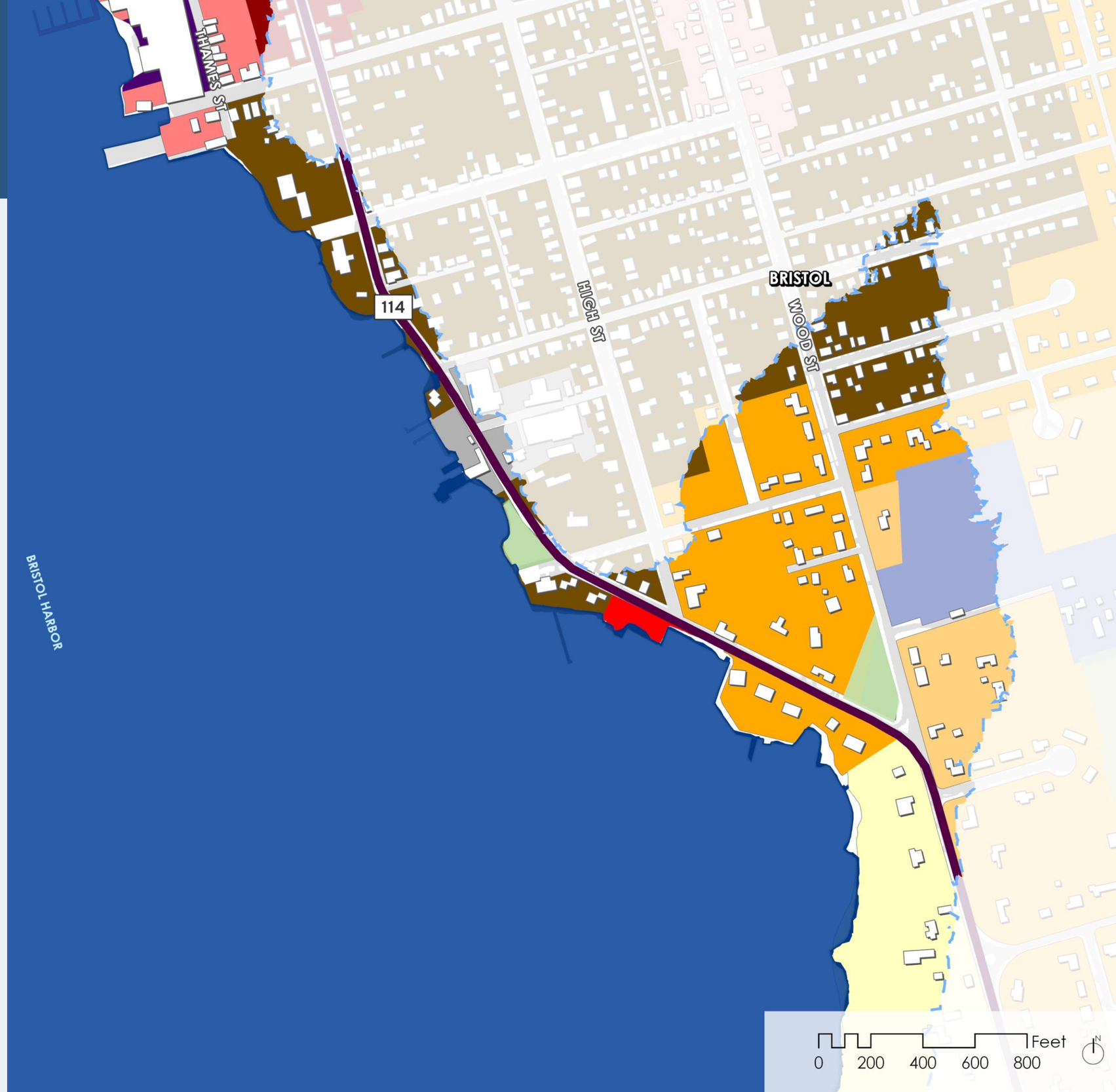
- 1% Annual Chance Flood with 2 Feet of SLR
- Residential 6,000 sq. ft. lot size
- Residential 10,000 sq. ft. lot size
- R-10 w/ sewer, water
- Residential 15,000 sq. ft. lot size
- Residential 20,000 sq. ft. lot size
- Open Space
- Public Institutional
- Waterfront PUD
- Rehab. PUD
- Limited Business
- Waterfront
- General Business



EXISTING ZONING MAPPING: AOV 7

LEGEND

- 1% Annual Chance Flood with 2 Feet of SLR
- Residential 6,000 sq. ft. lot size
- Residential 10,000 sq. ft. lot size
- Residential 15,000 sq. ft. lot size
- Residential 40,000 sq. ft. lot size
- Open Space
- Public Institutional
- Waterfront PUD
- Limited Business
- Waterfront
- Downtown
- General Business
- Manufacturing



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