

SUB-WATERSHEDS AND RESILIENCE OPPORTUNITY AREAS

The regional strategies described in the preceding section will advance resilience to flooding and other climate impacts throughout the region.

Taken together, these strategies have the potential to advance targeted improvements to watersheds, communities, and individual sites across RRBC. This section will illustrate how the combination of regional strategies described in the preceding section could result in actions at the watershed and neighborhood scales to address flooding and generate additional opportunities for community amenities, economic development, and ecosystem enhancement.

Sub-Watersheds are sub-geographies within the region identified based on hydrologic unit code 14 (HUC14) watershed boundaries as well as the shared flood risks and land use patterns within each. For more information on how and why these were defined, see “Applying a Watershed-Based Planning Approach” in *Chapter 04*.

These sub-watersheds are:

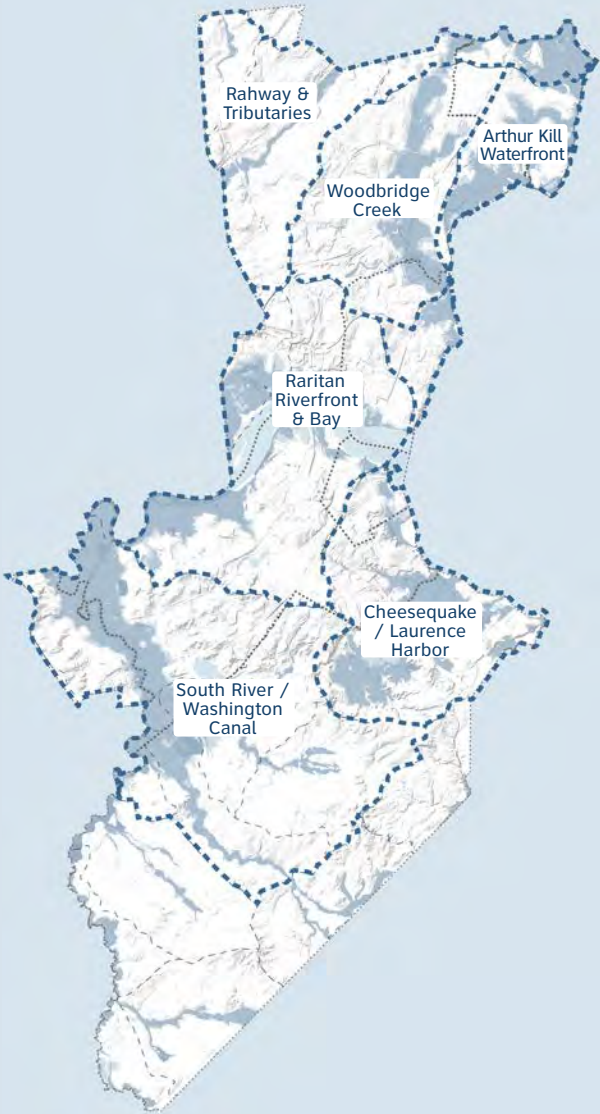
- Arthur Kill Waterfront
- Woodbridge Creek
- Raritan Riverfront and Bay
- South River / Washington Canal
- Cheesequake / Laurence Harbor
- Rahway River and Tributaries

Resilience Opportunity Areas are a specific selection of smaller, localized areas within the sub-watersheds, identified based on their significant flood risk and stakeholder priorities, for which a suite of resilience-building strategies were developed in more detail. The intent of these resilience opportunity areas is to show how regional strategies can be designed and implemented in combination locally to address resilience needs and how coordinated actions across jurisdictions can result in improved resilience and other community benefits. Taking action in these areas can also be a catalyst to advancing additional related actions across the region. Activities in these areas should be prioritized not only because they address urgent flood risks, but because they can serve as a demonstration of the potential for a range of different types of physical and non-physical interventions to reduce flood risk and create additional benefits.

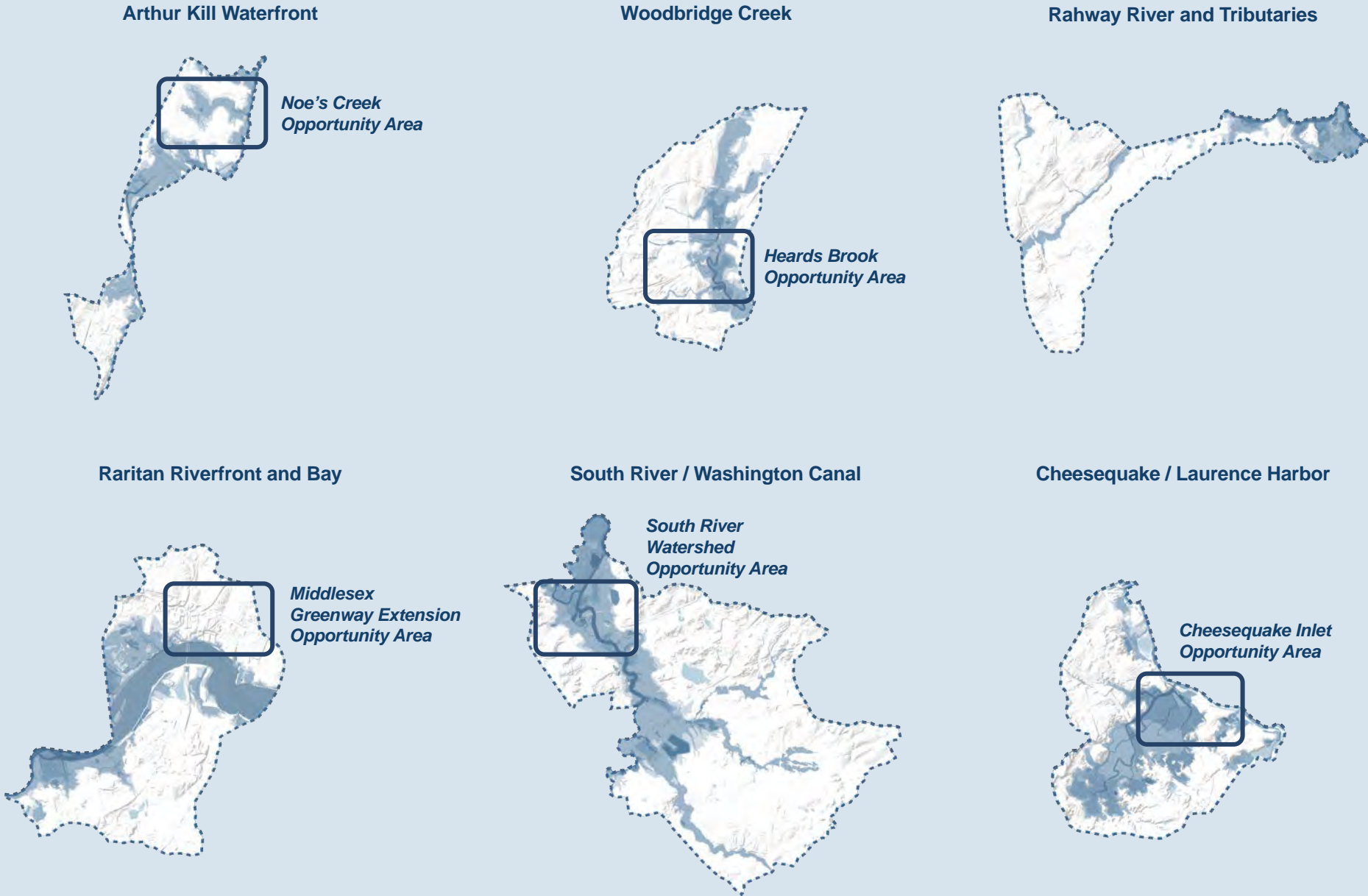
The Resilience Opportunity Areas are:

- Noe’s Creek
- Heards Brook
- Middlesex County Greenway Extension
- South River and Sayreville Main Street
- Cheesequake Inlet

SUBWATERSHEDS



RESILIENCE OPPORTUNITY AREAS



SUB-WATERSHED: ARTHUR KILL WATERFRONT

CARTERET, PERTH AMBOY, WOODBRIDGE

The Arthur Kill Waterfront sub-watershed includes industrial areas along the Arthur Kill coast in Carteret, Woodbridge, Perth Amboy, and the surrounding residential areas. The area is exposed to flooding from both heavy rainfall and storm surge, with some sites directly on the coast also vulnerable to future sea level rise. The waterfront in this area is characterized by oil and gas terminals, many brownfield sites, and critical infrastructure, in addition to more recent warehousing and distribution facilities.

Recently, new investments in waterfront parks and residential and mixed-use development have opened portions of the waterfront to public access and a broader mix of uses. Inland of the waterfront are more residential neighborhoods, including the center of Carteret, a diverse community with many people identifying as Hispanic or Latinx, as well as a large Sikh community. The poverty rates in some neighborhoods in Carteret are among the highest in the region, and there are several public housing complexes in area prone to flooding. The center of Carteret also includes many publicly owned sites, including parks, schools, and municipal buildings.

To address coastal flooding risks in this area, coastal protection can be integrated into the buildout of the planned waterfront greenway along the Arthur Kill in Carteret by **constructing a multi-purpose flood barrier** with bike and pedestrian paths. This alignment should cross Noe’s Creek and tie-in to redeveloped waterfront sites (as discussed in the next section).

Additional inland strategies are needed to manage heavy rainfall events, such as **increasing flood storage capacity on publicly owned lands**.

RECOMMENDED ACTIONS	ID*	LEAD ENTITY
A. Review and amend Chrome Waterfront Redevelopment Area to accommodate proposed Noe’s Creek flood mitigation and resilience projects.	C1	Carteret
B. Multi-purpose coastal flood barrier and tide gate along Arthur Kill as part of the Noe’s Creek project	C4, C5	Carteret
C. Explore opportunities for expanded stormwater storage on facilities and right of ways owned by Carteret	C7, C8	Carteret
D. A pump station at Noe’s Creek inlet for improved coastal and inland flood management	C9	Carteret
E. Outreach to private owners and operators of industrial facilities and critical utilities (PSE&G)	NJ33	NJDEP
F. Implement living shoreline at Boynton Beach	W23	Woodbridge
G. Promote redevelopment of waterfront industrial properties and brownfields along the Arthur Kill and Woodbridge Creek to new forms of light industry like warehousing and incorporate resilience standards and wetland restoration	W1	Woodbridge
H. Multi-purpose coastal flood barrier with bike and pedestrian paths along Perth Amboy shoreline from Armstrong Lane to Perth Amboy Harborside Marina	P4	Perth Amboy

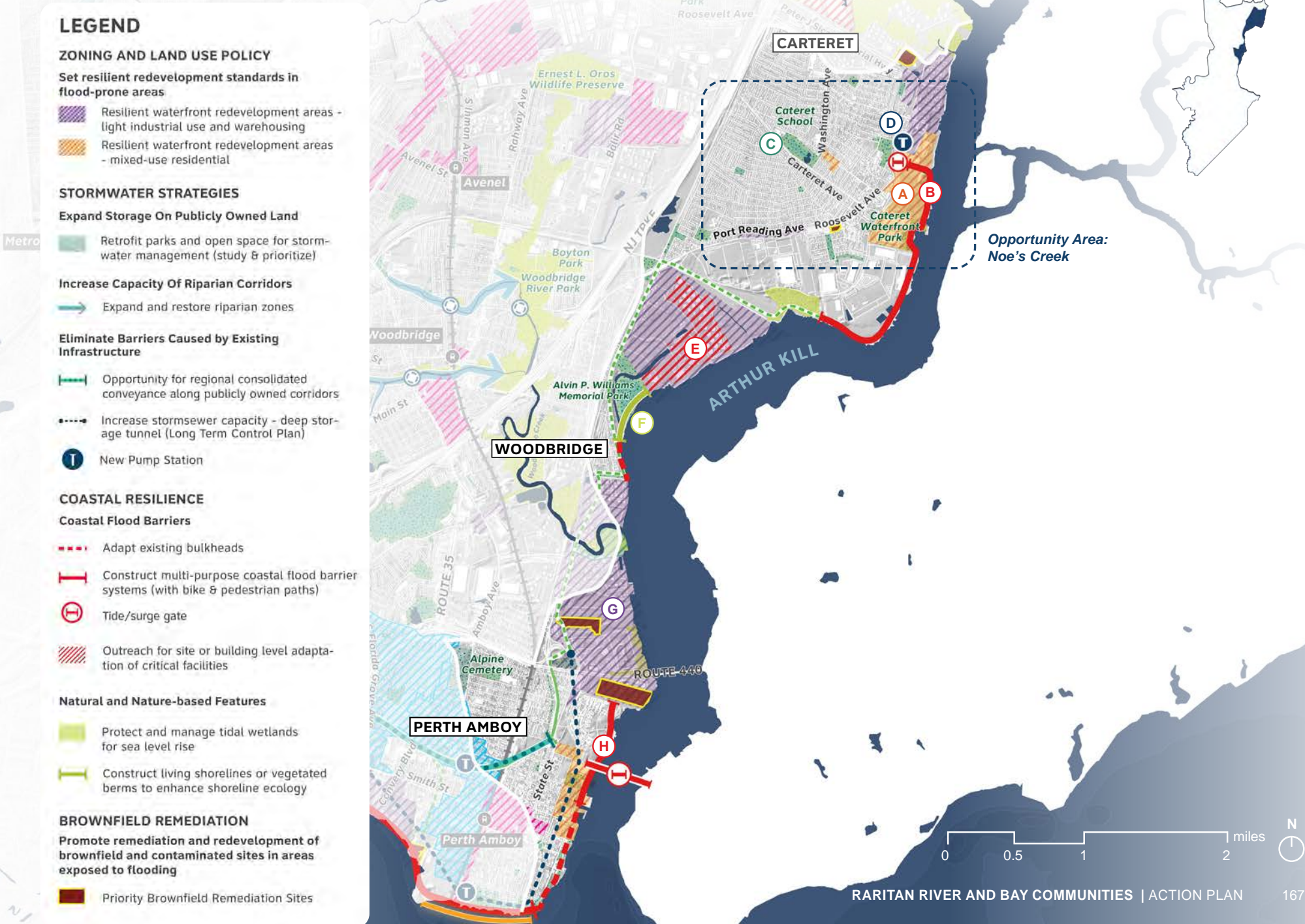
**See Summary Table of Recommended Actions starting on page 223 for additional details.*

Park improvements to provide flood storage can also serve to enhance neighborhood recreational amenities.

Waterfront industrial sites, such as oil and gas terminals and the PSE&G power station in Sewaren, are also exposed to flooding. Since Hurricane Sandy, some facilities have made resiliency improvements (including PSE&G), but further coordination is needed with these property owners to promote **site-specific adaptation to address future flooding risks**.

Many industrial uses along the waterfront have recently transitioned to warehouse and logistics uses. Incorporating resiliency strategies, such as stormwater storage, coastal protection, and site elevation, can promote the safety of these uses as through **resilient redevelopment**.

PREFERRED SCENARIO



ARTHUR KILL WATERFRONT OPPORTUNITY AREA: NOE’S CREEK

Flood Risk and Impacts

Noe’s Creek is a tidal inlet in Carteret that was once a much more extensive waterway. The creek and surrounding wetlands were filled in to enable the urban development of the borough. Today, the culverted creek is a major pathway for coastal flooding and the surrounding watershed is low-lying, leading to frequent ponding and flooding from heavy rain events, particularly at high tide.

With climate change, the risk of flooding in this area is expected to increase. If no action is taken to reduce risk, the potential for damage and disruption is significant. Potential monetary losses due to physical damages to structures and their contents, human impacts, direct business impacts, and the loss of function of public and essential facilities add up to **\$496M** in damages due to a future storm surge event and **\$159M** in damages due to a future heavy rainfall event. Flood events in this area have the potential to damage many critical and community assets including places of worship, stores, parks, municipal buildings, and more.

Densely populated residential areas in this area are also vulnerable to the impacts of flooding. The area has a high concentration of people of color—especially Hispanic, Latinx and Sikh populations—many of whom are also in low-income households. Notably, this area also has a very high concentration of low-income households with limited broadband internet access and low food access within 1 mile, with many characterized by the U.S. EPA Environmental Justice Screening and Mapping Tool as linguistically isolated. These neighborhoods are therefore less likely to have easy access to the resources and information needed to prepare for and respond to major flood events and are more likely to experience negative impacts from events—ranging from serious financial difficulty stemming from direct damages to homes and contents, to further restricted access to already scarce essential resources such as food.



Coastal Storm Surge



\$496 Million
in expected losses



Areal Rainfall Flooding



\$159 Million
in expected losses

Case Study: Noe Street Waterfall Park

The recently rebuilt Noe Street Waterfall Park features a detention basin used to collect stormwater from new and additional catch basins on the street. Once the water exceeds a certain level, a new stormwater pump station moves excess water to upgraded outflows off of Peter J. Sica highway to Noe’s Creek which then drains into the Arthur Kill. The park also serves as an all-season multipurpose recreational amenity with fountains, vegetation, ice-skating, and interpretive signage.



Noe Street Park, Carteret, NJ

Image Credit: Google Streetview



Overview of Strategies

The resilience strategies at Noe’s Creek combine coastal flood barriers, resilient redevelopment, and multi-benefit stormwater storage on publicly owned land. They not only reduce flood risk to existing residents, community facilities, and important commercial assets, but also enhance recreational amenities, increase multi-modal connectivity, and provide economic development opportunities for this entire small watershed.

To reduce coastal flood risks, a **multi-purpose flood barrier system** in the form of an elevated waterfront greenway integrated into redevelopment sites on either side of Noe’s Creek is proposed. This is combined with a tide gate across the creek to block coastal storm surge when closed but allow for continued tidal exchange under day-to-

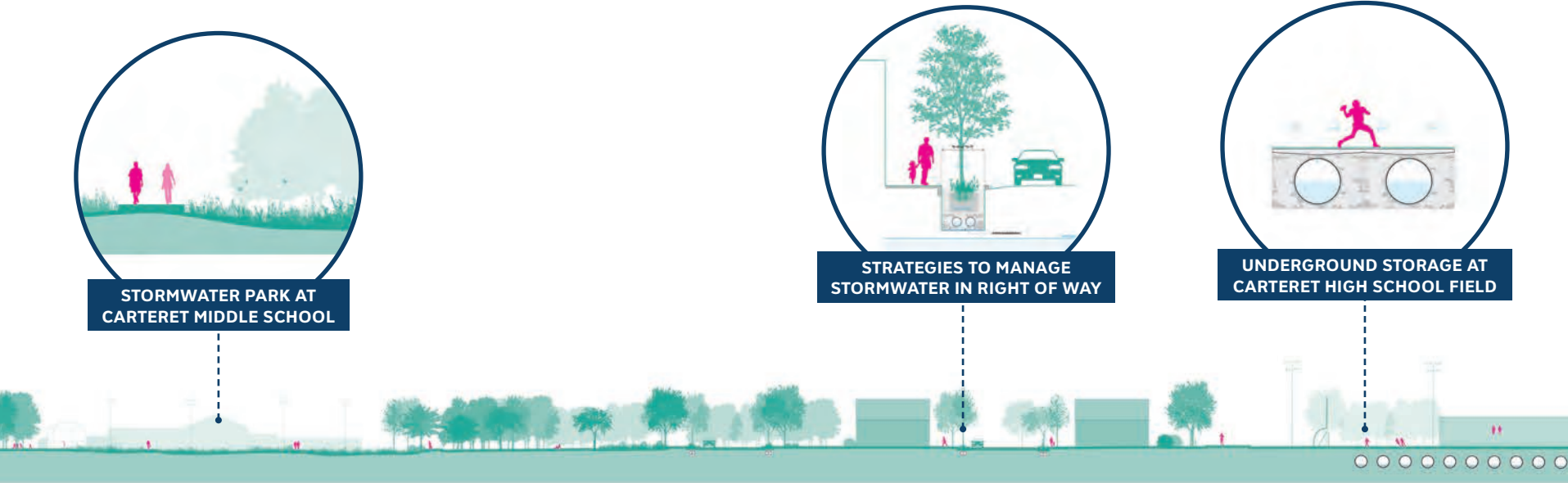
day conditions. The alignment shown here is a potential pathway for the coastal protection system, but further study is needed to identify a design flood elevation, assess site-specific constraints, and develop a preferred alignment and design. Waterfront redevelopment parcels are elevated and **incorporate resilience into their redevelopment plans** as they are developed to tie into the new coastal defense system and ensure that new development is resilient whether it is constructed before or after the complete flood defense system. A **pump station** is needed to manage stormwater on the inland side of this coastal protection system.

To address risk from heavy rainfall, an extensive system of stormwater storage improvements are included, building on the recent Noe Street Waterfall Park improvements. These consist of multiple actions to expand storage capacity

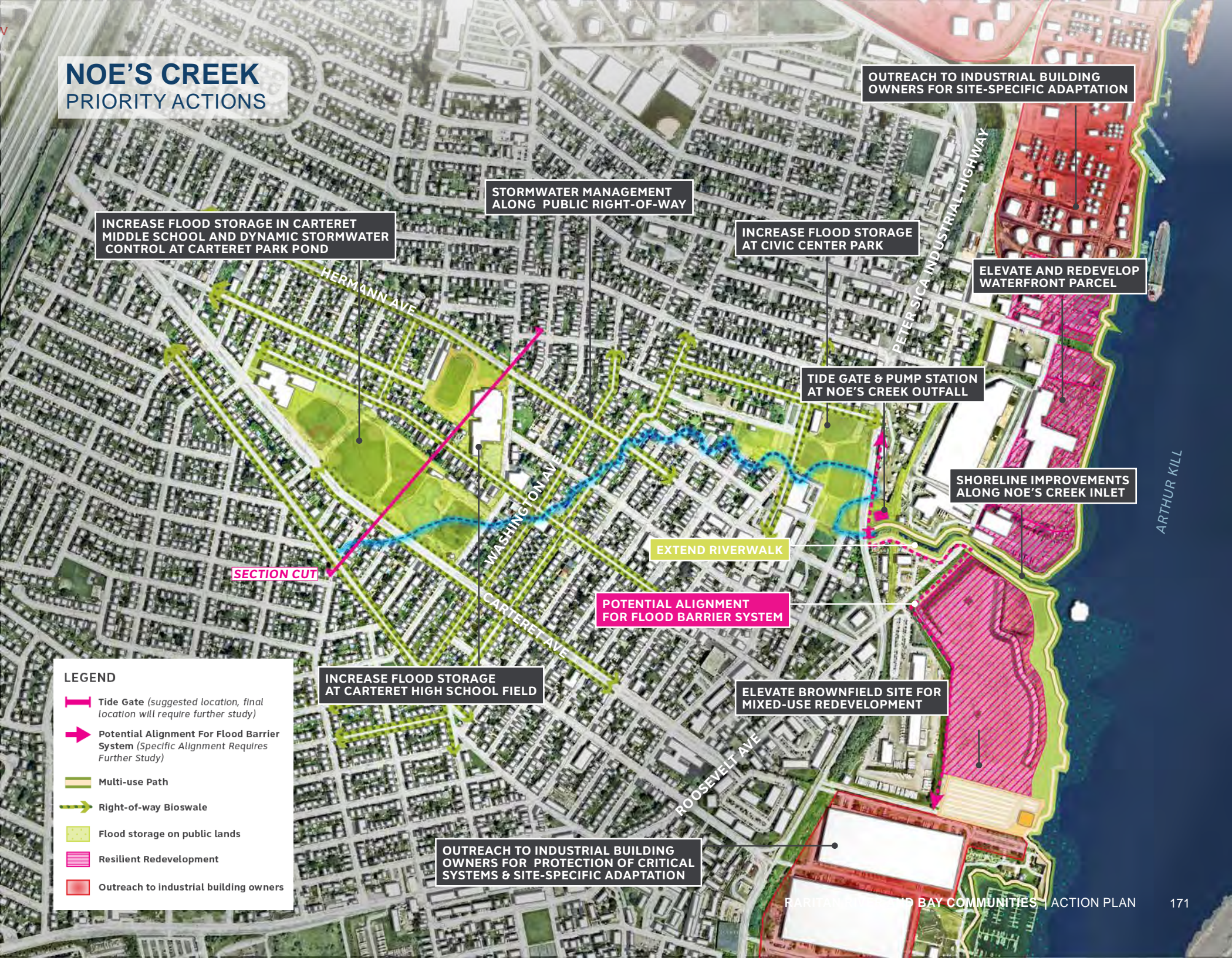
on publicly owned land including: integrating green infrastructure into public right-of –ways, specifically streets, in the form of bioswales and raingardens; and retrofitting parks and open space for stormwater management at sites like Civic Center Park, Carteret High School, Carteret Middle School, and Carteret Pond Park.

Implementation of these projects should involve close collaboration with residents and include partnerships with the schools to incorporate educational opportunities.

There is also interest in buyouts in this area from property owners who were impacted heavily by Hurricane Ida. Re-use of bought-out properties may include additional opportunities for stormwater management.



Increase flood storage in Carteret Middle School through a stormwater park, dynamic stormwater control at Carteret Park Pond, and underground storage at Carteret High School football field



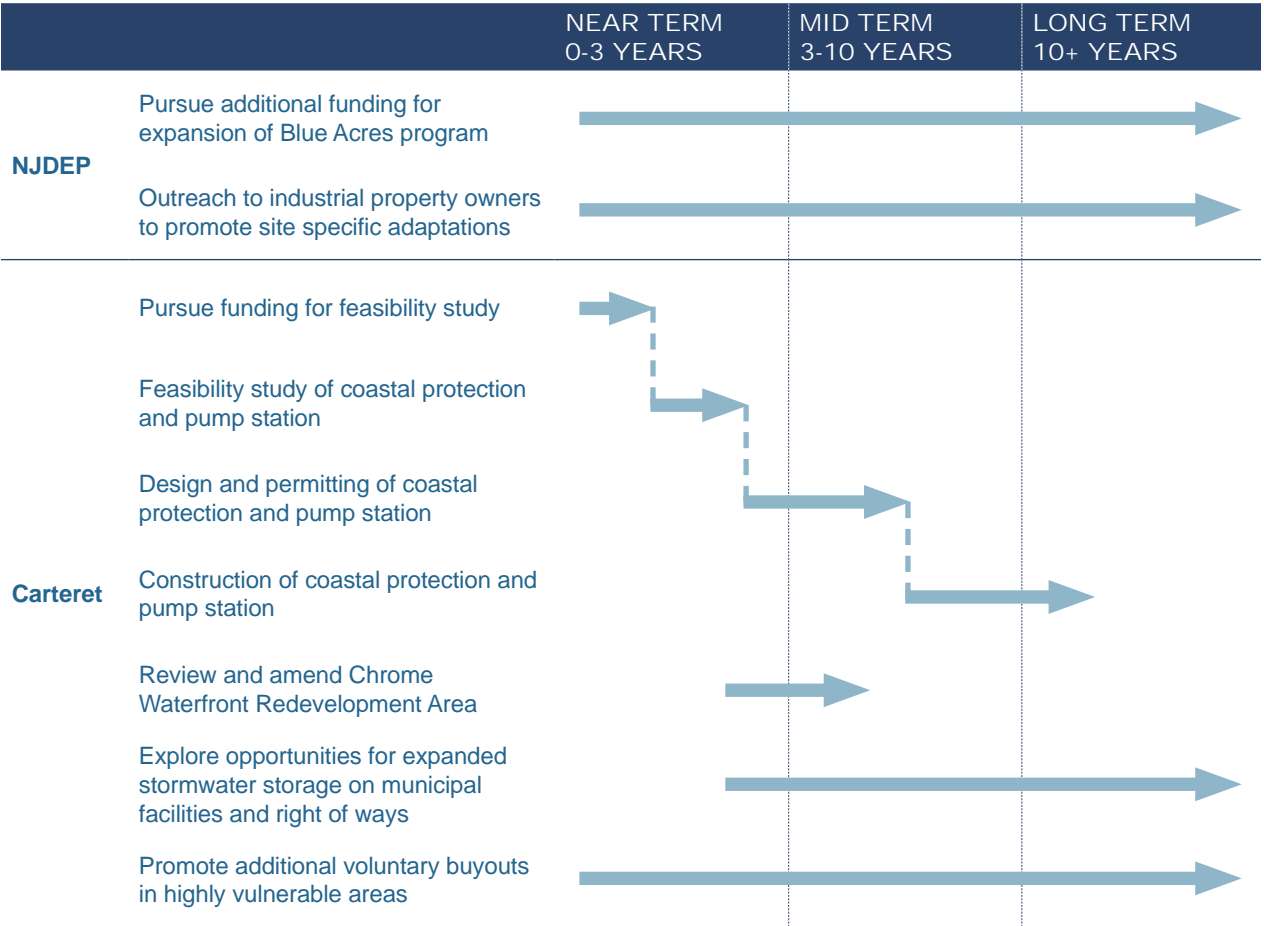


NOE’S CREEK INLET TODAY FROM ROOSEVELT AVE BRIDGE

Implementation Roadmap

Both NJDEP and Carteret should play key roles in the implementation of actions within the Noe’s Creek Resilience Opportunity Area. Primary responsibilities of NJDEP include pursuing additional funding to expand the Blue Acres program, making buyouts available to property owners impacted by Ida. NJDEP should also play a role in facilitating outreach to industrial private property owners along the Arthur Kill in order to promote site-specific adaptation. NJDEP could pilot outreach programs in Noe’s Creek and other Resilience Opportunity Areas before expanding regionally or statewide.

Carteret should serve as the lead entity for the Noe’s Creek Resilience Opportunity Area. Responsibilities may include pursuing funding for further study, facilitating further study, and all activities related to design, permitting, and construction of the coastal protection and pump station. Additionally, Carteret should explore amendment of the Chrome Waterfront Redevelopment Area to accommodate proposed Noe’s Creek flood mitigation and resilience projects. Exploring and pursuing opportunities to expand stormwater storage on municipal-owned facilities and right of ways will be essential to increase storage capacity in the area.



Implementation roadmap for Noe’s Creek Resilience Opportunity Area

NOE'S CREEK



ELEVATED REDEVELOPMENT
(INDUSTRIAL / LOGISTICS)

ELEVATED OPEN
SPACE

ELEVATED PATH - CARTERET
RIVERWALK EXTENSION

ELEVATED MIXED-USE
DEVELOPMENT

BULKHEAD / LIVING SHORELINE
FOR FUTURE DEVELOPMENT

LIVING SHORELINE/
REMEDATION

SUB-WATERSHED: WOODBRIDGE CREEK

CARTERET, PERTH AMBOY, WOODBRIDGE

The Woodbridge Creek watershed drains a large urban area with residential and commercial uses in Woodbridge Township. Downtown Woodbridge, which has been a focus for recent mixed-use and affordable housing redevelopment, as well as the Avenel community, are within this sub-watershed. Woodbridge Creek extends from the Arthur Kill north to where it nearly meets the Rahway River. Along the creek are extensive wetlands, with several recent restoration projects at Heards Brook and the Ernest L. Oros Wildlife Preserve. There are many creeks that feed into Woodbridge Creek, some of which have been channelized. These creeks are a frequent source of flooding during heavy rain events, particularly in areas where flood waters back up behind culverts.

During a major coastal storm, storm surge can enter the area through the Rahway River as well as up the Woodbridge Creek, resulting in extensive flooding on either side of the Creek. During heavy rainfall events, floodwaters can overwhelm the inland creeks, causing flooding along their banks, as well as ponding in low-lying areas.

Increasing the capacity of the riparian corridors along Heards Brook, Wedgewood Brook, and other tributaries of Woodbridge Creek can reduce flood impacts from heavy rainfall. This includes expanding the riparian area, or zone along the river, along with expanding the capacity of culverts under road and rail crossings, to help convey water and provide additional space to manage floodwaters. While there have been some buyouts in this area post-Hurricane Sandy, **additional buyouts** can create more space along the stream corridors for these improvements. Buyouts can also reduce risks from future coastal flooding in the area.

RECOMMENDED ACTIONS	ID*	LEAD ENTITY
A. Exploration of long-term opportunities for increased density outside the floodplain, such as along the Route 1 corridors	W2	Woodbridge
B. Encourage mixed-use development outside floodplain near Avenel and Woodbridge train stations	W4	Woodbridge
C. Wedgewood Brook and NJ TRANSIT Line Culvert Expansion	NJ17	NJ TRANSIT
D. Heards Brook and Route 35 Culvert Expansion	NJ30	NJDOT
E. Protect and manage tidal wetlands along Woodbridge Creek for sea level rise	W15	Woodbridge
F. Increase the storage and conveyance capacity of Heards Brook along with ecological restoration	W19	Woodbridge
G. Increase the storage and conveyance capacity of Wedgewood Brook along with ecological restoration	W21	Woodbridge
H. Explore opportunities for expanded stormwater storage on municipal-owned facilities and right of ways.	W16	Woodbridge
I. Promote redevelopment of waterfront industrial properties and brownfields along the Arthur Kill and Woodbridge Creek to new forms of light industry like warehousing and incorporate resilience standards and wetland restoration.	W1	Woodbridge
J. Examine sections of the NJ Turnpike (I95) at risk of future flooding and identify mitigation measures	NJ12	NJ Turnpike Authority

**See Summary Table of Recommended Actions starting on page 223 for additional details.*

While portions of this area are vulnerable to flooding, the areas adjacent to the Woodbridge and Avenel train stations are well-poised to meet the demand for new housing in the region. Areas on higher ground with less risk from flooding should be prioritized for increased density though **zoning and land use** approaches. When it is necessary to site development in flood prone areas, resiliency improvements should be incorporated.

PREFERRED SCENARIO

LEGEND

ZONING AND LAND USE POLICY

Set resilient redevelopment standards in flood-prone areas

Resilient waterfront redevelopment areas - light industrial use and warehousing

Create development opportunities in low flood risk areas

Enable greater density/floor area in low flood risk areas near transit

STORMWATER STRATEGIES

Expand Storage On Publicly Owned Land

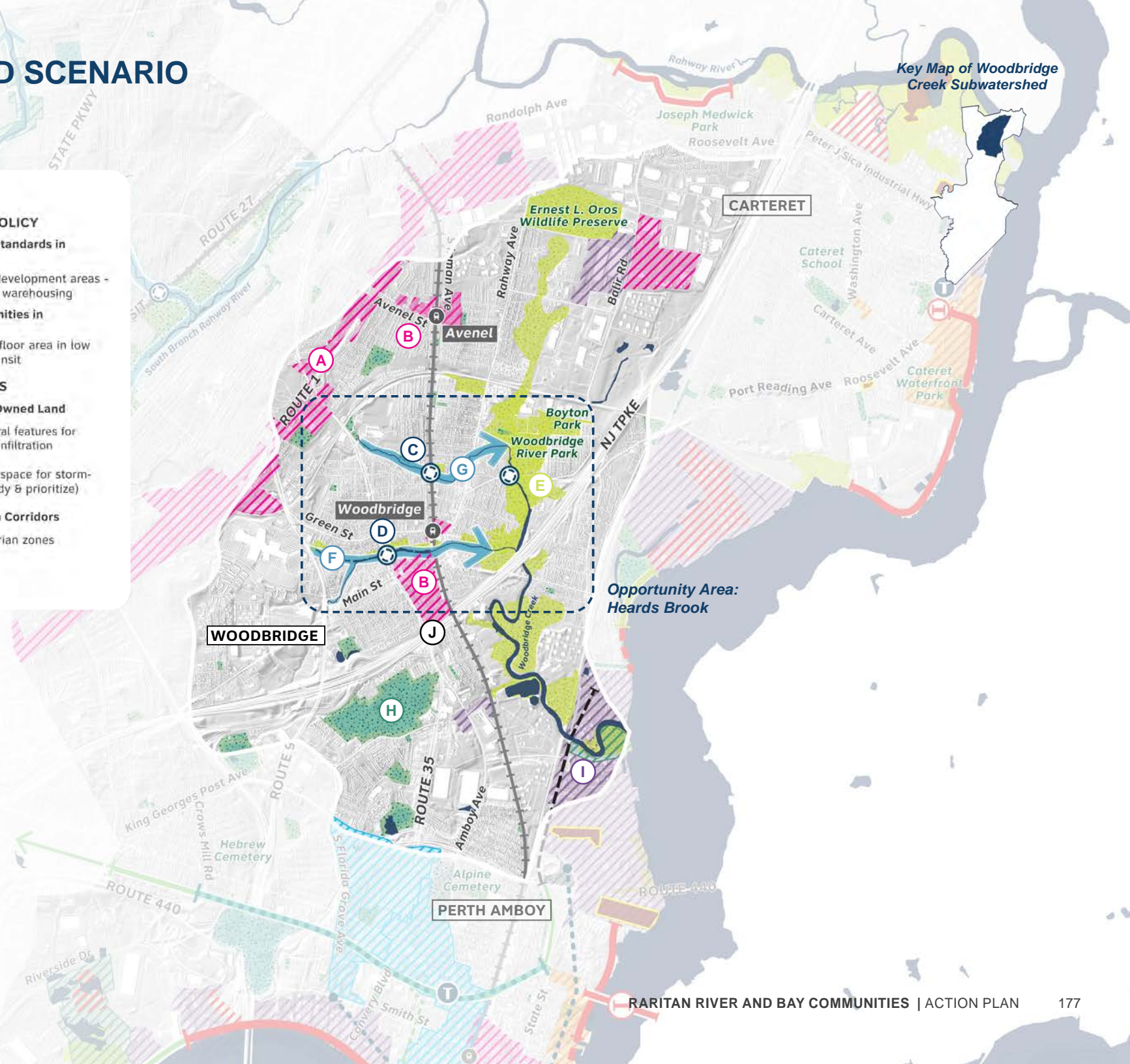
Protect and restore natural features for stormwater storage and infiltration

Retrofit parks and open space for stormwater management (study & prioritize)

Increase Capacity Of Riparian Corridors

Expand and restore riparian zones

Culvert enlargements



OPPORTUNITY AREA: HEARDS BROOK

Flood Risk and Impacts

Coastal flooding extends up Woodbridge Creek and its tributaries, Heards Brook and Wedgewood Brook, to the rail corridor. Heavy rainfall can cause flooding in areas on the banks of the waterways, as well as other low-lying areas. Outdated and undersized drainage infrastructure and culverts contribute to back-ups and localized flooding from heavy rainfall.

With climate change, the risk of flooding in this area is only expected to increase. If **no action is taken** to reduce risk, the potential for damage and disruption is significant. Potential monetary losses due to physical damages to structures and their contents, human impacts, direct business impacts, and the loss of function of public and essential facilities add up to \$100M in damages due to a future storm surge event and \$14M in damages due to a future heavy rainfall event. Flood events in this area have the potential to prevent ingress and egress via critical mobility routes including the NJ Turnpike (I-95) and the NJ TRANSIT line. Residential areas in the vicinity of Heards Brook and Wedgewood Brook may experience increased flooding with more water backing up behind undersized culverts due to more frequent and more severe precipitation events. High concentrations of hazardous waste and wastewater discharge in the area may also pose dangerous public health impacts if they interact with flood waters, threats that are especially acute for environmental justice communities and low-income households in the area. Parts of the area around Heards Brook rank as high as the 90th to 95th national percentile for environmental justice indices (U.S. EPA EJScreen) that account for hazardous waste proximity and wastewater discharge exposure, respectively.



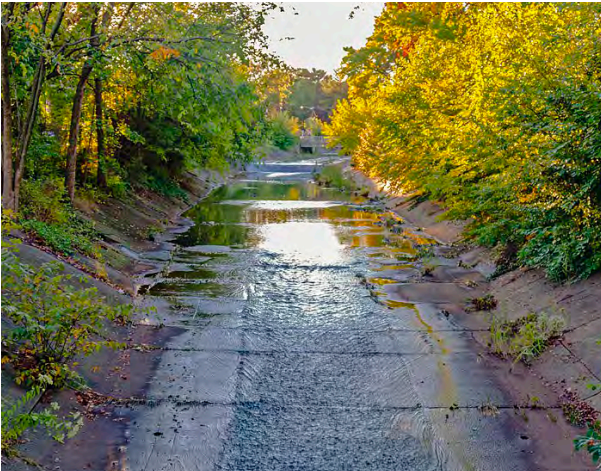
Coastal Storm Surge

\$100 Million
in expected losses



Areal Rainfall Flooding

\$14 Million
in expected losses



HEARDS BROOK
Seen from the Pearl Street bridge near Woodbridge Train Station, Heards Brook is channelized from Route 9 downstream to Woodbridge Creek.

Image Credit: Daniel Case



WEDGEWOOD BROOK
Seen from Barron Ave Bridge, Wedgewood Brook is a channelized stream that drains to Woodbridge Creek



Overview of Strategies

This area requires a watershed-scale stormwater management strategy that starts with further modeling and study to assess and clearly identify where drainage improvements are needed to be most effective. Thus, although the specific interventions and locations shown here are preliminary, they nevertheless represent the range of layered actions that will be necessary to reduce flood risk along these flood-prone creeks while illustrating the variety of non-flood related benefits that such measures could yield for residents, businesses, infrastructure, and community amenities.

These actions consist of measures to **increase the capacity of riparian corridors** by **expanding and restoring riparian zones** along both Heards Brook and Wedgewood Brook and **culvert enlargements** at road and rail crossings where existing culverts constrain these creeks and contribute to upstream flooding. These measures can be supplemented with restoration of these stream corridors that provides additional ecosystem and recreational benefits. The **protection and restoration of natural features** and the **retrofitting of parks and open space** (and even parking lots) for stormwater management along both creeks will further expand the stormwater management capacity of these watersheds and provide additional co-benefits.

In addition to these physical and nature-based strategies, **zoning and land use** changes to promote smart and resilient re-development and ensure the incorporation of stormwater management requirements into redevelopment and new development will be key to ensuring long-term

effective flood risk reduction here. **Protecting and preserving open space** where these restoration and stormwater management strategies can be implemented will be key. Creating development opportunities in lower risk areas—like the area south of Heards Brook between Route 35 and the rail line can be incorporated into resilient redevelopment plans.

Additionally, sections of the NJ Turnpike (I-95) at risk of future flooding should be evaluated to identify mitigation measures near Woodbridge Creek. Potential actions may include **elevation or building a berm/floodwall along the roadway**. These physical and nature-based infrastructure strategies can be complemented by policy strategies to **encourage resilient development through higher redevelopment standards** and expanding access to voluntary buyouts in highly vulnerable areas.



STREAM RESTORATION
Muddy River stream restoration and bank stabilization, Boston, MA



STORMWATER RETROFITS IN PARKING LOTS
Dia Beacon Parking Lot, Beacon NY



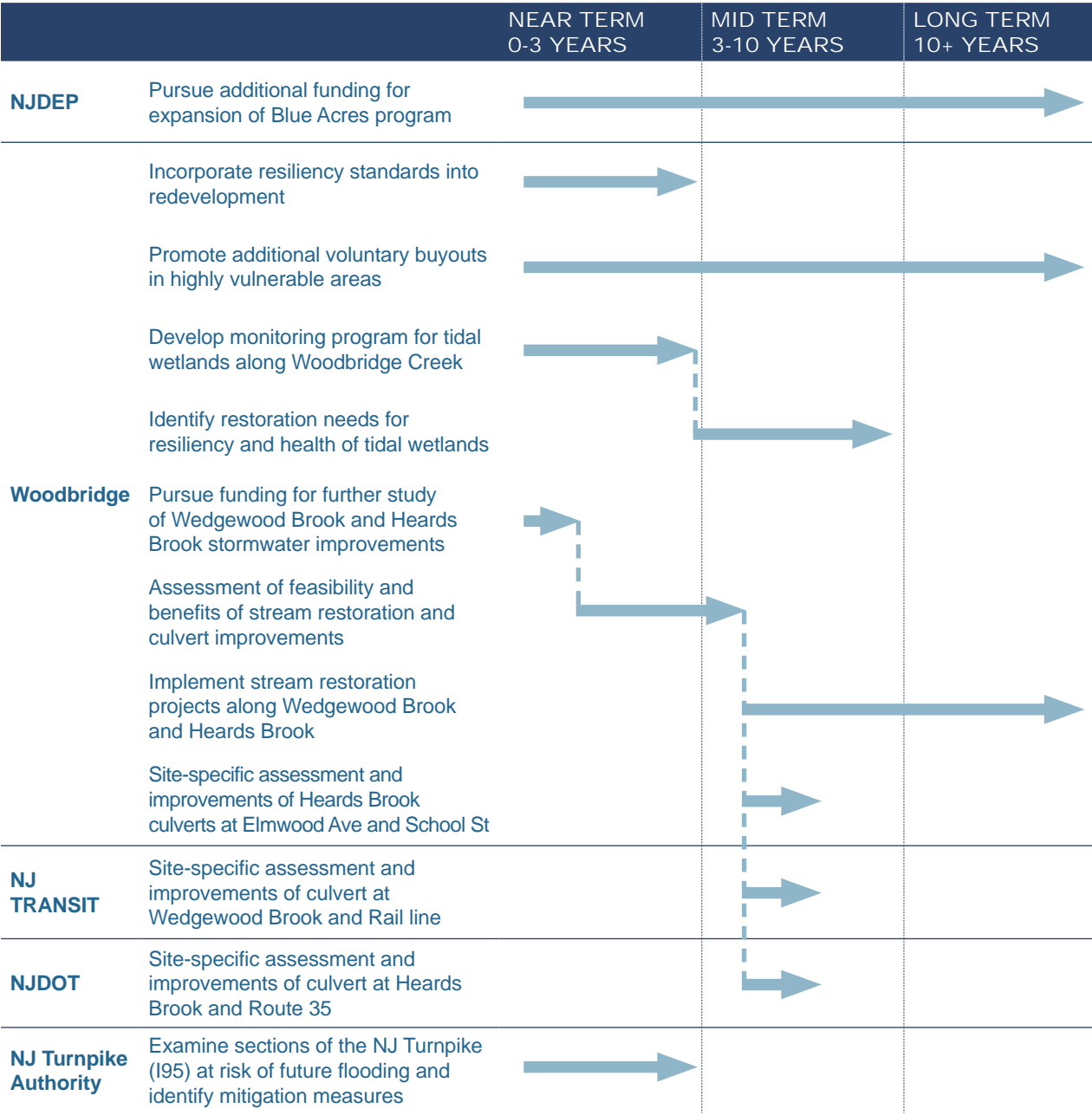


CHANNELIZED HEARDS BROOK TODAY
FROM ROUTE 35 CULVERT BRIDGE

Implementation Roadmap

NJDEP, Woodbridge and various transportation authorities should play key roles in the implementation of actions within the Heards Brook Resilience Opportunity Area. The primary responsibility of NJDEP in this area is pursuing additional funding to expand the Blue Acres program, making buyouts available to property owners in higher risk areas. To encourage resilient, transit-oriented development in lower risk areas near the Woodbridge train station, Woodbridge should lead efforts to incorporate resiliency standards into redevelopment. This action should take priority as redevelopment is already underway in this area. Additionally, Woodbridge should be the lead entity in pursuing funding, conducting feasibility assessments and implementing restoration projects along tributaries of Woodbridge Creek in order to expand available area for flood management. Monitoring and restoration of tidal wetlands is recommended to complement these riparian areas and reduce coastal flooding impacts inland. Transportation agencies including NJ TRANSIT, NJDOT, and NJ Turnpike Authority should coordinate efforts to assess potential culvert improvements to their assets in the area and identify opportunities for mitigating flood risk to critical transportation corridors.

Implementation roadmap for Heards Brook
Resilience Opportunity Area



HEARDS BROOK



CULVERT ENLARGEMENT

MULTIUSE PATH

NATURAL CHANNEL DESIGN &
STREAM RESTORATION

CITIZEN SCIENCE
/ EDUCATIONAL
OPPORTUNITY

SUB-WATERSHED: RAHWAY RIVER & TRIBUTARIES

CARTERET, WOODBRIDGE

The Rahway River and Tributaries sub-watershed is bounded by the Woodbridge Creek sub-watershed to the east, Raritan River sub-watershed to the south, and the Woodbridge municipal boundary to the north. Rahway River and Tributaries represents part of the Arthur Kill Watershed and includes the northeast portion of Woodbridge. This area is not expected to experience significant coastal flooding, because it is further inland and at a higher elevation above sea level, which protects it from storm surge. Most buildings in this sub-watershed are residential. A heavy rainfall event is expected to cause the highest damages, specifically to commercial and residential structures.

Strategies in this region focus on reducing flood risk due to widespread heavy rainfall events and limited coastal flooding impacts near Peter J Sica Industrial Highway through a variety of approaches. These include:

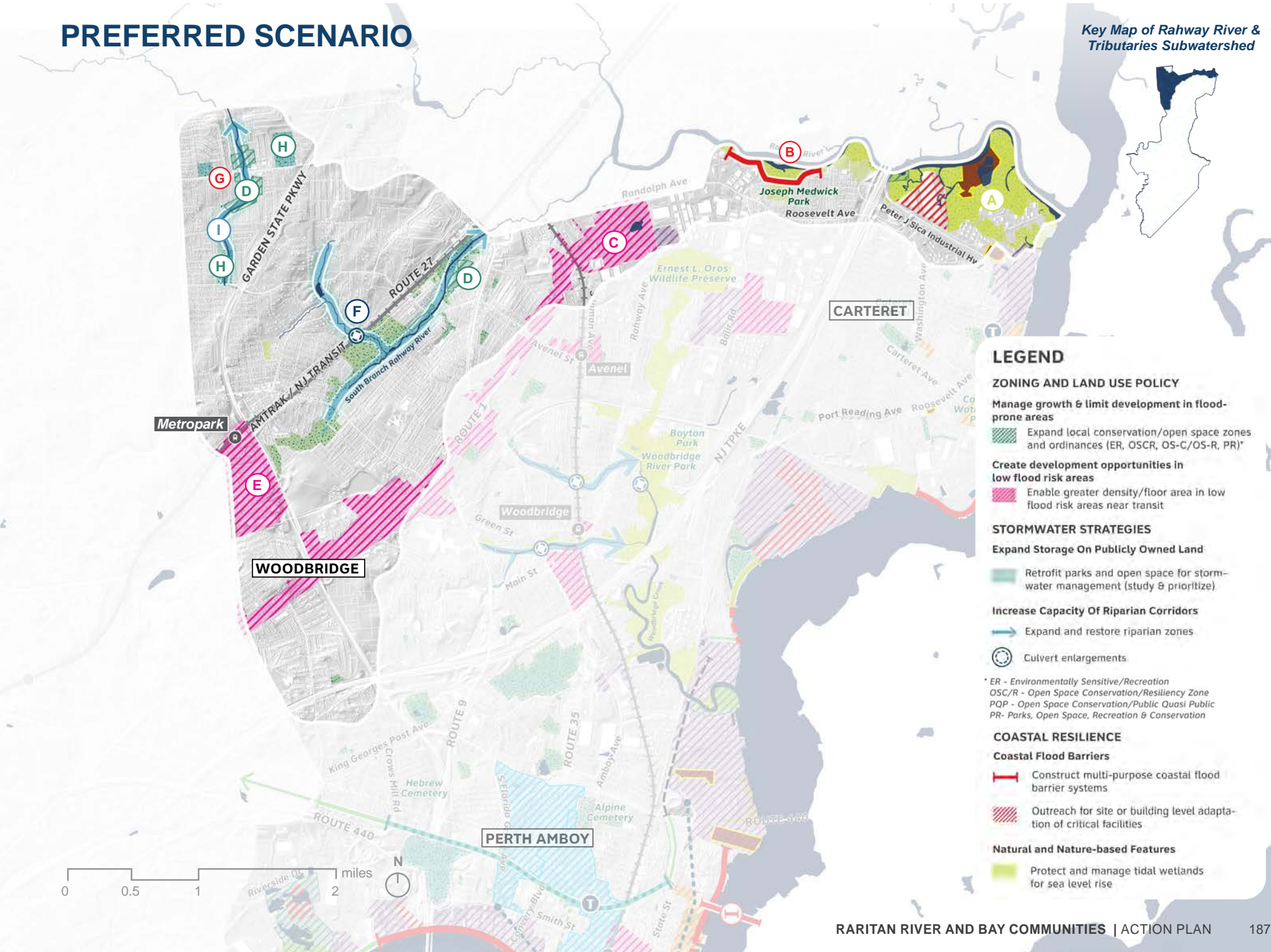
- Targeted outreach on mitigation options to homeowners throughout the region flooded by Ida (including along Pumpkin Patch Brook, Avenel, and other areas of Woodbridge)
- Encouraging mixed-use development outside floodplain near Metropark train station through zoning and land use changes
- South Rahway River at Route 27 Culvert expansion
- Increasing the storage and conveyance capacity of Pumpkin Patch Brook riparian corridor
- Identifying brownfield sites north of Peter J Sica Industrial Highway that are suitable for wetland restoration

RECOMMENDED ACTIONS	ID*	LEAD ENTITY
A. Identify brownfield sites north of Peter J Sica Industrial Highway that are suitable for wetland restoration	C6	Carteret
B. Implement Rahway River Basin project along the south bank of the Rahway River along with road raising	US6	USACE
C. Exploration of long-term opportunities for increased density outside the floodplain, such as along the Route 1 corridors	W2	Woodbridge
D. Use zoning to limit development potential of highly vulnerable areas along Pumpkin Patch Brook and the South Branch of the Rahway River, promote additional voluntary buyouts in highly vulnerable areas and targeted outreach on mitigation options to Ida impacted homeowners	W3, W6, W22	Woodbridge
E. Encourage mixed-use development outside floodplain near Metropark train station. Development should avoid portions of the area vulnerable to flooding from the South Branch of the Rahway River.	W5	Woodbridge
F. South Rahway River Under Northeast Corridor Rail Line Culvert Expansion	NJ16	NJ TRANSIT
G. Site-specific mitigation of flood-prone assets at Henry Inman Library	W10	Woodbridge
H. Explore opportunities for expanded stormwater storage on municipal-owned facilities and right of ways, such as Lynn Elementary School and Colonia Middle School	W16	Woodbridge
I. Increase the storage and conveyance capacity of Pumpkin Patch Brook riparian corridor along with ecological restoration	W20	Woodbridge

*See Summary Table of Recommended Actions starting on page 223 for additional details.

- Outreach to industrial building owners for protection of critical systems and site-specific adaptation north of Peter J Sica Industrial Highway
- Implementation of the USACE Rahway River Basin project

PREFERRED SCENARIO



SUB-WATERSHED: RARITAN RIVERFRONT AND BAY

PERTH AMBOY, SAYREVILLE, SOUTH AMBOY, WOODBRIDGE

The Raritan Riverfront and Bay sub-watershed is characterized by the historic downtowns of South Amboy and Perth Amboy, which are both situated on higher ground just inland from the coast, as well as the area of Sayreville close to Raritan Bay. Recently, new developments in all three municipalities have introduced new housing and open spaces along the waterfront.

Coastal flooding has the potential to impact low-lying areas along the Raritan River and Bay, including the waterfront of Perth and South Amboy, and areas of Woodbridge and Sayreville along the Raritan River. Heavy rainfall flooding can cause ponding in low-lying areas across the area. Perth Amboy is the most densely populated municipality in Middlesex County, with a majority of residents identifying as Hispanic or Latinx. The city is one of the oldest settlements in the region, and has a combined sewer system, which means that under heavy rain events, untreated sewage can be released into the area’s waterbodies, posing a major threat to public health.

Resilience strategies in this area work together to address both heavy rainfall flooding and coastal flooding. Strategies include **increasing storm sewer capacity** in Perth Amboy and **expanding storage on publicly owned lands** including Washington Park and 440 Connector. Expansion of the Middlesex County Greenway, explained in more detail below, increases **right-of-way flood storage** along an inactive rail easement and allows for better conveyance of flood waters.

Zoning strategies such as **encouraging mixed use development outside the floodplain near transit** and conservation zoning along the Raritan River **limit development and reduce density in high risk areas**. Coastal flood barriers including a **berm with integrated multi-use pathways**, a

RECOMMENDED ACTIONS	ID*	LEAD ENTITY
A. Exploration of opportunities for increased density outside the floodplain, such as near the train station and along 2nd street	P1	Perth Amboy
B. Protect vulnerable portions of the Perth Amboy Train Station	NJ14	NJ TRANSIT
C. Site-specific mitigation of flood-prone assets at MCUA Wastewater Treatment Plant and Middlesex Generating Facility	MC2	MCUA
D. Assess opportunities for incorporating flood storage and conveyance into an extension of the Middlesex County Greenway	RRBC7	Resilient RRBC
E. Restore wetlands and riparian areas along the Raritan River	NG3	Rutgers
F. Floodwall and elevated harborwalk on Sadowski Parkway	P3, W14	Perth Amboy, Woodbridge
G. Explore opportunities for expanded stormwater storage on facilities and right of ways owned by Perth Amboy	P5, P6	Perth Amboy
H. Implement the Long-Term Control Plan to reduce CSOs and improve drainage (Improvements include deep storage, new pumping station at 2nd street and beach, additional storage and treatment strategies, sewer separation, and green infrastructure)	P7	Perth Amboy
I. Work with Riverton developer to incorporate nature-based solutions along the shoreline, such as a living shoreline/ into redevelopment plan	SV4	Sayreville
J. Beach replenishment in Perth Amboy to protect waterfront park and recreational assets	US3	USACE
K. Site-specific mitigation of flood-prone assets at Woodbridge Recycling Center	W12	Woodbridge
L. Site-specific flood mitigation of South Amboy Fire Mechanicsville Hose Company	SA3	Sayreville

**See Summary Table of Recommended Actions starting on page 223 for additional details.*

living shoreline along the Riverton development and beach replenishment in Perth Amboy work together to reduce the impacts of coastal flooding while expanding public access to the coast.

PREFERRED SCENARIO

LEGEND

ZONING AND LAND USE POLICY

Manage growth & limit development in flood-prone areas

Expand local conservation/open space zones and ordinances (ER, OSCR, OS-C/OS-R, PR)*

Set resilient redevelopment standards in flood-prone areas

Resilient waterfront redevelopment areas - light industrial use and warehousing

Resilient waterfront redevelopment areas - mixed-use residential

Create development opportunities in low flood risk areas

Enable greater density/floor area in low flood risk areas near transit

STORMWATER STRATEGIES

Expand Storage On Publicly Owned Land

Retrofit parks and open space for storm-water management (study & prioritize)

Eliminate Barriers Caused by Existing Infrastructure

Opportunity for regional consolidated conveyance along publicly owned corridors

Stormsewer separation

Increase stormsewer capacity - deep storage tunnel (Long Term Control Plan)

New Pump Station

COASTAL RESILIENCE

Coastal Flood Barriers

Adapt existing bulkheads

Construct multi-purpose coastal flood barrier systems (with bike & pedestrian paths)

Outreach for site or building level adaptation of critical facilities

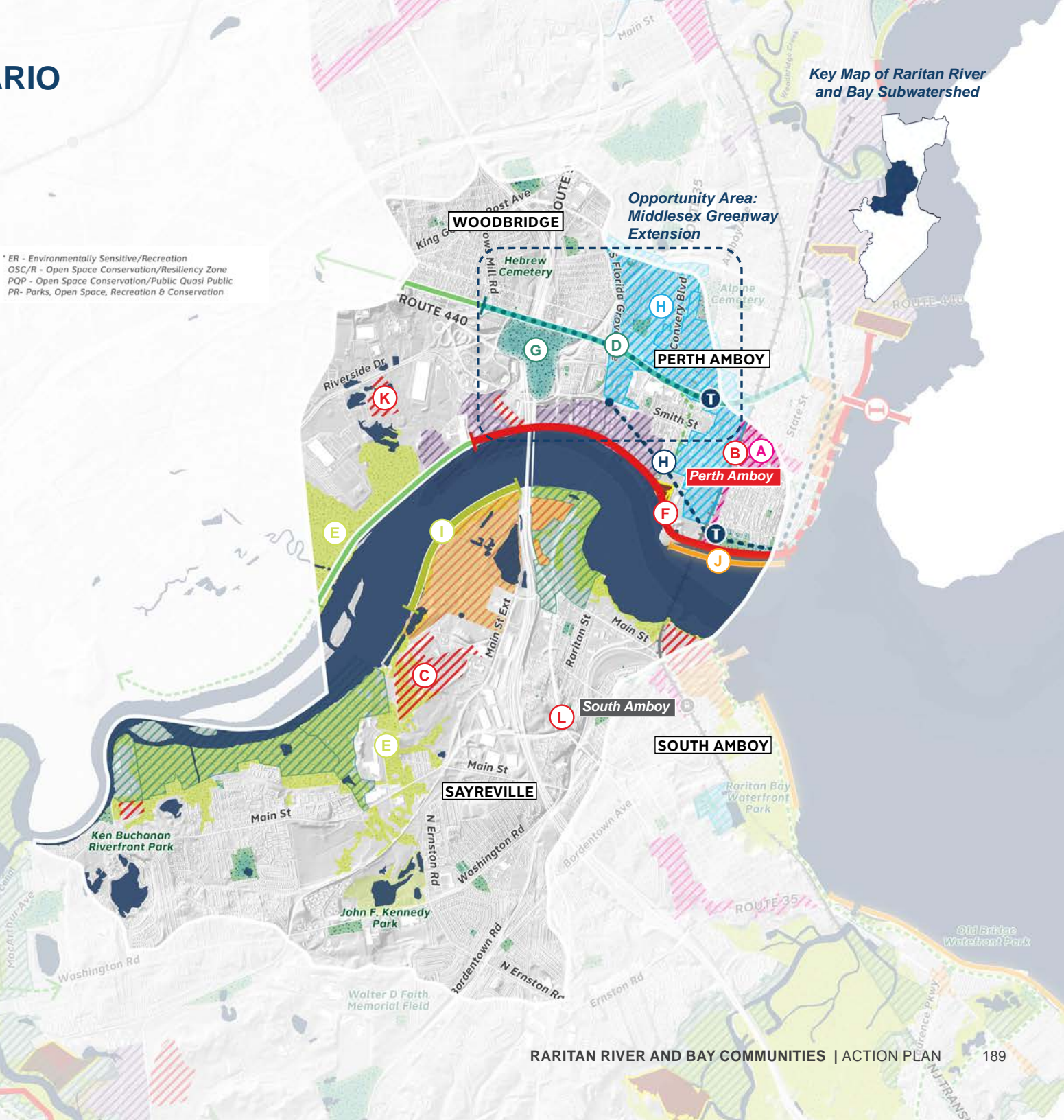
Natural and Nature-based Features

Protect and manage tidal wetlands for sea level rise

Construct living shorelines or vegetated berms to enhance shoreline ecology

Implement beach and dune restoration and renourishment

* ER - Environmentally Sensitive/Recreation
OS-C/R - Open Space Conservation/Resiliency Zone
PQP - Open Space Conservation/Public Quasi Public
PR- Parks, Open Space, Recreation & Conservation



OPPORTUNITY AREA: MIDDLESEX GREENWAY EXTENSION

Flood Risk and Impacts

Flooding from heavy rainfall in the Hopelawn neighborhood of Woodbridge and in the Washington Park area of Perth Amboy is exacerbated by the highway and rail corridor, which cut off natural drainage pathways. These flows need to travel past an abandoned rail embankment, the complicated interchange of NJ-440 and the Garden State Parkway, and residential, commercial, and industrial properties.

With climate change, the risk of flooding in this area is only expected to increase. If no action is taken to reduce risk, the potential for damage is significant. Potential monetary losses due to physical damages to structures and their contents, human impacts, direct business impacts, and the loss of function of public and essential facilities add up to \$87M in damages due to a future heavy rainfall event. Hopelawn Engine Company #1 is within this opportunity area and may be impacted by heavy rainfall events today and in the future. Flooding of this critical facility would impact its ability to provide vital services to the community. Very high concentrations of wastewater discharge and hazardous waste in the area may also pose dangerous public health impacts if they interact with flood waters, threats that are especially acute for environmental justice communities and low-income households in the area. Parts of the area around Hopelawn rank as high as the 95th to 100th national percentile for environmental justice indices (U.S. EPA EJScreen) that account for wastewater discharge exposure and hazardous waste proximity, respectively. Notably, this area also has a very high concentration households without broadband internet access. These neighborhoods are less likely to have easy access to the resources and information needed to prepare for and respond to major flood events.



Areal Rainfall
Flooding

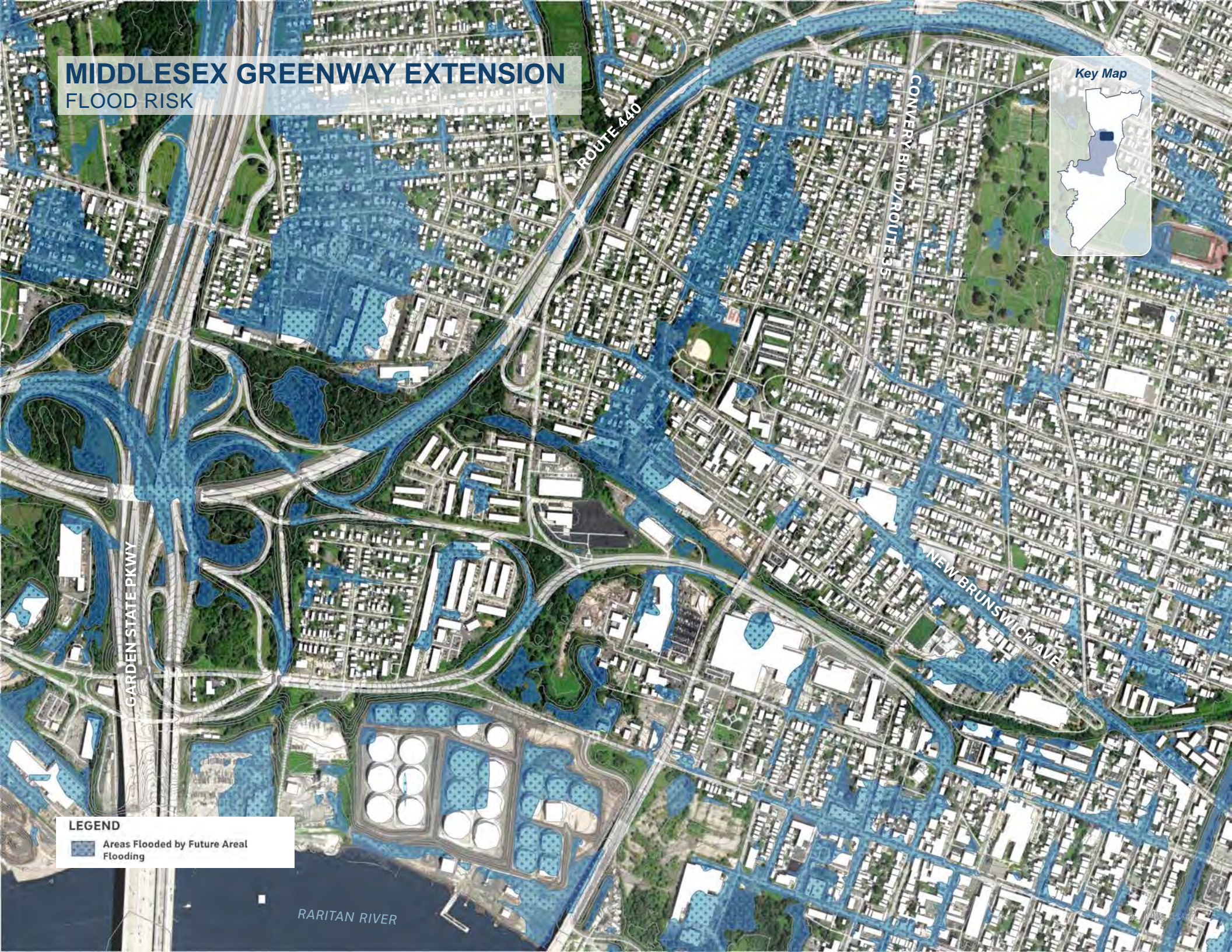
\$87 Million
in expected
losses



LEHIGH FREIGHT RAIL LINE IN PERTH AMBOY
View of underutilized rail right of way near YMCA
Perth Amboy



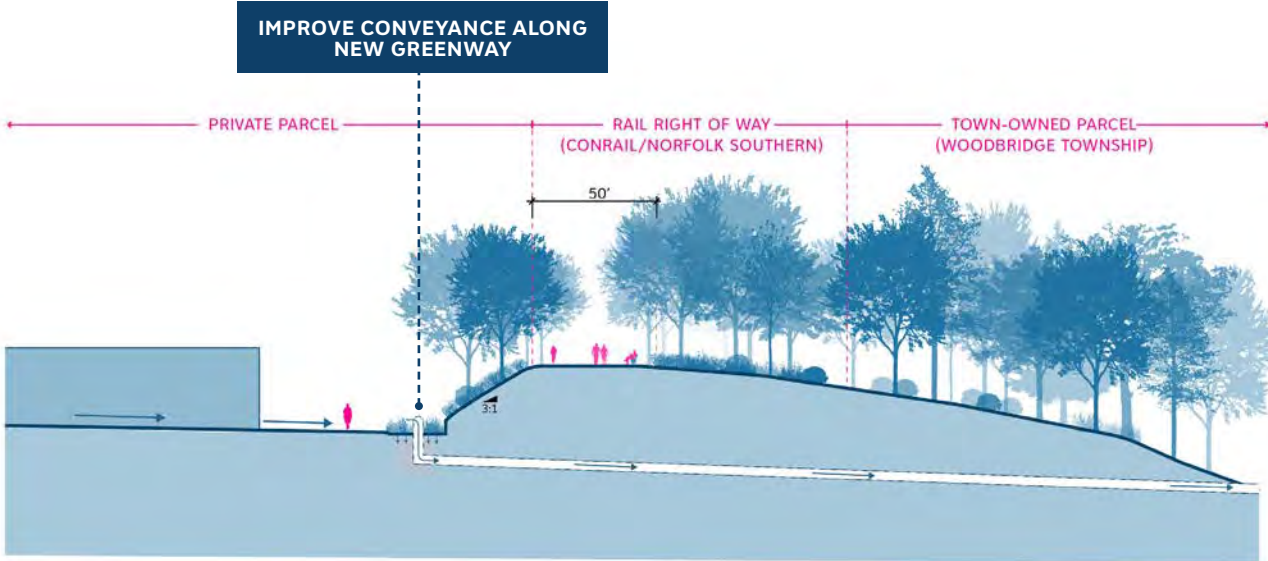
LEHIGH FREIGHT RAIL LINE IN HOPELAWN, WOODBRIDGE
View of underutilized rail right of way near Quincy
Heights Apartments



Overview of Strategies

Portions of this abandoned, former freight rail line have been repurposed into the Middlesex County Greenway, a bike and pedestrian trail which connects the Hopelawn neighborhood to Metuchen. As part of an extension of the trail into Perth Amboy, the rail embankment can be leveraged to help consolidate stormwater by collecting drainage through **right-of-way flood storage** along the abandoned railway. This allows floodwater in the area to be sent past the other barriers in a more efficient and effective location. Additional study of drainage pathways to convey water to existing channels and ultimately to the Raritan River may be needed.

Drainage can also be improved through improvements to Washington Park to increase **stormwater storage** and increasing the capacity of the city’s storm sewer infrastructure.



Improve conveyance along new greenway extension with green and grey infrastructure and study drainage pathways to convey stormwater to existing waterways or the Raritan River



MIDDLESEX GREENWAY
Middlesex Greenway Trail at New Jersey Turnpike Mac Arthur Drive Liddle Avenue Gross Avenue LVRR Perth Amboy Branch



RIGHT-OF-WAY BIOSWALE
Whittier Greenway Trail integrates bioswales with greenways, Los Angeles CA
Image Credit: Whittier Daily News

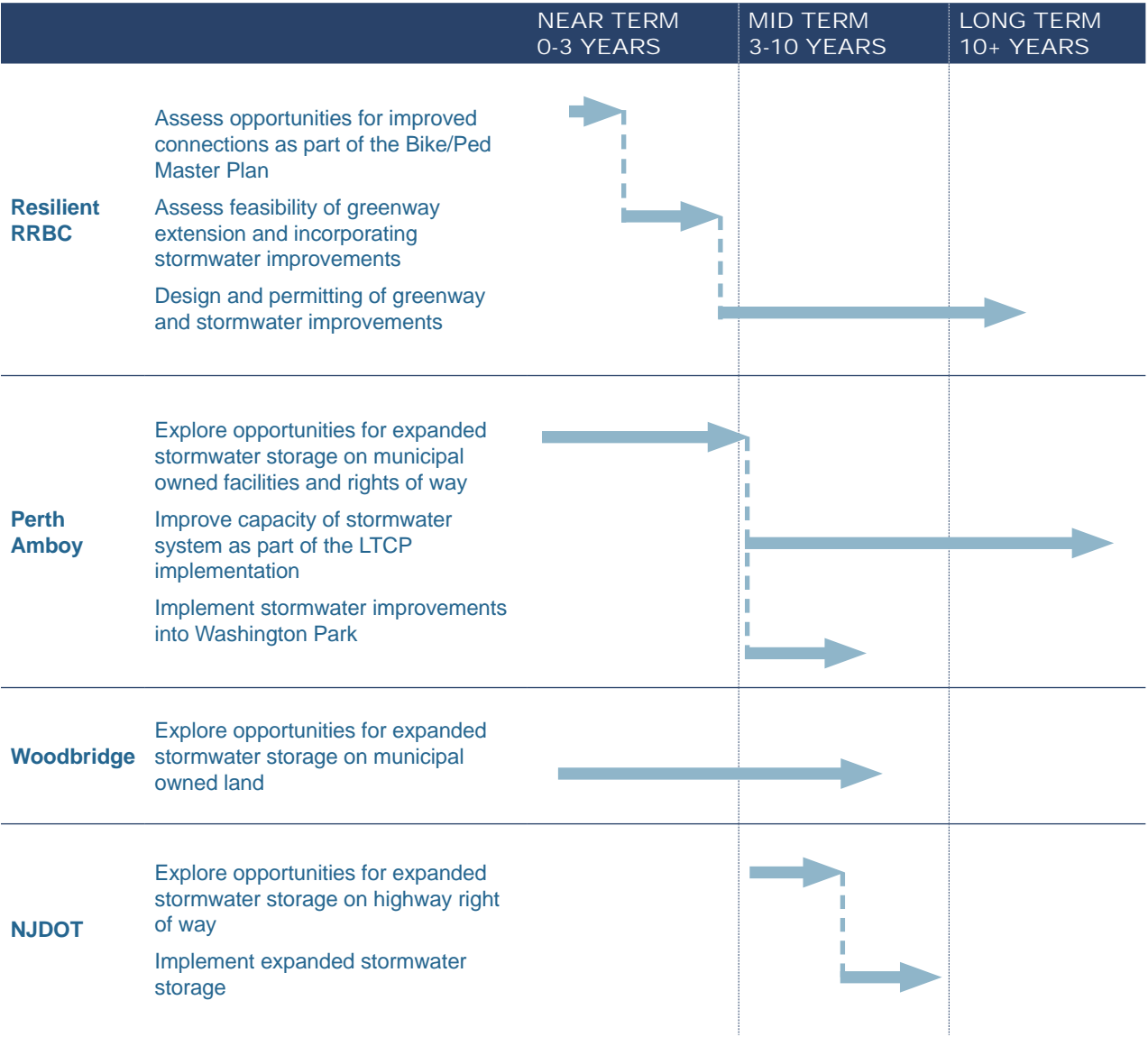




LEHIGH RAILWAY EASEMENT FOR MIDDLESEX GREENWAY EXTENSION

Implementation Roadmap

Middlesex County, Perth Amboy, Woodbridge, and NJDEP should play key roles in the implementation of actions within the Middlesex County Greenway Extension Resilience Opportunity Area. As part of the County's Bike/Pedestrian Master Plan, the County is examining the potential extension of the greenway, and additional analysis of the feasibility of this extension, and opportunities to incorporate stormwater improvements could be pursued as a follow-up study. Both Perth Amboy and Woodbridge should pursue opportunities to expand stormwater storage on municipal-owned facilities and rights of way. Perth Amboy should also look for opportunities to improve capacity of the stormwater system through implementation of their LTCP. NJDOT should also lead identification of opportunities for stormwater storage on the highway right of way and implementation of these opportunities.



Implementation roadmap for Middlesex Greenway Extension Resilience Opportunity Area

MIDDLESEX GREENWAY EXTENSION

ELEVATED REDEVELOPMENT
(INDUSTRIAL / LOGISTICS)

IMPROVE CONVEYANCE
ALONG NEW GREENWAY
THROUGH GREEN AND GREY
INFRASTRUCTURE

STORMWATER
BIOSWALES

MULTI USE PATH

STORMWATER
BIOSWALES

SUB-WATERSHED: SOUTH RIVER & WASHINGTON CANAL

OLD BRIDGE, SAYREVILLE, SOUTH RIVER

The South River / Washington Canal sub-watershed is bounded by the South River sub-watershed (below Duhernal Lake), Tennent Brook and Deep Run sub-watersheds, and the South River municipal boundary to the west. It includes portions of Old Bridge, Sayreville, and South River. The sub-watershed includes the mixed-use downtown of South River, in addition to residential and industrial areas along the river in all the municipalities.

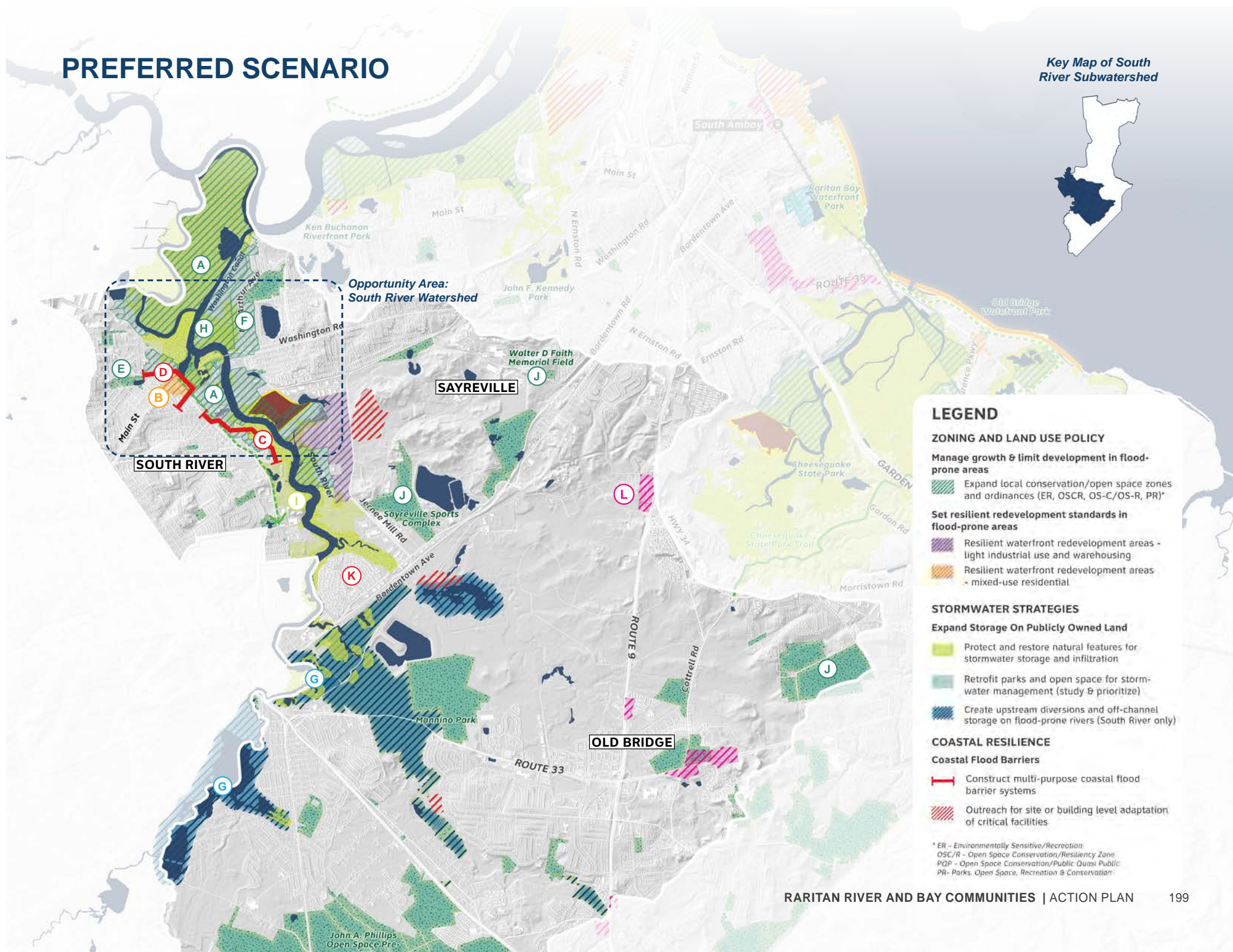
In this sub-watershed, coastal flooding from the Raritan Bay and Raritan River is expected to extend inland for great distances along the South River. Coastal flooding in this sub-watershed is compounded by riverine flooding from upstream tributaries including Tennent Brook and Deep Run and rainfall flooding which has widespread impacts throughout the area.

A watershed-based management strategy is needed to look at opportunities to **increase flood storage in the upper tributaries** to reduce downstream flooding from heavy rainfall events. This can be done in combination with opportunities for **wetland restoration**. Additional **buyouts**, particularly in South River, can reduce impacts from future flood events and transition areas vulnerable to sea level rise to open space. Targeted **outreach** to property owners on flood protection options is needed, along with development of new funding sources to support adaptation of existing buildings. In densely populated areas, like the Winding Woods apartment complex, additional outreach on evacuation is needed.

RECOMMENDED ACTIONS	ID*	LEAD ENTITY
A. Use zoning to limit development potential of sites that have not been bought out along the South River by expanding parks, open space and conservation zones to encompass more of the flood hazard area and promote additional voluntary buyouts in highly vulnerable areas	SR1, SR3	South River
B. Promote resilient redevelopment along Main Street and incorporate resiliency standards, such as elevating first floors and streetscape standards, into redevelopment plans	SR2	South River
C. Coastal flooding protection along the South River (evaluate flood protection alternatives for riverfront from the railroad crossing at Whitehead Avenue south to Bissetts Recreational Area)	SR4	South River
D. Coastal flooding protection of South River downtown core	SR5	South River
E. Explore opportunities for expanded stormwater storage on municipal-owned facilities and right of ways (potential sites include Dailey's Pond Recreation Area, Burton Ave and Louis Street Baseball Field)	SR6	South River
F. Use zoning to limit development potential of sites that have not been bought out along the South River (Expand the OS-C Zone within the SED Zones and remaining residential neighborhoods along MacArthur Avenue)	SV2	Sayreville
G. Study opportunities and potential benefits of upstream storage and diversion within the South River watershed	RRBC11	Resilient RRBC
H. Implement the South River Ecosystem Restoration & Flood Resiliency Enhancement Project and explore additional coastal resilience opportunities along the South River	NG1, NG2	Lower Raritan Watershed Partnership
I. Restore wetlands and riparian areas along the Raritan River	NG3	Rutgers
J. Explore opportunities for expanded stormwater storage on municipal-owned facilities and right of ways (Potential sites include the Sayreville Sports Complex, Walter D. Faith Memorial Fields, Veterans Park)	SV5	Sayreville
K. Promote flood awareness campaign and evacuation for Winding Woods apartment complex	SV6	Sayreville
L. Exploration of opportunities for increased density outside the floodplain, such as along Route 9 to accommodate growth	O2	Old Bridge

*See Summary Table of Recommended Actions starting on page 223 for additional details.

PREFERRED SCENARIO



OPPORTUNITY AREA: SOUTH RIVER AND SAYREVILLE MAIN STREET

Flood Risk and Impacts

Within the South River and Sayreville Main Street Resilience Opportunity Area, both rainfall and coastal flooding are expected to have widespread impacts. In both South River and Sayreville, development on either end of Veterans Memorial Bridge and along the banks of the South River are vulnerable to flooding. Areas of downtown South River face chronic flooding during high tide events today and this is expected to become even more frequent with sea level rise. Following extensive damage in the area caused by Hurricane Sandy, a number of properties were bought out within both municipalities.

With climate change, the risk of flooding in this area is only expected to increase. If **no action is taken** to reduce risk, the potential for damage is significant. Potential monetary losses due to physical damages to structures and their contents, human impacts, direct business impacts, and the loss of function of public and essential facilities add up to \$224M in damages due to a future storm surge event and \$88M in damages due to a future heavy rainfall event. Notably, parts of this Opportunity Area—especially in eastern South River—have some of the highest rates of unemployment in the country. The consequences of a major flood event for unemployed individuals and their households could be especially dire. Conversely, many of the strategies proposed for this Opportunity Area could help spur economic revitalization in the neighborhood, if implemented thoughtfully and equitably in close collaboration with the community.



Coastal
Storm Surge



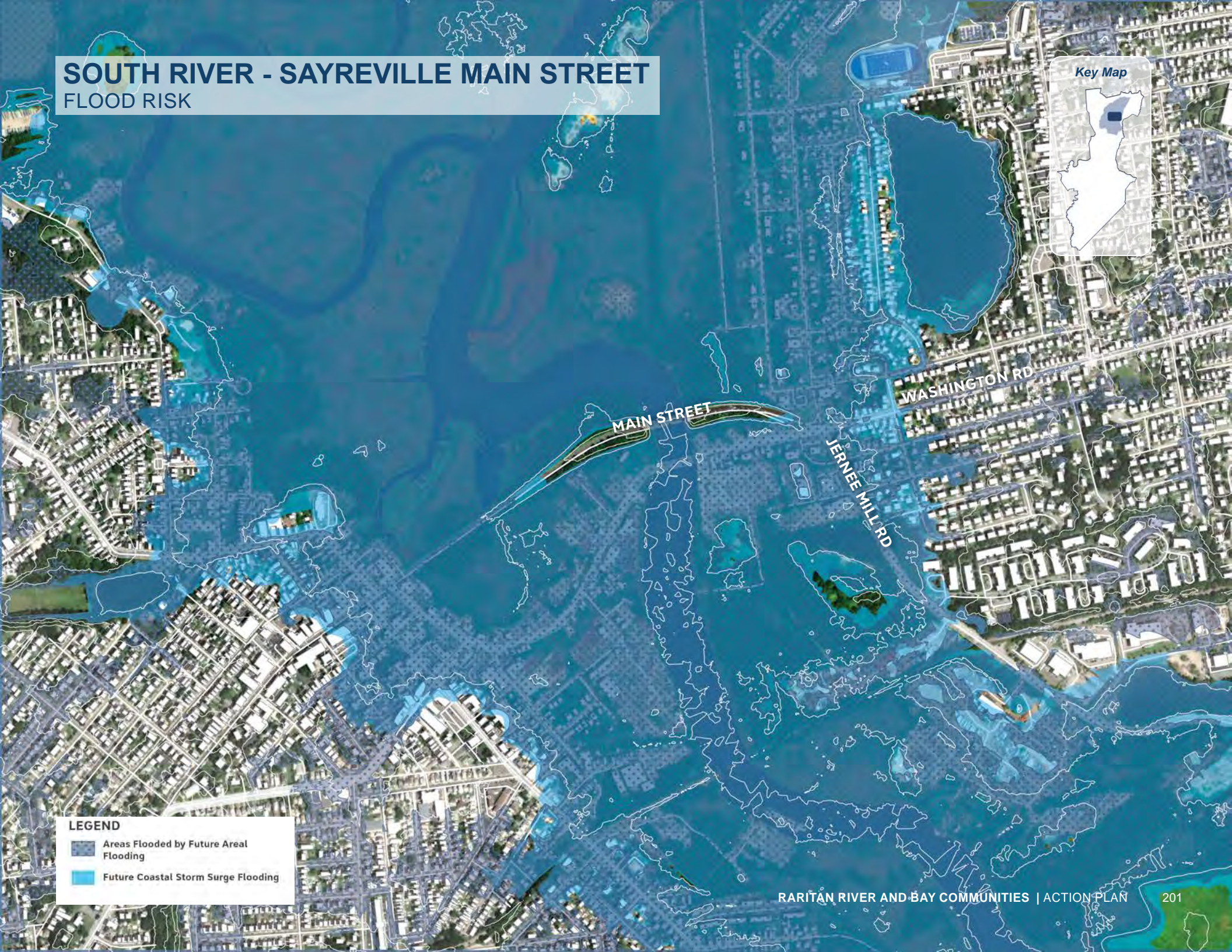
Areal Rainfall
Flooding



WATER STREET AFTER HURRICANE IRENE
South River, NJ on Aug 28, 2011.



MAIN STREET AFTER HURRICANE IRENE
Sayreville Bridge and the Causeway in South River, NJ on Aug 28, 2011.



Overview of Strategies

In South River, an exploration of a **coastal protection** alignment to protect the town’s Main Street district is needed. This area is a priority for redevelopment with a mix of uses including ground floor retail. The area closet to the South River has experienced flooding and is projected to increase in the future. A coastal protection system could be a mix of permanent floodwalls, as well as temporary deployable measures. The proposed alignment shown here is one potential route that should be further explored and confirmed for feasibility. Stormwater drainage inland of the protection system will also need to be evaluated and developed.

Areas close to South River and north and south of Main Street where there have been extensive buyouts should be prioritized for **additional buyouts** and **reuse of land** for open space and waterfront access. Outreach to property owners in needed in these areas, to communicate ongoing flood risk and provide information on potential mitigation options, including buyouts. The zoning in these areas should also be examined and are good candidates for the extension of conservation zoning to reduce the development potential of properties that have not yet been bought out. For those areas along the South River, including acquired open spaces could be repurposes for marinas and boating opportunities, and the zoning should be sure to allow such uses.



MARSH RESTORATION

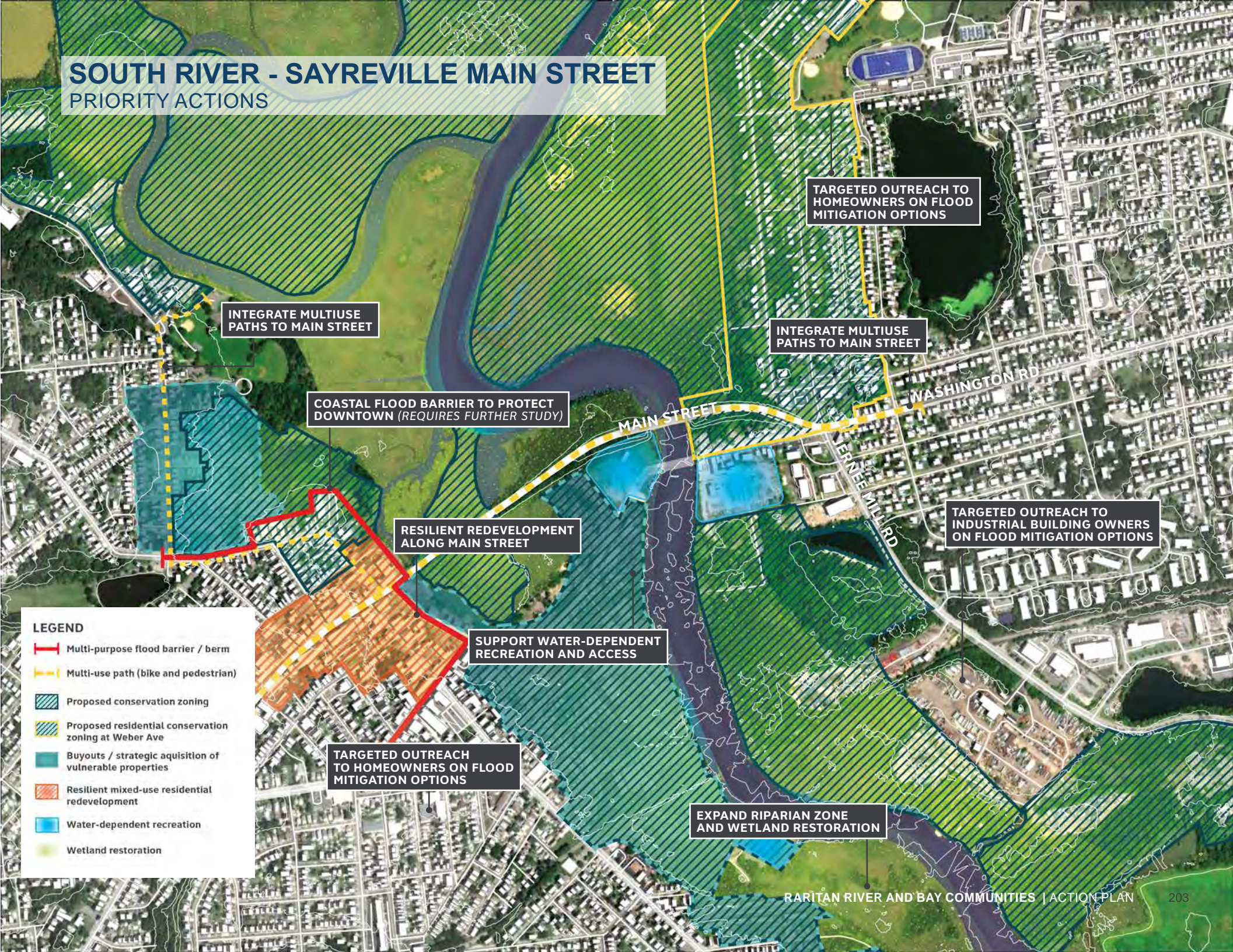
In Avalon, NJ, thin layer placement of sediment across low-lying and degraded sections of the salt marsh helped restore native plants to keep pace with sea level rise

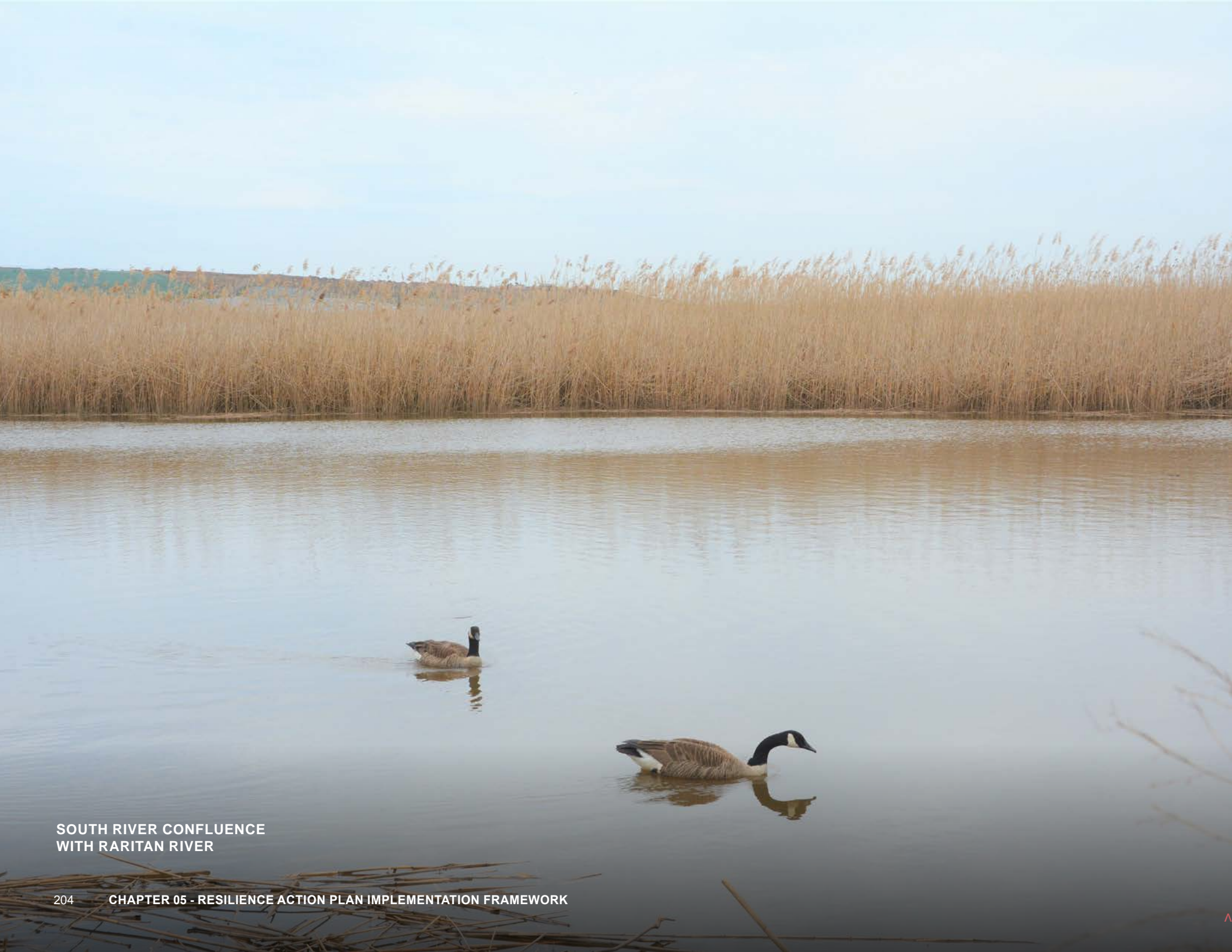
Image Credit: The Nature Conservancy



BUYOUTS

In the Watson-Crampton neighborhood of Woodbridge, properties bought out after Hurricane Sandy have been transformed into public open space

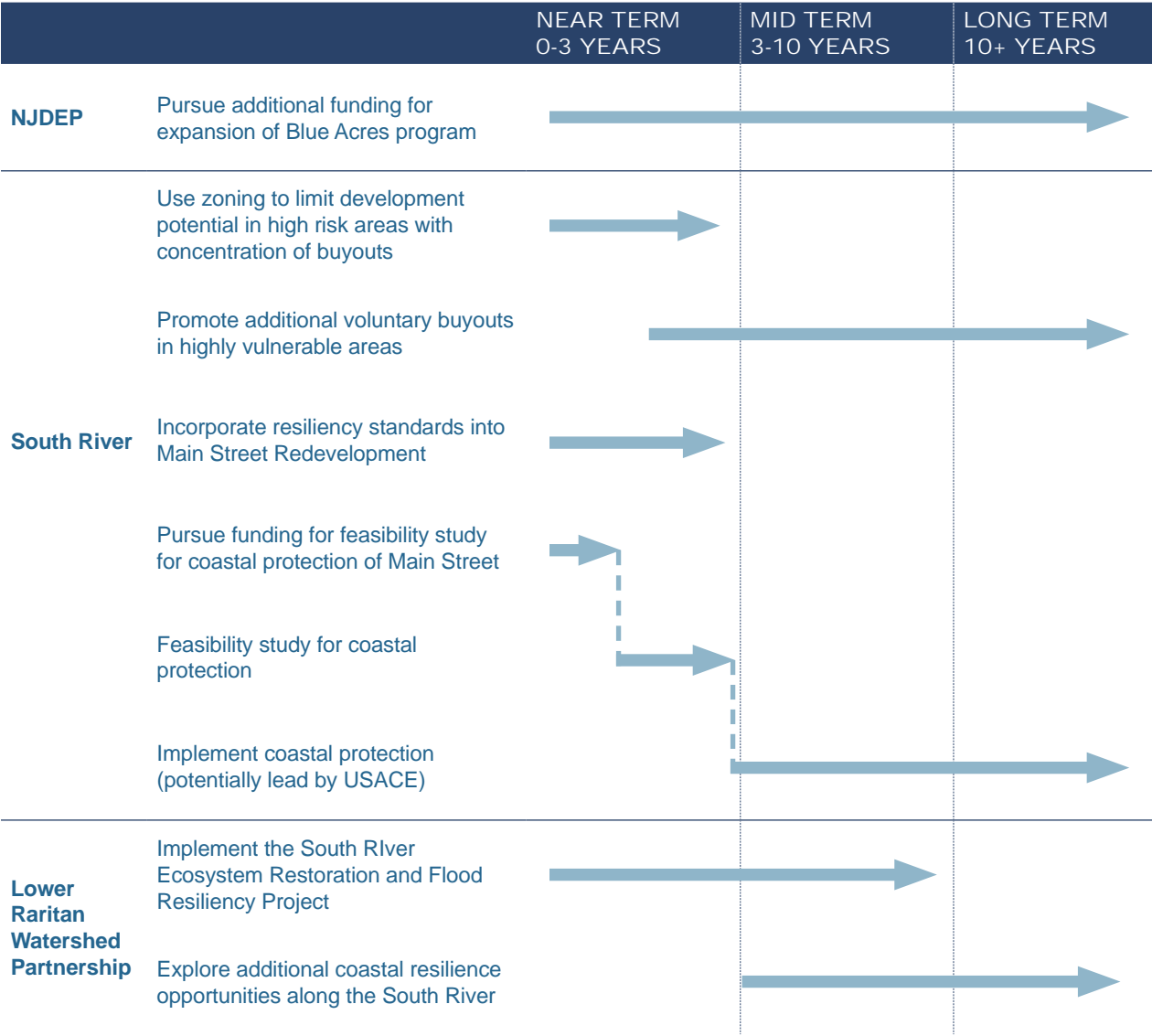




SOUTH RIVER CONFLUENCE
WITH RARITAN RIVER

Implementation Roadmap

NJDEP, South River, Sayreville, and the Lower Raritan River Watershed Partnership should play key roles in the implementation of actions within the South River and Sayreville Main Street Resilience Opportunity Area. The primary responsibility of NJDEP in this area is pursuing additional funding to expand the Blue Acres program, making buyouts available to property owners in higher risk areas. Sayreville should lead efforts to limit development in higher risk areas through zoning. In South River primary responsibilities should include using zoning to limit development in higher risk areas, promoting additional buyouts in higher risk areas, incorporating resiliency standards into redevelopment and pursuing funding to study the feasibility of installing coastal protection for Main Street. Implementation of the South River Ecosystem Restoration & Flood Resiliency Enhancement Project by the Lower Raritan Watershed Partnership will round out efforts in this opportunity area by reducing flood risk near Washington Canal.



Implementation roadmap for South River and Sayreville Main Street Resilience Opportunity Area

SUB-WATERSHED: CHEESEQUAKE & LAURENCE HARBOR

OLD BRIDGE, SAYREVILLE, SOUTH AMBOY

The Cheesquake / Laurence Harbor sub-watershed is bounded by Cheesequake Creek / Whale Creek sub-watershed and the Old Bridge municipal boundary to the east. Cheesequake and Laurence Harbor include expansive wetland areas, including Cheesequake State Park, and coastal beaches across parts of Sayreville, South Amboy, and Old Bridge. The South Amboy waterfront has been the focus of recent waterfront developments, located in proximity to a walkable town center and train station.

The Laurence Harbor section of Old Bridge was developed as a beachfront resort and bungalow colony in the early 20th century. The community was damaged badly from Hurricane Sandy, resulting in damaged homes and some buyouts.

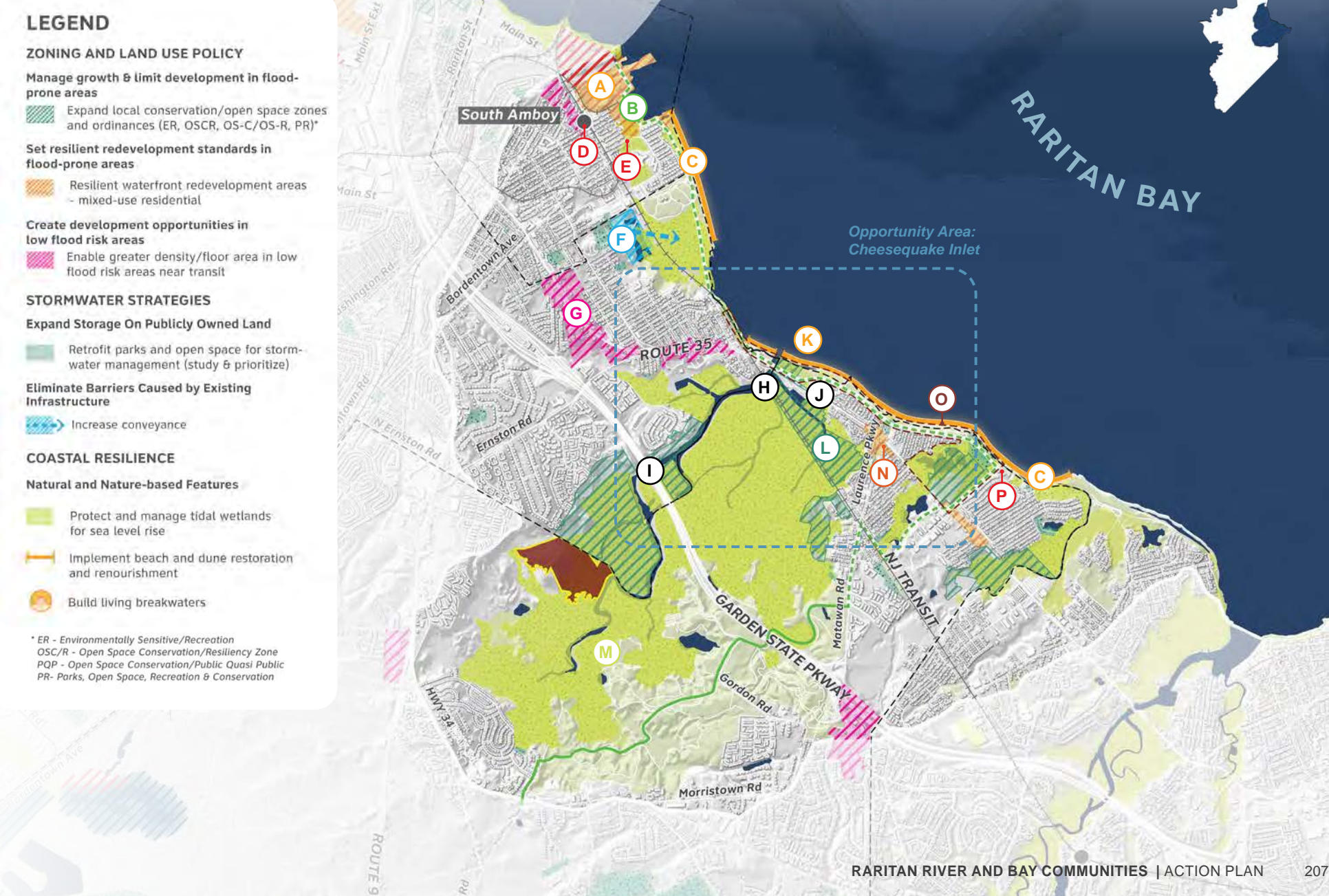
Cheesequake State Park, just inland from the coast, includes a mix of ecosystems, from saltwater marsh and a tidal estuary near the mouth of Cheesequake Creek on the Raritan Bay to hills of northeastern hardwood forest, open fields, a white cedarswamp, and a small portion of Atlantic coastal pine barrens. Monitoring, management, and restoration of the wetlands to improve flood storage capacity should be pursued. There are also sections along the edge of the park that should be examined for additional buyouts and limitations on future development.

Resilience strategies in this area include **beach and dune nourishment** along the coast, and **protection of key transportation corridors**, including the New Jersey Coast Line, Route 35, and the Garden State Parkway.

**See Summary Table of Recommended Actions starting on page 223 for additional details.*

RECOMMENDED ACTIONS	ID*	LEAD ENTITY
A. Promote resilient redevelopment along the South Amboy waterfront	SA1	South Amboy
B. Require contiguous waterfront walkway during redevelopment for future coastal protection infrastructure and waterfront access	A2	All Municipalities
C. Beach Nourishment along Raritan Bay	US2, US5	USACE
D. Protect or adapt South Amboy Pump Station	MC1	MCUA
E. Site-specific flood mitigation of South Amboy Fire Department Snorkel Fire Company	SA2	South Amboy
F. Increase conveyance between rail line and marsh inland of Raritan Bay Waterfront	NJ15	NJ TRANSIT
G. Exploration of opportunities for increased density outside the floodplain, such as along Route 35 to accommodate growth	SV3	Sayreville
H. Study and develop alternatives to reduce flood risk to NJ TRANSIT Coast Line	NJ13	NJ TRANSIT
I. Examine sections of the Garden State Parkway at risk of future flooding and identify mitigation measures	NJ 11	NJ Turnpike Authority
J. Examine opportunities to protect vulnerable sections of Route 35 in Old Bridge	NJ27	NJDOT
K. Installation of breakwaters along the coast could serve to buffer storm waves and reduce erosion of the beach	US8	USACE
L. Coordinate with the NJDEP Blue Acres program to identify suitable buyout properties in areas of high risk, such as area surrounding Cheesequake State Park that are prone to coastal flooding from Cheesequake Creek	O3	Old Bridge
M. Monitoring, management, and restoration of wetlands to improve flood storage capacity within and around the edges of Cheesequake State Park	NJ19	NJDEP
N. Explore zoning changes and other tools to promote resilient redevelopment of waterfront along Laurence Parkway	O1	Old Bridge
O. Remediation of Slag superfund site	US1	US EPA
P. Site-specific mitigation of Laurence Harbor Pump Station	O7	Old Bridge Municipal Utilities Authority

PREFERRED SCENARIO



OPPORTUNITY AREA: CHEESEQUAKE INLET & LAURENCE HARBOR

Flood Risk and Impacts

The Laurence Harbor beachfront is highly vulnerable to coastal flooding. Cheesequake inlet serves as a major flood pathway to coastal flooding further inland. Low-lying portions of the area are also vulnerable to ponding from heavy rainfall.

The beachfront is part of the Raritan Bay Slag superfund site that is being examined by the U.S. Environmental Protection Agency. Due to the lead content in the area, public access at the beach has been limited.

With climate change, the risk of flooding in this area is only expected to increase. If no action is taken to reduce risk, the potential for damage is significant. Potential monetary losses due to physical damages to structures and their contents, human impacts, direct business impacts, and the loss of function of public and essential facilities add up to \$29M in damages due to a future storm surge event and \$16M in damages due to a future heavy rainfall event. In addition to providing flood risk mitigation for the surrounding communities, the strategies proposed below could provide substantial ecosystem benefits while increasing open space and waterfront access for nearby populations, improving overall quality of life and potentially mitigating the risks of Additional Climate Hazards.



Coastal Storm Surge



\$29 Million in expected losses



Areal Rainfall Flooding



\$16 Million in expected losses



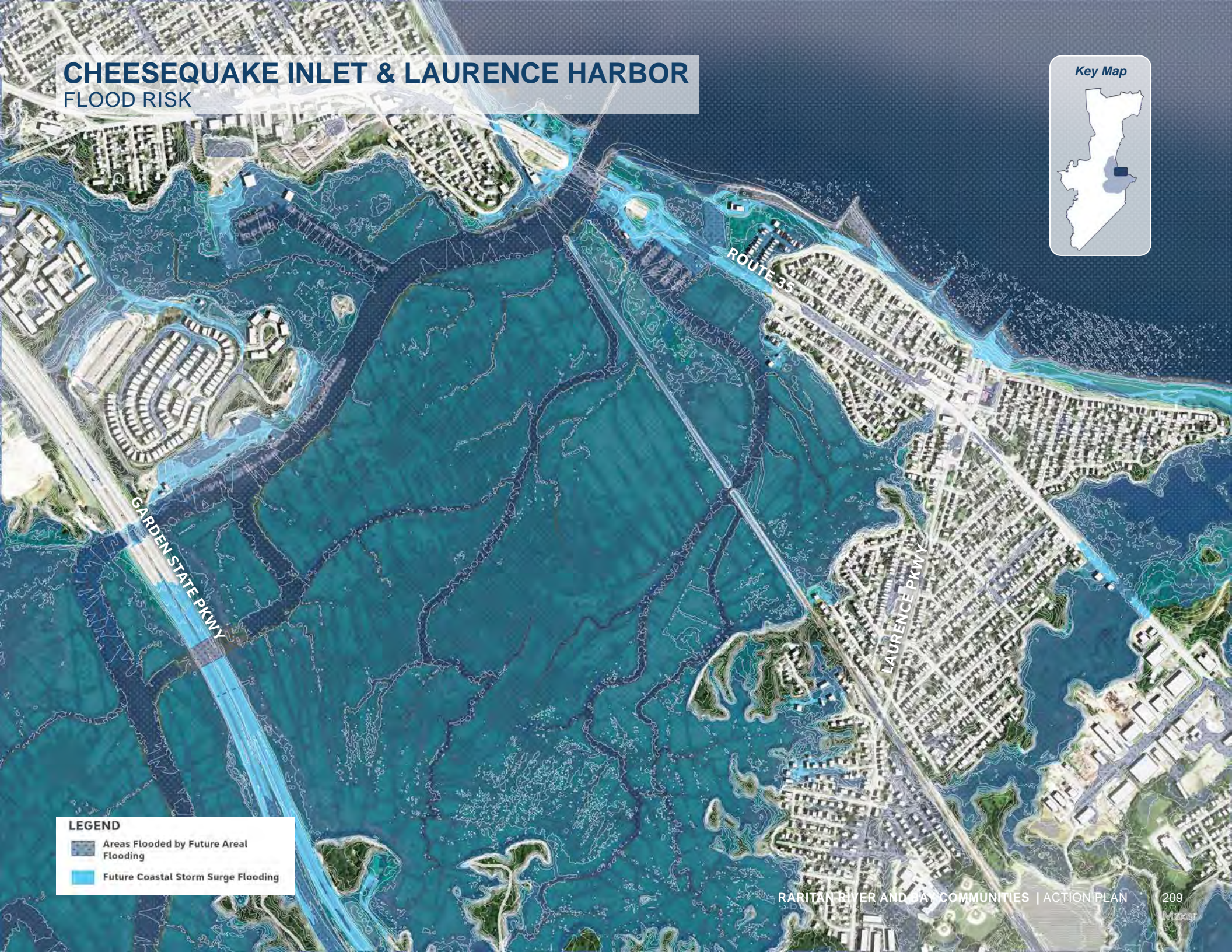
MORGAN MARINA AT CHEESEQUAKE CREEK
Parlin, NJ

Image Credit: Marinas.com



LAURENCE HARBOR BEACH BOARDWALK
Laurence Harbor, NJ

Image Credit: Mapio



Overview of Strategies

Proposed flood risk reduction strategies in this area focus on coastal resilience measures along the waterfront including **beach and dune restoration** and **living breakwaters** in addition to **protection of key regional transportation corridors** that cross through this area.

In the 1960’s the U.S. Army Corps of Engineers (USACE) built a beach berm in Laurence Harbor. After Hurricane Sandy the stretch was replenished again. Additional future replenishment may be needed, which could include additional dune habitat creation and an offshore breakwater to attenuate storm waves and reduce beach erosion.

With funding from the recent Federal Bipartisan Infrastructure Bill, the USACE will be rebuilding the jetty at Cheesequake Inlet, which will maintain the navigation of the creek for recreational boats.

Elevation of Route 35 will protect the key evacuation route from future flood events. Potential flood mitigation opportunities for the vulnerable New Jersey Coast Line and Garden State Parkway should also be examined, in addition to looking at how additional tidal exchange can improve the health of the tidal wetlands in the park.



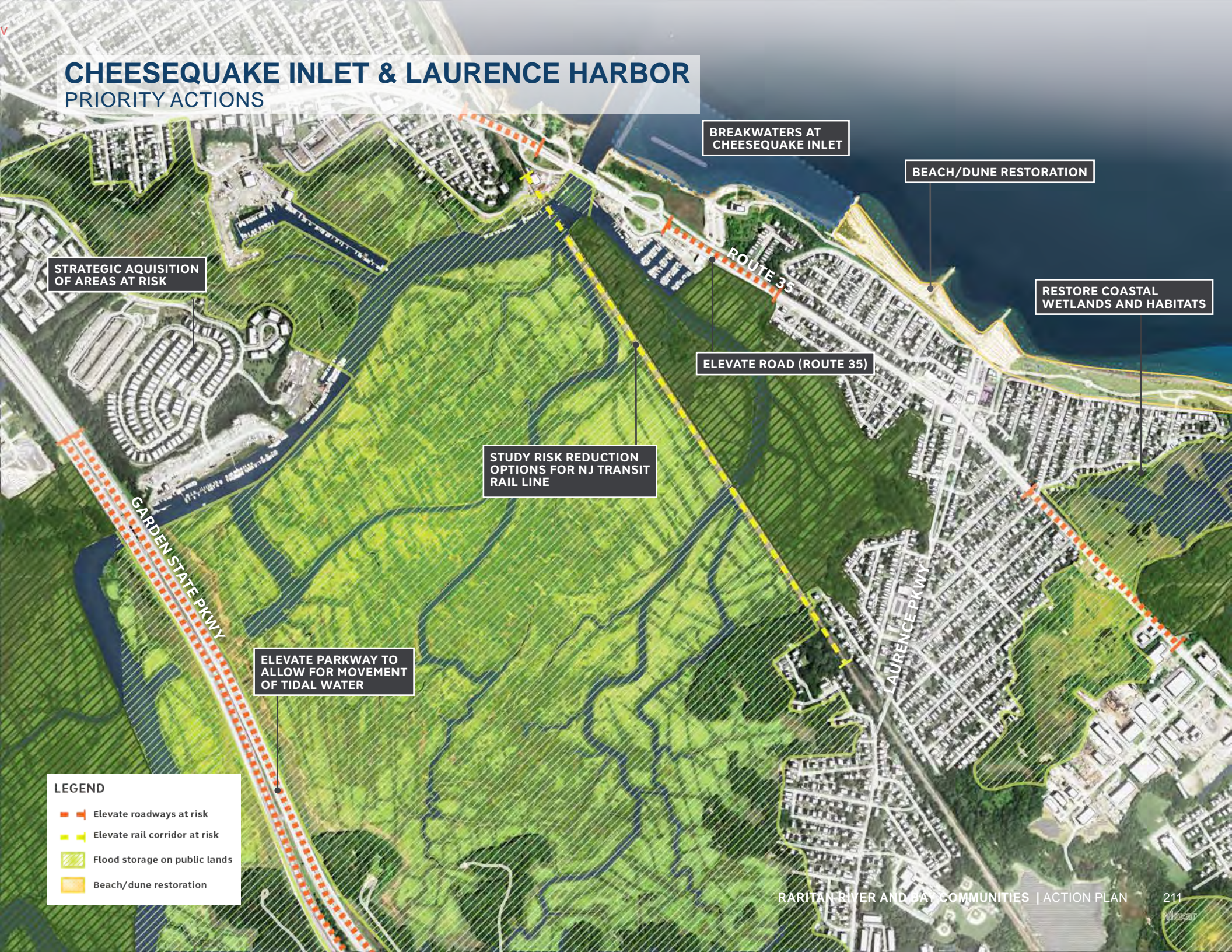
DUNE RESTORATION
Dunes in Midway Beach, South Seaside Park, New Jersey



MARSH RESTORATION
In Avalon, NJ, thin layer placement of sediment across low-lying and degraded sections of the salt marsh helped restore native plants to keep pace with sea level rise (Image Credit: TNC)



LIVING BREAKWATERS
Just across Raritan Bay in Tottenville, Staten Island (NY), living breakwaters are being constructed to reduce long-term beach erosion, knock down storm waves, and provide structured habitat for a variety of aquatic species. (Image Credit: SCAPE)



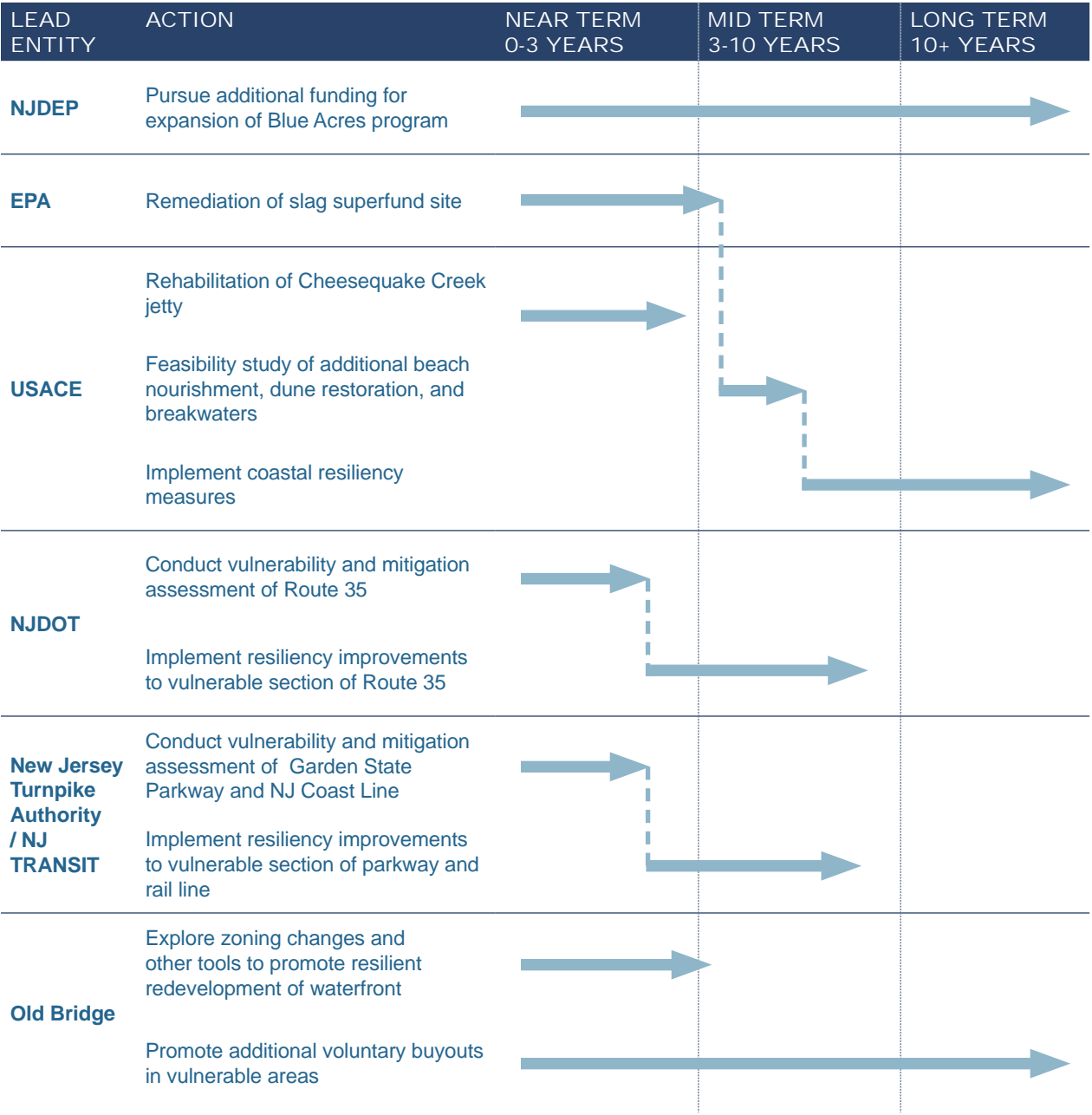


CHEESEQUAKE INLET TODAY
Image Credit: Marinas.com

Implementation Roadmap

NJDEP, EPA, USACE, NJDOT, NJ Turnpike Authority / NJ TRANSIT, and Old Bridge should play key roles in the implementation of actions within the Cheesequake Inlet Resilience Opportunity Area. Federal Agencies including EPA and USACE should continue leading ongoing projects in the area to remediate the Slag superfund site and rehabilitate the Cheesequake Creek Jetty, respectively. USACE should also consider pursuing a feasibility study to explore additional mitigation opportunities to reduce flood risk and maintain the inlet. Transportation agencies, including NJDOT, NJ Turnpike Authority, and NJ TRANSIT, should lead efforts to conduct vulnerability assessments and mitigation of risks to their key assets in this opportunity area. The primary responsibility of NJDEP in this area is pursuing additional funding to expand the Blue Acres program, making buyouts available to property owners in higher risk areas bordering Cheesequake State Park. Old Bridge should take the lead in exploring zoning changes and other opportunities to promote resilient redevelopment along the waterfront and promote buyouts in higher risk areas.

Implementation roadmap for Cheesequake Inlet & Laurence Harbor Resilience Opportunity Area



CHEESEQUAKE INLET

