

# Exeter Resilience Project: Innovative Approaches to Stormwater Management and Communications

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## OVERVIEW

- ✓ Innovative Communication Methods
- ✓ Climate Adaptation Policy
- ✓ Resilient Stormwater Management



*This project was funded, in part, by NOAA's Office of Coastal Management under the Coastal Zone Management Act in conjunction with the NH Department of Environmental Services Coastal Program.*



# Innovative Communications

Climate Change – Adaptation - Resilience

## Ensuring a Successful Initiative

What is unique about the watershed or area of interest?

What resources are important, prominent, and tell the story?

What is the place-based connection?

Who are the key stakeholders to engage?

What is the community benefit?

**Identify the Audience**

**Maximize Exposure**

**Develop Impactful Message(s)**

**Permanent/Repeatable**

**Installation or Event**



# Innovative Communications

Educational installation at Main Street and Lincoln Street Elementary Schools

Reaches students Kindergarten through grade 5, yearly reinforcement, workbooks

## 1 Exeter Water Trail

**LET'S EXPLORE THE WATER TRAIL**

Welcome to the Water Trail at Main Street and Lincoln Street Elementary Schools. The Water Trail shows water in many settings as it moves across the landscape.

Water is everywhere — above ground, below ground, and in between.

Follow the water trail markings around the playground and along the nature trail to the Lincoln Street Elementary School.

**LET'S EXPLORE THE WATER TRAIL**

- NATURAL WETLANDS
- WATER TO MANAGE WATER
- LANDSCAPE SURFACES
- WATER YESTERDAY & TODAY

**WHAT IS A WATERSHED?**

A watershed is an area of land where all the water that flows into it or off of it drains to a single body of water like a wetland, river, lake or the ocean.

**WHAT IS THE WATER CYCLE?**

The water cycle, also known as the hydrologic cycle, describes the movement of water on, above, and below the surface of the Earth.

## 2 Exeter Water Trail

**NATURAL WETLANDS**

Water from rain and streams collects on the landscape in low areas to form natural wetlands. Wetlands are important for storing flood water's energy on storms and snow melt.

**WHY ARE WETLANDS IMPORTANT?**

Certain plants and animals that prefer to live in wet areas thrive in wetlands, which provide critical habitat for them, and remove harmful chemicals that cause water pollution. Wetlands help protect us from flooding and climate change by absorbing water.

## 3 Exeter Water Trail

**A WAY TO MANAGE WATER**

This stormwater collection area finds water that comes from the 177 acre Lincoln Street watershed. Some of the water travels underground in pipes and some flows across the land.

**WHY DO WE MAKE WETLANDS?**

If a natural wetland no longer exists, wetlands can be created to collect rain water and stormwater into a large basin. Once in the basin, dirt particles settle to the bottom and plants clean the water by taking in pollutants and extra nutrients from the water. They also store water and help reduce flooding.

**WHAT IS STORMWATER?**

Stormwater comes from rain, snow, and ice that melts and soaks into the soil, runs off hard surfaces into nearby streams and rivers, or reabsorbs back into the air. Stormwater that flows over land, and surfaces like parking lots and rooftops, can pick up toxic chemicals and pollutants that harm water quality and are harmful to people, animals, and plants.

## 4 Exeter Water Trail

**LANDSCAPE SURFACES**

The Main Street Elementary School campus is composed of many different types of surfaces — a wood chip playground, grass, pavement, and forest. Water moves differently over these types of surfaces. Wood chips, grass, and forests can absorb water while other surfaces, like pavement, shed water which runs off and flows to a low area nearby. Some of this water is collected in drains and piped underground into the town's stormwater systems.

**WHAT IS POROUS PAVEMENT?**

Porous pavement is made of marble-sized particles of gravel coated in asphalt or sticky tar coating. When these particles are stuck together, spaces form between the particles. When stormwater flows across the porous pavement surface it seeps into these spaces and flows down below the ground instead of pooling on the parking lot or road. Porous asphalt acts like a sponge by soaking up stormwater to reduce flooding.

**WHY DO WE NEED TO MANAGE STORMWATER?**

Stormwater is managed to help clean the water and allow water to flow where we want it to. When stormwater is not managed properly, it can flood landscapes, roads, buildings, natural places and animal habitats. Too much water is as harmful as not enough water.

Continue through the nature trail to the Lincoln Street Elementary School and the next stop on the Water Trail.

## 5 Exeter Water Trail

**WATER, YESTERDAY & TODAY**

Water once flowed around the Lincoln Street Elementary school through a natural stream, but today water flows through pipes underground.

Water is everywhere — above ground, below ground, and in between.

Follow the water trail markings along the parking lot and through the woods to the Main Street Elementary School.

**WHAT IS AN URBAN WATERSHED?**

Some watersheds have natural landscapes like forests, meadows, and native plants and animals. Other watersheds are located in places where many people live and the land is developed with roads and buildings. These developed or "urban" watersheds have some, but not many, natural places where water flows above the land. In urban watersheds, much of the water is collected and piped underground for long distances until it flows into a river or the ocean.

**WHAT IS BURIED BELOW THE PARKING LOT AND THE PLAYING FIELD?**

Water from the upper parts of the Lincoln Street watershed flows underground in pipes below Lincoln Street, then it continues under the parking lot and below the playing fields at the Lincoln Street Elementary School. One pipe reaches the land surface to allow water to flow into a wetland for a short distance before entering an underground pipe at the Main Street Elementary School.

*Water Cycle, Flooding  
Surface interactions  
Natural Wetlands  
Constructed Wetlands  
Porous Pavement  
Stormwater Management*

# Innovative Communications

Educational installation at Swasey Parkway, Exeter

Highly Visited Area – Permanent Messaging – Expand with Future Installations

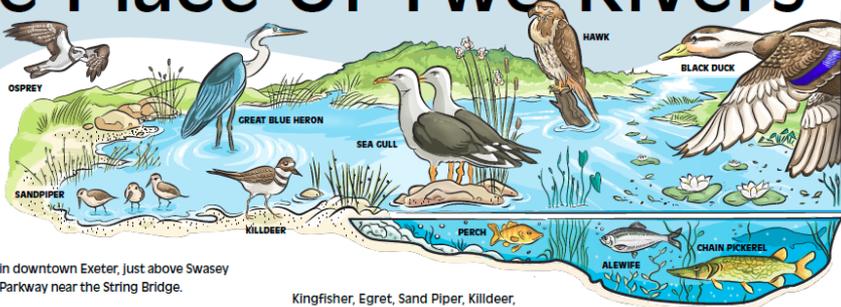


## The Place Of Two Rivers

### THE EXETER-SQUAMSCOTT RIVER



YOU ARE HERE



In downtown Exeter, just above Swasey Parkway near the String Bridge.

**WHAT TYPES OF FISH AND WATERFOWL LIVE HERE?**

In 2016, the Great Dam on the Exeter River was removed, restoring 21 miles of habitat for anadromous fish, which are fish that live in salt water but travel each year up the Exeter River to spawn. Species of anadromous fish include Alewife and Blueback Herring. The Exeter-Squamscott River provides habitat for over 17 fish species including Brook Trout, Small and Large Mouth Bass, Yellow Perch, Smelt, and Chain Pickerel.

A variety of shorebirds feed on animals and fish that live in the saltmarshes including the Mallard Duck, Black Duck, Blue-Wing Teal Duck, Green-Wing Teal Duck, Osprey, Bald Eagle, Great Blue Heron,

Kingfisher, Egret, Sand Piper, Killdeer, Cormorant, and many kinds of hawks, owls, and seagulls.

**WHAT IS THE IMPORTANCE OF A TIDAL SALTMARSH?**

Saltmarsh is abundant along the shores of the Squamscott River. Flooded by the tidal waters of the Great Bay Estuary, it is a complex ecosystem containing a variety of plants and animals. A saltmarsh has low marsh grass which is submerged at high tide, and high marsh grass along its upper fringe. Saltmarsh plays an important role in protecting roads, buildings and homes by storing tidal floodwater during highest annual tides and during storm events. However, because of its proximity to development, saltmarsh is threatened by pollution running off of the land.

**WHAT IS SEA-LEVEL RISE AND HOW MAY IT EFFECT THE RIVERS AND THE ESTUARY?**

Sea levels adjust locally and globally to changes in the Earth's environment. Sea-level rise is caused by several factors, including the melting of glaciers and sea ice, and an increase of ocean temperatures. Research in N.H. reports that sea levels may rise up to several feet, or more, by 2100 projections range from a low of 1.7 feet to a high of 6.6 feet. In a natural environment, saltmarsh is able to move inland with rising sea levels, but in a "built" environment where obstacles such as roads and buildings prevent this process from happening, an increase in sea level could transform saltmarsh into mudflats or open water.

This project was funded, in part, by NOAA's Office of Coastal Management under the Coastal Zone Management Act in conjunction with the NH Department of Environmental Services Coastal Program.



*Exeter-Squamscott Rivers*

*Watershed Facts*

*Importance of Saltmarsh*

*Riverine Ecosystems*

*Impacts of Sea-level Rise*



# Climate Adaptation Policy *(draft)*

## Vision Statement

*Proactive strategies are identified and implemented that address the impacts of coastal hazards and climate change to create a more sustainable and resilient community.*

## Purpose

Unified vision, goals, and actions

Guide planning, investment, management, regulations

Support for grants and other funding sources

Living document, informed by best available science/information



# Climate Adaptation Policy *(draft)*

## Goals

Ensure the community is better prepared to protect the security, health and safety of its citizens.

Protect natural resources from the impacts of flooding from sea-level rise and storm events.

Provide for a stable and viable economic future.

Minimize the future costs of infrastructure replacement and maintenance.

Support installations of renewable energy systems and electric vehicle charging stations.

***Municipal Policy and Actions***

***Management and Investment***

***Environment-Natural Resources***

***Regulatory and Land Use Planning***

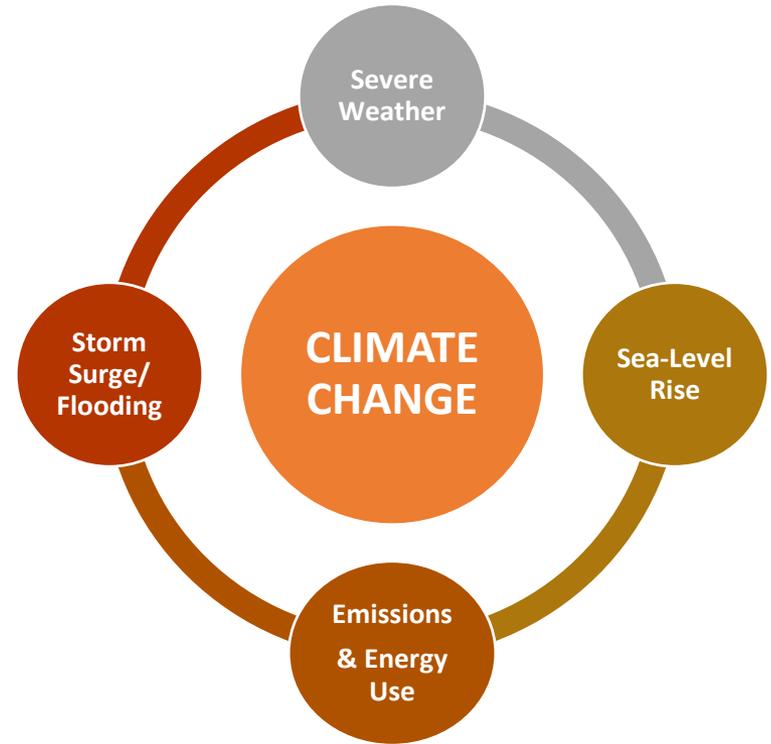
***Community-Based***



# Climate Adaptation Policy *(draft)*

## Recipe for Process/Methods

- ✓ Supported by Master Plan
- ✓ Audit of Zoning and Regulations
- ✓ Community Initiatives and Activities
- ✓ Capital Improvement/Infrastructure Management Plans
- ✓ Coordination with elected officials, staff, boards, commissions
- ✓ Exeter “Climate Proclamation” (to uphold principles of Paris Climate Accord)



# STORMWATER RETROFIT OPPORTUNITIES



1. The total annual nitrogen load from the 179-acre Lincoln Street watershed is 1,265 pounds.
2. The project identified green infrastructure retrofit opportunities for 14 stormwater installations
3. BMPs expected to reduce nitrogen load by 691 pounds annually, a 76% reduction.
4. Retrofit unit costs averaged \$1,000 and ranged from \$498 - \$5,080 per pound of nitrogen in comparison with \$1,200 for the new wastewater facility
5. The estimated cost to implement green infrastructure retrofits at these 14 locations is \$689,000.

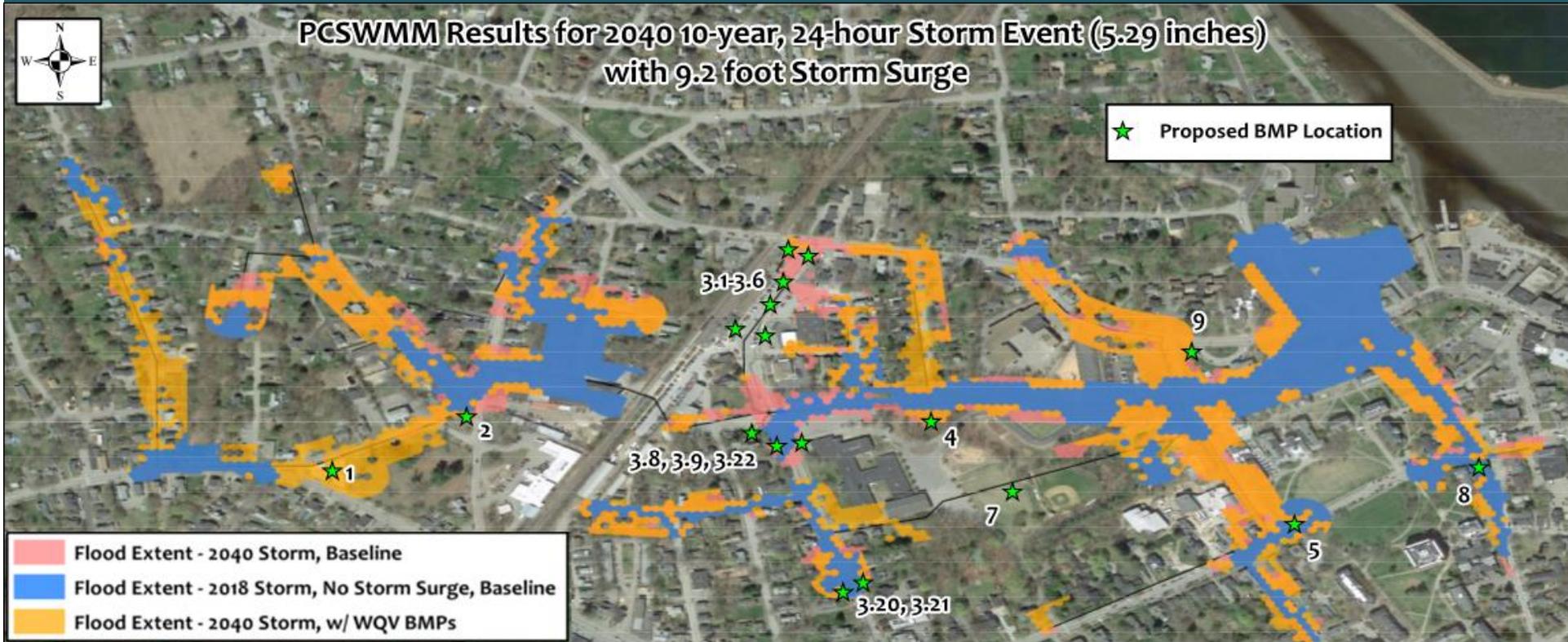
Rain Garden



Tree Filter

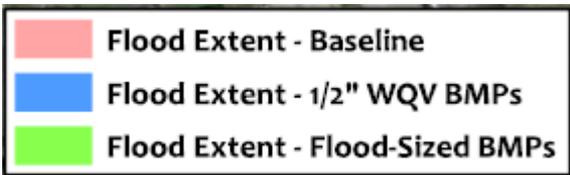
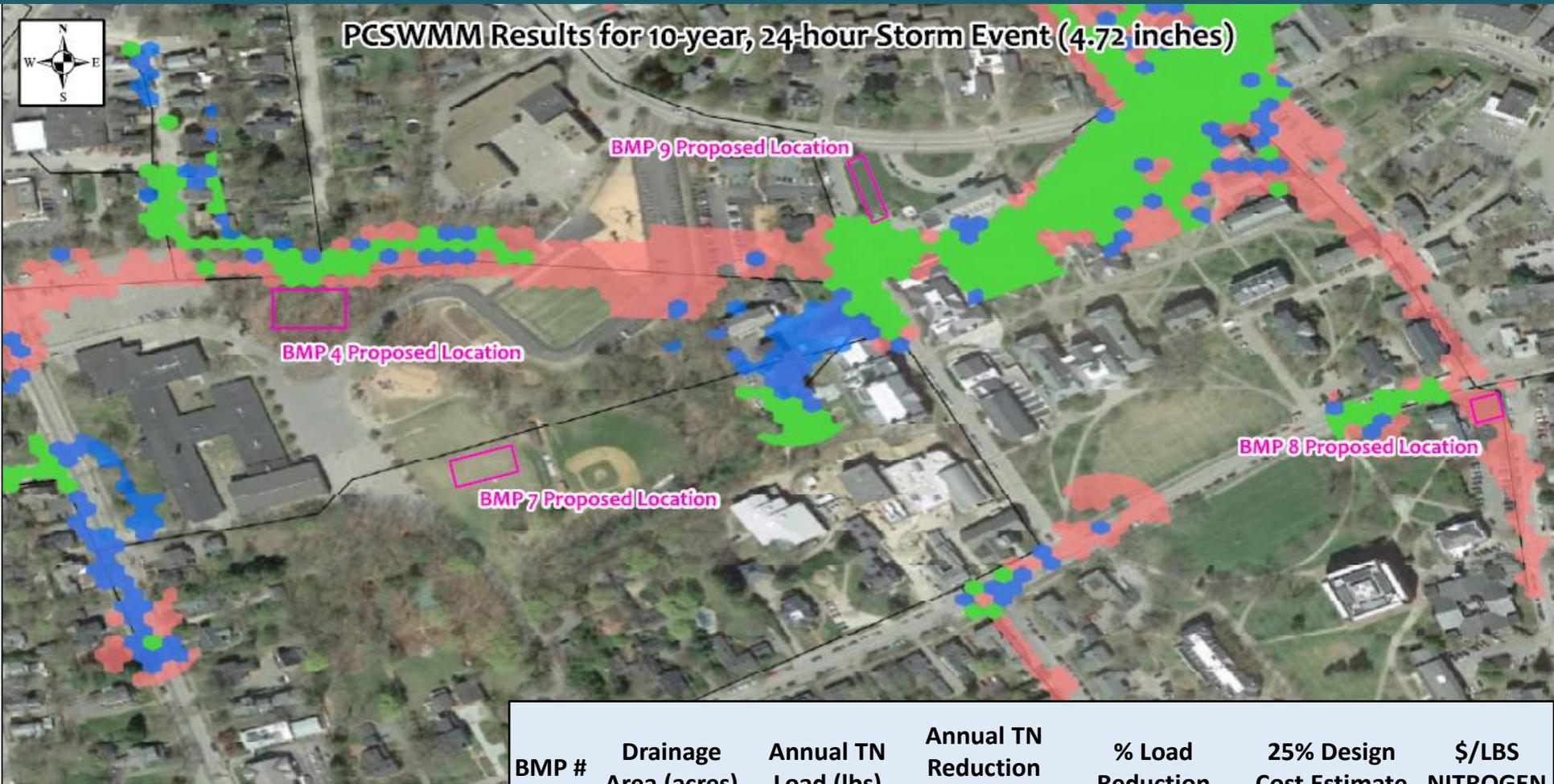


# FLOOD REDUCTION FROM GREEN INFRASTRUCTURE



- 1. Flood reduction volume from green infrastructure are estimated at 60% for the current 10-year storm and 50% for the projected year 2040 storm event with 9.21 feet of storm surge.**
- 2. The figure shows the modeled flood impact with and without green infrastructure for the 2040 rainfall and storm surge conditions with and without water quality volume best management practices**

# FLOODING WITH AND WITHOUT BMPS



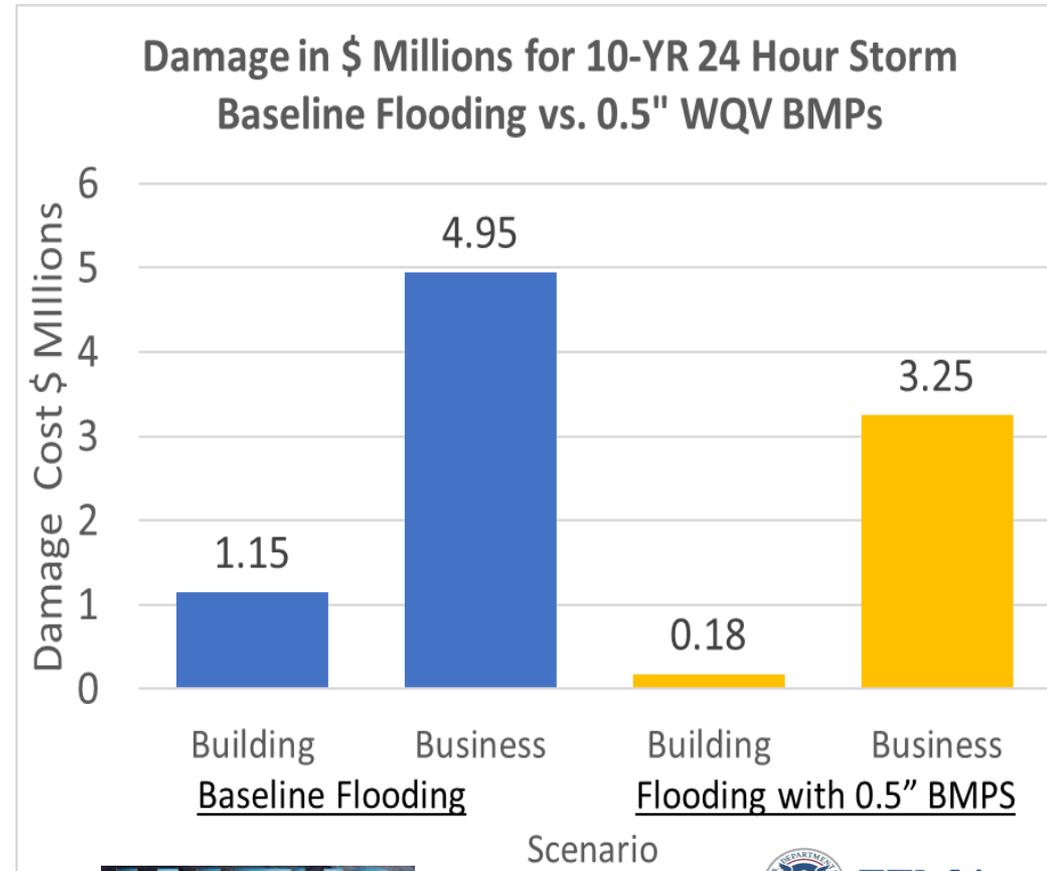
BMP #	Drainage Area (acres)	Annual TN Load (lbs)	Annual TN Reduction (lbs)	% Load Reduction	25% Design Cost Estimate	\$/LBS NITROGEN
4	34.7	275	206	75%	\$312,000	\$1,500
7	7.4	58	43	75%	\$35,000	\$800
8	16.0	108	82	76%	\$84,000	\$1,000
9	5.9	48	36	76%	\$38,000	\$1,000
<b>Total</b>	<b>64.0</b>	<b>489</b>	<b>367</b>	<b>75%</b>	<b>\$469,000</b>	<b>-</b>

# ECONOMIC BENEFITS OF FLOOD AVOIDANCE



Photo: Flooding at Exeter Town Landing March 2018 Nor'easter

1. The estimated flood loss from a current 10-year storm is \$6.11 million or \$3.43 million with green infrastructure, a 51% reduction.
2. The total estimated cost to implement green infrastructure at 14 sites is \$689,000.
3. The greatest benefit is from small sized Best Management Practices that provide water quality and flood protection for a 0.5" storm, the most frequent annual rainfall event.



# LOW MAINTENANCE GREEN INFRASTRUCTURE WITH PRETREATMENT IS ESSENTIAL

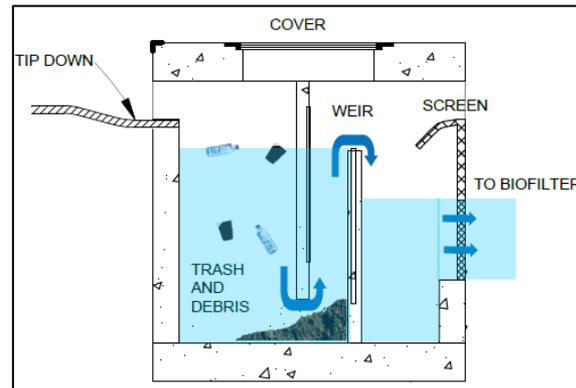
- Goal is to use existing staff, equipment for standard catch basin cleaning
- Land-use and trash and debris load
- Aesthetics
- Cost to maintain versus cost of pretreatment
- In urban environments return on investment may be 1-2 years



Condition Shortly After Install



Mini Cooper Bioswale with PREX



PRETX Pretreatment by ACF

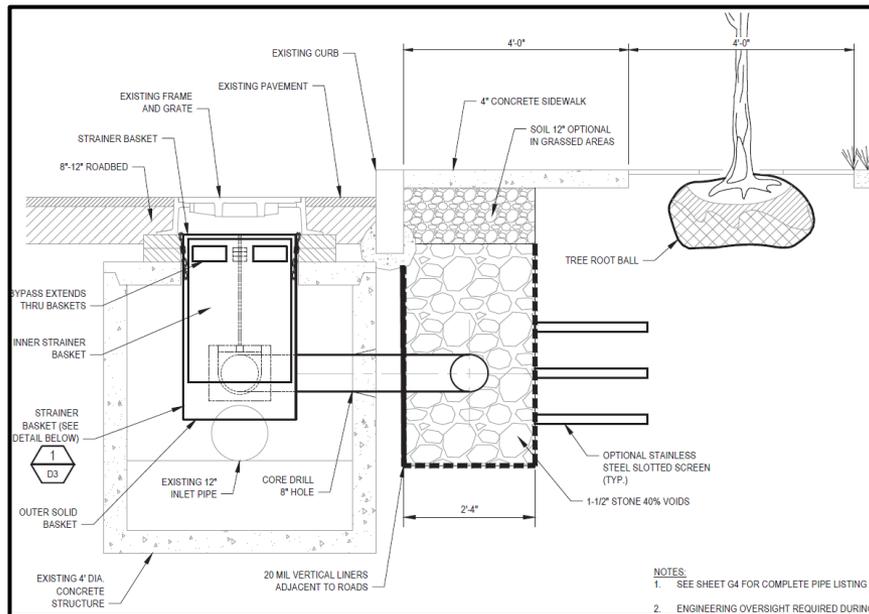
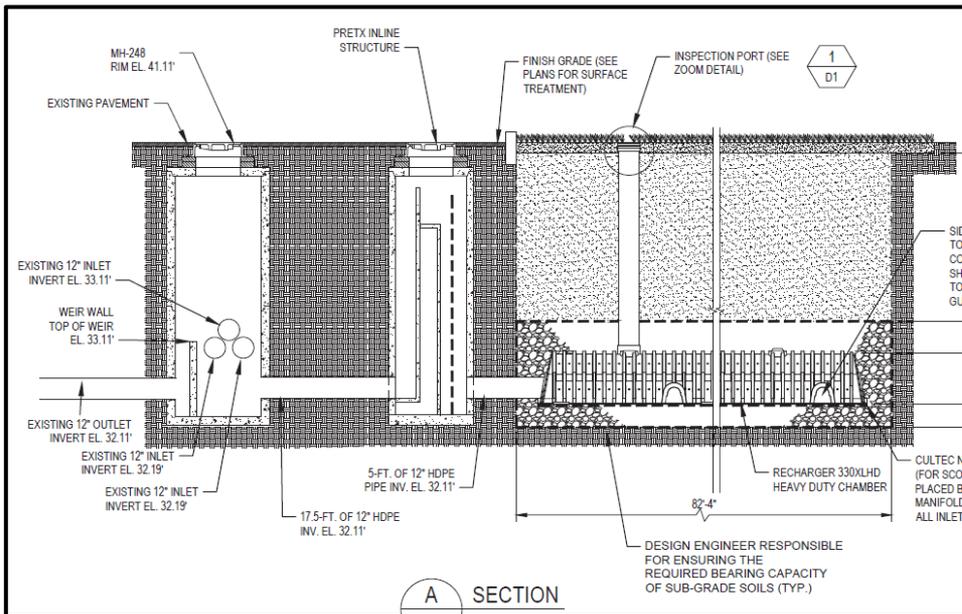


Condition After Winter

# RIGHT OF WAY – PLANTERS AND INFILTRATION



# ROW Infiltration/Filtration



# Thank you!



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# EXETER STORMWATER RESILIENCE LINCOLN STREET PHASE II PROJECT



## Project Summary and Goals

1. Achieve municipal capacity building around planning for climate change and flood events.
2. Implement public outreach and communication to build support for and understanding of adaptation planning including economic considerations.
3. Advance green infrastructure and other effective means of adaptation implementation for flood damage avoidance and water quality improvements.



**Resilient Green Infrastructure**  
**Climate Adaptation Policy**  
**Innovative Messaging**

## Watershed Assessment, Flood Analysis, and Adaptation with Green Infrastructure

1. The total annual nitrogen load from the entire Lincoln Street watershed is 1,265 pounds.
2. Installation of BMPs 1, 2, 3, 4, 5, 7, 8 and 9 is expected to reduce this load by 691 pounds annually, a 76% reduction.
3. The BMP unit cost performance ranged from \$498 - \$5,080 is estimated to be \$1,200 \$3 mg/L.
4. Flood reductions are estimated 10-yr storm and 50% for 9.21 ft of storm surge.
5. These activities address the NH Small MS4 General Per nitrogen source identification optimization and prioritization.



# EXETER STORMWATER RESILIENCE STORMWATER RETROFIT OPPORTUNITIES



Retrofit Opportunity

## Resilient Green Infrastructure

1. New Hampshire coastal communities have experienced rising populations resulting in an increase in development in nitrogen pollution and flooding from impervious surfaces.
2. Green infrastructure is an effective method to both improve water quality and avoid stormwater related flood damages.
3. The use of green infrastructure supports other economic and quality of life benefits such as creation of attractive public spaces, and landscaping that supports walkable communities.
4. This project developed construction-ready designs for inclusion in future capital improvement projects in Exeter's largest subwatershed.



## Performance of Stormwater Retrofits

1. The total annual nitrogen load from the 179-acre Lincoln Street watershed is 1,265 pounds.
2. The project Exeter Resilience project identified green infrastructure retrofit opportunities for 14 stormwater installations expected to reduce nitrogen load by 691 pounds annually, a 76% reduction.
3. Retrofit unit costs averaged \$1,000 and ranged from \$498 - \$5,080 per pound of nitrogen in comparison with \$1,200 for the new wastewater facility.
4. The estimated cost to implement green infrastructure retrofits at these 14 locations is \$689,000.



Support for this project was provided by the National Oceanic and Atmospheric Administration Office for Coastal Management pursuant to the Coastal Zone Management Act of 1972 in conjunction with the NH Department of Environmental Services Coastal Program, as a FY2018 Project of Special Merit Grant, Award # NA18R01054180127.

# EXETER STORMWATER RESILIENCE ECONOMIC BENEFITS OF FLOOD AVOIDANCE



Photo: Flooding at Exeter Town Landing March 2018 Nor'easter

## Green Infrastructure and Climate Adaptation

1. New Hampshire coastal communities have experienced rising populations resulting in an increase in impervious surfaces, stormwater runoff, and associated flooding.
2. At the same time, communities are faced with a changing climate including extreme rainfall events and sea-level rise.
3. Green infrastructure is an important form of climate adaptation which can have significant economic benefits for flood damage avoidance.
4. The Exeter Resilience project conducted a cost impact analysis to evaluate the potential for flood damage avoidance with implementation of green infrastructure.

## Green Infrastructure Flood Reduction



## Flood Damage Avoidance

1. The cost impact analysis graphic at right shows the potential for flood damage avoidance with implementation of green infrastructure.
2. The estimated flood loss from a current 10-year storm is \$1.11 million or \$3.43 million with green infrastructure, a 76% reduction. The total estimated cost to implement green infrastructure 14 sites is \$689,000. The greatest benefit is from small sized Best Management Practices that provide water quality and flood protection for a 0.5" storm, the most frequent annual rainfall event.



# EXETER STORMWATER RESILIENCE LINCOLN STREET PHASE II PROJECT



## Project Summary and Goals

1. Achieve municipal capacity building around planning for climate change and flood events.
2. Implement public outreach and communication to build support for and understanding of adaptation planning including economic considerations.
3. Advance green infrastructure and other effective means of adaptation implementation for flood damage avoidance and water quality improvements.



**Resilient Green Infrastructure**  
**Climate Adaptation Policy**  
**Innovative Messaging**

## Exeter Climate Adaptation Policy (draft)

The purpose of a Climate Adaptation Policy (CAP) is to guide local decision making and investments in climate adaptation and implementation actions. The CAP is supported by statements in the Vision section of the Master Plan (draft 2017) which states that local government will protect the welfare of residents and continue to provide support that helps prepare for a changing climate. Elsewhere in the Master Plan, responses to changes in climate and its impacts are detailed in the Support, Steward and Prepare sections as well as in the Action Agenda.

**VISION FOR THE FUTURE** "Proactive strategies are identified and implemented that address the impacts of climate change to create a more sustainable and resilient community."

### CLIMATE ADAPTATION POLICY PRINCIPLES

- Ensure the community is better prepared to protect the security, health and safety of its citizens.
- Protect natural resources from the impacts of flooding from sea-level rise and storm events.
- Provide for a stable and viable economic future.
- Minimize the future costs of infrastructure replacement and maintenance.
- Support installations of green infrastructure, renewable energy systems and electric vehicle charging stations.

### IMPLEMENTATION ACTIONS - FOCUS AREAS

- Municipal Policy and Actions
- Management and Investment
- Environment-Natural Resources
- Regulatory and Land Use Planning
- Community-Based

# EXETER STORMWATER RESILIENCE FLOOD REDUCTION FROM GREEN INFRASTRUCTURE



## Flood Reduction from Green Infrastructure

1. New Hampshire coastal communities have experienced rising populations resulting in an increase in development in nitrogen pollution and flooding from increased impervious surfaces and increased stormwater runoff.
2. At the same time, communities are faced with a changing climate, including increased extreme rainfall events and sea-level rise.
3. Green infrastructure is an important method to both improve water quality and avoid flood related damages.
4. Flood reductions from green infrastructure implementation are estimated at 60% for the current 10-year storm and 50% for the projected year 2040 storm event with 9.21 feet of storm surge.
5. The figure below shows the modeled flood impact with and without green infrastructure for the projected year 2040 rainfall and storm conditions with and without water quality volume best management practices.



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# Nutrient Removal Unit Cost Comparison

Nutrient Control Strategy	Total Annual Cost	Life Cycle Cost Estimate	Lbs N Reduced Per Year	Unit Cost \$/Lb N
Durham WW 5 mg/L <sup>1</sup>	\$971,140	\$13,800,000	5,254	\$2,627
Durham WW 3 mg/L <sup>1</sup>	\$1,680,340	\$23,200,000	8,757	\$2,649
WW Incremental Increase <sup>1</sup>	\$709,200	\$9,400,000	3,503	\$2,683
Durham NPS IC Program <sup>1</sup>	\$95,000	\$475,000	250	\$1,900
WISE NPS @ IP 3/5/8 mg/L <sup>2</sup>	\$453,333	\$13,600,000	17,000	\$800
WISE WW @ IP 3/5/8 mg/L <sup>2</sup>	\$3,046,667	\$91,400,000	95,000	\$962
WISE Total @ IP 3/5/8 mg/L <sup>2</sup>	\$3,500,000	\$105,000,000	112,000	\$938
Exeter WW 3 mg/L <sup>3</sup>	\$5,789,000	\$115,780,000	95,400	\$1,214

## Notes and Assumptions

Data is from 2012 Oyster River Watershed Integrated Management Plan by VHB, NOS data generated by VHB, WW data by Wright Pierce Facilities Plan Draft

WW data reported is based on 7 month period. It was not adjusted for 12 months as perhaps should be considered for direct comparison with NPS

Assumes 20 Yr SRF Loan for Exeter @3.25% with no state or federal aid

Life Cycle includes capital and operations and maintenance

Present worth is capital at 20-yr;

Data sources: <sup>1</sup> ORWIMP 2014; <sup>2</sup> WISE 2015, <sup>3</sup> Wright Pierce 2014