

# Vermont's Resilience

---

TARA KULKARNI, PhD. P.E.

ASSOCIATE PROFESSOR, CIVIL AND  
ENVIRONMENTAL ENGINEERING

DIRECTOR, CENTER FOR GLOBAL  
RESILIENCE AND SECURITY @  
NORWICH UNIVERSITY

FEB 04, 2020



# Introduction

---



Resilient Vermont  
network



Water and  
wastewater



Green stormwater  
infrastructure



Resilient cities

Resilience. Metrics. Actions



# From the roadmap to resilience

---

### **A Resilient Vermont:**

A resilient Vermont is better prepared for and able to more effectively manage and bounce back from natural disasters and climate-related shocks, and the risks they pose to our economy, environment, and social well-being.

A resilient Vermont focuses on both proactively reducing our vulnerabilities and improving our response and recovery, to ensure that we are continually strengthening our resilience.

We must be resilient at every level – from individual residents, households, and businesses and neighborhoods, to the entire community and state. There is a shared sense of responsibility for resilience at every level and across the public, private, and nonprofit sectors.

# resilience

---

Better prepared

Proactive

Reduce vulnerability

Improve response and recovery

Continually strengthen

Resilient at every level

Shared responsibility



## Know Our Risks

Vermont needs to not only conduct the research to be well informed about risks posed by a changing climate, but also fully utilize the data we already have by making information easily accessible, in formats and tools that are useful to communities and individuals as they plan for the future.



## Elevate & Integrate Emergency Management

The work to plan, prepare, respond to and recover from disasters is ongoing, it shouldn't receive attention only in the immediate aftermath of disaster and it shouldn't be isolated within one department, division or local organization.

Vermont needs to elevate emergency management as critically important at all times, and integrate it throughout local, regional and statewide work.



## Align Rules & Investments for Stronger Communities

We know that our state is vulnerable to climate change, and that our risks grow as the climate becomes more unstable. Yet, we also have inherited a system of incentives, rules, and frameworks for decision making that don't reflect this reality. We need to structure rules and direct our investments towards greater resilience and create disincentives for actions that increase vulnerability.



## Working Together & Learning Together

The challenges Vermont faces in establishing resilience are complex, they reach across sectors and across jurisdictions, and require collaboration and continuous learning. It is easy for communications and collaboration to break down, even in a small state like Vermont, and we need to remain proactive in continuing to work, and learn, together.

# Key takeaways

---

SOURCE: VERMONT'S  
ROADMAP TO RESILIENCE, 2013



### ALIGN RULES & INVESTMENTS FOR STRONGER COMMUNITIES

**KEY**  
● Significant progress ● Some progress ● No progress

**RECOMMENDATION**

**STATUS**

<b>11.</b> Provide guidance and incentives for proactive investment in transportation infrastructure.	<ul style="list-style-type: none"> <li>In 2013 VTrans and ANR released new road and bridge standards and a manual on Standard River Management Principles and Practices (coupled with a River and Roads Training Program) to reflect lessons learned from Tropical Storm Irene.</li> <li>To date, 86% of municipalities have adopted standards that meet or exceed the new guidance from VTrans.</li> <li>The state has also created a new incentive for the adoption of these standards through the Emergency Relief and Assistance Fund (ERAF).</li> <li>The work underway at VTrans to incorporate risk into project prioritization (see #3) may provide an opportunity to create additional incentives for municipalities.</li> </ul>
<b>12.</b> Prioritize investment in resilient water and wastewater infrastructure.	<ul style="list-style-type: none"> <li>The Vermont Drinking Water Revolving Loan Fund has adjusted priority points to boost projects that will make water infrastructure more resilient.</li> <li>ANR is partnering with willing municipalities to evaluate opportunities for increasing the resilience of water distribution and treatment facilities.</li> </ul>
<b>13.</b> Invest in training and technical assistance programs to promote cost-effective action and preparedness, and reduce future disruptions to state and municipal infrastructure systems.	<ul style="list-style-type: none"> <li>VT Rural Water is working on trainings for asset management and capital improvement.</li> <li>Vermont League of Cities and Towns and Green Mountain Water Environment Association are also providing support to communities.</li> </ul>
<b>14.</b> Engage private landowners as key partners to implement land management practices that reduce hazards and support healthy ecosystems.	<ul style="list-style-type: none"> <li>No progress to report.</li> </ul>
<b>15.</b> Leverage existing investment in conservation and stormwater management to maximize resilience benefits.	<ul style="list-style-type: none"> <li>New screening tools are enabling land trusts to identify potential areas for restoration of floodplain functions through conservation.</li> <li>New stormwater policy has focused attention on opportunities to maximize the resiliency benefits of our stormwater and water quality investments.</li> </ul>



### ALIGN RULES & INVESTMENTS FOR STRONGER COMMUNITIES

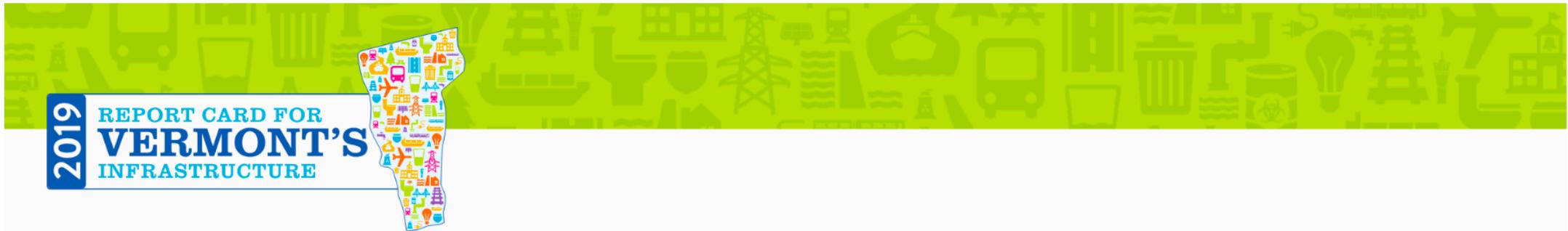
**KEY**  
● Significant progress ● Some progress ● No progress

**RECOMMENDATION**

**STATUS**

<b>16.</b> Create a regulatory framework/ approach to land use that does not create any new or additional vulnerabilities along Vermont's waterways ("No Adverse Impact" approach).	<ul style="list-style-type: none"> <li>ANR has established No Adverse Impact (NAI) regulations for river corridor and floodplain uses not regulated by municipalities (i.e., energy generation/transmission facilities, schools, accepted agricultural and silvicultural practices, roads and other transportation infrastructure). The NAI framework has also been established in Act 250 procedures used by the ANR in defining floodways, including river corridors.</li> <li>There is no consistent regulatory framework for small scale development at the local level.</li> </ul>
<b>17.</b> Develop model flood resiliency bylaws for compact communities located in river corridors.	<ul style="list-style-type: none"> <li>DEC is in the process of developing a draft model bylaw and will engage a multi-agency/stakeholder group in review by the end of 2015.</li> </ul>
<b>18.</b> Establish a dedicated fund to support the purchase of hazard-prone properties that are at high risk but are not eligible for funding through FEMA or other programs.	<ul style="list-style-type: none"> <li>No progress to report.</li> </ul>
<b>19.</b> Designate pilot adaptation areas and direct investments into those areas.	<ul style="list-style-type: none"> <li>The Vermont Economic Resilience Initiative (VERI) has taken an approach similar to what is described in this recommendation. VERI began with a statewide assessment of the relationship between Vermont's economic assets and flood vulnerabilities. Five economic centers were then selected as pilot communities and are engaged in detailed planning. This effort focused ACCD's planning resources; however, it is not linked to any implementation funding.</li> </ul>

Source: Progress Report, Vermont's Roadmap to Resilience, August 20, 2015



# DRINKING WATER

C-

## SUMMARY

Vermont's approximately 1,391 public water systems consist of sources, treatment, reservoirs, pumping facilities, and pipes, which deliver quality water to customers. Overall, Vermont's public water systems have shown an improving compliance rate. However, the system is aging. In 2016, a leak detection service surveyed approximately 257 miles of pipe across 32 systems and identified 117 leaks. An estimated 963,720 gallons per day of drinking water was being lost through these leaks. The Environmental Protection Agency estimates that Vermont drinking water infrastructure will need \$642.9 million over the next 20 years. This estimate is a large increase from previous EPA total needs numbers, and reflects that much of Vermont's drinking water infrastructure is aging and will need to be replaced and upgraded to maintain compliance and ensure quality drinking water to customers. Vermont's aging and rural populations are especially vulnerable to the costs associated with replacing aging assets and addressing emerging contaminants. The cost to maintain, replace and upgrade the infrastructure will ultimately be the responsibility of the water users. Smaller communities with low median household incomes will need to continue to utilize loan programs to offset needed improvements.



# WASTEWATER

D+

## SUMMARY

Vermont processes over 15 billion gallons of wastewater annually in its 92 municipal direct discharging permitted wastewater treatment plants (WWTPs) used by half the state's population, and even more in its soil-based wastewater treatment systems, such as septic systems, used by the other half. The WWTPs and septic systems, along with piping networks and pumping stations, make up Vermont's wastewater infrastructure. Many of these systems are in need of expensive upgrades, especially in communities with combined sewer systems, where overflows pose potential for public safety concerns, and in WWTPs required to meet new phosphorus standards. In 2015, the passage of Vermont's Clean Water Act focused available resources toward addressing impaired waters across the state. As a result of this higher prioritization and concerted efforts by the state, increased state and federal dollars, including an increased Lake Champlain Basin Program award, the funding gap between what wastewater infrastructure needs and what revenues provide was reduced.<sup>1</sup> In 2017, the Vermont Treasurer's Clean Water Report estimated an average annual gap, between wastewater infrastructure need and available revenues, of \$13.7 million for each of the next twenty years, to upgrade and maintain Vermont's municipal wastewater direct discharge infrastructure.

# AGING INFRASTRUCTURE

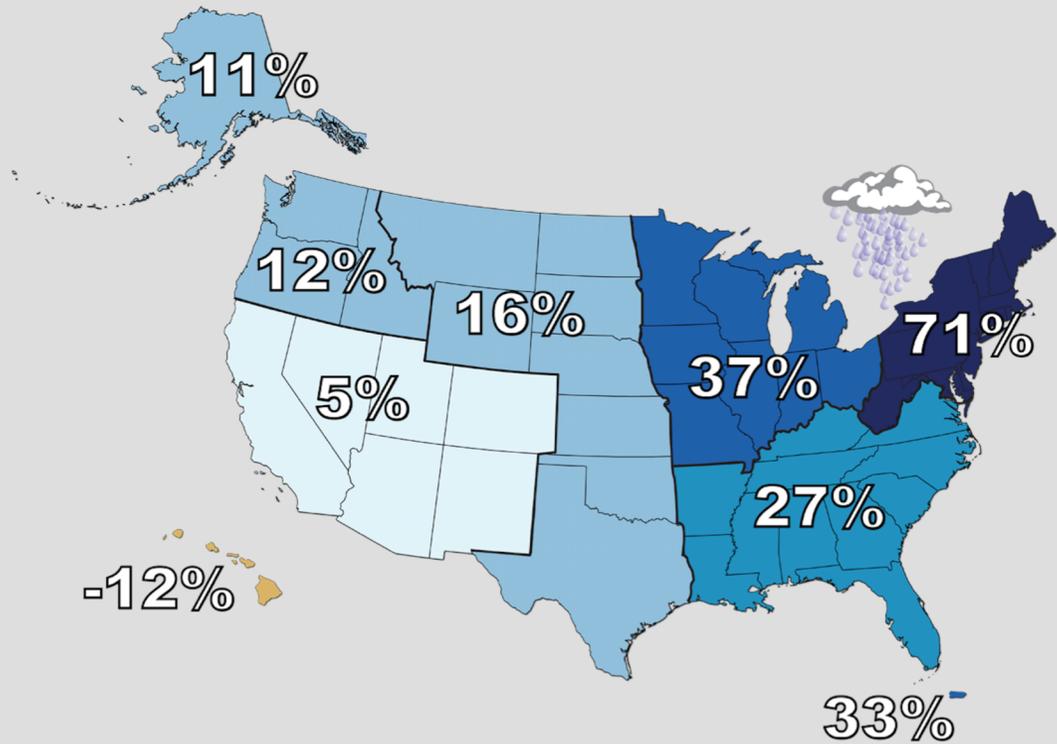
---



**D+**



<u>2013 REPORT CARD</u>	D+
<u>2009 REPORT CARD</u>	D+
<u>2005 REPORT CARD</u>	D
<u>2001 REPORT CARD</u>	D+
<u>1998 REPORT CARD</u>	D
<u>1988 REPORT CARD</u>	C



## LOTS OF RAINFALL

### Key Message: Urbanization and Infrastructure Systems

Climate change and its impacts threaten the well-being of urban residents in all U.S. regions.

Essential infrastructure systems such as water, energy supply, and transportation will increasingly be compromised by interrelated climate change impacts. The nation's economy, security, and culture all depend on the resilience of urban infrastructure systems.

# Defining resilience

---

“Infrastructure resiliency is the ability to gracefully degrade and subsequently recover from a potentially catastrophic disturbance that is internal or external in origin

- Source: American Society of Civil Engineers (ASCE) and National Science Foundation (NSF) researchers under the Resilient and Sustainable Infrastructure (RESIN)

In the context of flooding, resilience is the capacity of a system (community, society, or environment), to adapt, resist, and/or recover from the flood in order to maintain or achieve an acceptable level of functioning.

- Source, Pelling, (2003)

In the context of resilience building: resilience is the potential to absorb and cope with impacts of climate shocks and extremes in the short-term, and to reorganize, and redevelop, preferably to an improved state in the longer term

- Source: Engel, et. al. (2014)





# Why are metrics important?

---

- ❖ The very act of defining a metric, and the discussions on its structure, help a community clarify and formalize an abstract concept.
- ❖ *Establishes a baseline*
- ❖ Prioritize needs (for improvement)
- ❖ *Monitor and track progress*
- ❖ Compare the benefits of increasing resilience with the associated costs
- ❖ *Metrics may be quantitative or have ordinate properties that allow it to be ranked into categories such as “unsatisfactory”, “marginal”, “satisfactory”; or “A, B, C, D” etc.*

## Resilient GSI Indicators:

---

Greenhouse gas emissions  $\Delta$  

---

Temperature (urban heat island effect)  $\Delta T$

---

Flooding  $\Delta V$ ,  $\Delta WQ$ ,  $\Delta \$$

---

Real estate  $\Delta \$$

---

GW recharge -  $\Delta H$

---

Economy (jobs created/added) -  $\Delta J$

---

Water use/reuse -  $\Delta V$ ,  $\Delta \$$

---

Building energy costs -  $\Delta e$

---

Wildlife habitat -  $\Delta$   

---

Recreation -  $\Delta$  

# 100 RESILIENT CITIES - RESILIENCE

---

## DEFINING URBAN RESILIENCE

Resilience is about **surviving and thriving**,  
regardless of the challenge.

**Urban resilience** is the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience.



Source: 100 Resilient Cities

# 100 RESILIENT CITIES – EXAMPLE ATLANTA

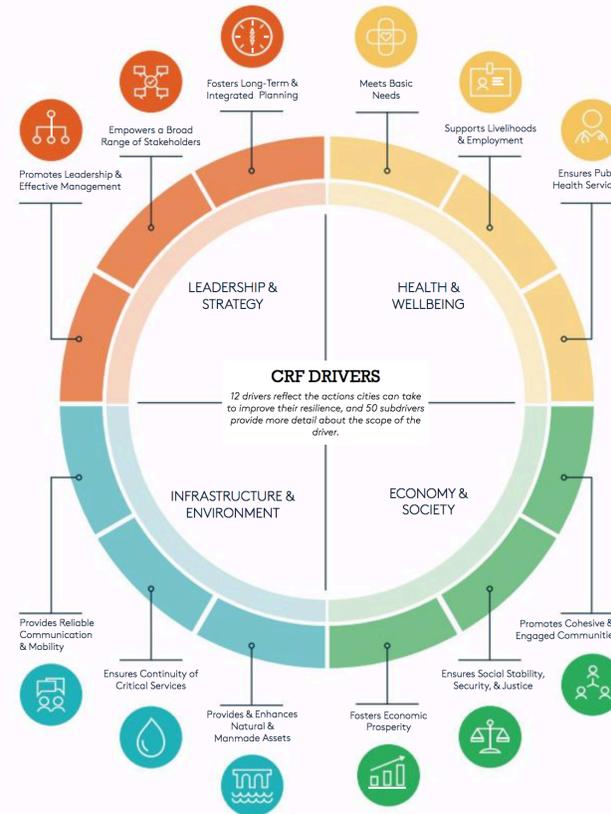
## City Resilience Framework

The City Resilience Framework (CRF) provides a lens to understand the complexity of cities and the drivers that contribute to their resilience, and a common language that enables cities to share knowledge and experiences. The CRF is built on four essential dimensions of urban resilience:

- **Health & Wellbeing:** of everyone living and working in the city
- **Economy & Society:** the social and financial systems that enable urban populations to live peacefully and act collectively
- **Infrastructure & Environment:** the way in which man-made and natural infrastructure provide critical services and protects urban citizens
- **Leadership & Strategy:** effective leadership, empowered stakeholders, and integrated planning



30



31

# 100 RESILIENT CITIES – ATLANTA (GSI)

## Vision 3 – Building our future city - today

### TARGET 3.4

#### Create 500 new acres of publicly accessible greenspace by 2022.



The City will create 500 new acres of publicly accessible greenspace by 2022. Public open spaces foster civic connection and build social capital while improving environmental health and increasing opportunity for physical activity. However, according to the 2009 City of Atlanta Project Greenspace assessment, only 41 percent of Atlantans live in areas where they can safely walk to a nearby park, and many of Atlanta’s existing parks are smaller than the national threshold for a full-service park. Since Project Greenspace was published, the City has worked diligently to add new parks and greenspace but there is still a critical need for accessible greenspace. In Action 3.4.1, the City will construct the Proctor Creek Greenway trail to increase public greenspace and transit access, catalyze economic development, and create a healthy livable environment for an area of the city which faces considerable environmental and economic challenges. Action 3.4.2 creates a funding strategy to support and ensure a more equal distribution of greenspace throughout the city. Action 3.4.3 expands the functions of the City of Atlanta Tree Recompense Fund to better protect and grow Atlanta’s tree canopy.

### TARGET 3.5

#### Install sustainable energy- and water-efficient infrastructure improvements in public spaces as well as around 500 homes and businesses each year.



The City will work with local organizations, businesses, and private-property owners to install water-and energy-efficient systems in order to manage drought, stormwater flooding, and rising energy costs to ensure a sustainable future for the city. For instance, most commercial entities, such as restaurants, are billed primarily at Tier 3-usage rates, so every gallon of water conserved would produce savings of \$21.85 per gallon of water.<sup>38</sup> Action 3.5.1 develops a restaurant water-efficiency program to reduce waste and water costs. Action 3.5.2 recommends the creation of a stormwater utility fee to fund green infrastructure improvements. Action 3.5.3 increases the use of solar improvements through bulk purchasing options. Action 3.5.4 educates and encourages homeowners to adopt energy-saving techniques. Action 3.5.5 supports a resilient infrastructure demonstration project on Ted Turner Drive to encourage innovation and greater use of resilient infrastructure across Metro Atlanta.

### Action 3.5.2: Create a stormwater utility fee to develop and fund a comprehensive stormwater management program

Establish a stormwater utility fee to fund the City’s stormwater management plan, which is designed to reduce surface flooding, address aging infrastructure, and improve the quality of water in our streams. This initiative will include funding projects identified in the City’s Watershed Improvement Plans, leveraging partnerships through the Green Infrastructure Strategic Action Plan, and providing incentives for customers to install green infrastructure best management practices (BMP’s) on private property to help manage on-site stormwater runoff. The Department of Watershed Management has proposed a comprehensive Stormwater Management Program to be supported by a sustainable stormwater utility fee established through the standard practice of billing property owners based on the amount of impervious surface present on a property. The program will be modeled after a combination of national best practices and programs from neighboring jurisdictions. Atlanta’s stormwater utility fee will be designed to specifically address equity concerns by providing grant programs to ensure low-income residents are neither adversely affected by the cost of the fee nor unable to participate in BMP implementation programs.

**Resilience Value to Atlantans:**

- Primary Driver*  
Ensures Continuity of Critical Services

- Secondary Driver*  
Provides & Enhances Natural & Manmade Assets

**Lead Implementing Partners:**  
CoA Department of Watershed Management, CoA Mayor’s Office of Resilience, The Conservation Fund, American Rivers, West Atlanta Watershed Alliance

- Potential Metrics/Measures of Success:**
- Volume of pollutants captured by installed Green Infrastructure Best Management Practices (BMPs)
  - # of BMPs installed
  - # of flooding incidents citywide and at U.S. Federal Emergency Management Agency recognized flood-prone areas
  - \$ collected through stormwater utility fee

### Partner Spotlight

#### Green Infrastructure Taskforce

In 2013, the City of Atlanta convened relevant City agencies, as well as partner groups, to promote and support the integration of green infrastructure into all types of public infrastructure investments. This Green Infrastructure Task Force has developed a Strategic Action Plan to address the challenges associated with managing stormwater runoff that leads to flooding, degraded water quality, and property damage. The Plan, which the Atlanta City Council unanimously approved in 2017, suggests actions for removing institutional barriers to green infrastructure construction;

increasing cost-effectiveness of green infrastructure; and engaging multiple City departments, citizens, developers, and environmental groups in working towards the goal of reducing stormwater runoff by 225 million gallons annually. Numerous projects have been completed, including Southeast Atlanta Permeable Pavers, Adair Park Rain Garden, and Historic Fourth Ward Park. Upcoming initiatives include Proctor Creek Greenway, Boone Park West with the Atlanta Urban Ecology Center @ Proctor Creek, and Rodney Cook, Sr. Park.

# 100 resilient cities- NYC

## NYC GREEN JOBS CORPS

New York City continues to be a leader in reducing the greenhouse gas emissions that contribute to catastrophic climate change and is the largest city on the globe to have committed to an 80 percent reduction in emissions by 2050. Achieving this goal requires significant investments across the city's energy supply, buildings, transportation, and solid waste sectors. At the same time, we are committed to providing New York City residents with greater economic opportunities and pathways to good-paying jobs.

At the 2017 State of the City address, Mayor de Blasio announced the NYC Green Jobs Corps, a partnership with industry and labor to train 3,000 New Yorkers with the skills needed to participate in the emerging clean energy economy over the next 3 years. This new program builds upon the successful efforts after Hurricane Sandy to connect New Yorkers to pre-apprentice training programs leading to apprentice programs, creating a pathway well-paid middle-class careers in the construction industry, and other related training programs.

## NYC °COOLROOFS

NYC °CoolRoofs is a partnership with the Department of Small Business Services (SBS), the Mayor's Office of Sustainability, the Mayor's Office of Recovery and Resiliency, and Sustainable South Bronx connects New Yorkers with training and work experience installing energy-saving reflective rooftops. By developing professional skills and receiving industry-relevant certifications, participants complete the program prepared for entry-level jobs in the construction industry. Seventy New Yorkers will participate this summer.

Since its launch in 2009, the program has coated over 6.7 million square feet of rooftops across the city, resulting reductions to energy consumption and mitigating the city's urban heat island effect. The City aims to coat one million square feet of rooftops annually to support the City's 80x50 goals.



## DEP GREEN INFRASTRUCTURE MAINTENANCE TRAINING

Thomas Arrington recently joined DEP as part of the agency's green infrastructure maintenance unit. Thomas is currently studying environmental science at Queens Community College and has a clear passion for the natural environment. Thomas is also very active in his community and is a member of the Friends of Idlewild Park in Queens.



"Previously, I've worked in landscaping and for the Parks Department and I hope this job at DEP will lead to a career in forestry in New York City's public sector."

DEP's green jobs will help to maintain the City's investment in green infrastructure and provide workers with basic skills in horticulture and green infrastructure maintenance. DEP will also provide opportunities for seasonal employees to become permanent staff, allowing for further professional advancement within the agency. DEP continues to hire additional employees for green jobs as it constructs new green infrastructure assets across the City.

## Initiative 3: Expand green infrastructure and smart design for stormwater management in neighborhoods across the city

(Source: OneNYC 2015)

Initiative/ Supporting Initiative	Lead Agencies	Initiative/ Funding Status	Progress Since April 2016	Milestones to complete by December 31, 2016	2016 Milestone Status	Milestones to complete by December 31, 2017
3.5.3 Continue the NYC Green Infrastructure Program in areas served by the combined sewer system to reduce CSO, and expand the use of green infrastructure to other parts of the city	DEP	In Progress/ Funded	The City, through DEP, continued its green infrastructure program as a part of a \$1.5B commitment by 2030. Ongoing program areas include right-of-way rain gardens, stormwater green streets, and porous pavement. To date, 3,800 green infrastructure assets are either completed or in construction.	› Submit the CSO Performance Metrics Report and the Green Infrastructure Contingency Plan to NYS DEC	Completed	› Submit Green Infrastructure Annual Report (April 30, 2017), and continue to make progress toward the next CSO Consent Order milestone in 2020 › Complete construction of Springfield Lake Bluebelt

## Initiative 3: Expand green infrastructure and smart design for stormwater management in neighborhoods across the city

(Source: OneNYC 2015)

Initiative/ Supporting Initiative	Lead Agencies	Initiative/ Funding Status	Progress Since April 2016	Milestones to complete by December 31, 2016	2016 Milestone Status	Milestones to complete by December 31, 2017
3.5.3A. Alleviate flooding in southeast Queens	DEP	In Progress/ Funded	The City, through DEP, completed an engineering study of the 50 hardest hit flooding grids and identified site-specific solutions. The City also began the design of 200 rain gardens in southeast Queens and expects construction to begin in the summer of 2017. In addition, DEP launched design for green infrastructure retrofits at three parks, while construction is underway for green infrastructure at two schools and on the Baisley Pond Bluebelt. Planning and design for green infrastructure on NYCHA properties in the area is expected to begin summer of 2017.	› Initiate design of green infrastructure on public land  › Complete an engineering study to assess the 50 hardest hit flooding grids and identify site-specific solutions for each grid  › Begin construction on Baisley Pond Bluebelt	Completed  Completed  Completed	› Issue RFP for green infrastructure construction on public land  › Initiate construction of right-of-way green infrastructure  › Continue construction on Baisley Pond Bluebelt

# Conclusions

---

Systems and communities are resilient when we are proactive about mitigating the impacts of current shocks and stresses and developing adaptation frameworks, policies, and supporting actions that help communities adapt.

---

What's measured gets counted! Metrics are important to assess efficacy and will help clarify the role of resilience, especially when actions may involve co-benefits, which are not always easy to monetize.

---

Mitigation and adaptation can help build community resilience when a strategic vision supports coordinated inter and multi-agency efforts in partnership with business, nonprofit organizations, academics, and citizens.