July 15, 2016

Climate Adaptation Plan for the Moonlight Brook Watershed

FINAL REPORT

Building Resilience to Flooding and Climate Change in the Moonlight Brook Watershed

Prepared for
Town of Newmarket, New Hampshire

Funded by
NOAA Office for Coastal Management
NH Coastal Program

Prepared by
Waterstone Engineering
Horsley Witten Group

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ACRONYMS

AOC	Administrative Order on Consent
CSO	Combined Sewer Overflows
CIP	Capital Improvement Plans
CWA	Clean Water Act
EPA	United States Environmental Protection Agency
I/I	Inflow and Infiltration
IP	Integrated Planning
GBNERR	Great Bay National Estuarine Research Reserve
GI	Green Infrastructure
LID	Low Impact Development
NHDES	New Hampshire Department of Environmental Services
NPDES	National Pollution Discharge Elimination System
NPS	Nonpoint source pollution
NRCC	Northeast Regional Climate Center
NRCS	Natural Resources Conservation Service
MS4	Municipal Separate Storm Sewer System
O&M	Operations and Maintenance
PCSWMM	PC Stormwater Management Model
PREP	Piscataqua Region Estuaries Partnership
PTAPP	Pollution Tracking and Accounting Pilot Program
PV	Present Value 50 year
SSO	Sanitary Sewer Overflows
STAP	Science and Technical Advisory Panel
SWMM	EPA Stormwater Management Model
UNH	University of New Hampshire
WISE	Water Integration for the Squamscott-Exeter
WWTF	Wastewater Treatment Facility

ACKNOWLEDGEMENTS

The Climate Adaptation Plan for the Moonlight Brook Watershed was made possible through funding by the National Oceanic and Atmospheric (NOAA) Office for Coastal Management and the New Hampshire Department of Environmental Services (NHDES) Coastal Program. We would also like to acknowledge and express our gratitude to all those who participated in the development of this plan and report.

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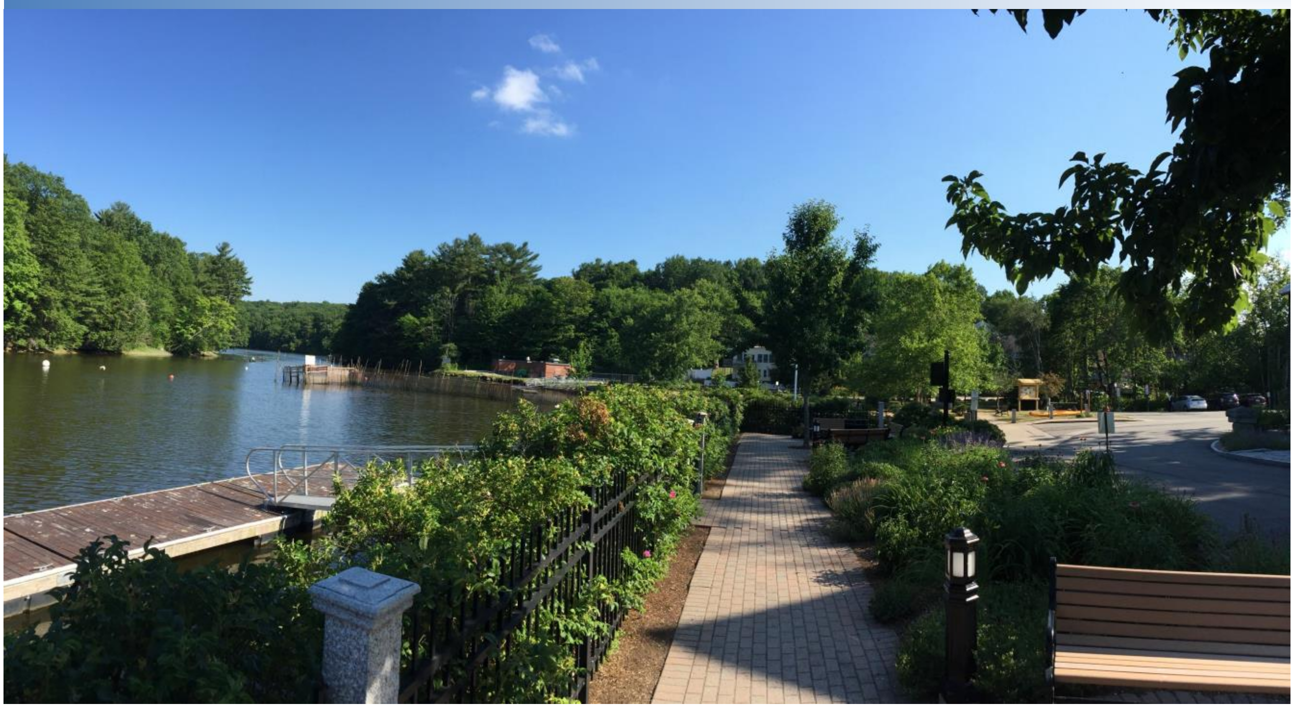
EXECUTIVE SUMMARY



What is the Moonlight Brook Climate Adaptation Plan?

This report presents information from studying climate resiliency for the Moonlight Brook Watershed in Newmarket, New Hampshire. Moonlight Brook is an important tributary of the Lamprey River drainage basin for Newmarket as it drains the center of town and outlets at the town landing. The town and this watershed in particular have experienced numerous and significant flood impacts caused in part due to changes in climate, a developing landscape with increasing impervious cover, and aging infrastructure. This study presents an examination of the relationship between flooding, future development, low-impact development (LID) zoning benefits, climate change, and the connection to using LID and green infrastructure (GI) to co-manage for flooding and water quality. Of significant importance for costing are two elements: 1) the process of optimizing and prioritizing stormwater management retrofit opportunities to achieve the lowest cost solution, and 2) harnessing the power of redevelopment through LID zoning to capture the private sector redevelopment cycle to gradually build resiliency and improve water quality through the upgrade of stormwater management and land development practices. Numerous effective examples of LID redevelopment have occurred with Newmarket and demonstrate how proactive LID zoning can reduce direct costs to municipal budgets. This report also presents how integrated planning for water management can cost-effectively address numerous needs for both flood mitigation and town National Pollution Discharge Elimination System (NPDES) permit requirements.

The process has included officials from the town working with a team from Waterstone Engineering, the Horsley Witten Group, and the New Hampshire Coastal Program. Funding was provided by the NOAA Office for Coastal Management through the New Hampshire Coastal Program for a project titled *Building Resilience to Flooding and Climate Change in the Moonlight Brook Watershed.*

Why Climate Adaptation Planning?

Climate change stresses are anticipated to pose considerable risks to coastal communities and populations in the decades to come. Extreme storm events, greater-intensity rains, flooding, storm surges, and sea-level rise (SLR) associated with a changing climate present significant and severe impacts to the infrastructure, properties, and natural resources of the seacoast region. Already, climate-related storm events and precipitation are straining the region's aging stormwater and wastewater systems.

As evident by the widespread devastation caused by the Mother's Day Flood and Superstorm Sandy, the need for long-term planning for more effective adaptation measures to protect at-risk communities is becoming increasingly more urgent. But bracing for climate change cannot be reactionary. Municipalities and governments must be preemptive in implementing flood protection, stormwater management, and resilience strategies for bracing critical assets and infrastructure against the expected changes. Recommendations advise that preparedness strategies be tailored to the circumstances of different communities—local, regional, and state government decision-makers must take an active role in preparing for climate change, because it is in their jurisdictions that climate change impacts are felt and understood most clearly.

Successful planning and preparedness can reduce a communities' risk and help avoid impacts to communities from extreme events including social, economic, and environmental damage. This Climate Adaptation Plan for the Moonlight Brook Watershed (hence referred to as the "Moonlight Brook Plan") represents one more important measure the Town of Newmarket is making toward becoming a climate resilient community.

Major Findings

Flood mitigation was studied for 1) current conditions; 2) future 2050 conditions with buildout of developable lands and retrofit of some redeveloped lands; 3) future 2050 conditions with climate change storm depths of 15%; and 4) all alternates with and without the Piscassic River breech.

The Piscassic River breech was found to be the most significant impact in terms of flooding and these initial results suggest that eliminating all inflows to Moonlight Brook from the Piscassic River would result in water surface elevation increases of between 0.27 and 1.01 feet along the Piscassic downstream of the breech and similarly reduce flooding within Moonlight Brook and the Route 108 corridor by nearly 50% for each condition. The feasibility of eliminating the breech is low due to the significant permitting issues associated with rerouting of flood waters.

Target retrofit areas identified would achieve a volume reduction of 42 acre-feet at the lowest cost from 417 acres of developed and redeveloped land. Implementing an LID-focused development strategy has the potential to reduce runoff within the Moonlight Brook watershed by 21%, reducing peak flow rates by 12%. Over a 35-year period, approximately 12 acres per year could be retrofitted. The choice of a 35-year schedule is a preliminary estimate reflective of what might be required of a nutrient control plan as part of an MS4 or administrative order on consent (AOC) requirement but would be revised based on a financial capability analysis.

This includes a combination of new development and redevelopment of existing residential, commercial and industrial areas sized to treat a capture depth of 0.25-0.5 inches. An implementation rate of 12 acres per year for 35 years would cost an estimated $212,000 per year with approximately 50% covered by the municipality and 50% covered by private section redevelopment.

1. INTRODUCTION

1.1 The Need to Address Climate Change

Climate change is causing transformations in the earth's environment, leading to profound shifts in temperature and weather patterns. These changes are evident on both a global and local scale and present significant risks to communities that are unprepared. Current research indicates that coastal communities and low-lying urban populations especially may be considerably vulnerable in the years to come, as higher-intensity weather, drought, storm surges, flooding, and rising sea levels associated with climate change could bring unprecedented impacts across these regions.

As evident by the widespread devastation caused by Superstorm Sandy, the need for long-term planning and more effective adaptation measures to protect at-risk communities are becoming increasingly more urgent. But bracing for climate change cannot be reactionary. Municipalities and governments must be preemptive in implementing flood protection, stormwater management, and resilience strategies for bracing our critical assets and infrastructure against the expected changes.

Guidance for planning a climate resilient community recommends that resiliency measures are not a "one size fits all" process. Rather, just as the impacts of climate change will vary from place to place, the combination of institutions and legal and political tools available to public decision-makers are unique from region to region. Recommendations advise that preparedness strategies be tailored to the circumstances of different communities—local, regional, and state government decision-makers must take an active role in preparing for climate change, because it is in their jurisdictions that climate change impacts are felt and understood most clearly.

1.2 Project Overview

This report presents the background, goals, findings, and final recommendations associated with the Moonlight Brook Plan in Newmarket, New Hampshire. Moonlight Brook is an important tributary of the Lamprey River drainage basin for the Town of Newmarket as it drains the center of town and outlets at the town landing. Several flood resiliency and risk studies have been performed in the Lamprey River watershed including the Moonlight Brook watershed.

This document also supports the project to build resilience to flooding and climate change in the Moonlight Brook Watershed, summarizing all project activity over the life of the coastal zone management grant to “Analyze Flood Risk and Design Practices That Simultaneously Reduce Flooding and Pollution in the Moonlight Brook Watershed” approved by Governor and Council on March 13, 2015.

The project is composed of a two-part effort to: 1) study flood risk associated with climate change including how future development and build out of the community affect these risks; and 2) design robust GI practices within the Moonlight Brook watershed to help reduce the risk of flooding while reducing pollutant load into the Brook and further downstream into the Lamprey River and ultimately Great Bay.

Additionally, the project builds on two recently completed efforts by Wake, Miller, Roseen, Rubin et al (2013) titled “Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire Resulting from Changes in Climate and Land Use” and a National Sea Grant Law Center project titled “New Floodplain Maps for a Coastal New Hampshire Watershed and Questions of Legal Authority, Measures and Consequences.”

This project proposes to expand these previous flood studies and watershed models by refining the study for Moonlight Brook and adding survey and infrastructure details previously unavailable. Climate change scenarios (current, 2050, and 2100) will be modeled to identify locations along Moonlight Brook that are considered high risk for flooding. The climate change scenarios will also be evaluated under community build-out conditions for the same time period. The build-out will be based on current land use zoning and future population projections. The findings of these analyses will be presented to the community as a public outreach and education component to help the community understand the effects of climate change and development and how these changes result in increased risk of flooding.

The second component of the project proposes to identify high flood risk location(s) along Moonlight Brook and develop designs for robust GI practices that could be implemented in the watershed to reduce the risk of flooding in these high-risk areas. GI will also provide water quality benefits to capture and treat stormwater runoff before infiltrating these flows or slowly releasing them to downstream waters. GI helps promote groundwater and stream recharge; maintain stream water temperatures; and reduce nutrient, sediment, and bacterial pollution downstream. This portion of the project will develop a

Figure 1-1 Largest recorded flows at Lamprey River during Mother's Day Flood May 16, 2006 at 8970 CFS

concept design for up to five GI practices and one final design that can be used for bidding and construction.

The project partners will identify a set of stormwater Best Management Practices (BMPs) that are feasible and realistic for the town. A linear optimization model will also be used to develop a Pareto Curve, a graph that relates cost to total volume reduction and illustrates the concept of diminishing returns (i.e. less cost-effective measures may be required to reach higher levels of load reduction). The results will be presented in terms of the Pareto Curve, and a detailed breakdown of BMP types by land use. This outcome will provide the town with an illustration of the types and extent of BMPs that would be required to reach various goals. The analyses will also provide specific cost performance information for the town on the various stormwater BMPs such as cost effectiveness, unit costs ($/ft3 reduced), and total minimum optimized cost.

1.3 Coastal Management Challenges and Opportunities

Like many coastal regions, population growth and development in Newmarket and the Lamprey River and Great Bay watersheds have contributed to increases in impervious cover, altering the hydrology of these areas and leading to higher volumes of stormwater runoff. As more impervious surface is added, flooding risks are elevated and impacts to water quality—as a result of increased stormwater discharge and nutrient loading to waterways—are exacerbated.

Climate change, by introducing higher-intensity precipitation events, increased rainfall depth, and greater variations in storm duration and frequency, serves to amplify these risks and impacts.

In 2009, NHDES concluded that the Squamscott and ten other sub-estuaries in the Great Bay Estuary were impaired by nitrogen, and in 2009 the Great Bay was placed on the Clean Water Act (CWA) Sec. 303(d) list of impaired and threatened waters (NHDES, 2009). As a result, communities and agencies in the Great Bay region are working towards the development of nutrient management strategies and solutions that will support attainment of ecosystem goals in an effective and affordable manner.

Climate adaptation planning presents a unique opportunity to address climate-related stresses and nutrient pollution simultaneously. Climate adaptation strategies can serve the dual purpose of boosting the resiliency of a coastal community while also providing for non-point source management. GI and LID are proven, effective tools in this regard—offering the capacity to minimize flooding risks while also reducing nutrient loading to waterways. This report addresses climate adaptation planning for the Moonlight Brook Watershed, which extends to challenges associated with nitrogen pollutant loading in this watershed in addition to the downstream watersheds of the Lamprey River and Great Bay.

2. CLIMATE ADAPTATION PLANNING

2.1 Building Climate Resilient Communities

Climate change stresses are anticipated to pose considerable risks to coastal communities and populations in the decades to come. Extreme storm events, greater-intensity rains, flooding, storm surges, and sea-level rise (SLR) associated with a changing climate present significant and severe impacts to the infrastructure, properties, and natural resources of the seacoast region. Already, climate-related storm events and precipitation are straining the region's aging stormwater and wastewater systems.

This is creating an increasingly urgent need to build resiliency into coastal facilities and infrastructure. Integrated planning and land use management strategies should factor in climate stresses to mitigate runoff volumes and to ensure that stormwater systems are adaptive to extreme wet conditions. In building a climate resilient community, infrastructure should be designed in such a way as to be flexible to climate extremes and recoverable after storm events and flooding have occurred.

A community that is prepared will have a greater ability to rebound quickly from weather and climate-related events—reducing human health, environmental, and economic impacts. Resilience is the ability to prevent a short-term hazard event from turning into a long-term community-wide disaster. While most communities effectively prepare themselves to respond to emergency situations, many are not adequately prepared to recover in the aftermath.

Municipalities can use many tools to build resilience and deal with climate-related stressors. The use of GI is one, and it provides multiple benefits. GI methods not only help resolve water quality issues but can also build resilience by mimicking natural processes. Using GI to control stormwater will benefit communities in many ways. Existing stormwater management systems designed to control runoff and protect life and property are not always able to handle extreme precipitation events. Better water resource management will reduce infrastructure costs and help to alleviate flooding. Treating and reducing runoff will protect water quality, which for many communities is a required action under the new MS4 permit.

There are many resources that municipalities can use to help develop integrated plans that include resilience components. New Hampshire has state and federal agencies as well as numerous other organizations and collaborations that offer outreach, education, and technical assistance on resilience building and climate adaptation. Available local agencies include NHDES, the regional office of the U.S. Environmental Protection Agency (EPA) , the local National Estuary Program, Piscataqua Region Estuaries Partnership (PREP), NOAA through Sea Grant and the GBNERR, the University of New Hampshire through multiple programs such as UNH Stormwater Center and Cooperative Extension, and the New Hampshire Coastal Adaptation Workgroup which is a local collaboration of over 20 agencies and organizations that help municipalities prepare for and adapt to climate change.

The International Council for Local Environmental Initiatives (ICLEI) has developed a Climate Resilient Communities (CRC) Five Milestones process to guide local governments through assessing vulnerabilities and identifying strategic opportunities to increase resiliency. The milestones process is designed to focus on the key community systems—built, natural, and social networks—that collectively provide the driving services or activities with a community region.

The Five Milestones include:

1. Initiate a climate resiliency effort
2. Conduct a climate resiliency study
3. Develop a climate resilient action plan
4. Implement a climate resilient action plan
5. Monitor, motivate, and e-evaluate

By effort of the Moonlight Brook Plan, the project team has addressed and completed the first three of ICLEI's CRC milestones.

2.2 Planning for Climate Resiliency: Newmarket's Master Plan Vision and Future Land Use Plan

The Newmarket Planning Board has been working with the Strafford Regional Planning Commission on updating sections of the town's master plan including the preparation of a vision statement and future land use plan with funding through the New Hampshire Coastal Program. Visioning is a way of engaging the community in the town's long range planning efforts through a number of techniques including interactive visioning, facilitated discussions, brainstorming exercises, and a community visioning survey. Through the process, the town was able to define community goals, reach consensus on critical planning issues, and provide policy direction to the town moving forward.

Through this process, the following themes emerged:

- Newmarket's coastal areas are important to the town's vitality and economic well being as they offer a multitude of scenic, natural, and cultural resources that are attractive to residents and visitors alike.

- Protection of the Great Bay and its contributing streams and tributaries is one of the highest priorities for the town.
- The risks of coastal flooding as a result of SLR is a very real concern and in the future will require actions on the part of the town to ensure the resiliency of infrastructure adjacent to these vulnerable areas.
- The integration of climate adaptation measures with municipal programs, policies, and operations reflect the town's commitment to reduce community risk. In the future, smart development will lead to greater resilience against the adverse impacts and infrastructure vulnerability associated with climate change, SLR, and increased flooding.

The visioning process helped to lay a solid foundation for the future land use plan which includes several recommendations for implementation, including:

- Recognition that climate change is an area of concern and that the town should plan for the future by conducting climate vulnerability assessments and increasing the capacity of infrastructure to protect against higher flood risks.
- Considering coastal protection zoning within the coast watershed with lower density residential development and making open space cluster development mandatory within vulnerable areas.
- Suggesting shoreland protection measures and extending buffers and setbacks along 1st, 2nd, and 3rd order streams of the Lamprey River.
- Updating stormwater regulations to continue efforts to minimize flooding and reduce the impacts of stormwater pollution on water quality.
- Highlighting the need for more public education and outreach related to stormwater management.
- Making stormwater management a priority through the development of a stormwater management plan to reduce non-point pollution.

2.3 Hazard Mitigation Planning, Prioritizing Assets and Threats

Threat identification and asset prioritization was conducted in 2013 by the Strafford Regional Planning Commission as part of the Hazard Mitigation Plan (2013). The purpose of the plan as per the Disaster Mitigation Act of 2000 (DMA) is to:

> "establish a national disaster hazard mitigation program –
>
> Reduce the loss of life and property, human suffering, economic disruption and disaster assistance costs resulting from natural disasters; and
>
> Provide a source of pre-disaster hazard mitigation funding that will assist States and local governments (including Indian tribes) in implementing effective hazard mitigation measures that are designed to ensure the continued functionality of critical services and facilities after a natural disaster."[1]

SRPC identified the following community characteristics.

Emergency Services	
Emergency Warning System(s)	None officially

Police Department	Yes; Full-time
Fire Department	Yes; Full-time & On-call
Fire Stations	1
Town Fire Insurance Rating	5/9 (Census Profile – 2009)
Emergency Medical Services	Volunteer
Established EMD	Yes
Nearest Hospital	Exeter Hospital, Exeter (8 miles, 97 beds)
Utilities	
Public Works Director	Yes
Water Works Director	Yes
Water Supplier	Municipal
Electric Supplier	PSNH
Natural Gas Supplier	Eastern Propane Home Gas
Cellular Telephone Access	Yes
High Speed Internet	Yes
Telephone Company	Fairpoint
Public Access Television Station	Yes
Pipeline(s)	No
Transportation	
Evacuation Routes	Yes (Route 108; Route 152) – Not marked
Nearest Interstate	I-95, Exit 3 (10 miles)
Railroad	Boston & Maine
Public Transportation	COAST; Wildcat Transit
Nearest Airport Scheduled Service	Manchester-Boston Regional (38 miles)
Nearest Public Use Airport	Hampton Airfield
Housing Statistics, 2010 Census Data	
Total Households	3,857
Average Household size	2.32
Total Housing Units	4,139
Occupied Housing Units	3,857
Vacant Housing Units	282
Other	
Web site	http://www.newmarketnh.gov/
Local Newspapers	Exeter Newsletter; Union; Fosters
Other social media	Local channel 13; Facebook; Twitter; Town Website
911 GIS data available	Yes
Assessed structure value 2009	$537,025,300
National Flood Insurance Program	Yes; May 2, 1991
Repetitive Losses	Yes
Information found in was derived from local input, the 2010 Census, or the Economic & Labor Market Information Bureau, NH Employment Security, 2010.	

A complete list of critical infrastructure and key resources is provided in Appendix A: Critical Infrastructure & Key Resources, excerpt from Newmarket, NH All-Hazard Mitigation Plan Update 2013. The plan identifies a middle school, high school, and Lamprey Health Care located within the Moonlight Brook Watershed as Facilities and Populations to Protect and Potential Resources. Figure 2-1 presents the map of historic flooding from the Plan. Flooding along Route 108 and Moonlight Brook is identified. Subdivision and site plan requirements for storm drainage are identified as one of the mitigation strategies and proposed improvements.

2.4 Moonlight Brook Cost Prioritization for Runoff Reduction

In developing a framework for assessing risks and potential impacts in the Moonlight Brook Watershed, climate-related threats and vulnerable areas must first be identified in order to feasibly evaluate adaptation options. The project team conducted a cost prioritization for flood risk reduction based on optimizing and ranking retrofits opportunities. This is similar to the requirements in the new proposed small MS4 permit for New Hampshire for nutrient management retrofit opportunities. Optimization of designs used at the watershed scale can significantly reduce costs for achieving volume and nutrient reduction targets. A combination of watershed modeling and linear optimization was used to find the lowest cost mix of control measures for non-point source, structural stormwater controls, and variable water quality volumes. Optimal reduction was achieved by targeting impervious surfaces that have the greatest runoff potential at the lowest cost.

This approach incorporates an integrated planning approach in assessing climate change risks and implementing solutions in the Moonlight Brook watersheds. In utilizing this practice, climate adaptation planning will be based on a more holistic standpoint, balancing resiliency measures with nutrient management strategies to enable for the most cost-efficient projects.

Integrated planning allows for flexibility in permitting of wastewater and stormwater controls to plan for the most cost-effective measures first, while still meeting regulatory standards that protect public health and water quality. GI is a key integrated planning strategy—allowing for nutrients and stormwater management while supporting other economic benefits and quality of life. Integrated planning has shown to provide great cost efficiencies through the comprehensive management of wastewater, stormwater, and nonpoint sources across the nation.

The results provide storm volume reduction, nutrient load reduction, cost and benefit information for likely scenarios, and enable for the development of recommended implementation strategies for each scenario.

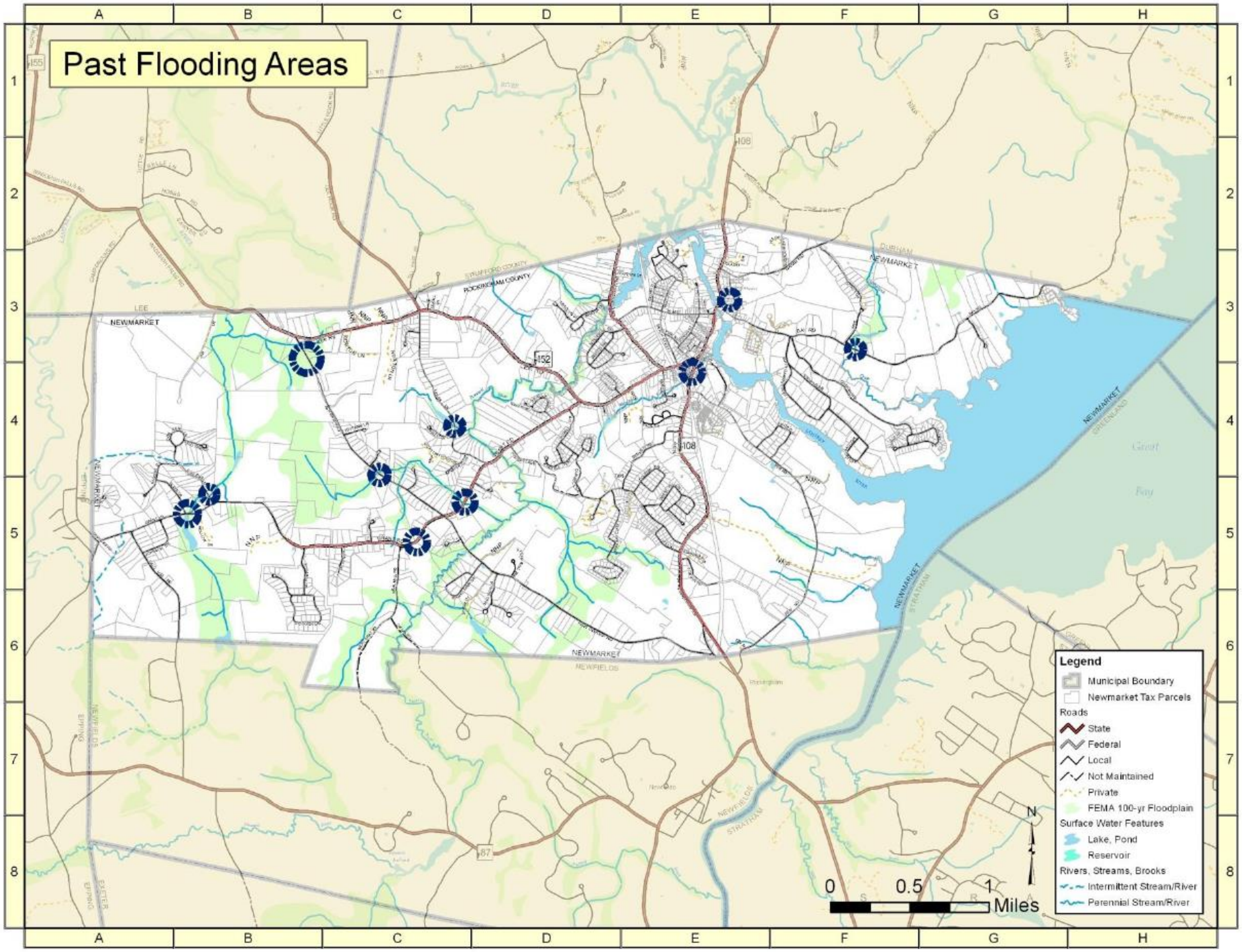


Figure 2-1: Map 1: Historic & Potential Hazards from 2013 Hazard Mitigation Plan

2.5 Coastal Risk and Hazards Commission Recommendations

In 2016, the New Hampshire Coastal Risk and Hazards Commission released a report that provides recommendations for preparing New Hampshire for projected storm surge, SLR and extreme precipitation.

Based on the need to prepare for existing and projected coastal flood hazards, the State Legislature established the New Hampshire Coastal Risk and Hazards Commission to "recommend legislation, rules, and other actions to prepare for projected sea-level rise and other coastal and coastal watershed hazards such as storms, increased river flooding, and storm water runoff, and the risks such hazards pose to municipalities and the state assets in New Hampshire."

In response, the Commission developed a final report and set of recommendations for state legislators, state agencies, and coastal municipalities to help better prepare and minimize coastal risks and hazards. These recommendations include:

- Review and evaluate the current state of climate change science in order to periodically update storm surge, sea-level rise, extreme precipitation, and other relevant climate projections; and provide planning guidance.
- Identify vulnerable state and municipal economic assets; structures and facilities; natural resources; and recreational and cultural resources at regional, municipal, and site-specific scales.
- Amend statutes, ordinances, rules and regulations, policies, programs, and plans to incorporate and consider the best available science and vulnerability information.
- Secure funding sources and develop funding mechanisms, including incentives and market-based tools, to pay for vulnerability assessments and implement climate adaptation strategies.
- Encourage businesses to create preparedness plans in order to minimize economic disruptions and ensure continuity of services to essential facilities, people, businesses, and employment centers.
- Make existing structures and facilities more resilient to flooding, acquire properties in high-risk areas, and avoid exposing new structures and facilities to current and future flood risks.
- Protect and restore vulnerable natural resources, and consider how natural resources reduce the impacts of flooding in state and municipal planning efforts.
- Develop plans and implement strategies to prepare and adapt recreational and cultural resources vulnerable to climate impacts.

2.5.1 Sea Level Rise and Extreme Precipitation Projections

In 2014, the Coastal Risk and Hazards Commission's Science and Technical Advisory Panel (STAP) released recommendations that present past and projected future trends associated with SLR, storm surges, and extreme precipitation in coastal New Hampshire. With climate change expected to bring significant impacts to critical infrastructure and natural and cultural resources in coastal New Hampshire over the next century and beyond, the report is intended to help municipal and state decision-makers prepare for projected SLR and other coastal hazards, minimizing the risks those hazards pose to municipalities and state assets.

According to the STAP report, global sea levels have been rising and are expected to continue rising well beyond the end of the 21st century. Rising seas pose significant risks to coastal communities, ecosystems, cultural resources, and other coastal property and infrastructure. Forecasting rates of global greenhouse gas emissions is challenging, but research shows that current greenhouse gas concentrations and current or accelerated emissions will continue to influence sea levels in the future.

Based on local tide gauge data, sea levels in New Hampshire have been rising by an average of 0.7 inches per decade since 1900. The rate of SLR has increased to approximately 1.3 inches per decade since 1993. Using 1992 sea levels as a baseline, New Hampshire sea levels are expected to rise 0.6 – 2.0 feet by 2050 and 1.6 – 6.6 feet by 2100.

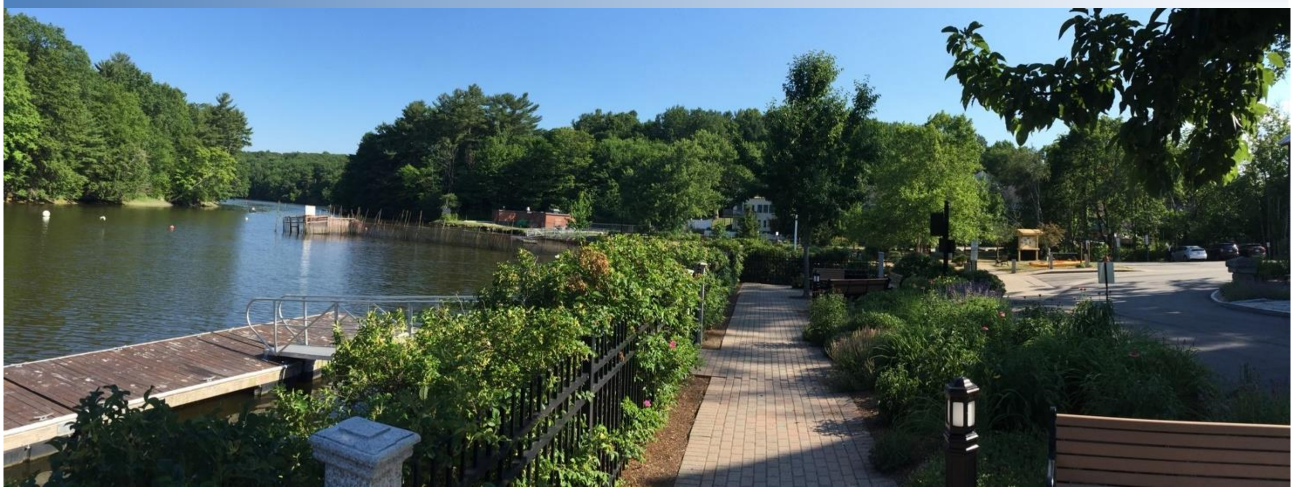
In terms of extreme precipitation, data from the report showed that the northeast experienced a 50% increase in total annual precipitation from storms classified as extreme events between 1901 and 2012. Here, “extreme” is defined as the number of times each year that the 24-hour rainfall amount exceeds the largest 1% of precipitation events in that year. Extreme precipitation events are projected to increase in frequency and in the amount of precipitation produced. In particular, the rainfall amount produced by hurricanes is projected to increase. However, current climate models and analyses are not as good at projecting future changes in the frequency or magnitude of extreme precipitation events. As a result, the report recommended the use of a 15% increase in current storm depths for future planning for the year 2050.

2.6 Uncertainty in Climate Science and Watershed Management Decisions

A key challenge to planning for climate change is how to factor in potentially significant, yet uncertain, data in regard to climate change trends and utilize that information for making better, local management decisions. Governments and municipalities are forced to develop plans at the local and regional level, whereas climate change data is typically only available at a macro-level scale. This approach selects plausible scenarios, not as an example of what will happen, but rather possibilities of what could occur based on the best available science at the time. The science will continue to improve along with the certainty of scenario planning.

Long-term implementation schedules and adaptive management are approaches that communities and regulators can employ for managing uncertainty in climate adaptation planning. A long-term implementation schedule combined with monitoring supports an iterative process of management actions that reduces uncertainty over time while offering potential cost savings. Additionally, an adaptive management process offers a long-term strategy to address concerns about uncertainty in the understanding of the relative significance of nitrogen and its role in declining estuarine health.

3. WATERSHED STATUS AND REGULATORY FRAMEWORK



3.1 Watershed Land Use and Growth Trends

The Moonlight Brook watershed has an area of roughly 486 acres, most of which has already been developed for urban use (see Figure 3-1). For the future scenario year 2050, all remaining developable land within the Moonlight Brook watershed was predicted to be converted to developed uses (see Figure 3-2). This was based on a previous study by Wake et al (2013) and is described in detail in Section 4.1.2. Table 3-1, below, shows the total acreages for each land use within the Moonlight Brook watershed under current conditions and for the projected 2050 buildout scenario. In these conditions, 107 acres of new residential, 229 acres of redeveloped residential, 19 acres of commercial and industrial were retrofitted.

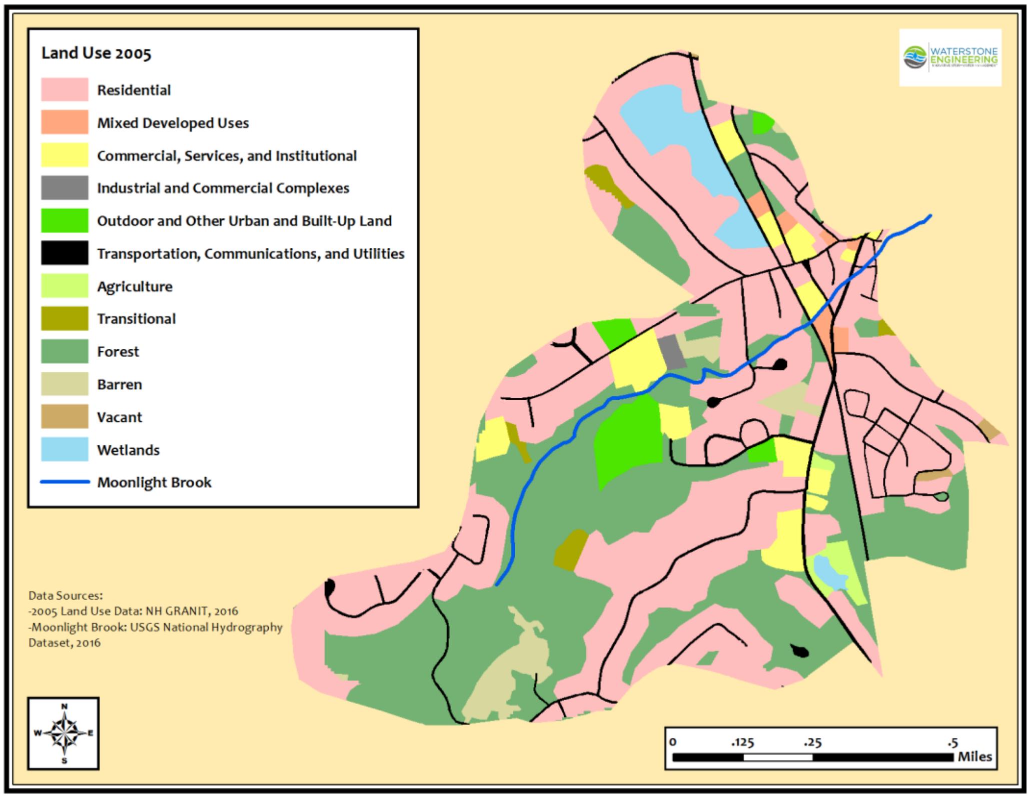


Figure 3-1 Current land use in the Moonlight Brook watershed

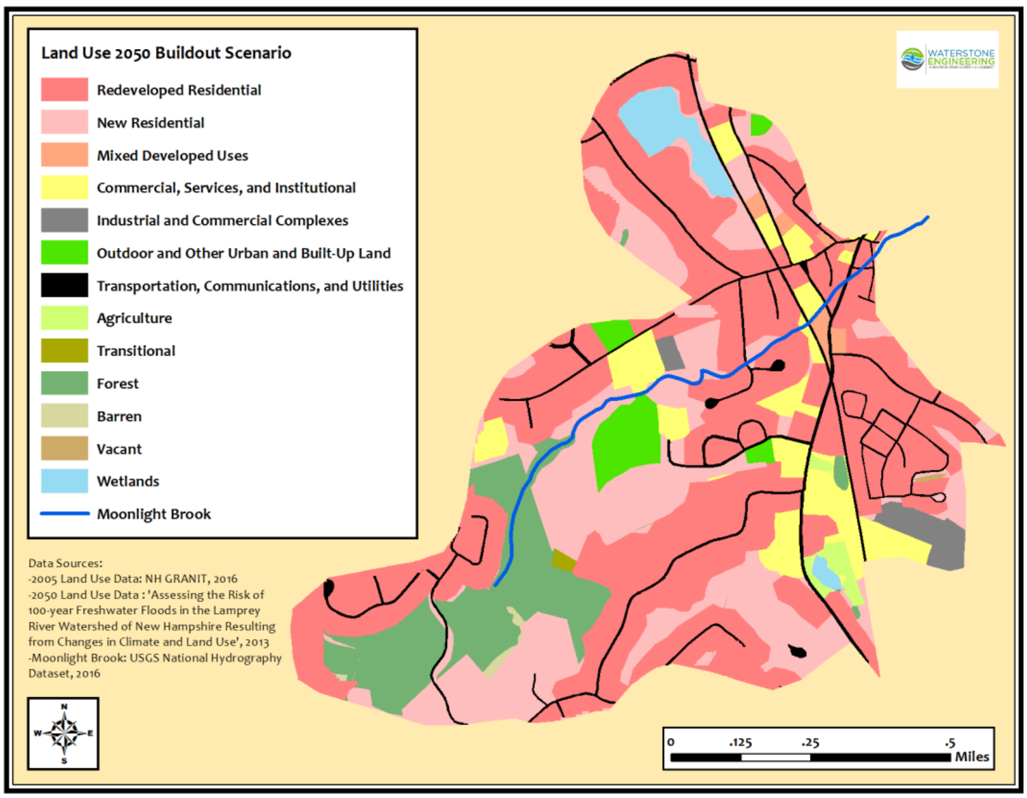


Figure 3-2 Projected 2050 land use in the Moonlight Brook watershed

Table 3-1 Current and projected 2050 land uses in the Moonlight Brook watershed

	Acreage	
Land Use Type	2005 (Current Conditions)	2050 Buildout Scenario
Redeveloped Residential	N/A	229
New Residential	229	107
Mixed Developed Uses	4	4
Commercial, Services, and Institutional	23	35
Industrial and Commercial Complexes	1	8
Outdoor and Other Urban and Built-Up Land	12	12
Transportation, Communications, and Utilities	24	24
Agriculture	4	4
Transitional	4	1
Forest	155	50
Barren	13	1
Vacant	1	0
Wetlands	16	11
Moonlight Brook Watershed	**486**	**486**

The main channel of Moonlight Brook runs for approximately 1.5 miles from its headwaters to its outlet into the Lamprey River. It is routed under three road crossings before passing under a railroad track near downtown Newmarket. Downstream of this point, Moonlight Brook is routed through a series of culverts and pipes before emerging back into its natural channel just upstream of its outlet to the Lamprey River.

In downtown Newmarket, Moonlight Brook receives inflows from the north (Beech Street drainage area) and the New Road drainage area Great Hill areas in the south. The New Road drainage system is comprised of a series of culverts and pipes, which ultimately daylight approximately 1/3 mile upstream from the confluence with the main channel of Moonlight Brook.

Altogether, the Moonlight Brook drainage network contains approximately 1.1 miles of pipes and culverts ranging in diameter from 1-8 feet, along with 2.4 miles of open channel (see Figure 3-3).

During large storm events, Moonlight Brook receives significant inflow from the Piscassic River breech, which connects to Moonlight Brook at its headwaters. During the 100-year storm event, inflows from the Piscassic River reach an estimated 307 cfs, almost doubling the peak flow within Moonlight Brook.

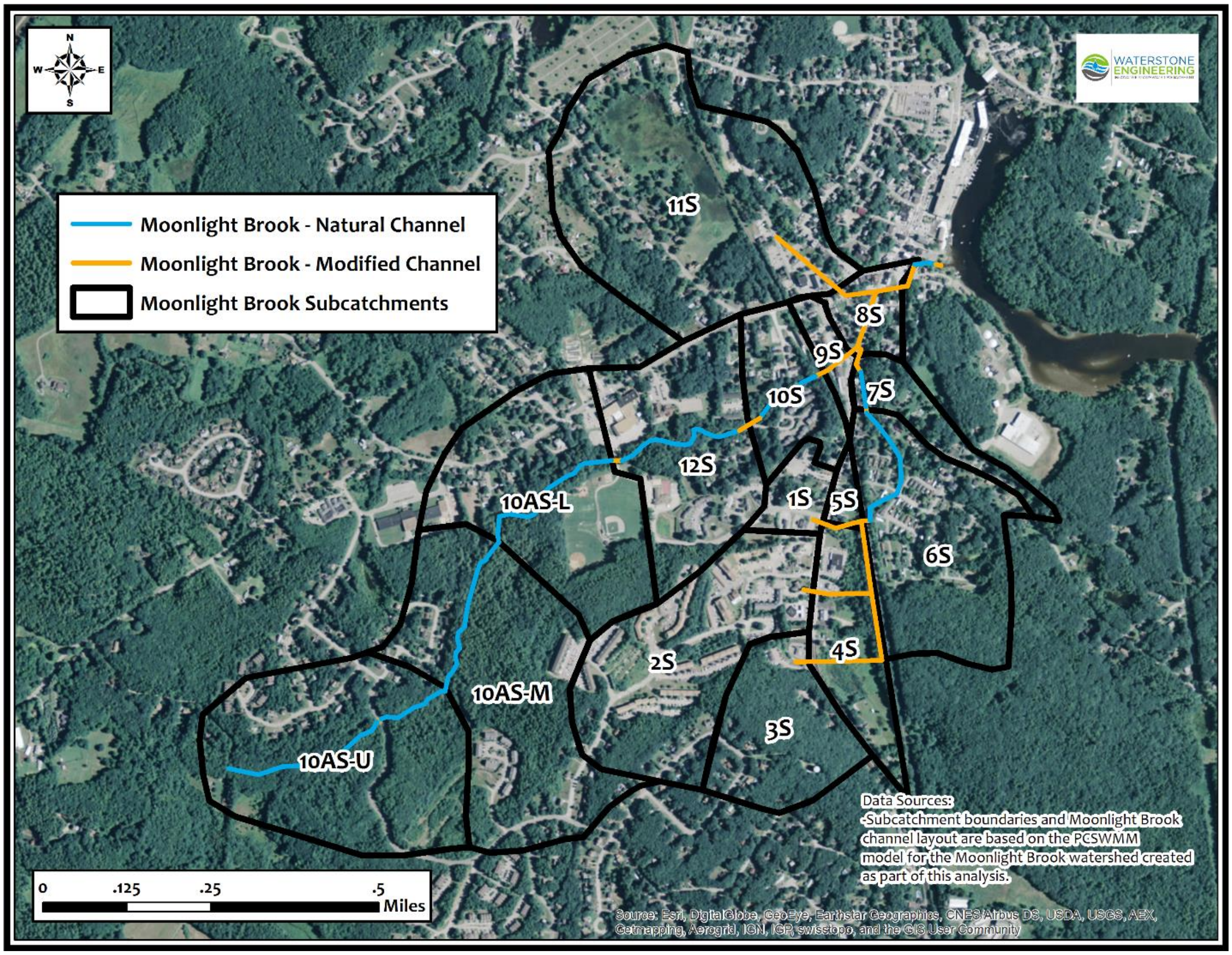


Figure 3-3 Moonlight Brook drainage network

3.1.1 Growth Trends

Growth trends for the Lamprey River Watershed were examined by Wake et al (2013) and found to be about 4% and 5% per year for conversion of residential and non-residential lands from 1962-2005 (Table 3-2). Similarly, population trends were shown to be about 3% per year from 1960 - 2010 as per census statistics (Table 3-3).

Table 3-2 Historical build-out rates for land used for residential development and non-residential development from 1962 to 2005 in the Lamprey River Watershed. Data from NH GRANIT (Wake et al 2013)

Year	Residential Development (acres)	Percent change per year	Non-Residential Development (acres)	Percent change per year
1962	3,381	-	531	-
1974	4,983	3.9%	829	4.7%
1998	11,201	5.2%	1,526	3.5%
2005	13,504	2.9%	2,169	6.0%
Mean	-	4.0%	-	4.70%

Table 3-3: Population data for all towns that have at least a portion of their area that lies within the Lamprey River Watershed. Data from the US Census Bureau (Wake et al 2013)

Year	Population	Percent change per year
1960	28,915	-
1970	39,749	3.7%
1980	56,306	4.2%
1990	76,987	3.7%
2000	88,333	1.5%
2010	98,990	1.2%
Mean	-	2.9%

3.2 Environmental Impacts from Growth

Monitoring and research conducted by various university, local, state and federal programs and projects have documented stresses in the Great Bay system. Prominent drivers of change include watershed modification and development resulting in increased impervious cover; increased nutrient and pollutant loading from a rapidly growing coastal population; and ecosystem instability and loss of diversity caused by invasive species, habitat destruction, disease, and others. Each stress drives additional physical, chemical, and biological pressures on the Great Bay system that effect the environmental, lifestyle, and economic benefits valued by local communities. Environmental indicators used by the National Estuaries Program to identify and track ecosystem health clearly illustrate an ecosystem in trouble. In the most recent *State of Our Estuaries 2013* report (PREP, 2013), 12 of 16 indicators showed a declining or cautionary condition. Impervious cover, an indicator of development, shows a long-term increasing trend which is related to condition indicators including nutrient concentration, eelgrass, dissolved oxygen, and macroalgae that show either no improvement or continued quality decline.

3.3 NPDES Wastewater Permit and Administrative Order on Consent

In 2004, the Town of Newmarket received an administrative order from the EPA requiring the town to upgrade its wastewater treatment facility in order to address the level of nitrogen that the facility was discharging to the Great Bay. As part of this order, the town would have to address non-point sources such as runoff, fertilizers and septic systems.

In 2011, the town received a draft National Pollutant Discharge Elimination System (NPDES) permit and was subsequently issued a final permit in 2012. The town entered into an AOC in order to address concerns raised in the permits. First, the town had to approve bonding of a $14.1 million wastewater treatment facility upgrade, a project that was required to begin by 2015 and completed by March 2017.

Once the facility is complete, the town cannot discharge effluent with nitrogen concentration higher than 5.0mg/l for an interim period. If the EPA determines that this requirement is not effective in reducing nitrogen levels in the Great Bay, they can mandate that the town fund another wastewater treatment facility upgrade to reduce effluent nitrogen to no more than 3.0mg/l. If required, the town would have five years from the determination date to complete this second upgrade.

In addition, the town has to track all activities that impact nitrogen loading to the Great Bay. This includes, but is not limited to, septic systems, decentralized wastewater treatment facilities, changes in the amount of impervious cover, conversion of existing landscape to lawn, and any new or modified BMPs. When the AOC went into effect, the town began coordinating with NHDES and other Great Bay communities on developing a tracking system for quantifying the total nitrogen associated within the town that affects the Great Bay estuary.

The Moonlight Brook project will augment work that is currently underway related to establishing a tracking/accounting system for total nitrogen, under the Pollution Tracking and Accounting Pilot Program (PTAPP), in response to the town's EPA administrative order and will provide credit to the town under the MS4 program for non-point source pollution abatement once the town's new stormwater management program is underway.

PTAPP is a cooperative forum of watershed communities within the Great Bay region, which are working together toward identifying a consistent, effective tracking and accounting system for monitoring pollutant loads, including nitrogen, into the Great Bay. Newmarket is required to monitor and track nitrogen loading from point and nonpoint sources as part of its AOC.

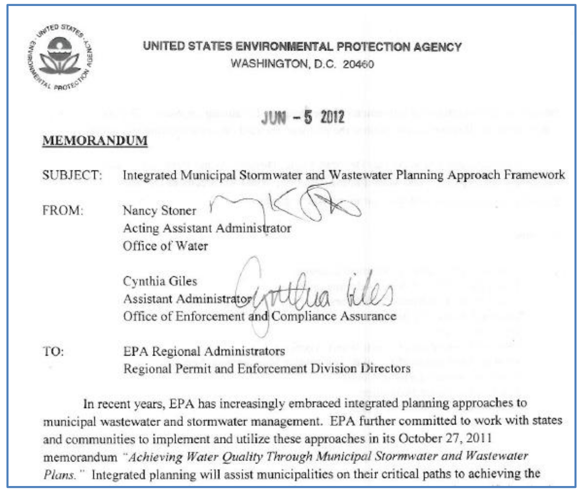
Planning staff in Newmarket continues to monitor progress with respect to the MS4 program by attending Seacoast Stormwater Coalition meetings. The group is discussing the feasibility of a coordination program involving a regional approach to assist communities with meeting the minimum NPDES permit requirements to help minimize costs and prevent the duplication of services at the local level for tasks such as outreach, bulk purchases of water quality monitoring equipment, and shared contracting for laboratory work.

3.4 Municipal Separate Storm Sewer System

Under the MS4 program, operated by EPA, towns with urbanized areas as defined by the US Census are required to obtain permit coverage for their stormwater discharges. Newmarket is subject to the pending requirements of EPA's Draft NH Small MS4 General Permit for stormwater discharges. EPA released a draft permit in 2013 with revisions in 2015 which contained new provisions for the 6 minimum measures (MM): 1) public education and outreach, 2) public participation/involvement, 3) illicit discharge detection and elimination, 4) construction site runoff control, 5) post-construction runoff control, and 6) pollution prevention/good housekeeping. Appendix H includes specific requirements for nitrogen source identification reporting including the identification and prioritization of retrofit opportunities for installation of structural BMPs. This includes optimization such as that conducted for Moonlight Brook for new and redevelopment stormwater management and a schedule for implementation to address the impairments.

3.5 EPA Integrated Planning Framework and Watershed Based Planning

The June 2012 EPA memorandum, "Integrated Municipal Stormwater and Wastewater Planning Approach Framework" provides guidance for EPA, states, and local governments to develop and implement effective integrated plans that satisfy the Clean Water Act (CWA). The framework outlines the overarching principles and essential elements of a successful integrated plan, which include:


UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUN - 5 2012

MEMORANDUM

SUBJECT: Integrated Municipal Stormwater and Wastewater Planning Approach Framework

FROM: Nancy Stoner
Acting Assistant Administrator
Office of Water

Cynthia Giles
Assistant Administrator
Office of Enforcement and Compliance Assurance

TO: EPA Regional Administrators
Regional Permit and Enforcement Division Directors

In recent years, EPA has increasingly embraced integrated planning approaches to municipal wastewater and stormwater management. EPA further committed to work with states and communities to implement and utilize these approaches in its October 27, 2011 memorandum *"Achieving Water Quality Through Municipal Stormwater and Wastewater Plans."* Integrated planning will assist municipalities on their critical paths to achieving the

- Maintaining existing regulatory standards that protect public health and water quality.
- Allowing a municipality to balance CWA requirements in a manner that addresses the most pressing public health and environmental protection issues first.
- The responsibility to develop an integrated plan rests on the municipality that chooses to pursue the approach. EPA and/or the state will determine appropriate actions, which may include developing requirements and schedules in enforceable documents.
- Innovative technologies, including GI, are important tools that can generate many benefits, and may be fundamental aspects of municipalities' plans for integrated solutions.

The elements in the Moonlight Brook Plan are consistent with guidance issued by EPA to support integrated permit planning, as well as the agency's nine-element watershed plans (Table 2.3)

Table 3-4. Comparison of EPA integrated planning (IP) guidance elements and EPA nine-element watershed planning.

EPA Integrated Planning Guidance Elements	EPA Nine-Element Watershed Planning
Element 1: A description of the water quality, human health and regulatory issues to be addressed in the plan	Element a: Identify causes and sources of pollution
Element 2: A description of existing wastewater and stormwater systems under consideration and summary information describing the systems' current performance	Element b: Estimate pollutant loads and expected load reductions
Element 4: A process for identifying, evaluating, and selecting alternatives and proposing implementation schedules	Element c: Describe management measures that will achieve load reduction Element d: Identify technical and financial assistance, and relevant authorities Element f: Project schedule Element g: Interim, measurable milestones

Element 5: Measuring success, which may include evaluation of monitoring data, information developed by pilot studies and other studies and other relevant information	Element i: Monitoring
Element 6: Improvements to the Plan	Element h: Identify indicators to measure progress
Element 3: A process which opens and maintains channels of communication with relevant community stakeholders	Element e: Information/education component

3.6 Municipal Regulations

For this approach to be effective, future regulations will need to be adopted by Newmarket that include: 1) provisions for new and redevelopment projects to require nitrogen controls, and 2) a means for tracking changes in significant land use activities that will impact the nitrogen load to surface waters. Newmarket is participating in a PTAPP, which intends to develop a uniform approach and means that can be used by communities for MS4 and AOC tracking and accounting.

The town has a range of existing land use regulations and policies designed to protect water quality, including shoreland and buffer ordinances, stormwater management regulations, land conservation programs, storm drain stenciling projects, and educating residents about properly disposing of pet waste and the proper application of lawn fertilizers.

PREP recently completed an assessment of local land use regulations and programs related to natural resources protection in the watershed. The March 2015 Piscataqua Region Environmental Planning Assessment (PREPA) report includes an evaluation of water quality protection regulations in the 52 communities in New Hampshire and Maine that comprise the watersheds for the Great Bay and Hampton/Seabrook estuaries.

Newmarket received a score of 50% for freshwater wetland protection, 25% for stormwater management, 20% for shoreland buffers and setbacks, and no ranking for climate change planning, with the following recommendations:

1. Adopt a 100’ buffer setback for septic and structures from water bodies.
2. Increase fertilizer application buffer setback to 100’.
3. Adopt mandatory conservation subdivision regulations.
4. Complete a climate vulnerability assessment.

The PREPA report recommends the adoption of the Southeast Watershed Alliance model stormwater management regulations.

3.6.1 Southeast Watershed Alliance Model Stormwater Management Regulations

The Southeast Watershed Alliance developed model stormwater standards in 2012 to provide minimum, consistent, and effective model stormwater management standards for communities in the Great Bay. These standards are intended to address some of the requirements for communities subject to MS4 permit. The model standards include 7 critical core elements:

Element A: applicability standards
Element B: minimum thresholds for applicability
Element C: BPMs

Element D: applicability for redevelopment
Element E: stormwater management plan approval and recordation
Element F: maintenance criteria
Element G: inspection of infrastructure

3.7 Impaired Waters

The CWA requires each state to submit a list of impaired waters to the EPA every two years. Listing of impaired waters (303d list) includes surface waters that:

- Are impaired or threatened by a pollutant or pollutant(s),
- Are not expected to meet water quality standards within a reasonable time even after application of best available technology standards for point sources or best management practices for nonpoint sources and,
- Require development and implementation of a comprehensive water quality study (i.e., called a Total Maximum Daily Load (TMDL) study) that is designed to meet water quality standards.

The impaired waters tributary to Moonlight Brook within the Town of Newmarket include: portions of the Piscassic River as non-supporting severe and marginal (5P, 5M), the Lamprey River behind the Macallen Dam and Lower as non-supporting marginal as detailed in the 2014 Water Quality Assessment for 303D listing (http://www2.des.state.nh.us/WaterShed_SWQA/WaterShed_SWQA.aspx).

4. CLIMATE RESILIENCY STUDY

Climate resiliency and vulnerability within the Moonlight Brook watershed was evaluated to understand the relationship between flooding, future development, the benefits of LID zoning, and climate change. A watershed model was developed building on a number of existing studies and methods (Underwood Engineers 2009, Scholz et al 2011, Wake t al 2013, Roseen et al 2015), and includes not only local runoff from within the Moonlight Brook watershed but also inflow from the larger Piscassic River, which is diverted into Moonlight Brook during large storm events.

The climate resiliency study included the following elements:

- Watershed survey
- Watershed hydrologic modeling
- Hydraulic flood modeling
- Scenario planning for both future climate conditions and future buildout conditions
- Analysis of the Piscassic River breech
- Bmp optimization and prioritization
- Flood modeling analysis of climate mitigation strategies
- Implementation plan costing

4.1 Runoff and Flood Modeling Approach

A complete base model of Moonlight Brook has been created in PCSWMM. The model uses the drainage areas in the Moonlight Brook flood study by Underwood Engineers (2009), the cross-sections from the Lamprey HEC-RAS model (2012), and the recent drainage infrastructure survey data collected by the project team in 2015.

The model was developed using a hydrologic response unit (HRU) approach. Unattenuated runoff volume was calculated for idealized 1-acre representative parcels, with varying combinations of land use, soil type, and impervious cover. Precipitation data from the Northeast Regional Climate Center (NRCC) specific to Newmarket is used to perform a 24-hour rainfall-runoff simulation of the HRUs to estimate the amount of stormwater volume generated by each HRU during a 100-year, 24-hour storm event.

Unattenuated runoff volume represents the volume of runoff that flows off the surface prior to any natural attenuation that occurs as the runoff migrates towards the receiving water. Once stormwater migrates from the surface on which it was initially generated, natural attenuation occurs as the water travels across pervious surfaces and vegetated buffers and through streams and natural waterways. By accounting for natural attenuation, the runoff volume which ultimately arrives at the receiving water can be estimated. Runoff volumes presented in this section have been adjusted to account for the estimated level of impervious surface disconnection in the Moonlight Brook watershed.

The modeled HRUs are idealized catchments used in the model to estimate the amount of stormwater runoff generated by precipitation. There are eight distinct HRUs representative of each combination of four hydrologic soil groups (HSG) and two imperviousness conditions (fully impervious and fully pervious). In this respect, an HRU is not used to model a single specific land use, but to model all land uses that share the soil type and impervious cover of the given HRU.

The Moonlight Brook flood hazard was assessed for current conditions (using a 2005 land use dataset), for 2050 conditions assuming a conventional buildout, and for 2050 conditions assuming an LID-focused buildout. For the ‘current conditions’ scenario a 24-hour storm event with 8.75 inches of rainfall was used to represent the 100-year storm based on estimates from the NRCC. For both 2050 scenarios, the rainfall depth for the 100-year 24-hour storm was increased by 15% to 10.06 inches to represent the likely impacts of climate change in the coming decades.

4.1.1 Management Scenarios

A range of management scenarios were evaluated for reducing flooding in the Moonlight Brook watershed. The scenarios include:

(1) Disconnecting the Piscassic River breech channel from the Moonlight Brook watershed with a current 100-year, 24-hour storm depths of 8.75 inch based on current NRCC data.

(2) Re-routing the New Road drainage network directly into the Lamprey River with a current 100-year, 24-hour storm depths of 8.75 inch based on current NRCC data.

(3) Future climate conditions for the year 2050 based on a 15% increase increases in storm depth as recommended by the CRHC STAP report with a 100-year, 24-our storm depths of 10.06 inch.

(4) Implementing LID strategies as a means of climate adaption for new and existing developments within the Moonlight Brook watershed for the year 2050 based on build-out projections and a 100-Yyear, 24-hour storm depths of 10.06 inch.

Inflows from the Piscassic River during simulated 100-year storm events make up around half of the total flow within Moonlight Brook. Eliminating these inflows is the single most effective option for reducing flood risk within the Moonlight Brook watershed. Initial modeling suggests that eliminating the Piscassic breech will increase flood flows by 0.5-1.0 feet in the Piscassic River. Re-routing the inflow from the New Road drainage system also has a significant impact on flow rates, reducing peak flow in the Moonlight Brook main channel by 4%.

Implementing an LID-focused development strategy has the potential to reduce runoff within the Moonlight Brook watershed by 21%, reducing peak flow rates by 12%. An analysis was conducted to determine the cost of installation and implementation of non-point source strategies for achieving a full range of reductions including management of all impervious areas and significant sources. To evaluate this, a linear optimization (LO) model was developed which analyzes a range of pollutant load reduction targets with a range of land use types, soil types, non-point management measures and capture depth sizes.

4.1.2 Buildout Methodology

The buildout methodology was adopted from a study by Wake et al (2013) excerpted below.

> The build-out scenario was based on a polynomial best fit to the historical 1962-2005 residential and nonresidential developed land data (Figure 4-1). This build-out scenario extrapolates the observed exponential increase in the rate of land use development in the Lamprey River watershed since 1962, even as the rate of increase in population had begun to decrease in 1990. The growth rates for all residential and nonresidential development over the past 50 years (i.e. from 1962 – 2005) were used as a basis to project future growth in development (Table 3-2, Table 3-3). The historic land use data for the years 1962, 1974, and 1998 included generalized commercial and industrial development classes, and did not parse out roads, airports, parking lots, ports, and other infrastructure. Accordingly, we relied upon these generalized commercial and industrial development classes (i.e., total non-residential land-use) growth rates in the past to estimate future development of commercial and industrial zoned land.
>
> This approach assumes that an increase in growth of associated infrastructure is required to support the development of commercial and industrial land use. Using this exponential growth scenario, residential development covers 66,002 acres (48% of total watershed area) and nonresidential development covers 14,620 acres (11% of total watershed area) by 2100. While the land use scenario (exponential growth of both residential and commercial/ industrial development) does represent considerable growth in the area of developed land in the Lamprey River watershed (59% of total land area in the watershed by 2100), it was eventually selected as the input for the hydrological and hydraulic modeling by the project team for two reasons. First, it most accurately captured the trends in past land use development. Second, it serves to maximize the differences between

current and projected future conditions with respect to build-out and flood risk and thus provides a valuable reference point for discussions with coastal decision-makers.

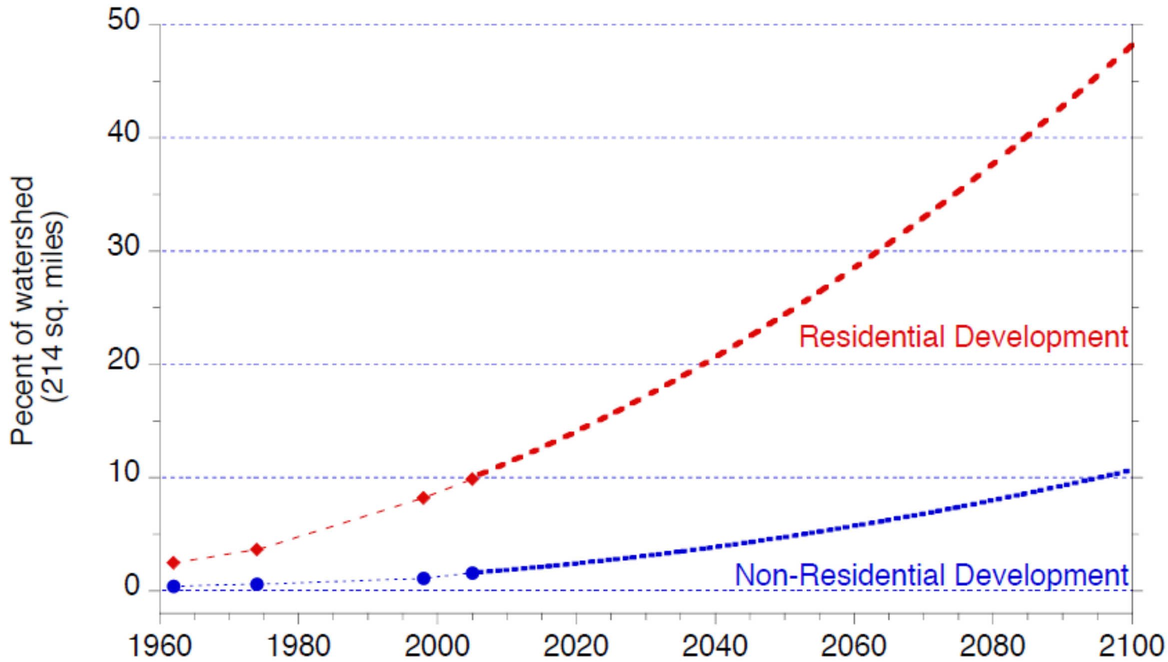


Figure 4-1: Exponential extrapolation of historical residential and non-residential development in the Lamprey River watershed out to 2100 (Wake et al 2013)

4.1.3 Costing of Climate Mitigation Strategies and Runoff Control Measures

To evaluate the cost of each control measure, costing data was collected from at minimum 5 sources using local data, design reports and professional judgment (EPA 1999, FB Environmental 2009, Filterra 2011, Herrera 2011, TetraTech 2009, UNHSC 2012, CRWA 2014, Geosyntec 2014). Costing information varies substantially by area and as such professional judgment was used in the final estimation of the cost range. Cost ranges were scaled based on capture volume. New and redevelopment costs were considered for porous pavements. As such redevelopment costs are total cost while new development costs are a limited cost differential over standard pavement as that would be covered separately. Figure 4-2 presents the cost per pound removed range for the nutrient management strategies evaluated as part of the optimization model. Figure 4-2 presents a single cost for non-structural measures and a cost range, defined by the length of the bar, for structural management measures. The structural practice cost range is defined by the management measure capture depth and the potential for pollutant removal is defined by structural practice type, underlying soil type (i.e., infiltration rate) and land use.

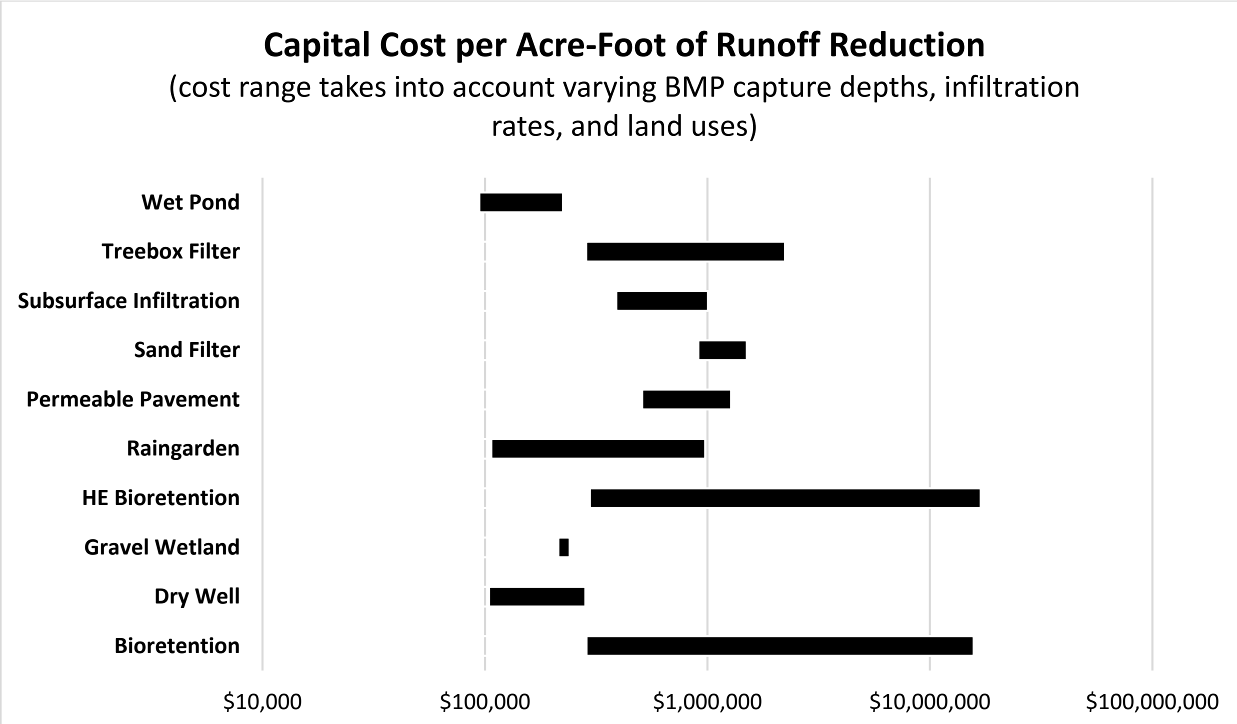


Figure 4-2 Runoff Management Strategy Capital Cost (Roseen et al 2015)

4.1.4 Modeling Results

Table 4-1, below, displays predicted peak and total streamflows in Moonlight Brook for ten modeled scenarios. For the baseline assessment, the total runoff volume from the Moonlight Brook watershed was estimated at 66 million gallons during the 100-year 24-hour storm (8.75 inches of rainfall). The Piscassic River contributes an additional estimated 199 million gallons to Moonlight Brook during a storm of this magnitude, leading to a peak outflow of 899 cfs at the Moonlight Brook outlet to the Lamprey River. Figure 4-5 shows the predicted flooding extent for this scenario. Figure 4-3 and Figure 4-4 il;lustrate peak flow reduction by scenario for the various scenarios.

Table 4-1 PCSWMM model results for various land use, climate, and management scenarios

2015 Land Use; 8.75 inch 24-hour storm	307.51 cfs inflow from Piscassic River	66	199	899	225
	No inflow from Piscassic River	66	0	447	63
	Disconnect Newroad Drainage; 307.51 cfs inflow from Piscassic River	66	199	864	207
	Disconnect Newroad Drainage; No inflow from Piscassic River	66	0	399	43
2050 Buildout; 8.75 inch 24-hour storm	307.51 cfs inflow from Piscassic River	69	199	922	227
	No Inflow from Piscassic River	69	0	545	79
2050 LID Buildout; 8.75 inch 24-hour storm	307.51 cfs inflow from Piscassic River	52	199	792	214
	No Inflow from Piscassic River	52	0	369	50
2050 Buildout; 10.06 inch 24-hour storm	612.35 cfs inflow from Piscassic River	84	396	1171	366
	No Inflow from Piscassic River	84	0	545	79
2050 LID Buildout; 10.06 inch 24-hour storm	612.35 cfs inflow from Piscassic River	72	396	1064	355
	No Inflow from Piscassic River	72	0	467	67

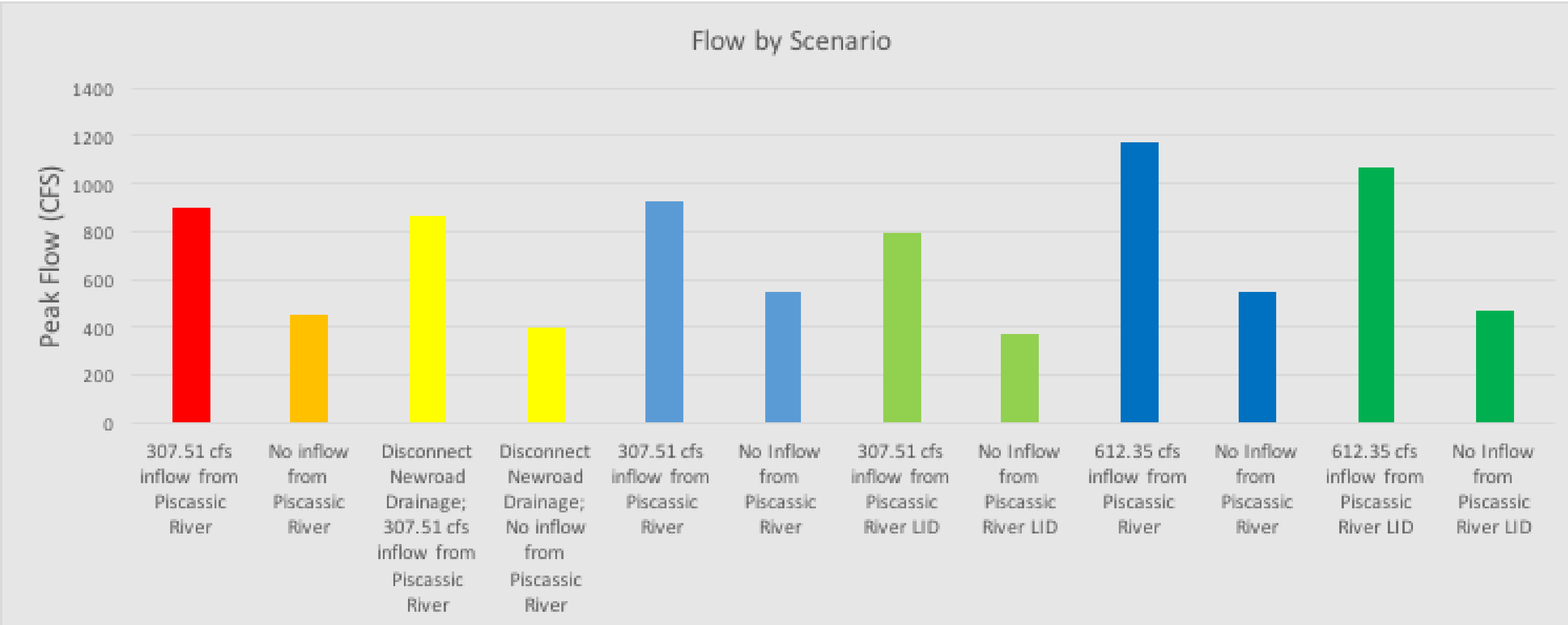


Figure 4-3: Peak Flows by Scenario; red as current, yellow as conventional zoning without Piscassic breech, yellow and light green as future 2050 buildout with 8.7" 100-YR storm depth with LID and blue with conventional zoning; blue and green for the future 250 buildout condition with 10" 100-YR storm depth with conventional and LID zoning

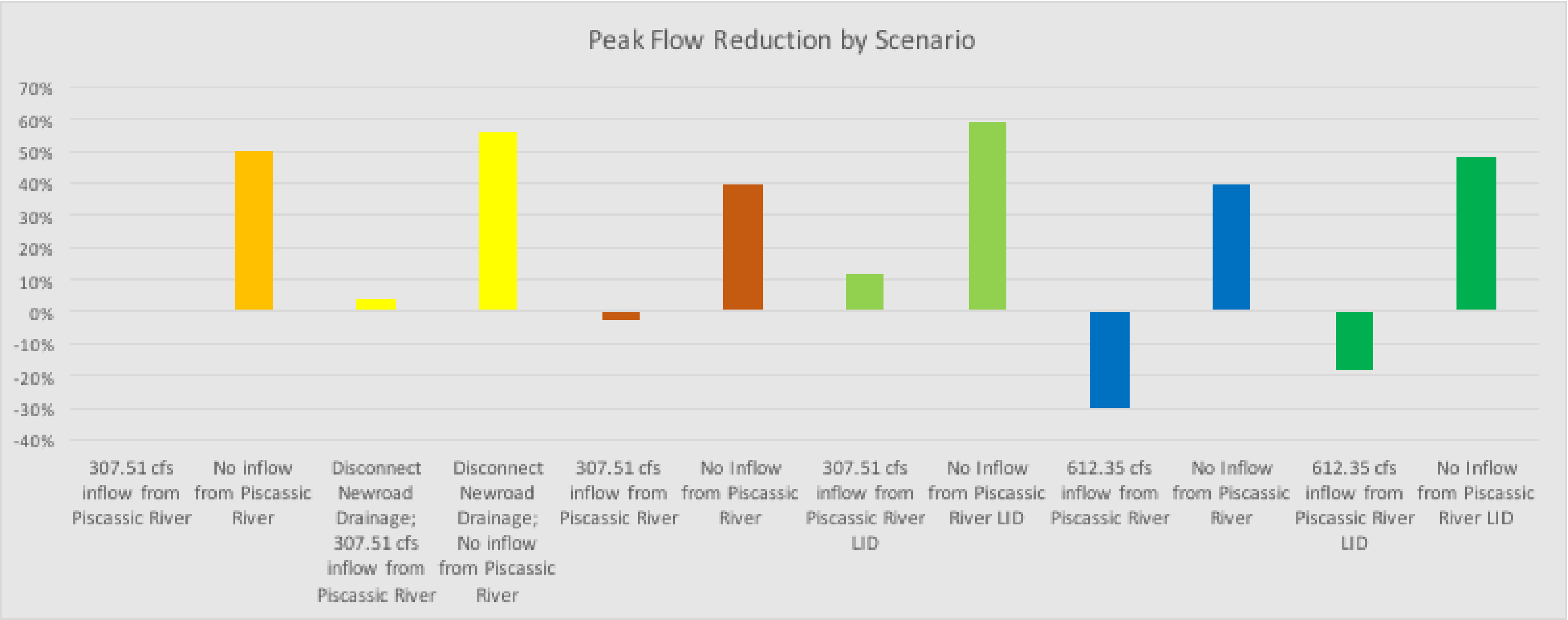


Figure 4-4: Peak Flows Reduction by Scenario; red as current, yellow as conventional zoning without Piscassic breech, yellow and light green as future 2050 buildout with 8.7" 100-YR storm depth with LID and blue with conventional zoning; blue and green for the future 250 buildout condition with 10" 100-YR storm depth with conventional and LID zoning

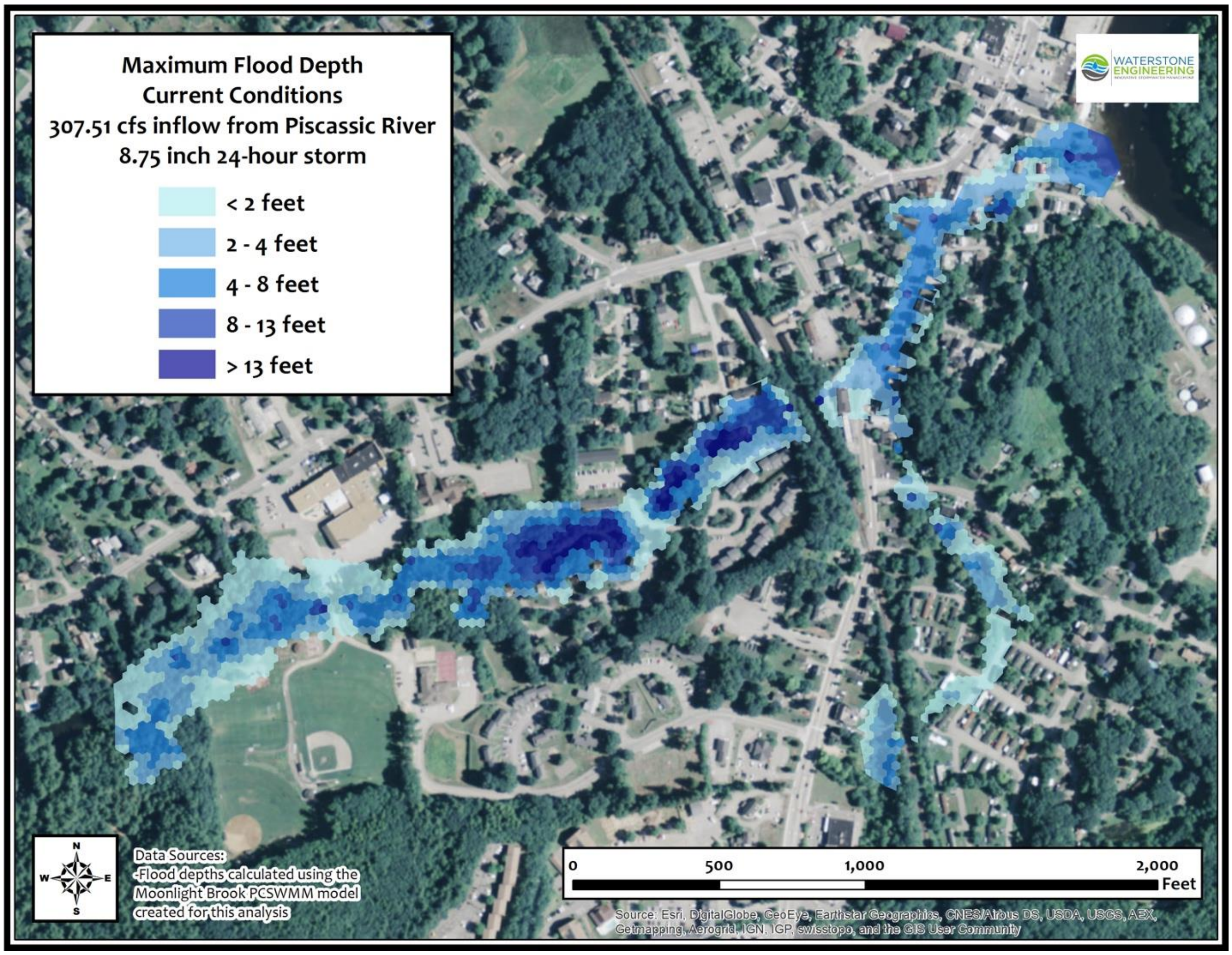


Figure 4-5 Modeled flooding extent for '2015 current conditions' scenario

Taking into consideration projected land use change by the year 2050, the total runoff volume from the Moonlight Brook watershed is expected to increase to 69 million gallons during the 100-year 24-hour storm (8.75 inches of rainfall). Combining this with inflows from the Piscassic River, a peak outflow of 922 cfs is estimated at the Moonlight Brook outlet.

Factoring in climate change in addition to projected land use change by the year 2050, the total runoff volume from the Moonlight Brook watershed is expected to reach 84 million gallons during the 100-year 24-hour storm (10.06 inches of rainfall), along with an increased inflow of 396 million gallons from the Piscassic River. Under these conditions, peak outflow to the Lamprey River from Moonlight Brook is estimated at 1171 cfs. Figure 4-6 shows the predicted flooding extent for this scenario.

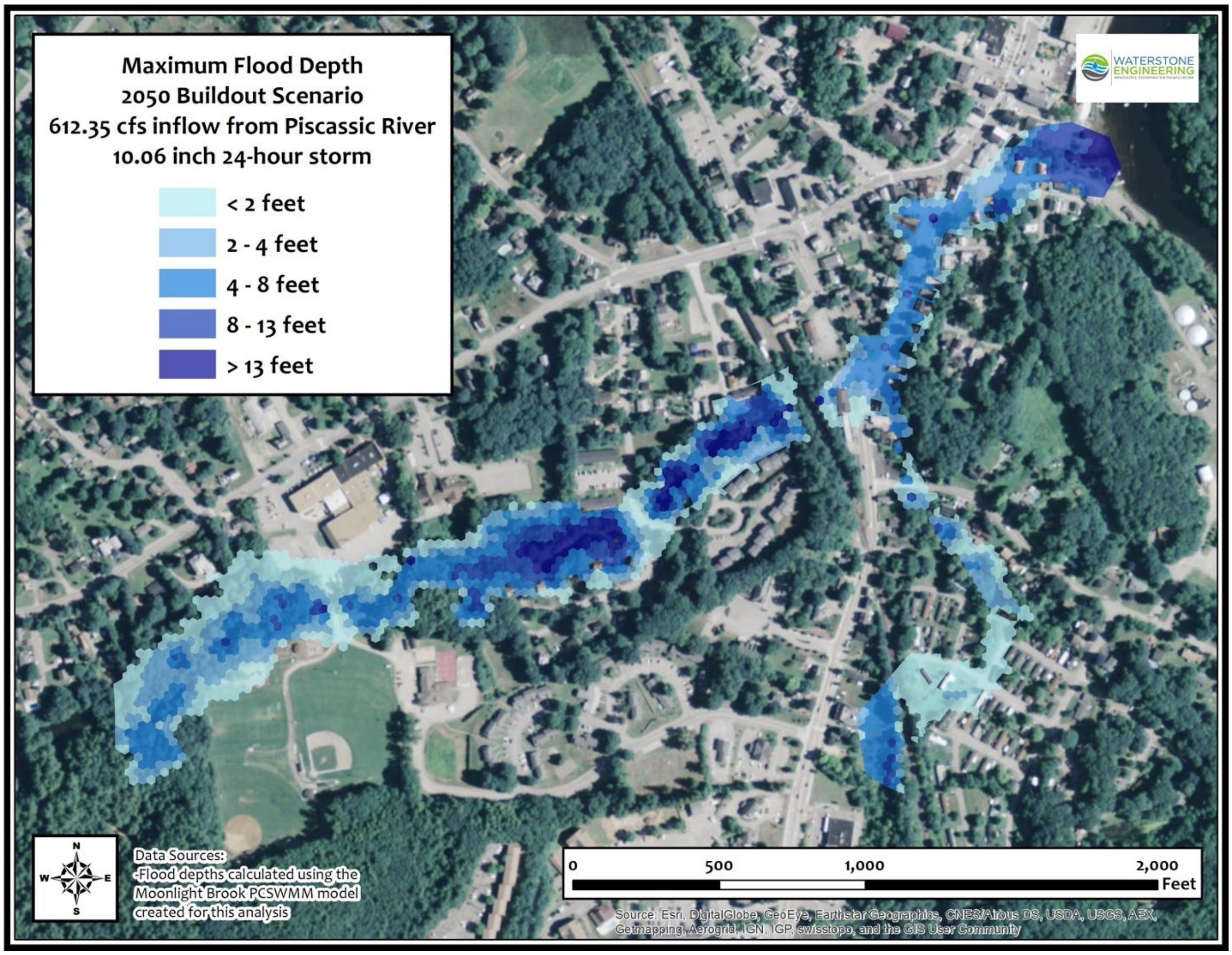


Figure 4-6 Modeled flooding extent for the '2050 Conventional Buildout' scenario

However, runoff from the Moonlight Brook watershed can be significantly reduced by employing a low-impact development approach throughout the watershed. Applying an LID approach to the projected land use changes by the year 2050, the total runoff volume during the 100-year 24-hour storm event from within the Moonlight Brook watershed is estimated at 52 million gallons without factoring in climate change (8.75 inches of rainfall) and 72 million gallons with climate change (10.06 inches of rainfall). Assuming inflows from the Piscassic River remain unchanged, model estimates for these conditions predict peak outflows from Moonlight Brook of 792 cfs and 1064 cfs, respectively. Figure 4-7 shows the predicted flooding extent for this scenario.

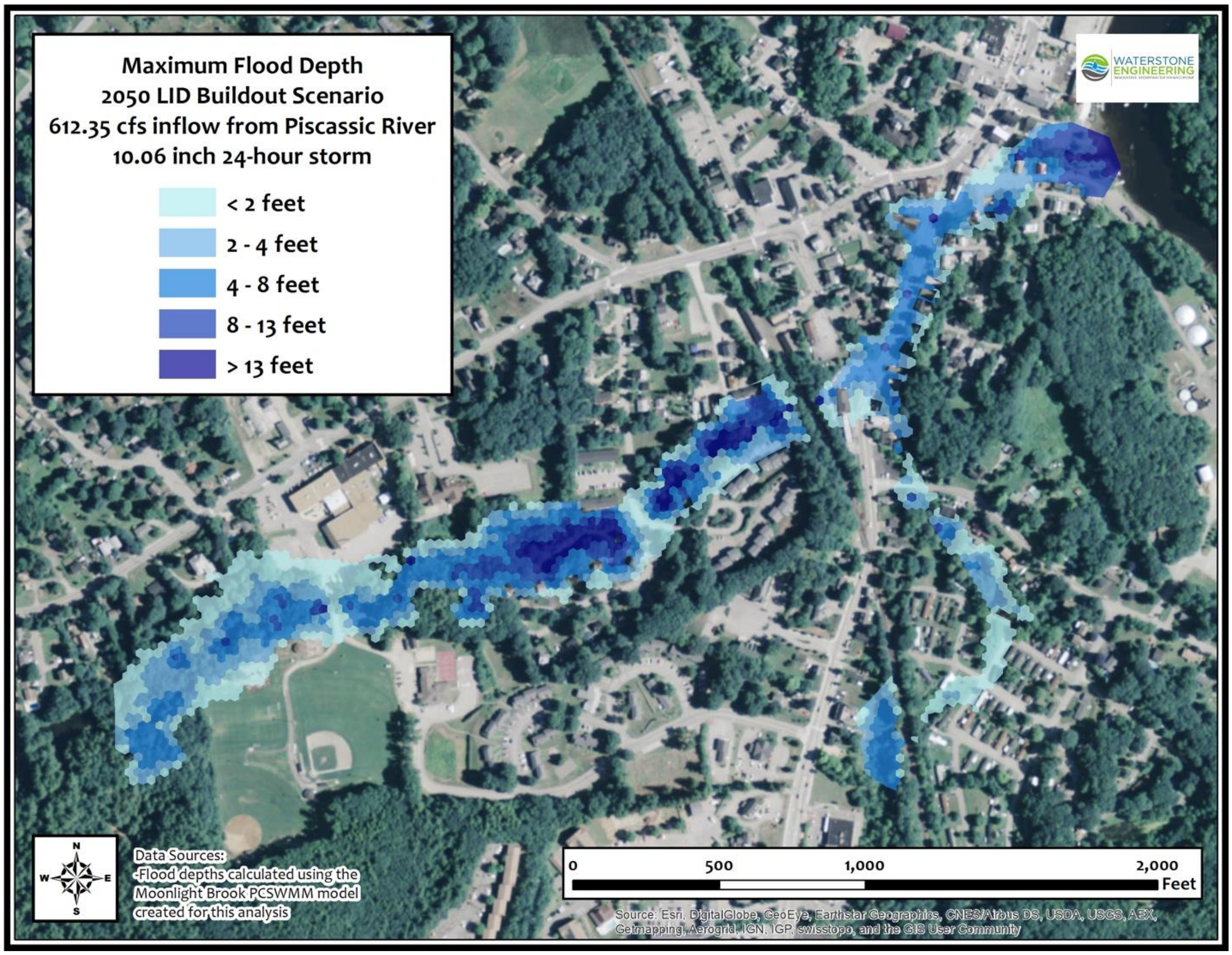


Figure 4-7 Modeled flooding extent for the '2050 LID Buildout' scenario

Inflows from the Piscassic River breech contribute nearly 50% of the total flow in Moonlight Brook for the current conditions scenarios (with an 8.75-inch storm event) and more than 50% of the total flow in Moonlight Brook for the 2050 conditions scenarios (with a 10.06-inch storm event). Disconnecting the Piscassic River breech from Moonlight Brook is the single most effective management strategy for reducing flooding in the Moonlight Brook watershed. Figure 4-8, Figure 4-9, and Figure 4-10 display the predicted flooding extent for each of the above scenarios but with no inflows from the Piscassic River.

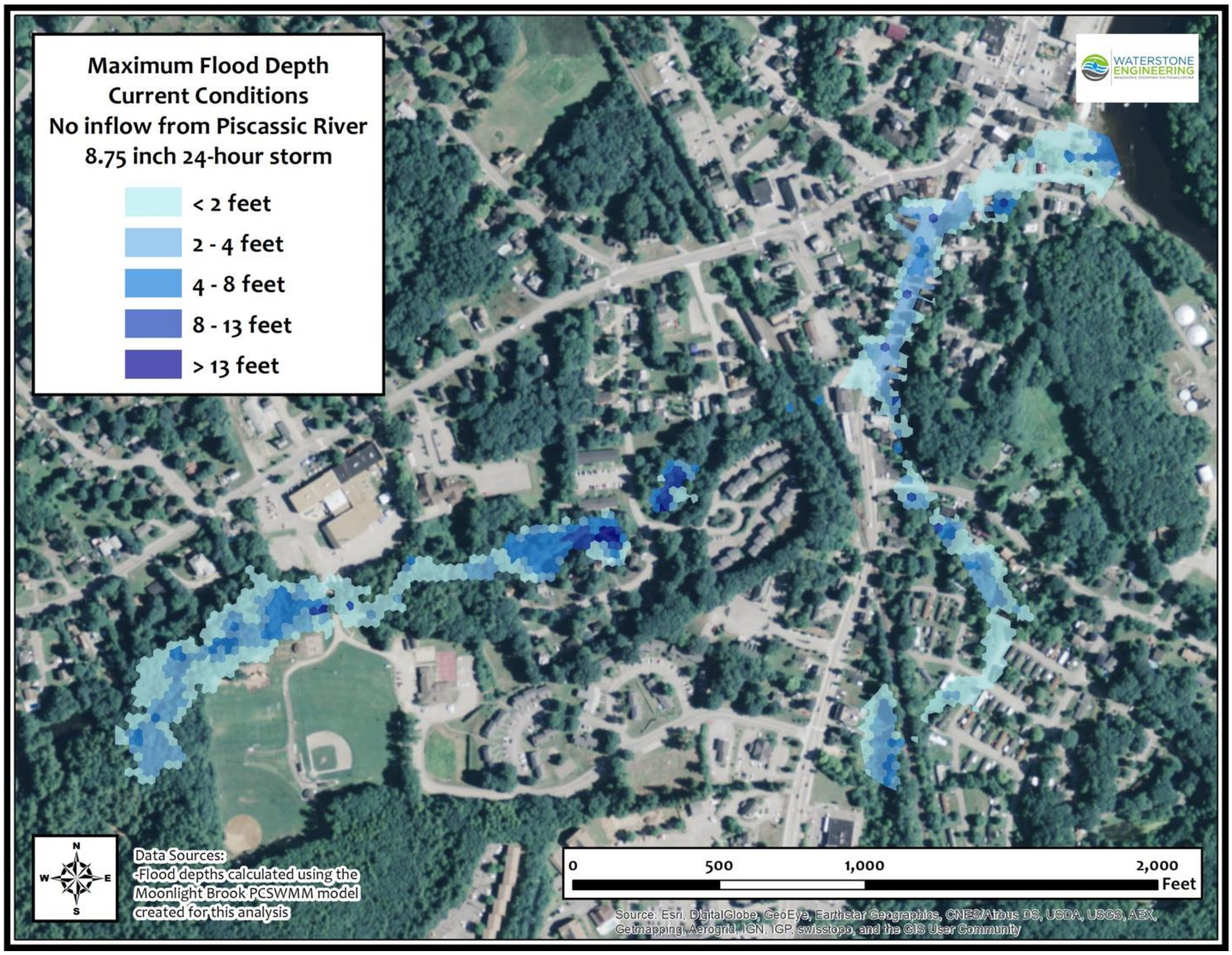


Figure 4-8 Modeled flooding extent for 'current conditions' scenario with no Piscassic River inflow

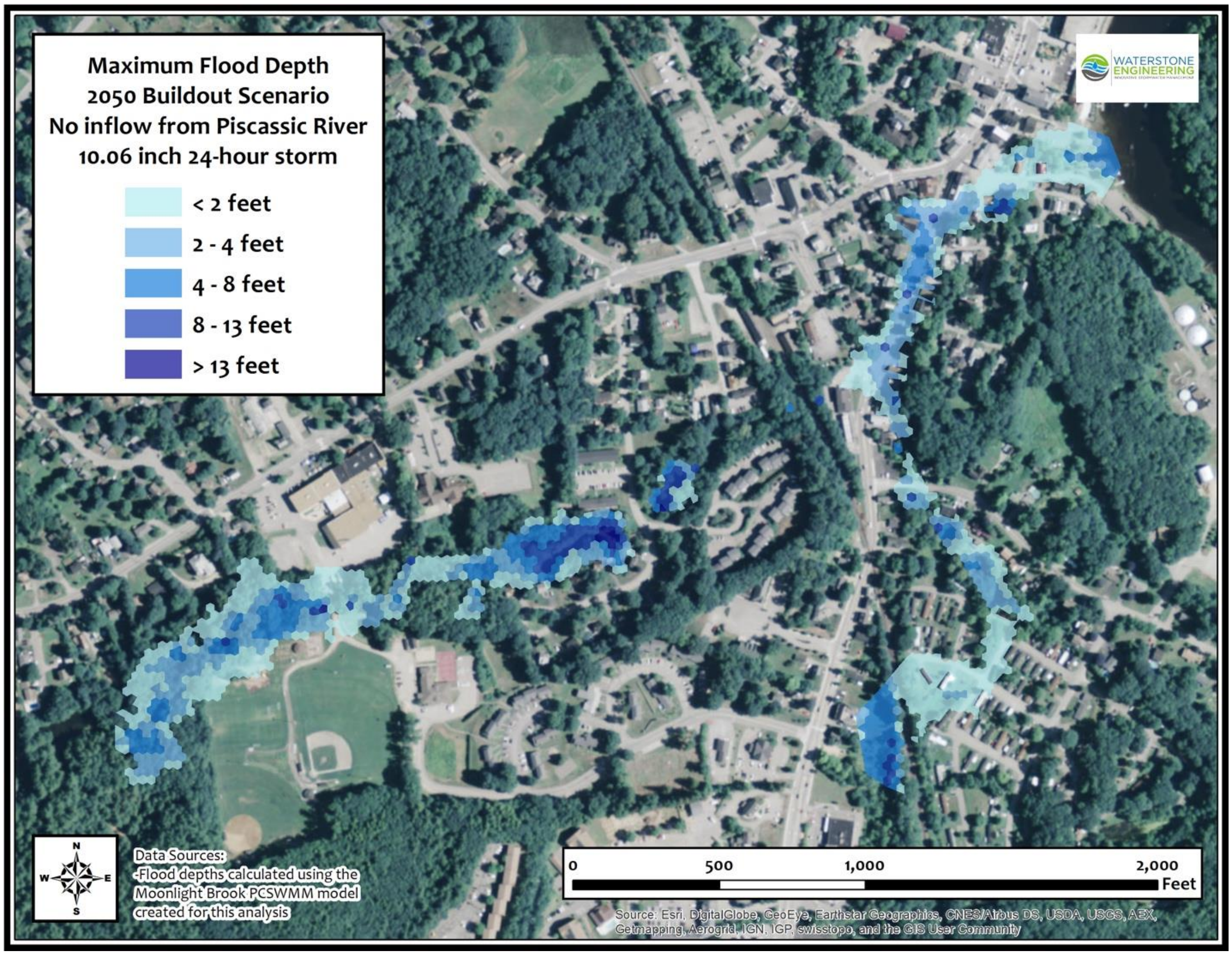


Figure 4-9 Modeled flooding extent for the '2050 Conventional Buildout' scenario with no Piscassic River inflow

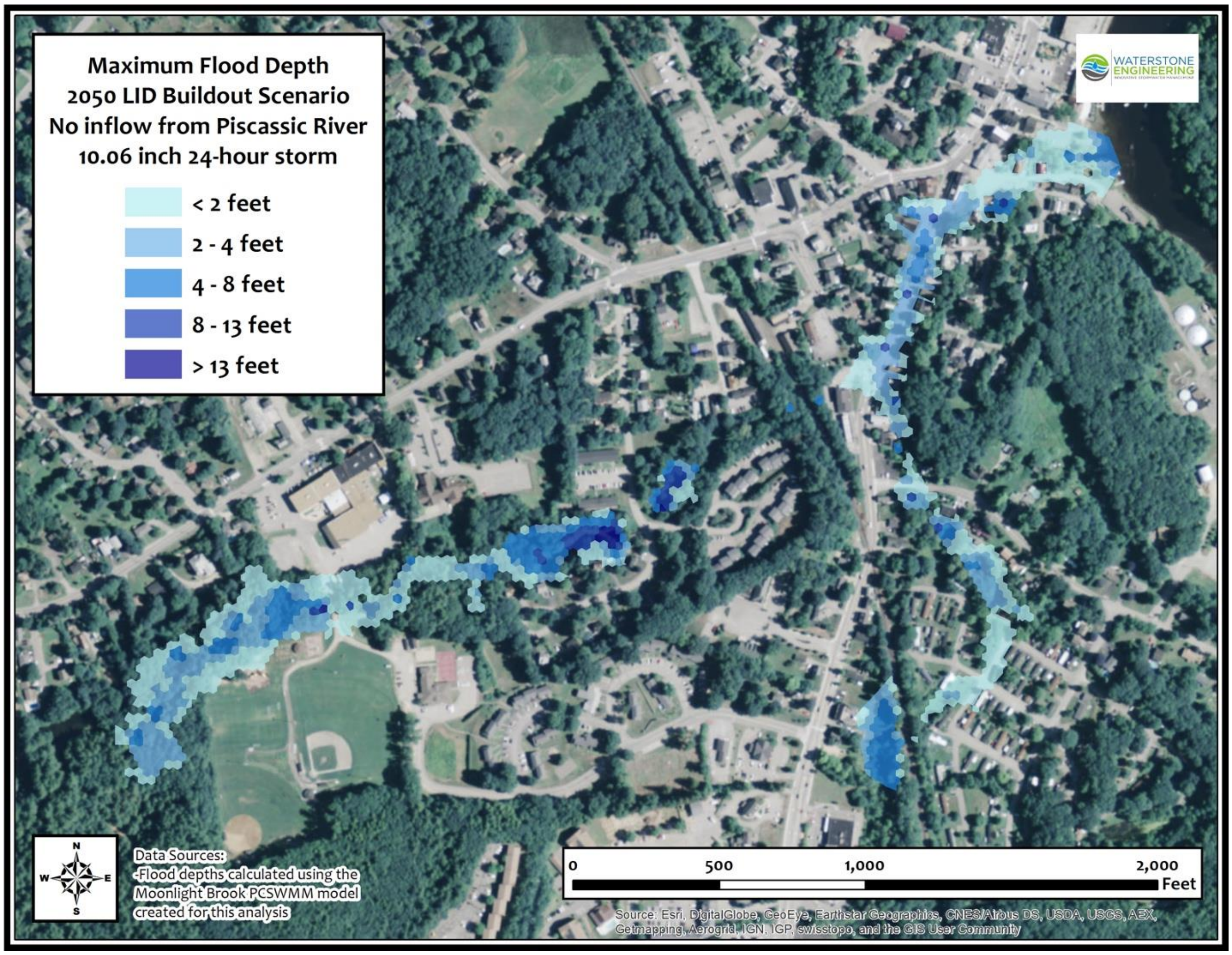


Figure 4-10 Modeled flooding extent for the '2050 LID Buildout' scenario with no Piscassic River inflow

Inflows from the New Road drainage area in the southern portion of the Moonlight Brook watershed contribute 10% of total flows to the Moonlight Brook main channel. Re-routing the New Road drainage to flow directly into the Lamprey River has the potential to reduce the flooding extent in downtown Newmarket. When implemented in conjunction with disconnecting the Piscassic River breech, flooding extent is reduced significantly. Figure 4-11 displays the predicted flooding extent for this scenario under current land use and climate conditions.

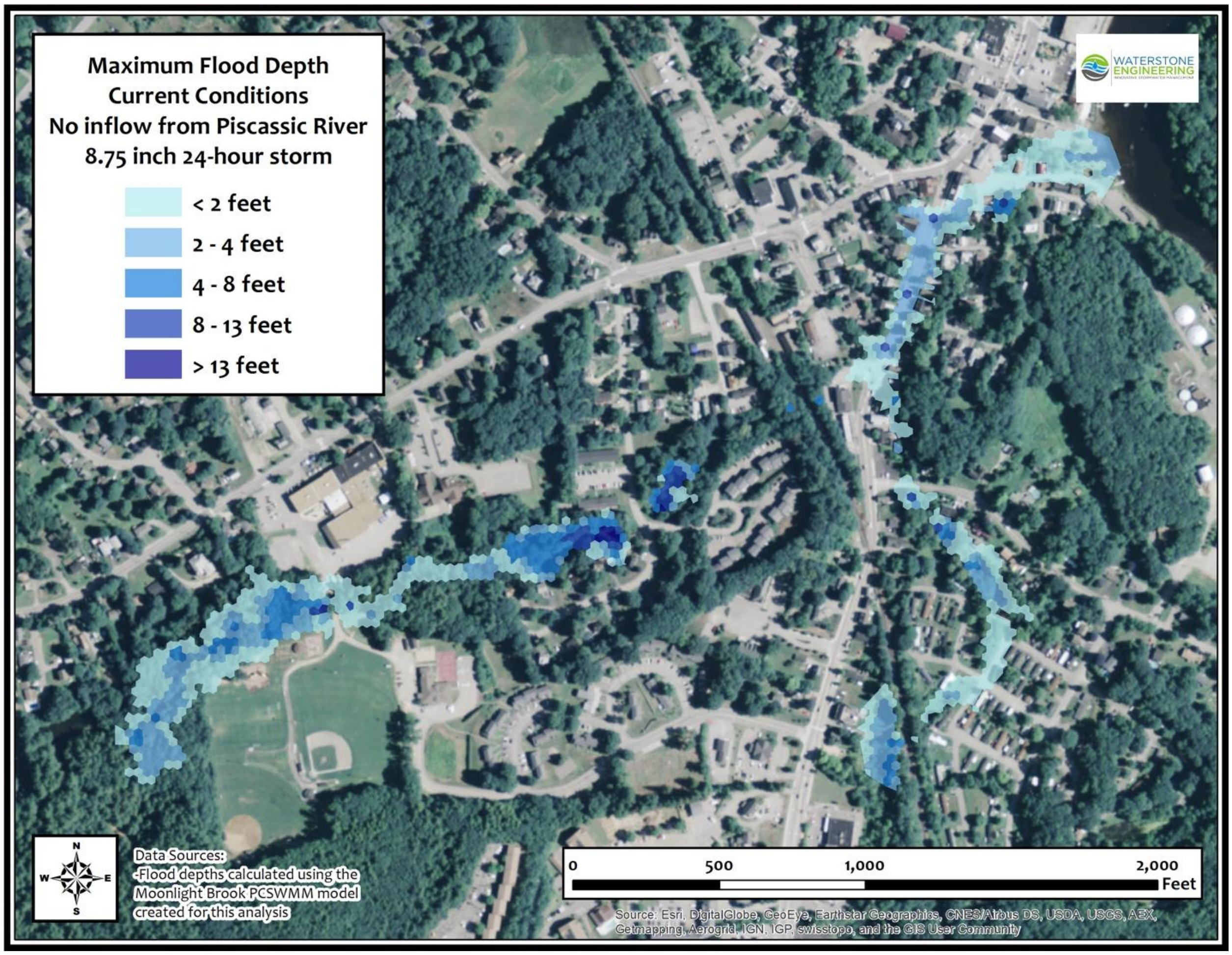


Figure 4-11 Modeled flooding extent for 'current conditions' scenario with no Piscassic River or New Road inflow

4.1.5 Piscassic Breech and Flood Impacts

Building off of work from 'Assessing Flood Risk in the Lamprey River Watershed' (Wake et al 2013), a HEC-RAS model for the Lamprey River basin was used to determine the impacts to the Piscassic River if the breech to Moonlight Brook was eliminated. The HEC-RAS model was used in a steady-state simulation for current conditions (1,589.1 cfs of streamflow), and with an added 307.51 cfs of flow (1,896.61 cfs) downstream of the Moonlight Brook breech channel. Predicted water surface elevations at the 14 river stations between the breech channel and the Piscassic-Lamprey confluence are shown in Table 4-2, below.

Table 4-2– Piscassic River water surface elevations with and without the Moonlight Brook breech

River Station	WSE (ft.) – Current Conditions	WSE (ft.) – Breech Removed	Change in WSE (ft.)
14680	67.34	68.23	0.89
13620.5	66.57	67.56	0.99
13578.1 BR U	63.87	64.48	0.61
13578.1 BR D	62.76	63.37	0.61
13544.4	62.17	62.57	0.4
11883.01	52.08	53.09	1.01
10827	48.8	49.54	0.74
6706.041	48.27	48.8	0.53
5422	47.9	48.35	0.45
4606	47.79	48.25	0.46
3940	45.97	46.27	0.3
3210.168	34.88	35.15	0.27
2070.144	34.88	35.15	0.27
487.0481	34.87	35.15	0.28

These initial results suggest that eliminating all inflows to Moonlight Brook from the Piscassic River would result in water surface elevation increases of between 0.27 and 1.01 feet along the Piscassic downstream of the breech.

4.1.6 Assumptions and Limitations

As with any modeling effort, and particularly for planning level analyses such as this one, there are methodological limitations which could be improved upon if a more in-depth analysis was desired. These limitations, along with several key assumptions, are listed below.

1. Rough model calibration has been conducted using known high water marks observed during the April 2007 storms at the High School and in the Bowl area, in combination with assumptions made using the existing calibrated 2012 Lamprey HEC-RAS model. No additional calibration is planned as the project results are intended for a planning level analysis only.

2. Future climate precipitation for 2050 was based off of the Coastal Risk Hazard Commission recommendation for a 15% increase in existing rainfall depth. PCSWMM Model

3. Design storm rainfall volumes based on data from the NRCC for Newmarket, NH,
4. Steady-state inflow from Piscassic River of 307 cfs for the current condition, 612 cfs for the 2050 condition
5. Subcatchment runoff characteristics for current conditions are based on 2005 land use data, the most current available data set
6. Subcatchment runoff characteristics for 2050 buildout are based on methodology outlined in the 2013 Lamprey study
7. Infiltration/runoff calculations are based on the least sophisticated method available in PCSWMM (CN vs. CN + Imp. Green-Ampt, or Horton methods)
8. Input/output flow volumes calculated using PCSWMM models designed primarily to calculate nutrient loads
9. Curve number adjustment calculations to develop curve numbers for the 2050 LID buildout condition are based on a slightly modified version of the methodology outlined in McCuen (2004)
10. Maximum treatment areas for each land use type assume that 100% of residential, commercial, institutional, industrial are suitable for LID controls

4.2 BMP Optimization and Lowest Cost Option

One of the core elements of integrated planning is the allowance that a permittee can take credit for actions associated with one permit (i.e., wastewater) and may also receive credit in another (i.e., MS4). For example, installation of green infrastructure (i.e., biofiltration to treat road runoff, or drywells to treat roof tops) for non-point source management under the WWTF permit would also satisfy requirements for Post Construction Stormwater Management (Minimum Measure 5) in the 2013 draft NH Small MS4 permit. This has the potential to be more economical than traditional permitting because it satisfies elements of both the MS4 and wastewater permits and it helps manage the uncertainty of environmental response.

Integrated planning also allows for flexibility as to when and what runoff management measures are implemented so long as the goal is the protection of public health and water quality. This approach allows for the use of various sizes (i.e., capture depths) of BMPs to allow for a greater number of smaller systems in replace of fewer systems designed to treat larger volumes.

To use this approach, an optimization model was developed which selects the most cost effective management measures for a range of increasing runoff reduction. The optimization model runs repeatedly, changing the target volume reduction with each iteration. It evaluates the runoff control strategies based upon user defined constraints including available land for implementation, volume reduction capability based on capture depth of the BMP, and cost to implement the strategy. This is first applied at the system level to develop a series of BMP performance curves. It is next applied at the land use scale to identify the most cost effective options for each particular land use. The optimization is then conducted at the watershed scale for the range of runoff control measures, and the range of land uses. Figure 5-9 illustrates BMP optimization at the system level. Example 1 below illustrates the process of how optimization of the size of a bioretention system can occur based on varying the capture depth of the water quality volume.

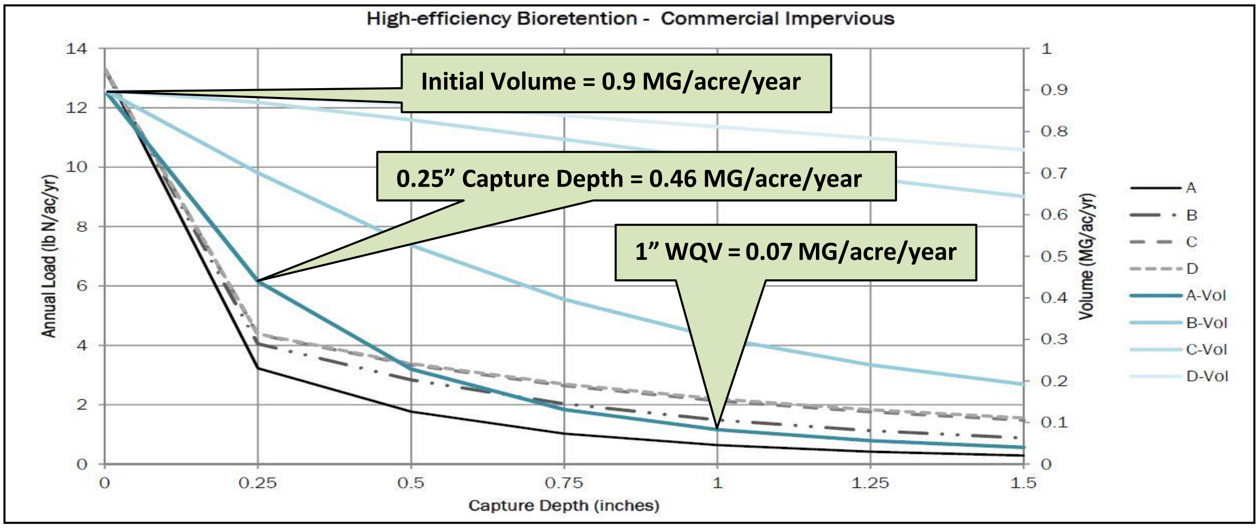


Figure 4-12 BMP Performance Curve for high-efficiency bioretention on commercial impervious areas illustrating annual volume (million gallons/acre /year) based on water quality volume (aka capture depth)

Example 1: BMP optimization for high-efficiency bioretention at 0.25" and 1" water quality volumes

> From the BMP performance curve for a high-efficiency bioretention system we can see that, for a type A soil, one system treating a 1" water quality volume for 1 acre will reduce runoff volume by approximately 0.83 MG/year. However, four smaller systems across 4 acres designed to treat a 0.25" water quality volume for 1 acre will each reduce runoff volume by 0.44 MG/year for a total of 1.76 MG/year. Constructing 4 smaller systems instead of 1 large system leads to an additional 0.93 MG of runoff capture per year at a nearly equivalent cost.

An example of optimization at the watershed scale is presented as a Pareto curve in Figure 4-13 as design storm runoff reduction vs. implementation capital cost. The Pareto curve illustrates the concept of diminishing returns (i.e. the most cost-effective options are pursued first) and each additional acre-foot of runoff reduction will have a higher differential cost. Higher target volume reduction amounts result in BMP combinations that have a higher average cost per acre treated. Figure 4-13 was used to prioritize the most cost effective scenario for the implementation of structural BMPs for flood mitigation.

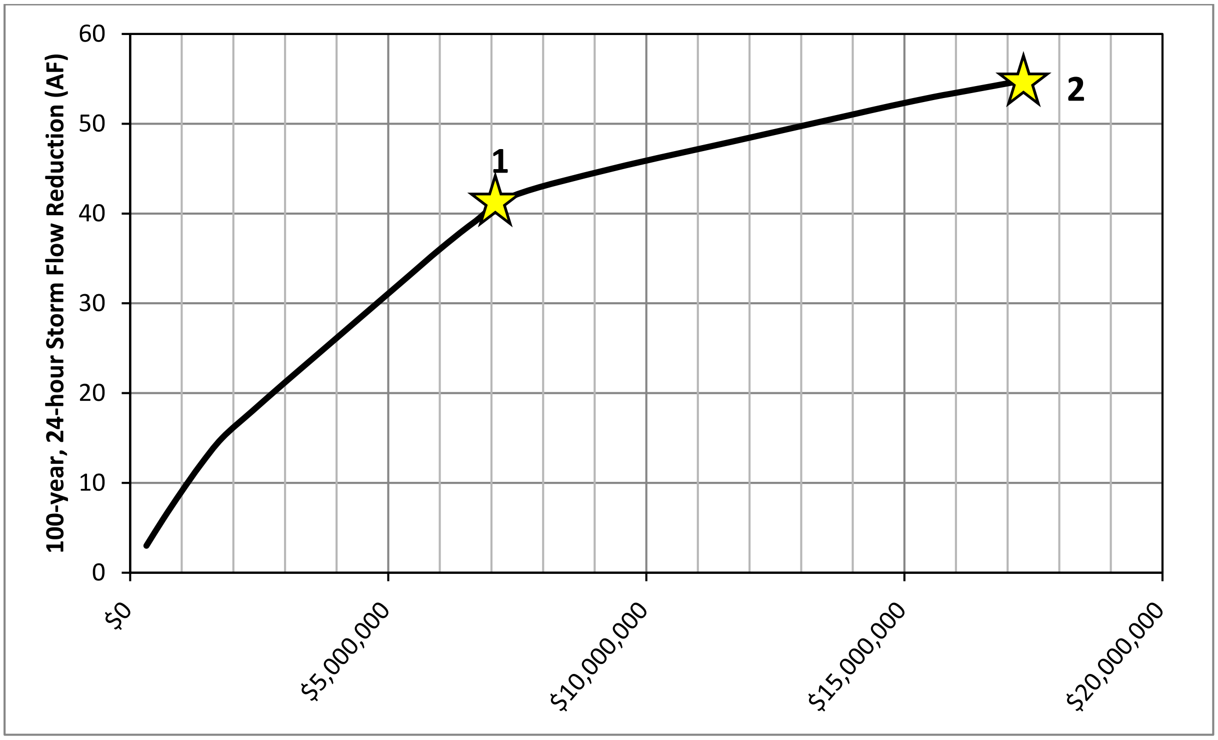


Figure 4-13 Watershed-scale total runoff reduction from non-point source management strategies

Looking at the Pareto Curve in Figure 4-13, at Point 1, LID has been implemented on all available acreage in the watershed. This point represents the least cost approach and results a 42 acre-foot runoff reduction at a cost of $7.43M, or $176,850 per acre-foot. Points on the Pareto Curve between Points 1 and 2 represent increased deployment of higher-cost BMPs, which result in a higher runoff reduction but at a higher per acre-foot cost. At Point 2 the maximum achievable runoff reduction of 55 acre-feet has been realized at a total cost of $17.39M, or $316,190 per acre-foot.

5. CLIMATE RESILIENCY ACTION PLAN

There are many tools that municipalities can use to build resilience and deal with climate related stressors. The use of Green Infrastructure (GI) is one, and it provides multiple benefits. GI methods not only help resolve water quality issues but they also can build resilience by mimicking natural processes. Using GI to control stormwater will benefit communities in many ways. Existing stormwater management systems designed to control runoff and protect life and property are not always able to handle extreme precipitation events. Better water resource management will reduce infrastructure costs and help to alleviate flooding. Treating and reducing runoff will protect water quality, which for many communities is a required action under the new MS4 permit.

Resources available to municipalities that can be used to develop mitigation strategies are available from New Hampshire state and federal agencies, as well as numerous other organizations and collaborations that offer outreach and education, or technical assistance on resilience building and climate adaptation. NHDES, the EPA through the regional office, NH Climate Adaptation Workgroup (CAW), NOAA through Sea Grant and the GBNERR, the University of New Hampshire through multiple programs such as UNH Stormwater Center and Cooperative Extension. The New Hampshire Coastal Adaptation Workgroup is a local collaboration of over 20 agencies and organizations that help municipalities prepare for and adapt to climate change, all are available local resources.

5.1 Implementation Plan for LID Mitigation Strategies

Target retrofit areas were identified to achieve the targeted volume reduction at the lowest cost that will have the greatest benefit for stormwater management and retrofitting with runoff control measures. Specific land use area targets, volume control measures, and capture depths are presented in Table 5-1 along with available acreage for tracking purposes. The measures, both structural and non-structural, target a wide variety of land uses and if implemented would provide 42 acre-feet of runoff reduction from 417 acres of developed land in the Moonlight Brook watershed. Over a 35-year period approximately 12 acres per year could be retrofitted. The choice of a 35-year schedule is a preliminary estimate reflective of what might be required of a nutrient control plan as part of an MS4 or AOC requirement but would be revised based on a financial capability analysis. This includes a combination of new redevelopment and redevelopment of existing residential, commercial and industrial areas The structural measures selected are sized to treat a capture depth or water quality volume equivalent to 0.25-0.5 inches, which is more cost effective than sizing and constructing larger structural measures.

An implementation rate of 12 acres per year for 35 years would cost an estimated $212,000 per year with approximately 50% covered by the municipality and 50% covered by private section redevelopment. The power of redevelopment and developing an affordable implementation schedule are described in greater detail below.

For example, proposed future developments that apply for Town building permits should be directed to use the recommendations below for determining which practices should be considered for their projects. It is in the best interest of the project applicants to follow the recommendations as they represent cost savings that can be achieved when compared with other practices.

Stormwater management is often opportunistic and may not be implemented based on the recommendations below. The recommendations represent the lowest cost alternative which need not be strictly adhered to. Tracking and accounting of retrofit implementation over time will enable adaptive management of the various nutrient control strategies and adjust practices as necessary.

A detailed Implementation Plan with specific details as to location and timing of nitrogen control practices will need to be developed for this Plan and similarly with a nitrogen focus to fulfill the AOC requirements for a Nitrogen Control Plan.

Table 5-1 Proposed Target Areas for Retrofit and Management Listed by Land-Use Use, Area and Water Quality Volume Treated

Land Use Type	Land Cover	BMP Type	BMP Size	Unit Runoff Reduction (AF / acre)	Recommended Acreage	Construction Cost ($/acre)	Unit Cost ($/AF)2	Total Potential Runoff Reduction (AF)	Total Cost of Optimal Solution ($)3
ROAD	I	WET POND	1.5	0.19	18.85	$ 22,400	$ 116,000.00	3.65	$ 423,000.00
ROAD	I	BIORETENTION	0.25	0.04	1.64	$ 11,400	$ 286,000.00	0.07	$ 19,000.00
RESIDENTIAL	R	RAINGARDEN	0.75	0.07	16.95	$ 10,000	$ 144,000.00	1.18	$ 170,000.00
RESIDENTIAL	I	RAINGARDEN	1.5	0.10	41.73	$ 18,000	$ 181,000.00	4.16	$ 752,000.00
RESIDENTIAL	R	RAINGARDEN	1.5	0.10	12.02	$ 18,000	$ 181,000.00	1.20	$ 217,000.00
RESIDENTIAL	C	RAINGARDEN	1.5	0.09	44.86	$ 18,000	$ 196,000.00	4.13	$ 808,000.00
RESIDENTIAL	D	RAINGARDEN	1.5	0.09	6.23	$ 18,000	$ 196,000.00	0.57	$ 113,000.00
RESIDENTIAL	B	RAINGARDEN	1.5	0.09	189.31	$ 18,000	$ 203,000.00	16.85	$ 3,408,000.00
RESIDENTIAL	A	RAINGARDEN	0.5	0.03	29.63	$ 7,000	$ 254,000.00	0.82	$ 208,000.00
OUTDOOR	C	GRAVEL WETLAND	1.5	0.15	0.78	$ 35,300	$ 230,000.00	0.12	$ 28,000.00
OUTDOOR	B	GRAVEL WETLAND	1.5	0.15	9.04	$ 35,300	$ 235,000.00	1.36	$ 319,000.00
OUTDOOR	I	GRAVEL WETLAND	1.5	0.15	1.61	$ 35,300	$ 235,000.00	0.24	$ 57,000.00
OUTDOOR	A	GRAVEL WETLAND	1.5	0.15	0.97	$ 35,300	$ 235,000.00	0.15	$ 35,000.00
INSTITUTIONAL	R	DRY WELL	0.25	0.04	2.57	$ 4,000	$ 105,000.00	0.10	$ 11,000.00
INSTITUTIONAL	C	WET POND	1.5	0.20	1.24	$ 22,400	$ 115,000.00	0.24	$ 28,000.00
INSTITUTIONAL	D	WET POND	1.5	0.20	0.16	$ 22,400	$ 115,000.00	0.03	$ 4,000.00
INSTITUTIONAL	I	WET POND	1.5	0.19	6.76	$ 22,400	$ 116,000.00	1.31	$ 152,000.00
INSTITUTIONAL	B	WET POND	1.5	0.19	2.45	$ 22,400	$ 116,000.00	0.47	$ 55,000.00
INSTITUTIONAL	A	WET POND	1.5	0.19	0.43	$ 22,400	$ 116,000.00	0.08	$ 10,000.00
INSTITUTIONAL	I	TREE BOX FILTER	0.25	0.04	0.56	$ 11,800	$ 285,000.00	0.02	$ 7,000.00
INDUSTRIAL	R	DRY WELL	0.25	0.04	0.30	$ 4,000	$ 105,000.00	0.01	$ 2,000.00
INDUSTRIAL	C	WET POND	1.5	0.20	0.19	$ 22,400	$ 115,000.00	0.04	$ 5,000.00
INDUSTRIAL	B	WET POND	1.5	0.19	6.63	$ 22,400	$ 116,000.00	1.28	$ 149,000.00
INDUSTRIAL	I	WET POND	1.5	0.19	0.55	$ 22,400	$ 116,000.00	0.11	$ 13,000.00
COMMERCIAL	R	DRY WELL	0.25	0.04	1.50	$ 4,000	$ 105,000.00	0.06	$ 7,000.00
COMMERCIAL	C	WET POND	1.5	0.20	4.10	$ 22,400	$ 115,000.00	0.81	$ 92,000.00
COMMERCIAL	B	WET POND	1.5	0.19	7.07	$ 22,400	$ 116,000.00	1.37	$ 159,000.00
COMMERCIAL	I	WET POND	1.5	0.19	5.16	$ 22,400	$ 116,000.00	1.00	$ 116,000.00
COMMERCIAL	A	WET POND	1.5	0.19	2.82	$ 22,400	$ 116,000.00	0.55	$ 64,000.00
COMMERCIAL	I	TREE BOX FILTER	0.25	0.04	0.60	$ 11,800	$ 285,000.00	0.02	$ 8,000.00
COMMERCIAL	I	SUBSURFACE INFILTRATION	0.25	0.05	0.26	$ 18,500	$ 389,000.00	0.01	$ 5,000.00
TOTAL					**417**			**42**	**$ 7,444,000.00**

5.1.1 Shared Costs Implementation by the Power of Redevelopment

To provide a better understanding of the total cost for municipal planning and decisions making, the management scenario total present value cost should be examined by dividing up by Town for total cost, capital cost and operation and maintenance cost, and costs anticipated to be incurred by private (i.e., commercial, industrial, residential) property owners and by the municipal sector (i.e., roads, parks, municipal buildings) based on estimated area for which the municipality will likely be required to manage. In neighboring towns approximately 57% of the total annual non-point source implementation cost (capital and O&M) is estimated to be incurred by the municipality for controls on municipally owned land (i.e., roads, parks, schools) and 47% to be covered by the private sector (Roseen et al 2015). With this approach the total cost of NPS management can be understood by the land uses which generate stormwater runoff, both private and municipal sector. The approach assumes that the expenses would be part of the redevelopment cycle as with any code and modernization requirements with which owners and operators are familiar. This type of planning requires revisions to existing stormwater ordinances and regulations, to require the installation of LID for resiliency and management of nitrogen for new and redevelopment including municipal capital improvement projects.

Figure 5-1. Bioswale in Elm Street Plaza

Figure 5-2. A newly constructed bioswale in Rockingham Green for stormwater management and volume reduction

Table 5-2. Matrix of structural runoff control measures by land use

CATEGORY		COVER TYPE	STRUCTURAL NUTRIENT MANAGEMENT MEASURES									
			Wet Pond	Gravel Wetland	Subsurface Infiltration	Sand Filter	Biofiltration	High Efficiency Biofiltration	Tree Pits	Raingarden	Dry Well	Permeable Pavement
LAND USE	Residential	Pervious						●		●	●	
		Impervious						●		●	●	
		Roof						●		●	●	
	Residential Subdivision	Pervious					●	●				
		Impervious					●	●				●
		Roof					●	●			●	
	Commercial/ Industrial/ Institutional	Pervious	●	●	●	●	●	●	●			
		Impervious	●	●	●	●	●	●	●			●
		Roof			●		●	●			●	
	Road/ Freeway	Impervious	●	●			●					
	Outdoor/ Other Urban Land	Pervious		●	●	●	●	●	●			
		Impervious		●	●	●	●	●	●			●

5.1.2 Guidance for Developing an Implementation Schedule

An assumed schedule of the year 2050 was used for modeling purposes. The choice of a 35-year schedule is a preliminary estimate reflective of what might be required of a nutrient control plan as part of an MS4 or AOC requirement but would be revised based on a financial capability analysis. A schedule can be developed based on affordability and ability to pay based on other competing community expenses. A financial capability analysis can be conducted to minimize financial hardship upon the community. Methods for developing schedules are available from guidance for CSO management, Integrated Planning, and MS4 implementation.

- Wastewater scheduling typically follows the FCA analysis. “Combined Sewer Overflows: Guidance for Financial Capability Assessment and Schedule Development” (FCA Guidance) (EPA 832-B-97-004)
- Integrated planning is using similar info FCA Framework 2014. Financial Capability Assessment Framework for Municipal Clean Water Act Requirements (EPA, 2014)
- MS4 implementation for NH currently does not indicate a specific implementation schedule. No minimum period for an implementation schedule for Post Construction Stormwater Management (Minimum Measure 5) is currently required in the 2013 Draft NH MS4 General Permit. We have heard from EPA in the public forum that an extended period of time will be allowable.
- Similarly, EPA Headquarters, and Region 1 Leadership spoke at the September 2013 NACWA Integrated Planning Workshop in Portsmouth, NH, that extended implementation periods similar to CSO implementation are conceivable in the range of 4 or more permit cycle period. Environmental Monitoring

5.2 LID Climate Adaptation Strategies

Climate adaptation strategies for runoff control, or BMPs, focused on nonpoint sources are one key element of climate resiliency. A matrix of BMPs was developed to identify feasible BMPs in the municipal context. The matrix has been developed with input from towns in the region based on the feasibility by land use types (Table 5-2). The management measures, both structural and non-structural, look to reduce runoff volume from stormwater sources including agriculture, managed turf (i.e., golf courses, lawn), impervious and pervious surfaces, residential, commercial/industrial/institutional, roads, and outdoor recreational spaces (i.e., parks). Appendix B provides a more complete listing of BMPs for consideration.

A wealth of BMP sources exists in the literature and locally at the UNH Stormwater Center and this Plan does not attempt to repeat that information. Strict adherence to design specifications can limit innovation which will be essential to effective nutrient management in the future. For this reason, we encourage the use of performance specifications detailing the runoff volume reduction required and encouraging innovation in design. A foundation of practices can be found in the New Hampshire Stormwater Manual is from the NHDES website at www.des.nh.gov/organization/divisions/water/stormwater/manual.htm.

Other stormwater practice design standards may be accepted at the discretion of the DPW and may include techniques or practices in use and accepted by other jurisdictions, (ie state agencies, municipalities, EPA) that have been demonstrated to have treatment benefits. This may include promising innovative practices (proprietary and non-proprietary) allowing for the continued advancement of the practice.

As part of the 2015 draft NPDES Small MS4 general permit for New Hampshire, the permit requires management of existing stormwater runoff in impaired watersheds. While new development is required to manage stormwater on-site, existing developments may have been constructed before stormwater management was required or modern criteria were established. Retrofits include new installations or upgrades to existing BMPs in developed areas where improved stormwater treatment is needed.

5.2.1 Municipal/Commercial/Industrial/Institutional Strategies

The following management strategies can be used in the municipal, commercial, industrial, and institutional sectors to manage both roof tops, impervious surfaces and pervious surfaces and include: dry wells, subsurface infiltration, wet ponds, gravel wetlands, porous pavements, biofiltration, and high efficiency bioretention. Figure 5-3 illustrates a bioswale installed as part of a commercial redevelopment project in the newly developed Elm Street Plaza. This bioswale disconnects approximately 1.3 acres of a 2 acre parcel and achieves approximately 65% disconnection of impervious cover at no cost to the town.

5.2.2 Residential Strategies

In residential areas raingardens, bioswales, dry wells, gravel wetlands, and porous pavements are common strategies. A valuable resource for homeowners includes the *New Hampshire Homeowner's Guide to Stormwater Management, Do-It-Yourself Stormwater Solutions for Your Home (NHDES 2001)*, which provides information on the common causes of stormwater problems and their effects and fact sheets for structural controls that residential homeowners can install to mitigate the effects of stormwater. NHDES has a program called "Soak up the Rain" which will provide resources for residential homeowners interested in installing LID. Figure 5-2 illustrates a bioswale as part of a new development in Rockingham Green. Figure 5-3 illustrates a green roof installed for rooftop disconnection as part of waterfront redevelopment. Approximately 0.13 acres of a 0.2 acre parcel is largely disconnected through redevelopment (approximately 65% disconnected impervious area) through green roofs, permeable pavement, and downspout recharge, also at no cost to the town. Through redevelopment and LID zoning much of the commercial downtown is gradually improving the resiliency and water quality benefits of the developed spaces.

Figure 5-3: Green Roof in Downtown Newmarket

Figure 5-4. Rooftop Disconnection with Xeriscape and Infiltration Son Water Street

5.2.3 Disconnect, Distribute and Decentralize Impervious Cover

Impervious surfaces such as roadways, parking lots, rooftops, sidewalks, driveways, and other pavements impede stormwater infiltration and generate surface runoff. Research has shown that total watershed impervious area is correlated with a number of negative impacts on our water resources such as increased flood peaks and frequency, increased sediment, nutrient, and other pollutant levels, channel erosion, impairments to aquatic biota, and reduced recharge to groundwater (Center for Watershed Protection, 2003).

The amount of runoff and associated pollutants from a project can be reduced by disconnecting impervious surfaces such as shown in Figure 5-4. Disconnection of rooftop down spouts and impervious cover are common practices. Disconnection of impervious surfaces increases the amount of EIC on a site, which allows for filtering and infiltration prior to discharging to the receiving water.

The draft NPDES Small MS4 permits for New Hampshire require regulated communities to estimate the number of acres of impervious area (IA) and directly connected impervious area (DCIA) that have been added or removed each year due to development, redevelopment, and or retrofitting activities.

Why Quantify Your IA & DCIA?

New construction, redevelopment, and restoration activities can change existing IA and DCIA – potentially exacerbating or reducing existing watershed impairments. Understanding watershed imperviousness is important for communities because it:

- Informs management of impaired waterbodies and prioritization of watershed restoration efforts;
- Facilitates investigation of existing chronic flooding and stormwater drainage problems, and avoidance of new problems;
- Indicates potential threats to drinking water reservoirs/aquifers; commercial fisheries, and recreational waters;
- Demonstrates progress toward achieving future **Total Maximum Daily Load (TMDL)** allocations based on impervious cover thresholds;
- Serves as an educational tool for encouraging environmentally sensitive land use planning and **Low Impact Development (LID);**
- Facilitates equitable derivation of possible stormwater utility fees based on parcel-specific impervious cover; and
- Provides guidance for stormwater retrofit efforts.

Figure 5-5 Impervious Cover Facts (Source: EPA, 2014)

5.2.4 Protection of Sensitive Areas and Valuable Resources/LID Planning

Buffers and riparian corridors are vegetated ecosystems along a waterbody that serve to protect the waterbody from the effects of runoff by providing water quality filtering, bank stability, recharge, rate attenuation and volume reduction, and shading of the waterbody by vegetation (Audubon et.al, 1997). Riparian corridors also provide habitat and may include streambanks, wetlands, floodplains, and transitional areas.

To minimize stormwater impacts, new and re-development projects should avoid affecting or encroaching upon areas with important natural stormwater functional values (floodplains, wetlands, riparian areas, drainage ways and buffers) and with stormwater impact sensitivities (steep slopes, adjoining properties, others) wherever practicable. Development should not occur in areas where sensitive resources exist so that their valuable natural functions are not lost and increasing stormwater impacts.

5.2.5 Long-Term Operations and Maintenance

To ensure long-term protection of water quality and the effectiveness of best management practices (BMPs), regular inspections and maintenance is necessary. Generally, inspection and maintenance falls into two categories: expected routine maintenance and non-routine (repair) maintenance. Routine maintenance is performed regularly to maintain both aesthetics and their good working order. Routine inspection and maintenance helps prevent potential nuisances (odors, mosquitoes, weeds, etc.), reduces the need for repair maintenance, and insures long term performance.

Under the EPA MS4 Phase II rules, owners and operators of small MS4 facilities are responsible for implementing BMP inspection and maintenance programs and having penalties in place to deter infractions. The rules recommend that all stormwater BMPs should be inspected on a regular basis for continued effectiveness and structural integrity. In addition to regularly scheduled inspections, all BMPs should be checked after each storm event. Scheduled inspections will vary among BMPs. Structural BMPs such as storm drain drop inlet protection may require more frequent inspection to ensure proper operation.

A series of maintenance fact sheets and recommendations are provided from the UNH Stormwater Center for a number of green infrastructure practices. These fact sheets are provided in Appendix C. Maintenance Guidance and Factsheets.

5.3 High School Adaptation Demonstration Project

A bioretention system was designed in conjunction with the High School and Town Staff for the purpose of demonstration of both mitigation strategies and opportunities for retrofit. The high school was supportive of the idea and the possibility of integrating with the applied science curriculum. The school grounds were toured and the parking lot area was identified as an ideal location for a BMP installation. Details provided below. The school is identified as a critical resource with potential to be directly impacted by extreme storms. The 2006 Mother's Day Flood elevation filled the Moonlight Brook valley and rose to the base of the building foundation. The 2050 future projected floodplain along Moonlight Brook similarly is in the vicinity of the school.

Bioswale Design Considerations

1. Easy location for an under-drained bioswale with an overflow into the Brook below.
2. High aesthetic value, lots of flowers
3. Should be very inexpensive to construct.
4. In location of existing depression between two paved areas where the parking lot run off currently goes.
5. Include a pre-treatment of some type for sand and trash enclosed like a rain guardian.
6. System sizing- use the complete available area, will want to use all of the available area. The estimated BMP area is about 1,150 ft^2 and a drainage area of 19,034 ft^2.

7. Could locate education signage to incorporate into curriculum. NHDES has signage templates that could be used.
8. May be an opportunity for DPW to construct BMP. Would be useful as part of MS4 training.

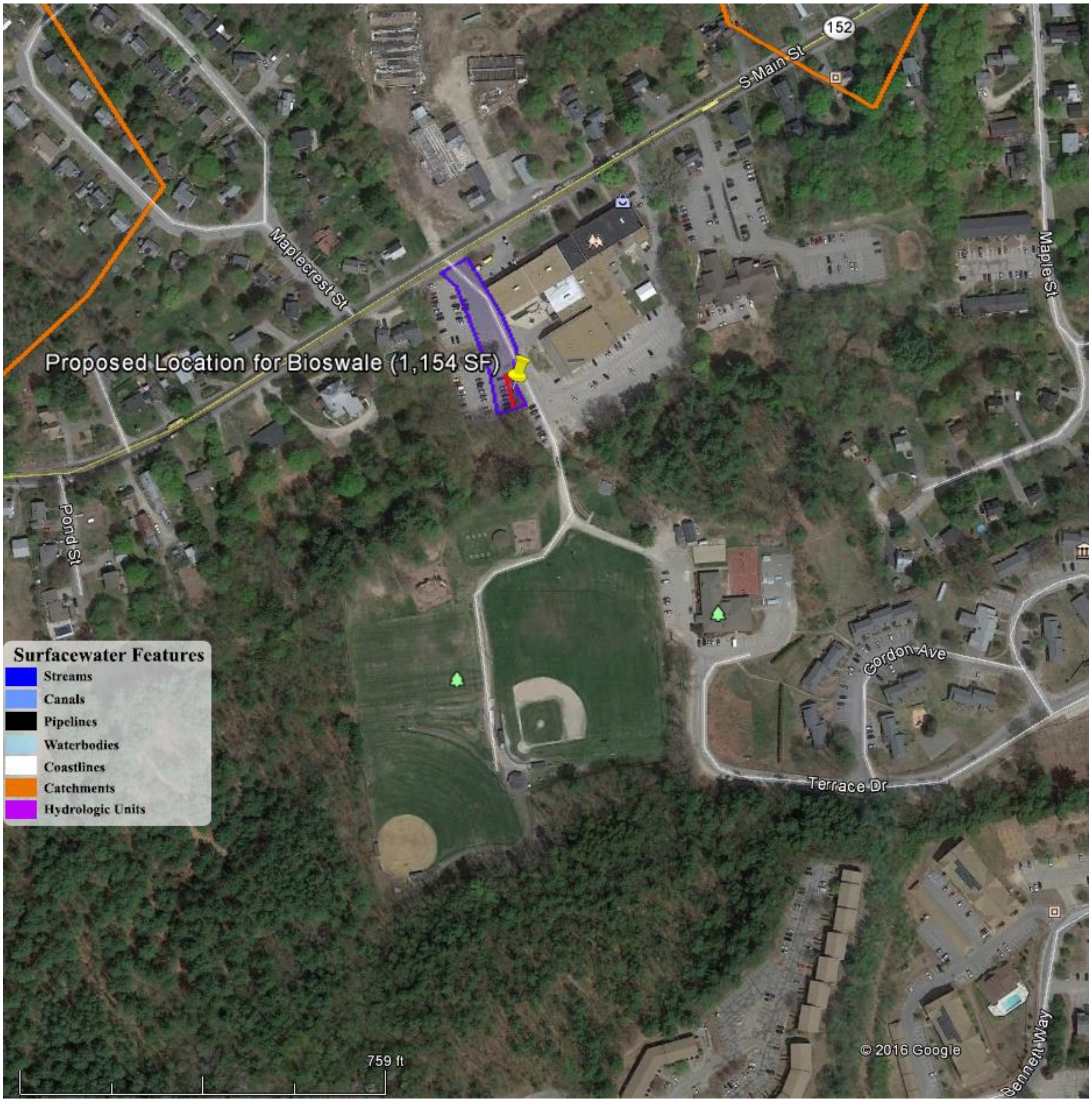


Figure 5-6. Location of Proposed BMP at Newmarket High School

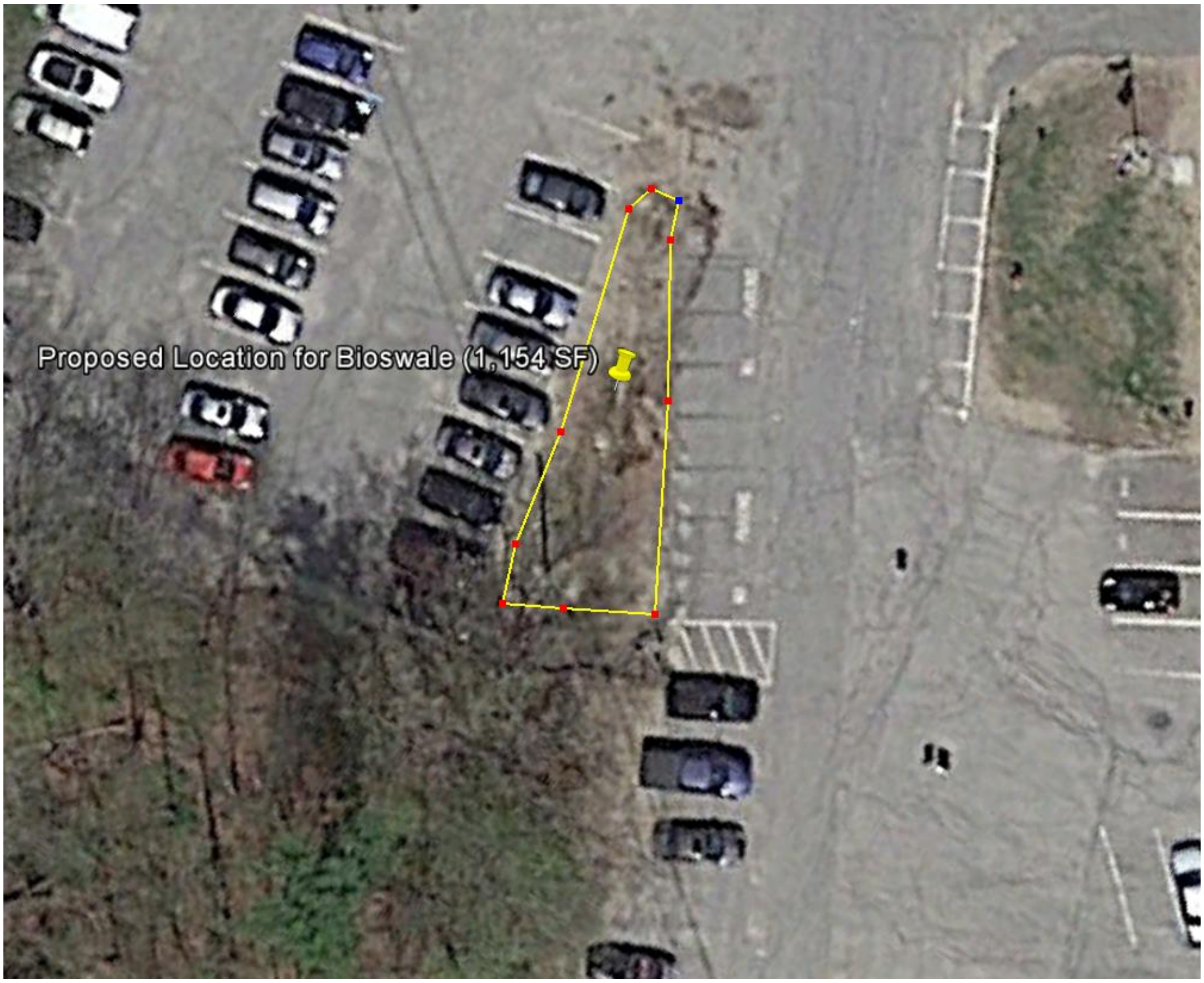


Figure 5-7. Bioswale footprint (Est. 1,154SF)

Figure 5-8. Bioswale and drainage area

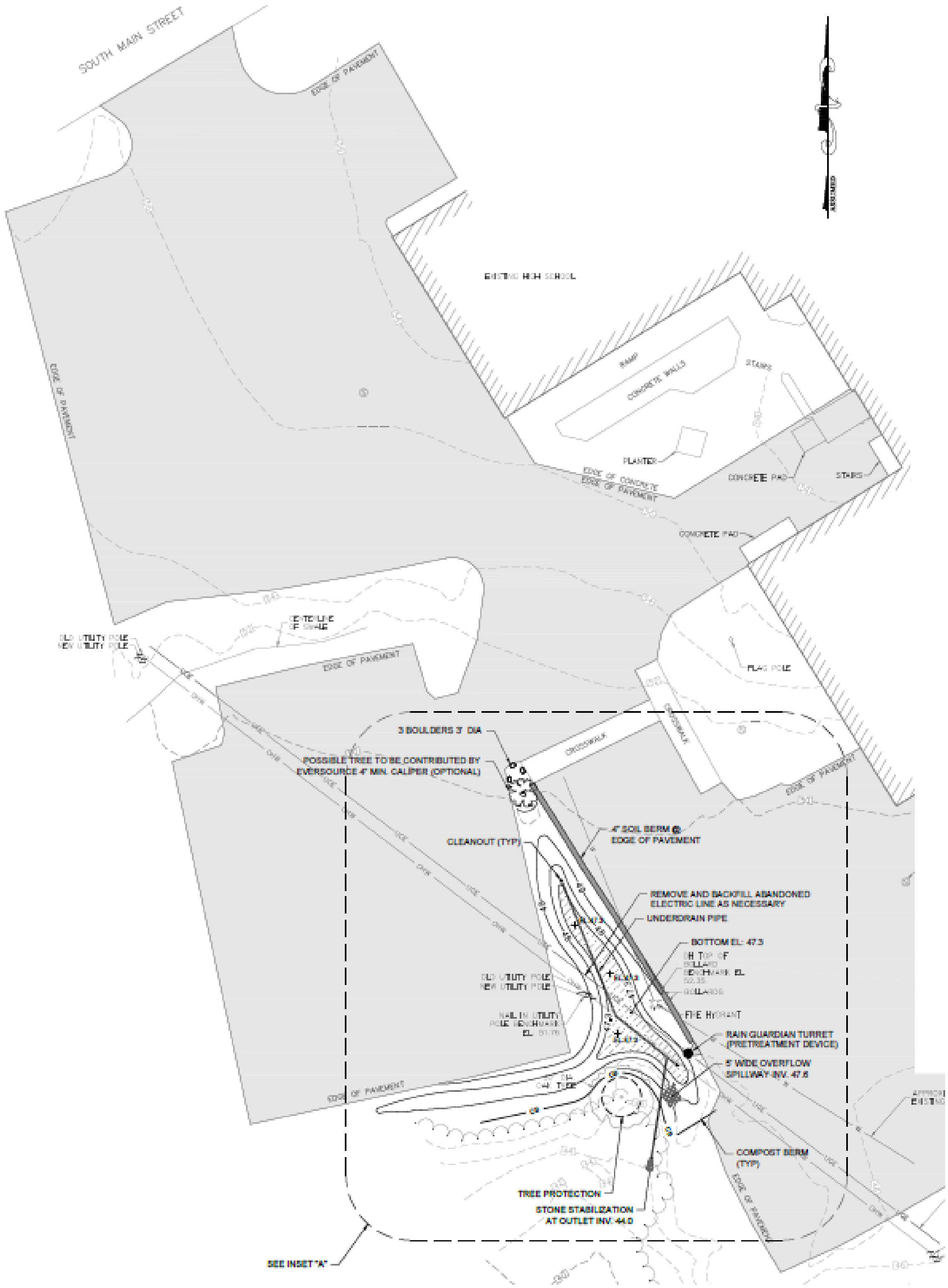

SOUTH MAIN STREET
EDGE OF PAVEMENT
EXISTING HIGH SCHOOL
RAMP
CONCRETE WALLS
STAIRS
PLANTER
EDGE OF CONCRETE
EDGE OF PAVEMENT
CONCRETE PAD
STAIRS
CONCRETE PAD
CENTERLINE OF SWALE
FLAG POLE
CROSSWALK
3 BOULDERS 3' DIA
POSSIBLE TREE TO BE CONTRIBUTED BY EVERSOURCE 4" MIN. CALIPER (OPTIONAL)
CLEANOUT (TYP)
4" SOIL BERM @ EDGE OF PAVEMENT
REMOVE AND BACKFILL ABANDONED ELECTRIC LINE AS NECESSARY
UNDERDRAIN PIPE
BOTTOM EL: 47.3
BOLLARDS
FIRE HYDRANT
RAIN GUARDIAN TURRET (PRETREATMENT DEVICE)
5' WIDE OVERFLOW SPILLWAY-INV. 47.6
COMPOST BERM (TYP)
TREE PROTECTION
STONE STABILIZATION AT OUTLET INV. 44.0
SEE INSET "A"

Figure 5-9. Bioswale design and location

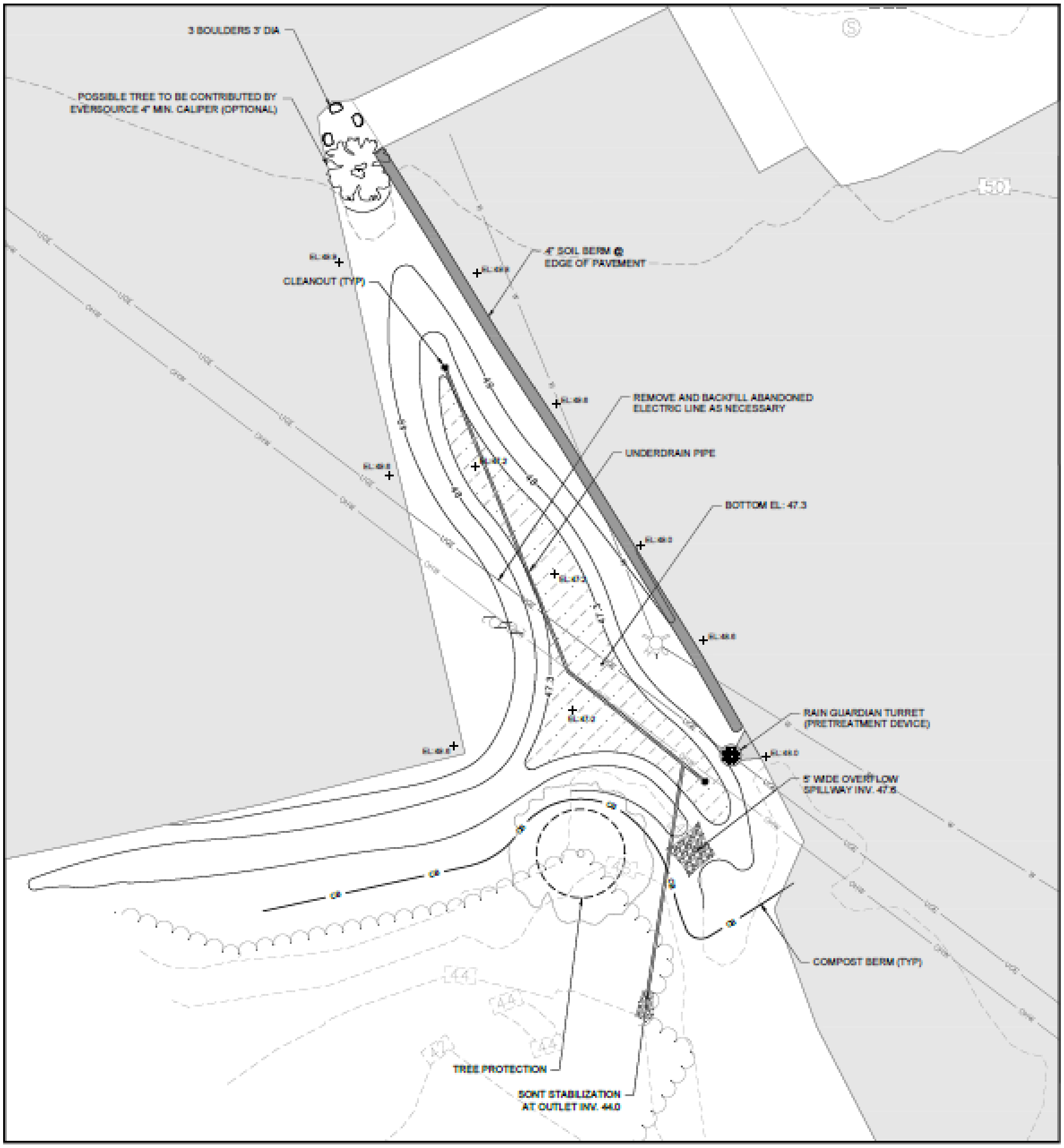


Figure 5-10. Bioswale design close-up

5.3.1 Observed Flood Elevations for the 2005 Mother's Day Flood

Flood elevation for the Mother's Day Flood 2005 was estimated to be 41" at the base of the building foundation. This point can be used as a calibration item for the watershed flood model.

This location was surveyed and the base of the foundation was found to be elevation 50.27 (50.38 by LIDAR) which would put the flood elevation at 54.69.

Figure 5-11. Observe high water mark for the 2005 Mother's Day Flood on building foundation

5.4 Public Outreach and Education

Public outreach and education is a critical component of raising awareness and building support for resiliency and water infrastructure management within any community. The Project Team conducted a workshop on *Climate Resiliency in Newmarket*. The workshop objectives were to 1) inform Newmarket residents about several completed, ongoing, and upcoming flood resilience-focused projects going on in Newmarket, 2) brainstorm next steps and other priorities, based on project the results, to enhance resilience to flood hazards in Newmarket, and 3) provide opportunities for residents to engage more on resilience projects and planning efforts in the coming year. The workshop materials are included in Appendix D. The workshop was recorded and aired on the Town public TV.

Workshop participants included:

Steve Fournier, Town Administrator introduced the project and Team and discussed the connection to the new town Vision Statement.

Nathalie Morison from the NH Coastal Program spoke about the NH Coastal Risk and Hazards Commission science summary and report recommendations, introducing the Commission's work in the context of Newmarket's vision, presenting the science from the technical advisory (STAP) panel summary, and providing example recommendations related to green infrastructure and stormwater management.

Robert Roseen of Waterstone Engineering spoke about the Moonlight Brook Project Findings & Suggested Next Steps

Phil MacDonald of Underwood Engineers spoke about ongoing projects in Newmarket including drainage improvements on New Road and Beech Street.

Liz Durfee of SRPC spoke about upcoming projects & ways to engage with the C-RiSe project and a recently begun Saltwater Intrusion Study.

Kirsten Howard of the NHCP spoke about a recent RFP Design 4 Resilience grant opportunity and facilitated a discussion about next steps for Newmarket.

Diane Hardy, Town Planner provided closing remarks and the project summary.

6. NEXT STEPS

The first three of the ICLEI CRC Five Milestones process have been completed for Moonlight Brook. Steps 4 and 5 are remaining.

The Five Milestones include:

1. Initiate a climate resiliency effort

2. Conduct a climate resiliency study

3. Develop a climate resilient action plan

4. Implement a climate resilient action plan

5. Monitor, motivate, and re-evaluate

A critical aspect of developing an implementation plan schedule is to conduct a financial capability analysis to determine an affordable rate of implementation. This would also include discussion and planning for long-term funding. Sustainable funding is a crucial component of a successful long-term implementation plan. A detailed implementation plan will include specific details as to the location and timing of BMPs and if done in conjunction with MS4 and AOC permit requirements, could leverage significant resources.

Lastly, it is necessary to monitor and assess progress towards environmental goals. Recommended monitoring in the Moonlight Brook Watershed will document watershed improvements, calibrate modeled loads, and track progress towards watershed runoff volume and nutrient load reduction, also in keeping with tracking and accounting requirements.

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8. APPENDICES

Appendix A. Critical Infrastructure & Key Resources, excerpt from Newmarket, NH All-Hazard Mitigation Plan Update 2013

Appendix B. Climate Mitigation Strategies and Nutrient Control Measures

Appendix C. Maintenance Guidance and Factsheets

Appendix D. Public Outreach Workshop, Climate Resiliency in Newmarket

Appendix E. Stormwater Demonstration Project Design Drawings

APPENDIX A.CRITICAL INFRASTRUCTURE & KEY RESOURCES, EXCERPT FROM NEWMARKET, NH ALL-HAZARD MITIGATION PLAN UPDATE 2013

Chapter IV: Critical Infrastructure & Key Resources (CI/KR)

With team discussion and brainstorming, Critical Infrastructure and Key Resources (CI/KR) within Newmarket were identified and mapped for the all-hazards plan. Facilities located in adjacent towns were not mapped.

Emergency Response Facilities (ERF)				
ERF's are primary facilities and resources that may be needed during an emergency response				
ID	Facility Name	Type of Facility	Address	Phone
	Town Hall	Municipal	186 Main St	603-659-3671
	Fire Station	Fire Station	2 Youngs Lane	603-659-3334
	Police Station	Emergency Operations/Dispatch	70 Exeter Rd	603-659-6636
	Public Works Garage	Emergency Fuel	2 Young's Lane	603-659-3093
	Middle/High School	Emergency Shelter	213 Main Street	603-659-3271
	Transfer Station	Emergency Fuel	Ash Swamp Lane	NA
Evacuation Routes (EVAC)				
	Route 108			
	Route 152			
Telephone Facilities				
	Fairpoint	Switching Station	Gerry Avenue	NA
	SBA Properties (Old DPW)	Cell Tower	Route 152	NA
	Sprint and Verizon	Telephone Antennae's	Great Hill Water Tower	NA
	Cell Service	Antennae	Great Hill Water Tower	NA
	Police Radio	Dispatch Service	Great Hill Water Tower	NA
*Another Telephone antenna has just been approved (Metrocast).				
Bridges				
	Bridge (State #125/054)	Transportation Infrastructure	NH 108 over B&MRR	NA
	Bridge (State #096/065)	Transportation Infrastructure	Ash Swamp Rd. over Piscassic River	NA
	Bridge (State #106/089)	Transportation Infrastructure	NH 152 over Piscassic	NA
	Bridge (State #098/079)	Transportation Infrastructure	Grant Rd. over Piscassic	NA
	Bridge (State #112/098)	Transportation Infrastructure	Packers Falls Rd. over Piscassic River	NA
	Bridge (State #120/089)	Transportation Infrastructure	NH 152 over B&MRR	NA
	Bridge (State #127/097)	Transportation Infrastructure	NH 108 over Lamprey River	NA

Non-Emergency Response Facilities (NERF)				
NERF's are facilities that although critical, not necessary for the immediate emergency response effort; hazardous material facilities also included				
Power Stations				
	Facility Name	Type of Facility	Address	Phone
	Sewage Treatment Plant	Water Treatment Facility	Youngs Lane	NA
	Water Works Plant	Water Treatment Facility	Packers Falls Road	NA
	Salmon Street Pump Station	Pump Station	Salmon Street	NA
	Cedar Street Pump Station	Pump Station	Cedar Street	NA
	Creighton Street Pump Station	Pump Station	Creighton Street	NA
	Ladyslipper Pump Station	Pump Station	Ladyslipper Drive	NA

Non-Emergency Response Facilities (NERF)				
	Moody Point Pump Station	Pump Station	Moody Point	NA
	Bay Road Pump Station	Pump Station	Bay Road	NA
	Route 152 Pump Station	Pump Station	Route 152	NA
	Packers Falls Pump Station	Pump Station	Packers Falls Road	NA
	Briallia Circle Pump Station	Pump Station	Briallia Circle	NA
	Mockingbird Lane Pump Station	Pump Station	Mockingbird Lane	NA
	PSNH Transformer	Power Station	Nichol's Avenue	NA

Facilities and Populations to Protect (FPP)				
FPP's are facilities that need to be protected because of their importance to the Town and to residents who may need help during a hazardous event				
Schools, Churches, and Daycare Facilities				
ID	Facility Name	Type of Facility	Address	Phone
	Newmarket School	School	243 S. Main St	603-659-2192
	Middle/High School	School	213 Main Street	603-659-3271
	Great Bay Kids	Daycare Facility	3 Simons Lane	603-659-2324
	Newmarket Head Start	Daycare Facility	1 Terrace Drive	603-659-4927
	Linked Together	Daycare Facility	243 South Main Street	603-659-6871
	St. Mary's Church	Church	192 Main Street	603-659-3643
	Community Church	Church	137 Main Street	603-659-3892
	Aryaloka Buddhist Retreat Center	Religious Center	14 Heartwood Circle	603-659-5456
	Great Hill Terrace	Assisted Living	34 Great Hill Terrace	603-659-5444
	Granite Street Assisted Living	Assisted Living	9 Granite Street	
	The Pines Assisted Living	Assisted Living	9 Grant Hill	603-659-6000
	The Willey House	Assisted Living	100 Main Street	603-431-3620
	Wadleigh Falls House LLC	Assisted Living	Route 152	
Historic Facilities				
	Town Hall	Historic Facility	186 Main Street	603-659-3617
	Essex Mills	Historic Facility	55 Main Street	603-659-5555
	The Stone Church	Historic Facility	5 Granite Street	603-659-6321
	Stone School (Historic Society)	Historic Facility	Zion's Hill	603-659-7420
	Fire Station (Engine House)	Historic Facility	Main Street	NA
	Town Library	Historic Facility	1 Elm Street	603-659-5311
	Water Works Plant	Historic Facility	Packers Falls Road	NA
	Town Hall	Historic Facility	186 Main Street	603-659-3617
	Riverside Cemetery	Historic Facility	Elm Street/Packers Falls	NA
	Downtown Historic District	Historic Facility	Main Street	NA
	The Agent's House	Historic Facility	Elm Street	NA
Commercial/Economic Development				
	Industrial Park	Commercial Development	Route 108	NA
	Downtown District	Economic Development	Main Street	NA
	Route 108 South	Economic Development	Exeter Road south of RR	NA
	Route 108 North	Economic Development	Main Street to Durham border	NA

Potential Resources (PR)				
PRs are potential resources that could be helpful for emergency response in case of a hazardous event				
Fuel/Food/Water/Retail/Lodging				
ID	Facility Name	Type of Facility	Address	Phone
	Proulx Oil/Propane	Fuel Station	Simon's Lane	603-659-7011
	Lang's Oil/Propane	Fuel Station	21 Lang's Lane	603-659-2256
	Irving Gas Station	Fuel Station	78 Exeter Road	603-659-6477
	Rockingham Gas	Fuel Station	35 North Main Street	603-659-3263
	Evans Express Mart	Retail	44 Exeter Road	603-659-6858
	Marielies Store	Retail	Main Street	
	L&M Variety	Retail	Elm Street	
	American Legion #67	Lodge	Main Street	603-659-3155
	Polish Club	Lodge	23 Central Street	603-659-6377
*Airport/Helipad: The following areas are potential helipad locations for use during an emergency response operations:				
	Leo Landroche Field	Potential Helipad Location	Junior-Senior High School	NA
	Rockingham Golf Course	Potential Helipad Location	Exeter Road	603-659-9956
	Fire Station	Potential Helipad Location	2 Youngs Lane	603-659-3334
Equipment/Hazardous Waste Facilities				
	Vyn-All Products Corporation	Hazardous Waste Facilities	12 Forbes Road	603-659-6439
Recreational Facilities [Indoor & Outdoor]				
	Community Center	Recreational Facilities	1 Terrance Drive	603-659-8581
	150 Landroche Field	Recreational Facilities	Junior-Senior High School	NA
	Beanie Howcroft Field	Recreational Facilities	Nichols Avenue	NA
	Beaulieu Field	Recreational Facilities	Elm Street	NA
	Waterfront Park/ Schanda Park	Recreational Facilities	Water Street	NA
	Great Bay Athletic Club	Recreational Facilities	Exeter Road	603-659-3151
	Rockingham Golf Course	Recreational Facilities	Exeter Road	603-659-9956
	Rockingham Ball Room	Recreational Facilities	22 Ash Swamp Road	603-659-4410
	Lou's Marina	Recreational Facilities	Lamprey River	NA
Medical Facilities				
	Lamprey Health Center	Medical Facility	207 South Main Street	603-659-3106
	Rite Aid	Medical Facility	71-73 Exeter Road	603-659-7852
	Great Bay Family Practice	Medical Facility	60 Exeter Road, Suite 300	603-659-0901
	Lane Chiropractic	Medical Facility	128 Exeter Road	
*Dams				
	Recreation Pond Dam	Non-Menacing Hazard Class	NA	NA
	Piscassic River Dam	Non-Menacing Hazard Class	NA	NA
	Macallen Dam	High Hazard Class	NA	NA
	Conservation Pond Dam	Non-Menacing Hazard Class	NA	NA
	Foxx Pond Dam	Non-Menacing Hazard Class	NA	NA
	Fire Pond Dam	Non-Menacing Hazard Class	NA	NA
	Wildlife Pond dam	Non-Menacing Hazard Class	NA	NA
	Ice Pond Dam	Non-Menacing Hazard Class	NA	NA
	Miller Dam	Non-Menacing Hazard Class	NA	NA

* A **Non-Menacing Hazard Class** means a dam that is not a menace because it is in a location and of a size that failure or misoperation of the dam would not result in probable loss of life or loss to property.

***** A **High Hazard Class** means a dam that has a high hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in probable loss of human life.

Water Resources (WR)				
Auxiliary Fire Aid				
ID	Facility Name	Type of Facility	Address	Phone
	Water Tower	Fire Aid	Access from Great Hill Dr.	NA
	Sewall Town Well	Fire Aid	Route 152	NA
	Bennett Town Well	Fire Aid	Route 152	NA
	Wade Farm Well	Fire Aid	Wade Farm Condominium	NA
	Schanda Well	Fire Aid	Schanda Drive	NA
	Moody Point Well	Fire Aid	Moody Point	NA
	Hamel Farm Pond Dry Hydrant	Dry Hydrant	Hamel Farm Road	NA
	Schanda Road Dry Hydrant (2)	Dry Hydrant(s)	Schanda Road	NA
	Gonet Drive Dry Hydrant	Dry Hydrant	Gonet Drive	NA
	Ash Swamp Dry Hydrant	Dry Hydrant	Ash Swamp Road	NA
	Ash Swamp Road	River Access	310 Ash Swamp Road	NA
	Piscassic Street	River Access	Piscassic River access	NA
	Crow and Eagle Falls	River Access	Grant Road	NA
	River Street	River Access	River Street	NA

May 2006 Flooding Event – Newmarket, NH

APPENDIX B. CLIMATE MITIGATION STRATEGIES AND NUTRIENT CONTROL MEASURES

Build in Green Features during Routine Right-of-Way Maintenance and Operations

FACT SHEET #1

A variety of green infrastructure practices can be used to manage stormwater and enhance the walkability and aesthetics of streets. Green infrastructure implemented in the street right-of-way can be used to

- Reduce impervious area
- Infiltrate/filter runoff from the street and adjacent property
- Provide shade using trees
- Improve air quality
- Reduce the urban heat island effect
- Create a sense of place
- Showcase public art
- Calm traffic
- Provide wildlife habitat
- Create a welcoming area
- Enhance aesthetics

This green street features low-maintenance vegetation and mature trees.

GREEN INFRASTRUCTURE OPPORTUNITIES

Permeable pavement — Choose permeable pavement for lower volume traffic areas, such as parking spaces, bike lanes, sidewalks, medians, and alleys.

Bioretention — Install bioretention in the right-of-way between the curb and sidewalk, in curb bump-outs, and in medians or roundabouts to filter stormwater and beautify the streetscape.

Trees — Plant trees or install tree boxes in the right-of-way between the curb and sidewalk, in curb bump-outs, in medians or roundabouts for enhanced stormwater infiltration, shade, and aesthetics.

Reduce impervious area — Replace pavement in medians, centerline safety strips, and roundabouts with pervious surfaces, and create shallow depressions to capture more runoff.

Project Complexity

Medium

Timeframe

1–3 years

Installation Costs

$50,000 and up, depending on site and scale

Factors Affecting Costs

- Scale of the project
- Retrofit, infill, or new development setting
- Green infrastructure practices selected
- If existing utilities require relocation or special designs
- Performance goals

Financing Opportunities

- Capital improvement funds
- Property tax assessments
- Stormwater utility fees
- State or private grants
- State revolving loans
- Private funding
- Bonds
- Federal funds

Necessary Maintenance

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement
- Soil replacement

THINGS TO CONSIDER BEFOREHAND

- Design for public safety and access
- Green streets and alleys are most cost-effective to complete in conjunction with necessary street or infrastructure improvements or rehabilitation projects.
- Select plants that do not impede driver sight lines or hide pedestrians from view.
- Design practices with sufficient access and features that make maintenance easier, such as inlets that are easy to clean.
- Choose vegetation that is densely rooted to filter debris and pollutants.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.
- Use wheel stops or curb cuts to ensure that cars do not drive over bioretention areas.
- Where possible, site stormwater retrofits in locations where pavement already drains in the right direction to avoid regrading.

Permeable pavement can be used for lower volume traffic areas such as parking and bicycle lanes.
Photo credit: Dan Christian, Tetra Tech, Inc.

POTENTIAL PROJECT PARTNERS

Downtown business associations, civic leagues, neighborhood associations, and **environmental groups** can provide input into the design and placement of the practices for maximum community benefit and can provide volunteer resources to keep the facilities free of trash and weeds. Partner groups could apply for grants to assist in the design or installation of key portions of the project or share costs on portions of the project. For example, an **arts council** might be willing to partner with a municipality to convert a pervious plaza into a park with an interpretive rain garden if the space incorporated public art.

FOR MORE INFORMATION

- National Complete Streets Coalition: www.smartgrowthamerica.org/complete-streets
- Federal Highway Administration's Street Design: Part 1 – Complete Streets: www.fhwa.dot.gov/publications/10julaug/03.cfm and Street Design: Part 2 – Sustainable Streets: www.fhwa.dot.gov/publications/11marapr/02.cfm
- Portland Green Streets website: www.portlandoregon.gov/bes/44407
- Seattle Streetscape Design Guidelines: Green Streets: www.seattle.gov/transportation/rowmanual/manual/6_2.asp

Roadside bioretention can include trees and attractive, low maintenance vegetation to enhance streetscapes.

CASE STUDY: NORTH STREET GREEN RETROFIT—PITTSFIELD, MASSACHUSETTS

The City of Pittsfield, Massachusetts is working to retrofit existing roadways with green street technology for stormwater management. One portion of the city's larger project is a 1,200 foot section of North Street in urban Pittsfield, where an existing streetscape plan included plantings and bump-outs for traffic calming. The city updated the original plan to incorporate three rain gardens to help manage stormwater. To successfully execute the rain gardens, the city needed to consider both urban conditions and local weather conditions. For example, the rain gardens were adapted for bioinfiltration with a specified medium, mulch, and appropriate plants that could withstand harsh New England conditions while aiding in pollutant removal.

In total, the three rain gardens covered an area of 520 square feet. The addition of rain gardens to North Street's renovation plan added the benefit of reducing stormwater pollutants from entering the West Branch of the Housatonic River. The rain gardens also reduce the volume of stormwater that is captured in catch basins and pumped to the municipal stormwater system with no treatment (Ogden et al. 2010). In addition to stormwater benefits, the retrofit achieves street calming measures in a downtown area that is emerging as an artistic and cultural hub in Pittsfield. The project successfully contributes to the goal of linking the city's dense urban center with green infrastructure (Greene et al. 2005). The cost of constructing the rain gardens along North Street totaled $44,379 (Ogden et al. 2010).

North Street before (top) and after (bottom) rain garden retrofits.
Photo credits: VHB, Inc., 2104

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Ogden, K.M., M.J. Seluga, and B.E. Eisenberg. 2010. Green street retrofits in the Northeast: Design and acceptance challenges for stormwater management retrofits. Low Impact Development 2010: pp. 628-641.

CASE STUDY: PLAINFIELD AVENUE—GRAND RAPIDS, MICHIGAN

In 2012, the City of Grand Rapids, Michigan updated the design of Plainfield Avenue to incorporate stormwater management features. The arterial roadway was redesigned to incorporate linear below-grade bioretention islands in the median that are designed to capture the first 0.5 inch of rainfall, eliminating the discharges to the storm sewer system from the most frequently occurring small storms. The islands effectively reduce 420,000 cubic feet of runoff, 60% of sediment, and 65% of phosphorus loading that would otherwise directly enter Grand River in flash flood events every year. In addition to runoff reduction and water quality benefits, the Plainfield Avenue island also serves the community by increasing pedestrian safety, calming traffic, and improving the area's aesthetics.

Design and construction costs of the Plainfield Avenue island totaled $264,000, which was funded by a collaboration of federal, local and private sources. Funding contribution sources included the Michigan Department of Transportation Enhancement Grant, Creston Neighborhood Association, Creston Business Association, Fishbeck, Thompson, Carr & Huber, Inc., and the West Michigan Environmental Action Council. In addition to capital costs, maintenance is expected to cost about $1,500 annually, $30,000 of which was endowed by the Cranston Business Association (SEMCOG 2013).

Reference:

SEMCOG. 2013. Great Lakes Green Streets Guidebook: A Compilation of Road Projects Using Green Infrastructure. http://www.semcog.org/uploadedFiles/Programs_and_Projects/Water/Stormwater/GLGI%20Guidebook_web.pdf.

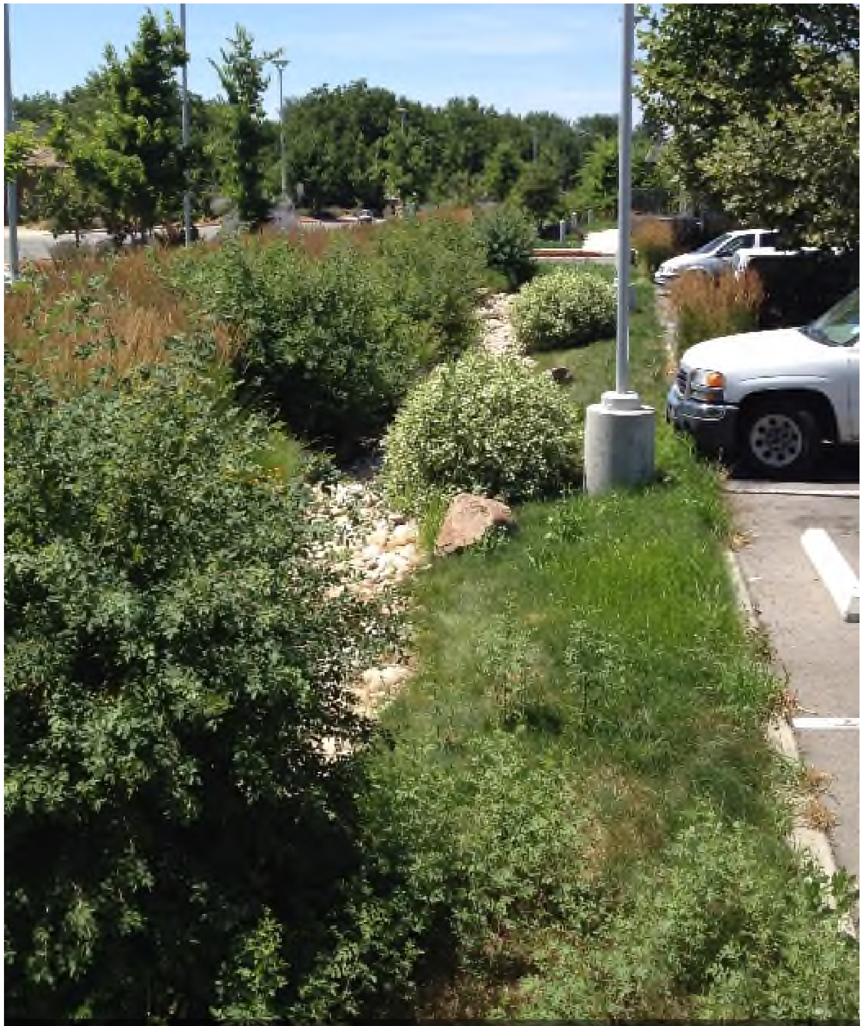
One of seven bioretention islands on Plainfield Avenue.
Photo credit: David Kidd, Governing Magazine.

Build or Retrofit Parking Facilities to be Greener

FACT SHEET #2

Parking lot pavement at municipal facilities constitutes a substantial portion of urban and suburban impervious surface area. These lots, as well as medians, curbs, and bump-outs, present opportunities for municipalities to incorporate green infrastructure features into new parking lot designs or retrofit existing parking lots with green infrastructure to capture runoff from parking spaces, parking lanes, and buildings before it leaves the site. Greener parking can be used to:

- Reduce effective impervious area
- Infiltrate runoff from parking lanes and stalls
- Improve parking lot drainage
- Provide shade when trees are used
- Improve pedestrian safety with curb bump-outs to reduce crossing distances
- Improve aesthetics
- Provide wildlife habitat



This parking lot drains to a vegetated bioretention area along the perimeter.

GREEN INFRASTRUCTURE OPPORTUNITIES

Permeable pavement Choose permeable pavement for areas with low volume traffic, such as parking stalls, fire lanes, pedestrian walkways, and overflow parking.

Bioretention Install or convert areas between parking rows to bioswales. Install bioretention along the parking lot perimeter and in corners where cars cannot park. Use curb bump-outs with bioretention at the end of stalls to calm traffic and reduce pedestrian crossing distances.

Trees Plant trees between parking rows, in bump-outs, and along perimeters. Use stormwater tree boxes in wide sidewalks and entrance courts.

Reduce impervious area Create shallow depressions in medians, centerline safety strips, and roundabouts and plant with low-profile vegetation. For retrofits, redirect stormwater flow from storm sewers to bioretention areas.

Project Complexity

Medium

Timeframe

1–3 years

Installation Costs

$10,000 and up, depending on site and scale

Factors Affecting Costs

- Scale of the project
- Retrofit, infill, or new development setting
- Green infrastructure practices selected
- If existing utilities require relocation or special designs

Financing Opportunities

- Capital improvement funds
- Property tax assessments
- Smart growth grants
- State or private grants
- State revolving loans
- Issuing bonds

Necessary Maintenance

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement

THINGS TO CONSIDER BEFOREHAND

- Select plants that do not impede driver sight lines or hide pedestrians from view.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.
- Design practices with sufficient access and features that make maintenance easier, such as paved forebays for easy sediment removal.
- Choose vegetation that is densely rooted to filter debris and pollutants.
- Use wheel stops or curbs with cuts to ensure that cars do not drive over bioretention.
- Grade drainage to slope toward bioretention areas or permeable pavement; avoid concentrated flows.
- Design curb cuts and inflow areas to manage adequate flow.

POTENTIAL PROJECT PARTNERS

Seek input from **business improvement districts** and **neighborhood associations** regarding desired features and amenities of green parking areas. Solicit funding from business associations to improve municipal parking areas serving a commercial district. Engage **civic leagues, environmental groups,** and **garden clubs** to provide support and volunteers to help build and maintain green infrastructure. Provide municipal incentives to **private property owners** to build new parking with green features. Consider provision of design assistance and expedited permit reviews.

FOR MORE INFORMATION

- EPA Office of Sustainable Development Green Parking Lot Fact Sheet: www.epa.gov/regionn2/ sustainability/parking/index.html
- Green Parking Council: www.greenparkingcouncil.org
- Parking Spaces/Community Places: Finding the Balance through Smart Growth Solutions: www.epa.gov/smartgrowth/pdf/EPAParkingSpaces06.pdf

Permeable pavers are used in compact parking stalls, which have lower traffic volume than the driving lanes.

A bioretention area treats runoff from the parking surface and is planted with low-maintenance vegetation.

CASE STUDY: LANCASTER PARKING LOT TRANSFORMATIONS—LANCASTER, PENNSYLVANIA

The City of Lancaster, Pennsylvania has taken on a series of four city-owned parking lot renovations in the city's southeast region. The renovated parking lot designs incorporate stormwater management features. Stormwater measures added to the parking lots on Plum Street, Dauphon Street, Pennsylvania Avenue, and Mifflin Street include repaving with permeable concrete, tree plantings, rain gardens, and reorganization of parking area placement to accommodate additional vehicles without expanding paved surface area (City of Lancaster 2014). The four renovated parking lots are each estimated to intercept between 600,000 and 700,000 gallons of stormwater that drains from surrounding blocks every year. Prior to the renovations, stormwater entered the sewer system and was overwhelming the treatment capacity of the facility, leading to raw sewage discharges into the Conestoga River, and ultimately the Chesapeake Bay (Harris 2011). Each of the parking lot renovations is estimated to cost about $160,000, with funding provided by a loan from the Pennsylvania Infrastructure Investment Authority and grant funding from the National Fish and Wildlife Foundation. The parking lot renovations are part of a series of green projects that the City of Lancaster implemented as an alternative to a $300 million grey infrastructure approach of building storage tanks to hold overflow until it could be treated (Harris 2011).

Plum Street parking lot retrofits.
Photo credit: CH2M Hill.

References:

City of Lancaster. 2014. *Parking Lots: Southeast Parking Lot Transformation*. http://www.saveitlancaster.com/local-projects/parking-lots/.

Harris, B. 2011, November 27. Lancaster city alley gets 'green' makeover. *Lancaster Online*. http://lancasteronline.com/news/lancaster-city-alley-gets-green-makeover/article_f05a7df8-8a75-5ab5-b799-c251c92905ec.html.

CASE STUDY: ST. LANDRY PARISH VISITOR'S CENTER—ST. LANDRY PARISH, LOUISIANA

The St. Landry Parish Visitor Center in Louisiana, was constructed to achieve LEED certification by incorporating sustainable materials with both aesthetic and functional purposes. For example, construction incorporated recycled building materials and stormwater control measures including permeable recycled asphalt in the conservatively sized parking lots. Stormwater runoff from the parking lot and roof is entirely retained on site by cisterns, rain gardens, and a series of bog ponds that collect and filter runoff. Native plants landscape the building's exterior, reducing maintenance and eliminating irrigation needs. In addition to stormwater control features, the visitor center incorporates energy saving measures, such as wind turbines, daylighting, low-energy insulated glazing, minimized east and west exposure to reduce solar heat gain, personal temperature controls, dual flush toilets, and energy star rated appliances. The resulting visitor center complements the existing landscape in a way that maximizes the natural meadow and landscape space and showcases sustainable strategies that are not only effective from ecological and monetary standpoints, but also serves as an educational example of the benefits of green infrastructure. The project was funded through public funding from federal and parish sources. Costs totaled approximately $330,000, with $130,000 allocated to parking sitework, walkways, and bioswales. The remaining $200,000 was split equally between landscaping, and utilities, drainage, gabion walls, and dirtwork. The stormwater measures incorporated in the visitor center are estimated to provide over 10% savings in construction costs compared to traditional site design and development and should result in long-term savings from landscaping that will not require potable water for irrigation.

Rain chains direct roof runoff to a cistern and infiltration area.
Photo credit: Jeffrey Carbo Landscape Architects.

Reference:

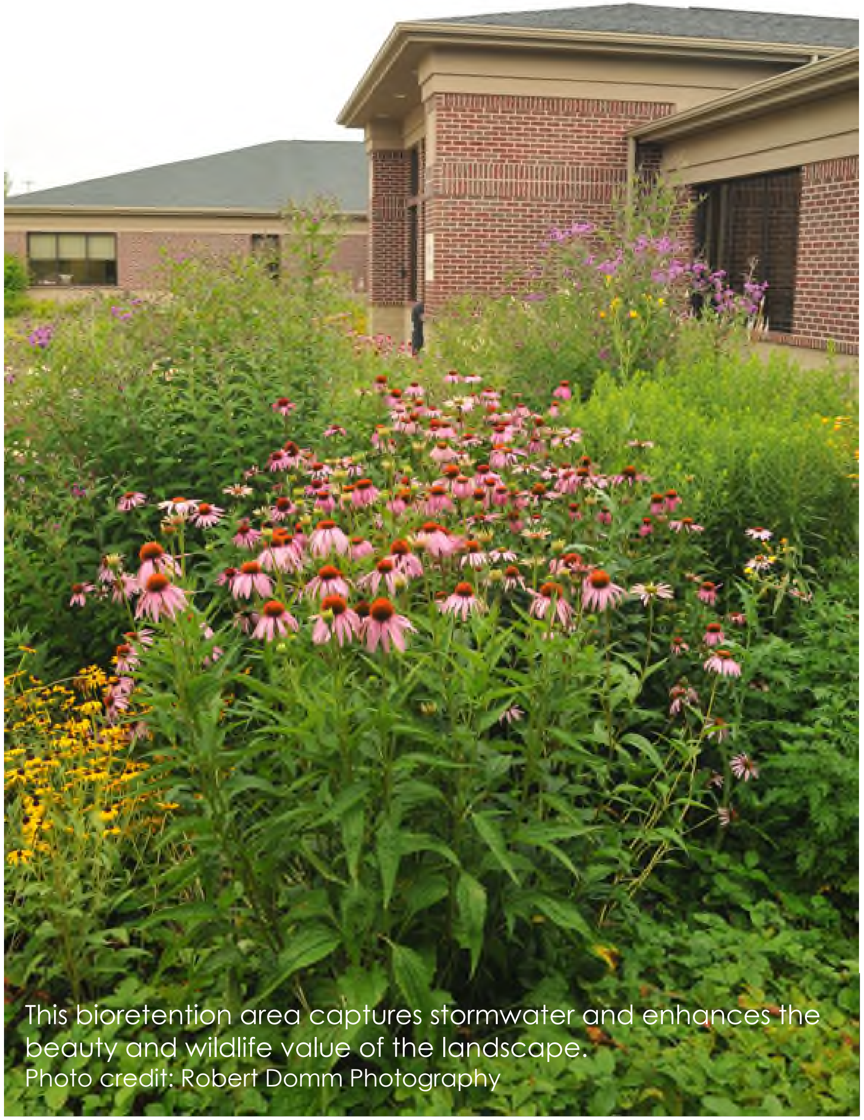
ASLA. No date. Green Infrastructure & Stormwater Management Case Study: St. Landry Parish Visitor's Center. http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20128%20St%20Landry%20Parish%20Visitor's%20Center,%20LA.pdf.

Build Green Infrastructure at Public Facilities

FACT SHEET #3

Municipal buildings, libraries, public parking lots, schools, community centers and parks offer opportunities for highly visible green infrastructure retrofits. Projects can be undertaken as part of the capital improvement process, ideally in conjunction with other needed maintenance such as building additions and modifications, repaving, re-landscaping, or infrastructure repair or replacement. Green infrastructure offers the following benefits:

- Reductions in impervious area
- Infiltration of runoff from paved areas and rooftops
- Public education opportunities (signage)
- Shade when trees are used
- Wildlife habitat
- Welcoming area
- Creation of park-like areas



This bioretention area captures stormwater and enhances the beauty and wildlife value of the landscape.
Photo credit: Robert Domm Photography

GREEN INFRASTRUCTURE OPPORTUNITIES

Permeable pavement	Choose permeable pavement for areas with low volume traffic, such as parking stalls, fire lanes, sidewalks, medians, and alleys.
Flow-through planters	Install fully-lined flow-through planters at the foot of buildings to slow the flow of runoff from rooftops to the storm drain system.
Bioretention	Replace paved and gravel areas between the curb and sidewalk, in parking islands and medians, and parking aisles with shallow depressions planted with low-maintenance vegetation.
Trees	Plant trees or install tree boxes in the right-of-way between the curb and sidewalk, in curb bump-outs, in medians or roundabouts, and in landscaped areas to provide shade and improve aesthetics.
Rainwater harvesting	Install cisterns and rain barrels to collect runoff from roof downspouts for nonpotable reuse (e.g., irrigation, wash water).
Reduce impervious area	Convert unused parking to open space or bioretention. Replace pavement in medians and traffic islands with vegetation.

Project Complexity

Medium

Timeframe

1–3 years

Installation Costs

$50,000 and up, depending on site and scale

Factors Affecting Costs

- Scale of the project
- Retrofit, infill, or new development setting
- Green infrastructure practices selected
- If existing utilities require relocation or special designs

Financing Opportunities

- Property tax assessments
- Stormwater utilities
- Smart growth grants
- State and private grants
- State revolving loans
- Issuing bonds

Necessary Maintenance

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement

THINGS TO CONSIDER BEFOREHAND

- Retrofitting public property to include green infrastructure features is most efficient and cost-effective when it occurs in conjunction with other needed maintenance and upgrades.
- Incorporate signage to educate the public about how stormwater is managed by the facilities.
- Choose vegetation that is densely rooted to filter debris and pollutants.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.
- Where possible, site stormwater retrofits in locations where pavement already drains in the right direction to avoid regrading.
- Site and design practices with sufficient access and features that make maintenance easier, e.g., include paved forebays for easy sediment removal.

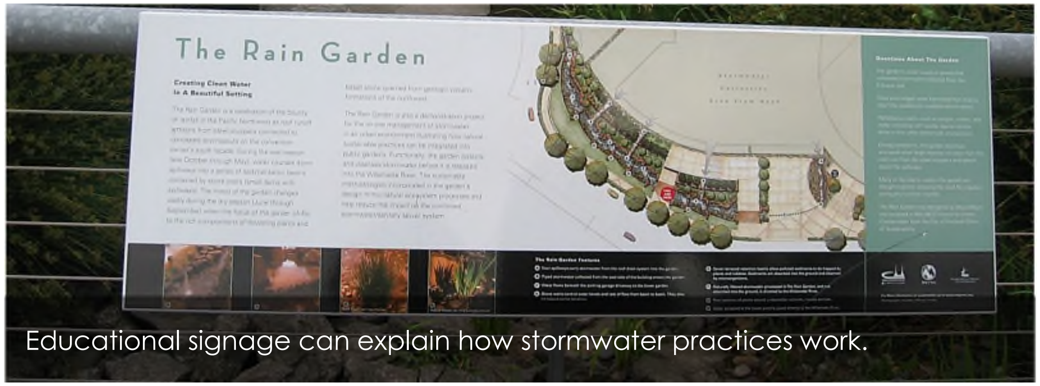
POTENTIAL PROJECT PARTNERS

School districts and students, parent/teacher associations, friends of the library, and downtown business associations can provide input into the design and placement of the practices for maximum utility and can provide volunteer resources to keep the facilities free of trash and weeds. Partner groups could apply for grants to assist in the design or installation of key portions of the project or share costs. Students can study, monitor, and maintain water quality facilities on school grounds as part of their science curriculum.

FOR MORE INFORMATION

EPA Green Infrastructure Page: http://water.epa.gov/infrastructure/greeninfrastructure

American Society of Landscape Architects Green Infrastructure Page: http://www.asla.org/greeninfrastructure.aspx and Stormwater Case Studies: http://www.asla.org/stormwatercasestudies.aspx



Educational signage can explain how stormwater practices work.

Tree boxes and other green infrastructure features enhance the aesthetics of a plaza space, create shade, and infiltrate stormwater.

CASE STUDY: NORTH AND SOUTH RIVERS WATERSHED ASSOCIATION RAIN GARDENS—SOUTH SHORE, MASSACHUSETTS

The South Shore Region of the Massachusetts Bays National Estuary Program (MassBays) and its host organization, the North and South Rivers Watershed Association (NSRWA), have worked to implement and encourage green infrastructure techniques throughout the region. Between 2006 and 2008, MassBays/NSRWA installed a rain garden in nearly every town on the South Shore. Partnering with local organizations to identify areas that receive high volumes of stormwater runoff, MassBays/NSRWA installed rain gardens in key public locations like schools and libraries in towns including Hull, Weymouth, Hingham, Norwell, Hanover, Pembroke, Scituate, Marshfield, Duxbury, Kingston, and Plymouth. Funding for the rain gardens was sourced by a 104b3 grant from EPA and MassDEP. MassBays/NSRWA also helped the Towns of Kingston and Pembroke obtain EPA 319 grants through MassDEP in 2006 to install green infrastructure practices like rain gardens, permeable pavement and pavers, and plastic grid at the Kingston Intermediate School and Pembroke's Town Hall and Oldham Pond boat ramp. In 2010, NSRWA/MBP worked with the Town of Marshfield to secure a 604b ARRA grant from the EPA and MassDEP for bacterial source tracking in the South River and subsequent design of stormwater BMPs to remediate bacterial pollution.

In 2011, MassBays provided funding to the town of Kingston received funding to evaluate the feasibility of installing green infrastructure at stormwater outfalls that discharge into the Jones River and Kingston Bay to address deteriorating water quality that resulted in restrictions on shellfish harvesting. Beginning with 35 known stormwater outfalls to the Jones River, the town identified a subset at which to perform water quality sampling during two storm events. Based upon the results of the sampling, local site conditions, and proximity of the site to the Bay, green infrastructure-based BMPs for 10 of the sites were brought to a conceptual design stage. Since 2012, detailed engineering designs have been developed for the most promising sites with funding from the state Office of Coastal Zone Management, and two BMPs are now in place. Based upon the conceptual designs, a materials quantity takeoff was performed and a construction cost estimate developed for each location. Construction costs were increased by 15% to cover contingencies and 25% to cover the cost of services for final design and construction inspection. The total construction cost, including final engineering design, construction, and construction inspection for all ten locations, was estimated to be $556,392. Based upon the matrix analysis results, two sites were selected for preliminary design. Two drawings were completed for the preliminary designs. Preliminary design at the paved swale on Delano Avenue was proposed to be comprised of a trench drain at the toe of the road, two 5' drain manholes with 4' sumps, and two 18' diameter rain gardens. Based on the preliminary designs, a total construction cost estimate of $268,778 has been calculated for the two catchment areas. The total construction cost includes 10% for construction contingencies and 25% for services related to design and construction inspection. The total construction cost estimate to mitigate all twelve outfalls is $825,170.

Rain garden off of Delano Avenue in Kingston, MA.
Photo credits: Maureen Thomas, Town of Kingston.

CASE STUDY: BAMBOO BROOK HISTORIC WATER SYSTEM RESTORATION—MORRIS COUNTY, NEW JERSEY

The Bamboo Brook Outdoor Education Center, formerly Merchinston Farm, underwent a restoration effort in 2009 to restore the existing but deteriorated system of scenic pools, streams, and tanks constructed by the original owner, a pioneer of landscape architecture. The design included water conservation measures such as bioswales, native plants, and rainwater harvesting devices. The system can now capture the runoff generated by a 2-year storm event. The restoration of the stormwater project was estimated between $1M and $5M, with public funding from state, local, New Jersey grant and Morris County Park Commission funding. The state estimates that 7 employment years were created by this project. To complete the project, approximately 6,346 hours were needed for planning and design; 6,820 hours for construction, and approximately 4,000 hours needed for annual maintenance.

Reference:

ASLA. No date. Green Infrastructure & Stormwater Management Case Study: Bamboo Brook Historic Water System Restoration. http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20055%20Bamboo%20Brook%20Historic%20Water%20System%20Restoration,%20Morris%20County,%20NJ.pdf.

Bamboo Brook Outdoor Education Center restoration.
Photo credit: Patricia M. O'Donnell, Heritage Landscapes LLC.

Design Traffic Safety Features to Manage Stormwater and Improve Aesthetics

FACT SHEET #4

Municipalities are tasked with ensuring that vehicles, pedestrians, and cyclists are safe on roads and sidewalks. Traffic-calming features, such as chicanes, roundabouts, and curb bump-outs, slow vehicle traffic and enhance pedestrian safety by drawing attention to pedestrians and reducing the distance pedestrians must travel to cross the road. These safety features offer opportunities to integrate green infrastructure. By building new streets and retrofitting existing streets with green infrastructure traffic calming measures, a municipality can do the following:

- Reduce street and sidewalk impervious area
- Infiltrate runoff from streets, sidewalks, and adjacent properties
- Calm vehicle traffic
- Enhance pedestrian safety
- Encourage multimodal transportation
- Improve streetscape aesthetics
- Provide wildlife habitat
- Improve water quality

This curb bump-out integrates bioretention and art. Its location at a crosswalk shortens the crossing distance for pedestrians.

GREEN INFRASTRUCTURE OPPORTUNITIES

Bioretention	Use bioswale islands at skewed intersections to decrease impervious area and make traffic paths more obvious. Install bioretention chicanes and bumpouts to slow vehicle traffic. Install curb bump-outs with bioretention at pedestrian crossings for increased visibility, safety, and convenience. Use narrow strips of bioretention (i.e., green gutters) to provide a visual barrier and buffer between bicycle and vehicle lanes.
Trees	Incorporate street trees for shade and aesthetic benefits.
Permeable pavement	Use permeable pavement for bicycle lanes to distinguish them from automobile travel lanes and to reduce standing water and ice formation.
Reduce impervious area	Convert raised medians and traffic islands to swales with curb cuts. Replace the center of paved cul-de-sacs with vegetated, shallow roundabouts.

Project Complexity

Low to medium

Timeframe

Months to several years depending on complexity

Installation Costs

$10,000 and up, depending on site and scale

Factors Affecting Costs

- Scale of the project
- Retrofit, infill, or new development setting
- Green infrastructure practices selected
- If existing utilities require relocation or special designs

Financing Opportunities

- Property tax assessments
- Stormwater utilities
- Transportation planning grants
- State and private grants
- Issuing bonds

Necessary Maintenance

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement

THINGS TO CONSIDER BEFOREHAND

- Ensure that traffic-calming measures do not interfere with emergency response vehicles.
- Select vegetation that will not impede driver sight lines or block pedestrians from view.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.
- Select vegetation that will be less likely to be stolen.
- Design facilities to manage the appropriate flow volumes to avoid blow-outs.
- Design to allow easy maintenance and reduce the potential for clogging.
- Consider a pilot project to incorporate green infrastructure and traffic calming features at an intersection or along a residential or commercial corridor that has a history of conflicts between drivers, cyclists, and pedestrians.
- Where possible, site stormwater retrofits in locations where pavement already drains in the right direction to eliminate the need for regrading.

POTENTIAL PROJECT PARTNERS

Residents can help municipalities identify areas of known conflicts between vehicles, cyclists, and pedestrians. Business associations benefit from slower traffic in commercial corridors and measures that encourage foot traffic. Public health organizations support measures that encourage walking and biking and reduce injuries to pedestrians. State highway departments can partner with municipalities to undertake projects on state-managed roads.

FOR MORE INFORMATION

National Complete Streets Coalition: www.smartgrowthamerica.org/complete-streets

Federal Highway Administration's Street Design: Part 1 – Complete Streets: www.fhwa.dot.gov/publications/10julaug/03.cfm and Street Design: Part 2 – Sustainable Streets: www.fhwa.dot.gov/publications/11marapr/02.cfm

Portland Green Streets website: www.portlandoregon.gov/bes/44407

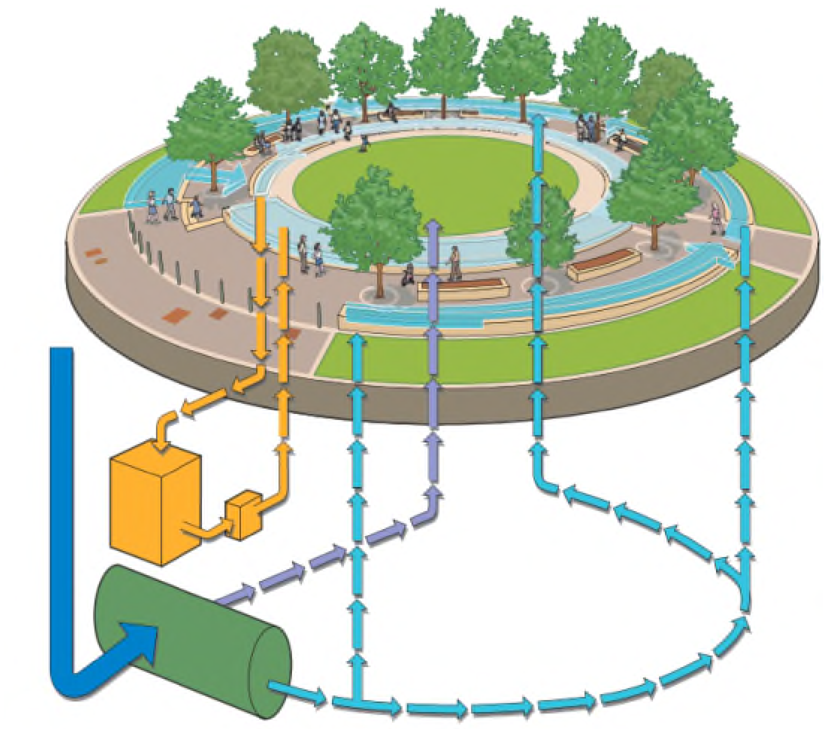
Seattle Streetscape Design Guidelines: Green Streets: www.seattle.gov/transportation/rowmanual/manual/6_2.asp

This bioretention bump-out captures runoff and slows traffic on a road frequented by cyclists and pedestrians.

CASE STUDY: UPTOWN CIRCLE TRAFFIC CALMING AND BIORETENTION PROJECT—NORMAL, ILLINOIS

Uptown Circle unites four Central Business District streets in Normal, Illinois. Completed as part of a larger business district redevelopment plan, the completed traffic circle transforms a formerly awkward intersection into a shared environment for motorists, pedestrians, and bicyclists, while providing community benefits such as slowed traffic, improved air quality, and reduced and mitigated stormwater runoff (Context Sensitive Solutions.org 2005).

The center of the circle provides innovative stormwater management by collecting stormwater using an obsolete storm sewer converted into a cistern. Subsequently, the stormwater flows via a series of filters into two subsurface channels where the water is filtered by plants in the outer channel and is slowed by a textured surface in the inner channel. SilvaCell™ trees and a grassy area enhance aesthetics and create a park-like setting (Context Sensitive Solutions.org 2005). The cistern beneath the traffic circle holds as much as 75,000 gallons of stormwater collected from the nearly 3 acres of paved surfaces draining to the system (Context Sensitive Solutions.org, no date).



Uptown Circle design.
Photo credit: Hoerr Schaudt, Landscape Architects

The project cost $1.5 million for Uptown Circle (Landscape Architecture Foundation, no date). The Landscape Architecture Foundation (no date) estimates many cost savings and environmental benefits from the traffic circle construction that include:

- Capture and reuse of 1.4 million gallons of stormwater onsite resulting in an estimated $7,600 annual potable water savings from the 58,800 square foot area.
- 1.4 million gallon reduction in stormwater load entering the municipal storm sewer from stormwater reuse for irrigation, onsite water feature, groundwater recharge, and water uptake by onsite green features (e.g., tree wells, planter areas, or underground storage facilities).
- Improved onsite water quality resulting from the sand, UV and bog filter systems. Estimates suggest that 91% of total suspended solids, 79% of total phosphorous, and 64% of total nitrogen can be removed each pass through the various filtration systems.
- Expected cost savings of over $60,000, across a 50 year period, from increased street tree lifespan resulting from the use of underground structural cells; thus, reducing costs associated with new street tree purchase and installation.
- Expected average carbon sequestration of more than 103 pounds of carbon annually from each of the 104 newly planted trees.
- Increase in Uptown financing district property values. Property values in the financing district increased by $1.5 million (or 9%) from 2009 to 2010, which translates to a 31% increase from 2004.
- Increase in revenue of more than $680,000 from conference events held in the newly developed multi-phase, mixed use Uptown Redevelopment project.

References:

Context Sensitive Solutions.org. 2005. Uptown Circle. http://contextsensitivesolutions.org/content/case_studies/uptown_circle/.

Context Sensitive Solutions.org. No date. The Uptown Normal Circle: A Living Plaza. http://contextsensitivesolutions.org/content/case_studies/uptown_circle/resources/b4/.

Landscape Architecture Foundation. No date. Uptown Normal Circle and Streetscape. http://landscapeperformance.org/case-study-briefs/uptown-normal-circle.

CASE STUDY: 14TH AVENUE NEIGHBORHOOD STREET FUND PROJECT—SEATTLE, WASHINGTON

The City of Seattle, Washington is benefitting from improvements to 14th Avenue that address previous stormwater treatment challenges while enhancing the appearance of the avenue. The project location has historically been susceptible to stormwater impacts due to soil with naturally low permeability and close proximity to a non-combined sewer system. To control stormwater impacts, 14th Avenue was redesigned at a cost of $75,000 to divert runoff through vegetated swales that are lined with a layer of aggregate and bioretention soil to promote retention and slow water velocity by a series of check dams. Additional water that is not retained by the bioswales is diverted to an existing stormwater system via curb cuts. While the city did not record water treatment improvement specific to this project, they estimate an 80 to 85 percent improvement in non-point source pollutants, based on a similar local project (ASLA 2013).

Rain garden along Seattle's 14th Avenue.
Photo credit: Aaron and Jennifer Britton

In addition to stormwater management improvements, pedestrian safety was addressed with the addition of a planted pedestrian island and curb bulb extensions that reduce the distance to cross the avenue and increase visibility distance for both pedestrians and motorists. Aesthetic appeal was enhanced with the installation of trees and public art (ASLA 2013, City of Seattle 2009).

The project was a collaborative effort among the city of Seattle, the 14th Ave Visioning project group, and the East Ballard Community Association and was implemented by the Seattle Department of Transportation. The $75,000 budget covered both stormwater and pedestrian safety features. Funding was sourced from the Neighborhood Street Fund, a local levy. The green infrastructure approaches were a cost effective alternative that the city estimates to have saved over 10% compared to traditional design approaches (ASLA 2013).

References:

ASLA. No date. Green Infrastructure & Stormwater Management Case Study: 14th Avenue Neighborhood Street Fund Project. http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20422%2014th%20Avenue%20Neighborhood%20Street%20Fund%20Project,%20Seattle,%20WA.pdf.

City of Seattle. 2009. 14th Avenue S Street Improvements. http://www.seattle.gov/transportation/14ave_south_improvements.htm.

Create Stormwater Microparks

FACT SHEET #5

Urban landscapes have many small-scale pockets of space that are underutilized and sometimes unsightly. These spaces often are located in triangles at junctions of diagonal streets, in spaces between buildings, in vacant lots, or in corners of parking lots. These underused areas are often paved or have high-maintenance turf that offers limited amenity value. They can be converted to a bioretention area or community garden with trees and attractive vegetation, and can accomplish the following:

- Reduce impervious surface
- Infiltrate runoff from the right-of-way and adjacent property
- Protect and restore water quality
- Improve aesthetics
- Create park-like areas
- Provide shade
- Showcase public art
- Provide wildlife habitat
- Promote urban agriculture

The low concrete walls of stormwater planters in a courtyard serve as seating. The project was designed with mixed textures and prominent structure to be safe for the visually impaired.

GREEN INFRASTRUCTURE OPPORTUNITIES

Permeable pavement Incorporate pavers into walkways and areas in deep shade where vegetation might not thrive.

Flow-through planters Use these practices, which are fully lined to prevent infiltration from undermining building foundations or other structures, alongside buildings to temporarily detain rooftop runoff from downspouts.

Bioswales Remove pavement or gravel and create a shallow depressed area with ornamental grasses, shrubs, and trees.

Trees Incorporate trees into microparks for shade, stormwater and climate change benefits, and to improve aesthetics.

Soil amendments Evaluate in-situ soils and amend them with organic matter or till them as necessary to improve infiltration and plant growth.

Reduce impervious area Remove pavement at underused sites to increase stormwater infiltration. Convert vacant lots and larger sites to community gardens for the benefit of neighborhood residents. Convert one or more street parking spaces to a micropark that serves as a seating area or gathering space.

Project Complexity

Easy

Timeframe

Less than 1 year to several years

Installation Costs

$5,000 and up, depending on site and scope

Factors Affecting Costs

- Scale of the project
- Green infrastructure practices selected
- If existing utilities require relocation or special designs

Financing Opportunities

- Neighborhood revitalization funding
- Parks bonds
- Property tax assessments
- Stormwater utility
- Smart growth grants

Necessary Maintenance

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement

THINGS TO CONSIDER BEFOREHAND

- Review local codes (setback requirements, sidewalk widths, parking requirements, etc.) to ensure there is space for green infrastructure practices.
- Identify possible conflicts with existing utilities.
- Ensure that there is adequate light for plant growth, or select shade-tolerant plants for microparks surrounded by buildings.
- For microparks adjacent to streets, consider enhanced pedestrian safety measures, such as wheelstops, railings, buffers, curb extensions, and painted crosswalks.
- Consider maintenance requirements and confer with public works staff who maintain such systems and landscapes.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.

POTENTIAL PROJECT PARTNERS

Business associations, neighborhood associations, garden clubs, and **private sponsors** can provide funding and volunteers to help build and maintain microparks. They can also offer input into the design and placement to maximize the benefit to the community.

FOR MORE INFORMATION

EPA Green Infrastructure Page: http://water.epa.gov/infrastructure/greeninfrastructure

American Society of Landscape Architects Green Infrastructure Page: http://www.asla.org/greeninfrastructure.aspx and Stormwater Case Studies: http://www.asla.org/stormwatercasestudies.aspx

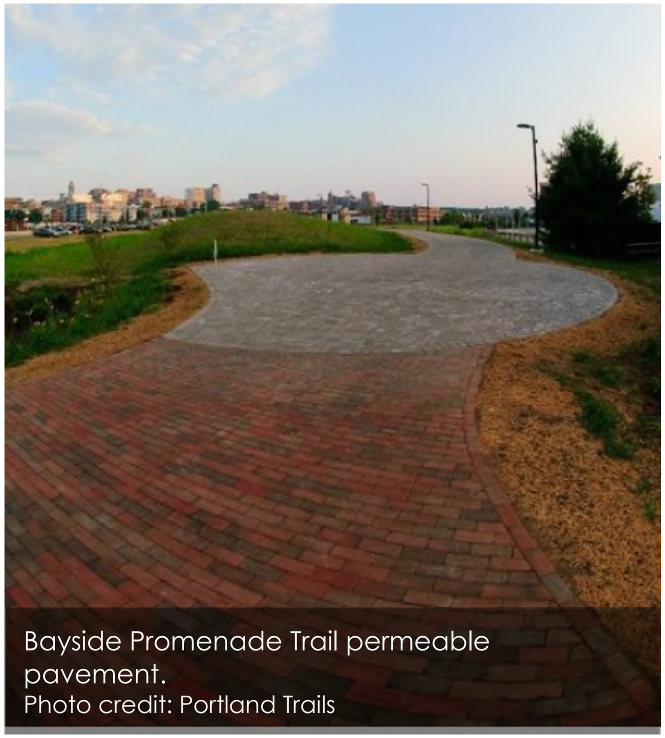
The concrete walls of this drywell offer seating around the perimeter of a courtyard, and an artful downspout creates a focal point.

The low stone walls on either side of this sidewalk artfully funnel rainwater to a flow-through planter along the side of a building.

CASE STUDY: BAYSIDE PROMENADE TRAIL MICROPARK AND REDEVELOPMENT PROJECT—PORTLAND, MAINE

In association with the City of Portland, Portland Trails, the Trust for Public Lands, and the Bayside Neighborhood Association, the 1.2-mile shared-use Bayside Promenade was constructed as a "spine" throughout the City, allowing pedestrian and bicycle access to pocket parks, residential areas, schools, and local businesses. The trail utilizes an abandoned railroad right-of-way and was constructed in the heart of the revitalized commercial and residential neighborhoods in Bayside and East Bayside.

No stormwater reduction analyses were performed for the full scale project; however, the project is expected to reduce stormwater runoff by 10% to 20% through a combination of newly installed LID practices including bioretention, rain gardens, bioswale, porous pavers, and curb cuts. The project cost between $100,000 and $500,000 and used public funding from federal, state, and local sources. Planning, design, construction, and long-term maintenance of the project increased jobs and boosted the local economy.


Bayside Promenade Trail permeable pavement.
Photo credit: Portland Trails

Reference:

ASLA. No date. Green Infrastructure & Stormwater Management Case Study: Bayside Promenade Trail. http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20332%20Bayside%20Promenade%20Trail,%20Portland,%20ME.pdf.

CASE STUDY: RINCON HEIGHTS MICROPARKS PROJECT—TUCSON, ARIZONA

As part of a larger neighborhood-scale retrofit project, a previously abandoned lot in the Rincon Heights Neighborhood in Tucson, Arizona, was retrofitted into a pocket park with multiple green infrastructure practices to capture stormwater runoff, improve water quality, and reduce flooding. The project features a 5,000 square foot pocket park featuring curb cuts, bioretention facilities (e.g., swale, gravel-filled trenches, basins), curb extensions, and removal of unnecessary impervious pavement onsite.

The estimated project cost was approximately $500,000 and included grant funding from the Arizona Department of Environmental Quality; Rincon Heights Neighborhood Association, the City of Tucson Department of Transportation, and Tucson Clean and Beautiful/Trees for Tucson were project partners. The project now showcases an innovative sustainable design in a previously underutilized residential area in Tucson. The green infrastructure practices aim to slow traffic and increase onsite infiltration providing aesthetic, safety, and stormwater benefits.


Rincon Heights, Feld Davis pocket park.
Photo credit: Alisha Goldstein

Reference:

Watershed Management Group. 2014. Demonstration Sites. http://watershedmg.org/demo-sites/tucson.

APPENDIX C. MAINTENANCE GUIDANCE AND FACTSHEETS

Regular Inspection and Maintenance Guidance for Bioretention Systems / Tree Filters

Regular inspection and maintenance is critical to the effective operation of bioretention system and tree filters. It is the responsibility of the owner to maintain the bioretention in accordance with the minimum design standards. This page provides guidance on maintenance activities that are typically required for these systems, along with the suggested frequency for each activity. Individual systems may have more, or less, frequent maintenance needs, depending on a variety of factors including the occurrence of large storm events, overly wet or dry (I.E., drought), regional hydrologic conditions, and any changes or redevelopment in the upstream land use.

ACTIVITIES

Visual inspections are routine for system maintenance. This includes looking for standing water, holes in the soil media, signs of plant distress, and debris and sediment accumulation in the system. Mulch and/or vegetation coverage is integral to the performance of the system, Including infiltration rate and nutrient uptake. Vegetation care is important to system productivity and health.

Activity	Frequency
A record should be kept of the time to drain for the system completely after a storm event. The system should drain completely within 72 hours.	After every major storm in the first few months, then biannually.
Check to insure the filter surface remains well draining after storm events. **Remedy**: If filter bed is clogged, draining poorly, or standing water covers more than 15% of the surface 48 hours after a precipitation event, then remove top few inches of discolored material. Till or rake remaining material as needed.	
Check inlets and outlets for debris. **Remedy**: Rake in and around the system to clear it of debris. Also, clear the inlet and overflow if obstructed.	Quarterly initially, biannually, frequency adjusted as needed after 3 inspections
Check for animal boroughs and short circuiting in the system. **Remedy:** Soil erosion from short circuiting or animal boroughs should be repaired when they occur. The holes should be filled and lightly compacted	
Check to insure the filter bed does not contain more than 2 inches accumulated material **Remedy:** Remove sediment as necessary. If 2 inches or more of filter bed has been removed, replace media with either mulch or a (50% sand, 20% woodchips, 20% compost, 10% soil) mixture.	
During extended periods without rainfall, inspect plants for signs of distress. **Remedy:** Plants should be watered until established (typical only for first few months) or as needed thereafter.	
Inspect inlets and outlets to ensure good condition and no evidence of deterioration. Check to see if high-flow bypass is functioning. **Remedy:** Repair or replace any damaged structural parts, inlets, outlets, sidewalls.	Annually
Check for robust vegetation coverage throughout the system. **Remedy:** If at least 50 % vegetation coverage is not established after 2 years, reinforcement planting should be performed.	
Check for dead or dying plants, and general long term plant health. **Remedy:** This vegetation should be cut and removed from the system. If woody vegetation is present, care should be taken to remove dead or decaying plant Material. Separation of Herbaceous vegetation rootstock should occur when over-crowding is observed.	As needed

CHECKLIST FOR INSPECTION OF BIORETENTION SYSTEM / TREE FILTERS

Location:
Inspector:
Date: Time: Site Conditions:
Date Since Last Rain Event:

Inspection Items	Satisfactory (S) or Unsatisfactory (U)		Comments/Corrective Action
1. Initial Inspection After Planting and Mulching			
Plants are stable, roots not exposed	**S**	**U**	
Surface is at design level, typically 4” below overpass	**S**	**U**	
Overflow bypass / inlet (if available) is functional	**S**	**U**	
2. Debris Cleanup (2 times a year minimum, Spring & Fall)			
Litter, leaves, and dead vegetation removed from the system	**S**	**U**	
Prune perennial vegetation	**S**	**U**	
3. Standing Water (1 time a year, After large storm events)			
No evidence of standing water after 72 hours	**S**	**U**	
4. Short Circuiting & Erosion (1 times a year, After large storm events)			
No evidence of animal boroughs or other holes	**S**	**U**	
No evidence of erosion	**S**	**U**	
5. Drought Conditions (As needed)			
Water plants as needed	**S**	**U**	
Dead or dying plants	**S**	**U**	
6. Overflow Bypass / Inlet Inspection (1 times a year, After large storm events)			
No evidence of blockage	**S**	**U**	
Good condition, no need for repair	**S**	**U**	
7. Vegetation Coverage (once a year)			
50 % coverage established throughout system by first year	**S**	**U**	
Robust coverage by year 2 or later	**S**	**U**	
8. Mulch Depth (if applicable)(once every 2 years)			
Mulch at original design depth after tilling or replacement	**S**	**U**	
9. Vegetation Health (once every 3 years)			
Dead or decaying plants removed from the system	**S**	**U**	
10. Tree Pruning (once every 3 years)			
Prune dead, diseased, or crossing branches	**S**	**U**	

Corrective Action Needed	Due Date
1.	
2.	
3.	

Regular Inspection and Maintenance Guidance for
Gravel Wetland Stormwater Management Device

Regular inspection and maintenance is critical to the effective operation of Gravel Wetland systems. It is the responsibility of the owner to maintain the Gravel Wetland in accordance with the minimum design standards. This page provides guidance on maintenance activities that are typically required for these systems, along with the suggested frequency for each activity. Individual systems may have more, or less, frequent maintenance needs, depending on a variety of factors including the occurrence of large storm events, overly wet or dry (I.E., drought), regional hydrologic conditions, and any changes or redevelopment in the upstream land use.

ACTIVITIES

Visual inspections are routine for system maintenance. This includes looking for standing water, accumulated leaves, holes in the soil media, signs of plant distress, and debris and sediment accumulation in the system. Vegetation coverage is integral to the performance of the system and vegetation care is important to system productivity and health. A gravel wetland is a subsurface horizontal filtration system and does not rely upon the surface soils for treatment. As such, surface infiltration rates are expected to be low and not a criterion for cleaning. Rather, stormwater access to subsurface treatment is by way of inlet standpipes. It is important to ensure these inlets are performing properly.

1ST YEAR POST-CONSTRUCTION ACTIVITY	FREQUENCY
1. Check that plants have adequate water, are well established and healthy. **Remedy:** Water plants as necessary, remove or treat diseased vegetation as necessary and re-vegetate poorly established plants as necessary	After every major storm in the first few months, then biannually.
2. Check for erosion in the system and short circuiting (holes) in the surface wetland soils. **Remedy:** Soil piping, erosion, and holes should be filled, lightly compacted, and reseeded.	

POST-CONSTRUCTION ACTIVITY	FREQUENCY
3. Check inlets outlets and stand pipes for leaves and debris. **Remedy**: Rake in and around the system to clear it of debris. Also, clear the inlet, outlets and standpipes if obstructed.	Quarterly initially, biannually, frequency adjusted as needed after 3 inspections
4. Check for animal burrows and short circuiting in the system. **Remedy:** Soil erosion from short circuiting or animal boroughs should be repaired when they occur. The holes should be filled and lightly compacted	
5. Check that the depth of accumulated sediment in the sedimentation chamber is less than 12 inches or 10 percent of the pretreatment volume. **Remedy:** The sedimentation chamber, forebay, and treatment cells outlet devices should be cleaned when drawdown times exceed 36 hours. Remove material with rakes where possible rather than heavy construction equipment to avoid compaction of the gravel wetland surface. Heavy equipment could be used if the system is designed with dimensions that allow equipment to be located outside the gravel wetland, while a backhoe shovel reaches inside the gravel wetland to remove sediment. Removed sediments should be dewatered (if necessary) and disposed of in an acceptable manner.	
6. Inspect inlets and outlets to ensure good condition and no evidence of deterioration. Check to see if high-flow bypass is functioning. **Remedy:** Repair or replace any damaged structural parts, inlets and outlets.	Annually
7. Check for robust vegetation coverage throughout the system. **Remedy:** If at least 50 % vegetation coverage is not established after 2 years, reinforcement planting should be performed.	
8. Cut and remove vegetation from the Gravel Wetland System and forebay in order to maintain nitrogen removal performance. **Remedy:** The vegetation should be cut and removed from the system to prevent nitrogen from cycling back into the system.	Once every 3 years

CHECKLIST FOR INSPECTION OF GRAVEL WETLAND

Location: Inspector:
Date: Time: Site Conditions:
Date Since Last Rain Event:

Inspection Items	Satisfactory (S) or Unsatisfactory (U)		Comments/Corrective Action
1st Year Post-Construction Monitoring (After every major storm for the first three months)			
Plants are stable, roots not exposed	S	U	
Vegetation is established and thriving	S	U	
No evidence of holes in the wetland soil causing short-circuiting	S	U	
No evidence of erosion at inlet and outlet structures	S	U	
Post-Construction Routine Monitoring (at least every 6 months thereafter as per USEPA Good House-Keeping Requirements. Inspection frequency can be reduced to annual following 2 years of monitoring indicating the rate of sediment accumulation is less than cleaning criteria listed below.)			
1. Standing Water			
Gravel wetland surface is free of standing water or other evidence of clogging, such as discolored or accumulated sediments	S	U	
2. Short Circuiting & Erosion			
No evidence of animal burrows or other holes	S	U	
No evidence of erosion	S	U	
3. Drought Conditions (As needed)			
Water plants as needed	S	U	
Dead or dying plants	S	U	
4. Sedimentation Chamber or Forebay Inlet Inspection			
No evidence of sediment accumulation, trash, and debris.	S	U	
Good condition, no need for repair	S	U	
5. Vegetation Coverage			
50 % coverage established throughout system by first year	S	U	
Robust coverage by year 2 or later	S	U	
6. Inlet and Outlet Controls			
Flow is unobstructed in openings (grates, orifices, etc)	S	U	
Structures are operational with no evidence of deterioration	S	U	
7. Vegetation removal (once every 3 years)			
Prune dead, diseased, or decaying plants	S	U	

Corrective Action Needed	Due Date
1.	
2.	
3.	

Regular Inspection and Maintenance Guidance for Porous Pavements

Regular inspection and maintenance is critical to the effective operation of porous pavement. It is the responsibility of the owner to maintain the pavement in accordance with the minimum design standards. This page provides guidance on maintenance activities that are typically required for these systems, along with the suggested frequency for each activity. Individual systems may have more, or less, frequent maintenance needs, depending on a variety of factors including the occurrence of large storm events, seasonal changes, and traffic conditions.

Inspection Activities

Visual inspections are an integral part of system maintenance. This includes monitoring pavement to ensure water drainage, debris accumulation, and surface deterioration.

Activity	Frequency
Check for standing water on the surface of the pavement after a precipitation event. If standing water remains within 30 minutes after rainfall had ended, cleaning of porous pavement is recommended.	2 to 4 times per year, more frequently for high use sites or sites with higher potential for run-on
Vacuum sweeper shall be used regularly to remove sediment and organic debris on the pavement surface. The sweeper may be fitted with water jets.	
Pavement vacuuming should occur during spring cleanup following the last snow event to remove accumulated debris, at minimum.	
Pavement vacuuming should occur during fall cleanup to remove dead leaves, at minimum.	
Power washing can be an effective tool for cleaning clogged areas. This should occur at mid pressure typically less than 500 psi and at an angle of 30 degrees or less.	
Check for debris accumulating on pavement, especially debris buildup in winter. For loose debris, a power/leaf blower or gutter broom can be used to remove leaves and trash.	
Check for damage to porous pavements from non-design loads. Damaged areas may be repaired by use of infrared heating and rerolling of pavement. Typical costs may be 2,000/ day for approximately 500 ft of trench.	

Maintenance Activities

Routine preventative cleaning is more effective than corrective cleaning.

Activity	Frequency
Controlling run-on and debris tracking is key to extending the life of porous surfaces. Erosion and sedimentation control of adjacent areas is crucial. Vacuuming adjacent non porous asphalt can be effective at minimizing run-on.	Whenever vacuuming adjacent porous pavements
Repairs may be needed from cuts of utilities. Repairs can be made using standard (non-porous) asphalt for most damages. Repairs using standard asphalt should not exceed 15% of total area.	As needed
Do not store materials such as sand/salt, mulch, soil, yard waste, and other stock piles on porous surfaces.	
Stockpiled snow areas on porous pavements will require additional maintenance and vacuuming. Stockpiling on snow on porous pavements is not recommended and will lead to premature clogging.	
Damage can occur to porous pavement from non-design loads. Precautions such as clearance bars, signage, tight turning radius, high curbs, and video surveillance may be required where there is a risk off non-design loads.	
Posting of signage is recommended indicating presence of porous pavement. Signage should display limitation of design load (i.e. passenger vehicles only, light truck traffic, etc. as per pavement durability rating.)	

CHECKLIST FOR INSPECTION OF POROUS PAVEMENTS

Location:
Inspector:
Date: Time: Site Conditions:
Date Since Last Rain Event:

Inspection Items	Satisfactory (S) or Unsatisfactory (U)		Comments/Corrective Action
1. Salt / Deicing *Note complete winter maintenance guidance is available at UNHSC			
Use salt only for ice management	S	U	
Piles of accumulated salt removed in spring	S	U	
2. Debris Cleanup (2-4 times a year minimum, Spring & Fall)			
Clean porous pavement to remove sediment and organic debris on the pavement surface via vacuum street sweeper.	S	U	
Adjacent non porous pavement vacuumed	S	U	
Clean catch basins (if available)	S	U	
3**. Controlling Run-On (2-4 times a year)**			
Adjacent vegetated areas show no signs of erosion and run-on to porous pavement	S	U	
4. Outlet / Catch Basin Inspection (if available) (2 times a year, After large storm events)			
No evidence of blockage	S	U	
Good condition, no need for cleaning/repair	S	U	
5. Poorly Drained Pavement (2-4 times a year)			
Pavement has been pressure washed and vacuumed	S	U	
6. Pavement Condition (2-4 times a year minimum, Spring & Fall)			
No evidence of deterioration	S	U	
No cuts from utilities visible	S	U	
No evidence of improper design load applied	S	U	
7. Signage / Stockpiling (As Needed)			
Proper signage posted indicating usage for traffic load	S	U	
No stockpiling of materials and no seal coating	S	U	

Corrective Action Needed	Due Date
1.	
2.	
3.	

Winter Maintenance Guidelines for Porous Pavements





Maintenance Guidelines

- Road surfaces, porous and non-porous, are commonly not treated and plowed until 2 or more inches of snow accumulation.
- Plow after every storm. If possible plow with a slightly raised blade, while not necessary, this will help prevent pavement scarring.
- Up to ~75% salt reduction for porous asphalt can be achieved. Salt reduction amounts are site specific and are affected by degree of shading.

  USE SALT REDUCTION NUMBERS WITH CAUTION!!!
- Pervious concrete salt reduction will vary and is heavily dependent upon shading. For shaded areas, pervious concrete may not achieve salt reduction.
- Apply anti-icing treatments prior to storms. Anti-icing has the potential to provide the benefit of increased traffic safety at the lowest cost and with less environmental impact.
- Deicing is NOT required for black ice development. Meltwater readily drains through porous surfaces thereby preventing black ice.
- Apply deicing treatments during, and after storms as necessary to control compact snow and ice not removed by plowing.
- Sand application should be limited since its use will increase the need for vacuuming
- Vacuum porous areas a minimum of 2-4 times per year, especially after winter and fall seasons when debris accumulation and deposition is greatest.
- If ponding water is observed during precipitation cleaning is recommended.

Winter Maintenance Challenges

- Mixed precipitation and compact snow or ice is problematic for all paved surfaces, but is particularly problematic for porous surfaces. This is corrected by application of excess deicing chemicals.
- De-icing chemicals work by lowering the freezing point of water. Generally, the longer a de-icing chemical has to react, the greater the amount of melting. Meltwater readily drains through porous surfaces thereby reducing chemical contact time. This is corrected by excess salt application.
- Excess salt application in these instances is offset by the overall reduced salt during routine winter maintenance and salt reduction.

Additional Resources

- The UNH Stormwater Center: http://www.unh.edu/erg/cstev/
- Pennsylvania Asphalt Pavement Association (PAPA) Porous Asphalt Pavements Guide: http://www.pahotmix.org/PDF/porous1.pdf
- National Asphalt Pavement Association (NAPA) Porous Asphalt Pavements for Stormwater Management Revised 11/2008, Information Series 131

INSPECTION AND MAINTENANCE GUIDANCE FOR UNDERGROUND SANDFILTER

REGULAR INSPECTION AND MAINTENANCE IS CRITICAL TO THE EFFECTIVE OPERATION OF AN UNDERGROUND SAND FILTER. IT IS THE RESPONSIBILITY OF THE CITY OF PORTSMOUTH TO MAINTAIN THE UNDERGROUND SANDFILTER IN ACCORDANCE WITH THE MINIMUM DESIGN STANDARDS. THIS PAGE PROVIDES GUIDANCE ON MAINTENANCE ACTIVITIES THAT ARE TYPICALLY REQUIRED FOR UNDERGROUND SAND FILTERS, ALONG WITH A SUGGESTED FREQUENCY FOR EACH ACTIVITY. INDIVIDUAL FILTERS MAY HAVE MORE, OR LESS, FREQUENT MAINTENANCE NEEDS, DEPENDING UPON A VARIETY OF FACTORS INCLUDING THE OCCURRENCE OF LARGE STORM EVENTS, OVERLY WET OR DRY (I.E., DROUGHT) REGIONAL HYDROLOGIC CONDITIONS, AND ANY CHANGES OR REDEVELOPMENT IN THE UPSTREAM LAND USE.

INSPECTION ACTIVITIES

Activity	Frequency
A record should be kept of the time to drain the filter bed completely after a storm event. The filter bed should drain completely within 48 hours.	After every major storm in the first few months, then biannually
Check to insure the filter surface does not clog after storm events	
Check inlets an outlets for debris and high efficiency	Quarterly initially, Biannually
Check to see that the filter bed is draining completely within 48 hours after a rain event	
Check to see that the filter bed does not contain more than 6 inches accumulated material	
Check to see that the pre-treatment sediment chamber is not more than 50% full.	Annually
Check to see that the pre-treatment sediment chamber is not full of trash, debris, and floatables	
Inspect inlets and outlets to ensure good condition and no evidence of deterioration	
Ensure that no noticeable odors are detected outside of the facility.	
Check to see if high-flow bypass is functioning	

MAINTENANCE ACTIVITIES

Activity	Frequency
Ensure the activities in the area minimize oil/grease and sediment entry to the system.	Biannually, frequency adjusted as needed after 3 inspections
Check to see that the filter bed is clean of sediment. Remove sediment as necessary.	
If filter bed is clogged or draining poorly, remove top few inches of discolored material. Till or rake remaining material as needed.	
If 6 inches or more of filter bed has been removed, replace media with sand meeting design specifications	As needed
Repair or replace any damaged structural parts, inlets, outlets, valves	

CHECKLIST FOR INSPECTION OF UNDERGROUND SANDFILTER

Location:
Inspector:
Date: Time: Site Conditions:
Date Since Last Rain Event:

Inspection Items	Satisfactory (S) or Unsatisfactory (U)	Comments/Corrective Action
1. Complete drainage of filter within 48 hours after rain event		
2. Sediment accumulation on filter bed, 6” or less		
3. Clogging of filter surface		
4. Filter clear of debris		
5. Pre-treatment chamber less than 50% full or ≥ 6 inches		
6. Pre-treatment chamber empty of trash, debris, and floatables		
7. Clogging of inlet/outlet structures		
8. Cracking, spalling, or deterioration of concrete		
9. Leaks or seeps in filter		
10. Animal burrows		
11. Undesirable vegetation		
12. Undesirable odors		
13. Complaints from residents		
14. Public hazards noted		
15. High-flow bypass structure functioning and clear of debris		

IF ANY OF THE ABOVE INSPECTION ITEMS ARE UNSATISFACTORY, LIST CORRECTIVE ACTIONS AND THE CORRESPONDING COMPLETION DATES.

Corrective Action Needed	Due Date
1.	
2.	
3.	
4.	
5.	

3/19/2010, UNHSC

APPENDIX D. PUBLIC OUTREACH WORKSHOP, CLIMATE RESILIENCY IN NEWMARKET

WORKSHOP ON CLIMATE RESILIENCY IN NEWMARKET

June 28th, 7-9PM
Newmarket Town Hall, Auditorium

AGENDA

Workshop Objectives:

- Inform Newmarket residents about several completed, ongoing, and upcoming flood resilience-focused projects going on in Newmarket
- Brainstorm next steps and other priorities, based on the results, to enhance resilience to flood hazards in Newmarket
- Provide opportunities for residents to engage more on resilience projects and planning efforts in the coming year

7:00 PM **Introduction, Steve Fournier, Town Administrator**
- Connect this work to the new town Vision Statement
- Introduce the workshop objectives

7:10 PM **NH Coastal Risk and Hazards Commission Science Summary and Report Recommendations, Nathalie Morison, NH Coastal Program**
- Introduce Commission's work in the context of Newmarket's vision, efforts
- Lay out the science from the STAP
- Example recommendation related to green infrastructure and stormwater management

7:20 PM **Results: Moonlight Brook Project Findings & Suggested Next Steps, Robert Roseen, Waterstone Engineering**
- Show results
- Describe recommendations for next steps for the town
- Take questions/discussion about the results

7:55 PM **Ongoing Projects in Newmarket: Drainage Improvements on New Road and Beech Street Phil MacDonald, Underwood Engineers**

8:15 PM **Upcoming Projects & Ways To Engage: C-RiSe, Saltwater Intrusion Study (Liz Durfee, SRPC), NHCP Design 4 Resilience grant opportunity (Kirsten Howard)**

8:25 PM **Facilitated Discussion about next steps for Newmarket, Kirsten Howard, NH Coastal Program**

8:50 PM **Closing Remarks, Diane Hardy, Town Planner**

Rev. June 27, 2016

NEW HAMPSHIRE COASTAL RISK AND HAZARDS COMMISSION

Preparing New Hampshire for Projected Storm Surge, Sea-Level Rise, and Extreme Precipitation

Draft Report Summary

Workshop on Climate Resiliency in Newmarket

Tuesday, June 28, 2016

Nathalie Morison
NHDES Coastal Program

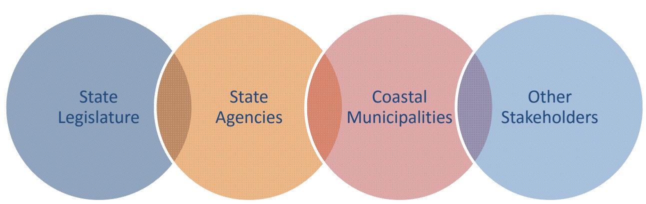
Coastal Risk and Hazards Commission

SENATE BILL 163 // RSA Chapter 483-E (eff. July 2, 2013)

- CLEAR MISSION:

  "…to recommend legislation, rules, and other actions to prepare for projected sea-level rise and other coastal and coastal watershed hazards… and the risks such hazards pose to municipalities and state assets in New Hampshire…"

- BROAD-BASED MEMBERSHIP (37 appointees):



- SUNSET: December 1, 2016

Understanding What We're Facing

2014 Science and Technical Advisory Panel (STAP) Report

EXTREME PRECIPITATION

Photo credit: UNH Stormwater Center

PROJECTIONS

- ⬆ Frequency
- ⬆ Amount

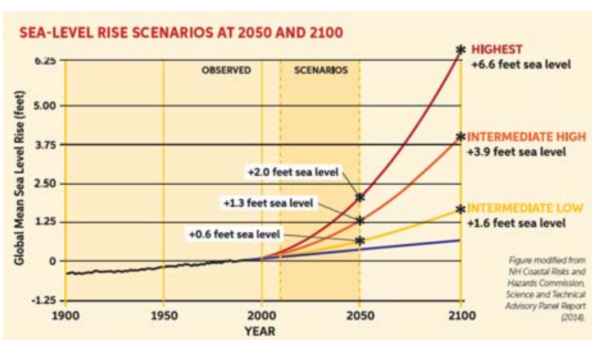
HOW TO PREPARE

1. **Pre-2050:** Design for storm intensities based on current Northeast Regional Climate Center precipitation data
2. **Post-2050:** Design to manage 15% increase in extreme precipitation

Understanding What We're Facing

2014 Science and Technical Advisory Panel (STAP) Report

SEA-LEVEL RISE



PROJECTIONS

- ⬆ 0.6 – 2.0 ft. by 2050
- ⬆ 1.6 – 6.6 ft. by 2100

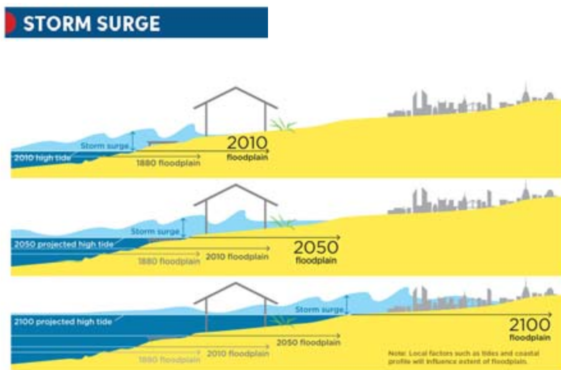
HOW TO PREPARE

1. Select time period
2. Commit to manage ***intermediate high***
3. Adjust if necessary

Example: If the design time period is 2050-2100, commit to manage 3.9 ft. of sea-level rise, but be prepared to manage and adapt to 6.6 ft. if necessary.

Understanding What We're Facing

2014 Science and Technical Advisory Panel (STAP) Report



Sea level sets a baseline for storm surge—the potentially destructive rise in sea height that occurs during a coastal storm. As local sea level rises, so does that baseline, allowing coastal storm surges to penetrate farther inland. With higher global sea levels in 2050 and 2100, areas much farther inland would be at risk of being flooded. The extent of local flooding also depends on factors like tides, natural and artificial barriers, and the contours of coastal land.

PROJECTIONS

Today's storm surge events (i.e., 100-year flood) will:

- ⬆ Inundation extent
- ⬆ Frequency
- ⬆ Flood duration

HOW TO PREPARE

Add projected sea-level rise heights to current storm surge heights (i.e., 100- and 500-year flood)

Understanding our Risks and Vulnerabilities

Key Topic Areas

OUR ECONOMY is the systematic and productive exchange and flow of goods, services and transactions that must be intact, functioning, and resilient to coastal risk and hazards in order to create and sustain jobs and a high quality of life in coastal New Hampshire.

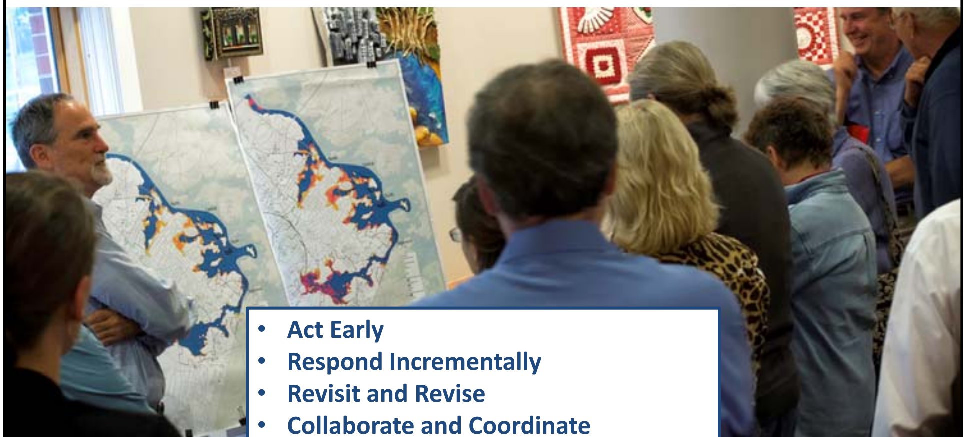
OUR BUILT LANDSCAPE is the network of structures and facilities owned by state and municipal governments and private entities in coastal New Hampshire. Our built landscape must be prepared to adapt and respond to coastal risk and hazards.

OUR NATURAL RESOURCES are the natural systems that support important species and biodiversity in coastal New Hampshire and provide critical and important services to coastal New Hampshire like food, flood protection, fresh water, raw materials, and recreation opportunities.

OUR HERITAGE encompasses the abundance of recreational, cultural, and historic resources, including economic assets and elements of the built landscape, in coastal New Hampshire that our state and municipalities wish to protect from coastal risk and hazards.

Understanding What We Need to Do

Our Guiding Principles



- Act Early
- Respond Incrementally
- Revisit and Revise
- Collaborate and Coordinate
- Incorporate 'Risk Tolerance' in Design
- Make 'No Regrets' Decisions

Our Goals, Recommendations, and Actions

SAIL: Four Goals for a Resilient Coast

Goal 1: SCIENCE

Research, understand, establish, and use the best available science about current and future coastal hazards in New Hampshire relating to storm surge, sea-level rise, and extreme precipitation

Goal 2: ASSESSMENT

Identify assets and resources within our economy, our built landscape, our natural resources, and our heritage that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.

Goal 3: IMPLEMENTATION

Identify and implement strategies that will enable the State and coastal municipalities to effectively protect, adapt, and sustain our current and future economy, built landscape, natural resources, and heritage.

Goal 4: LEGISLATION

Recommend timely considerations for legislation that leads to actions, both immediate and long-term, that reduce and/or eliminate vulnerability and result in adaptation to existing and future coastal hazards.

Recommendation Highlights

Examples Related to Stormwater / Green Infrastructure

- Establish buffer requirements for setbacks from rivers, shorelines, and wetlands that account for changing conditions and support local enforcement [NR3]
- Implement strategies to maintain/restore pervious surfaces, provide nutrient barriers, protect vegetated buffers, and maintain wildlife passage [NR4]
- Explore options to minimize shoreline hardening and promote natural/hybrid shoreline stabilization techniques (e.g., living shorelines) [NR4]
- Explore innovative funding mechanisms (e.g., stormwater utility) [CC1]

How to Submit Public Comments

IT'S *NOT* TOO LATE!

- **Deadline: June 30, 2016**
- **Download the report online at:** http://nhcrhc.stormsmart.org/draft-for-comment
- **Email comments to:** crhc-comments@rpc-nh.org
- **Mail comments to:**
  Attn: Julie LaBranche
  Rockingham Planning Commission
  156 Water Street
  Exeter, NH 03833

Questions?

For more information, visit:
http://nhcrhc.stormsmart.org/

Photo credit: Ron Sher

Nathalie Morison
Coastal Resilience Specialist
NHDES Coastal Program
nathalie.morison@des.nh.gov
(603) 559-0029

Cliff Sinnott, Chair
NH Coastal Risk and Hazards Commission
Executive Director, Rockingham Planning Commission
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(603) 778-0885

Climate Resiliency In Newmarket

Robert Roseen, Jake Sahl, Waterstone Engineering
Nigel Pickering, Rich Claytor, Horsley Witten Group
Tuesday June 28, 2016

Funding Source:
NOAA Office for Coastal Management
NH Department of Environmental Services Coastal Program

PROJECT TEAM

Waterstone Engineering

Robert Roseen, Project Director
Jake Sahl, Modeler and Analyst

Town of Newmarket, NH

Diane Hardy, Town Planner
Rick Malasky, Public Works Director
Steve Fournier, Town Administrator

Horsley Witten Group

Rich Claytor, Project Design
Nigel Pickering, Project Review

NHDES

Kirsten Howard, Coastal Program Project Manager
Steve Couture, Supervisor

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MAY 16, 2006 MOTHERS DAY STORM


ARKING FOR
ERICAN LEGION
TRONS ONLY
SPEED LIMIT
20

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15 Highest Events –

Daily Discharges on Lamprey River near Newmarket

Rank	Date	Discharge (cfs)
1	**16-May-06**	**8400**
	15-May-06	*7600*
2	**18-Apr-07**	**7590**
	17-Apr-07	*7410*
3	**7-Apr-87**	**7360**
	8-Apr-87	*5920*
	6-Apr-87	*5460*
4	**16-Mar-10**	**6550**
	17-Mar-10	*5610*
	15-Mar-10	*4810*
5	**22-Oct-96**	**6310**
	23-Oct-96	*6150*
6	**17-May-06**	**6240**
7	**20-Mar-36**	**5270**
	21-Mar-36	*4690*
8	**1-Apr-10**	**5240**
	31-Mar-10	*4600*
9	**19-Apr-07**	**4830**
10	**27-Feb-10**	**4640**
11	**15-Mar-77**	**4620**
12	**3-Apr-04**	**4550**
13	**16-Jun-98**	**4500**

Of 15 largest events since 1934:
11 have occurred in last 25 years
10 have occurred in last 15 years
7 have occurred in last 5 years

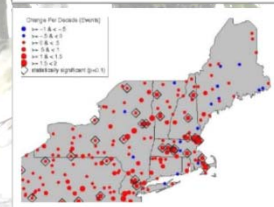
Primary Causes of Runoff Increase

CAUSES

- Land Use Changes→Increase in impervious cover
- Changes in storm depth, duration, and frequency→Increased rainfall depth and runoff volume

SOLUTIONS

- Land use management strategies to mitigate runoff volumes



The New Orleans Hurricane Protection System: What Went Wrong and Why-- 1**0 Lessons Learned from Katrina** by the ASCE Hurricane Katrina External Review Panel and the USACE Interagency Performance Evaluation Task Force

1. Failure to think globally and act locally-We must account for climate change
2. Failure to absorb new knowledge
3. Failure to understand, manage, and communicate risk-Need to take rigorous risk based approach,
4. Failure to build quality in
5. Failure to build in resilience
6. Failure to provide redundancy
7. Failure to see that the sum of many parts does not equal a system
8. The buck couldn't find a place to stop--Poor organization, lack of accountability
9. Beware of interfaces: materials and jurisdiction
10. Follow the money-People responsible for design and construction had no control of the monies.

OBJECTIVES AND OUTCOMES

OBJECTIVES

1. To study flood risk associated with climate change as well as how future development and build out of the community affect these risks, and
2. Design green infrastructure (GI) practices within the watershed to help reduce the risk of flooding while reducing pollutant load into the Brook and into the Lamprey River.

OUTCOMES

1. To provide an illustration of the types and quantities of BMPs that could be used to reduce flooding.
2. Provide cost performance on BMPs for cost effectiveness, unit costs ($/ft3 reduced), total minimum optimized cost, flood mapping for volume and the duration.
3. Develop a GI concept and final design that can be used for bidding and construction.
4. Green Infrastructure will also provide water quality benefits to:
   a. promote groundwater and stream recharge,
   b. maintain stream water temperatures and
   c. reduce nutrient, sediment and bacterial pollution

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TASKS

1. **Watershed Model Development**
   a. GIS Data Review
   b. SW Infrastructure Mapping
   c. Watershed site walk Topographic Survey
   d. Rework existing HECRAS Model based on survey
   e. Develop Model Conduit Data
   f. Select/Analyze suitable climate data
   g. Modeling Report
2. **Review Existing Build Out Analysis**
   a. Review existing buildout analyses Lamprey Study
3. **Green Infrastructure and Climate Adaptation Modeling**
   a. Develop/modify LO model, apply constraints
   b. Run LO model to develop cost performance curve
   c. Analyze detailed results
   d. Compare costs of implementation by scenario
4. **Build Out and Resiliency Flood Impact Analysis**
   a. Update hydrologic and hydraulic models for scenarios
   b. Analyze results, compare to Task 1 results
   c. Update modeling report
5. **Green Infrastructure BMP Design**
   a. Develop 35% conceptual design drawing BMPs
   b. Site Survey for 1 BMP locations
   c. Final Design Drawings and Specifications
   d. Cost Estimate/Bid Package and O&M Plans

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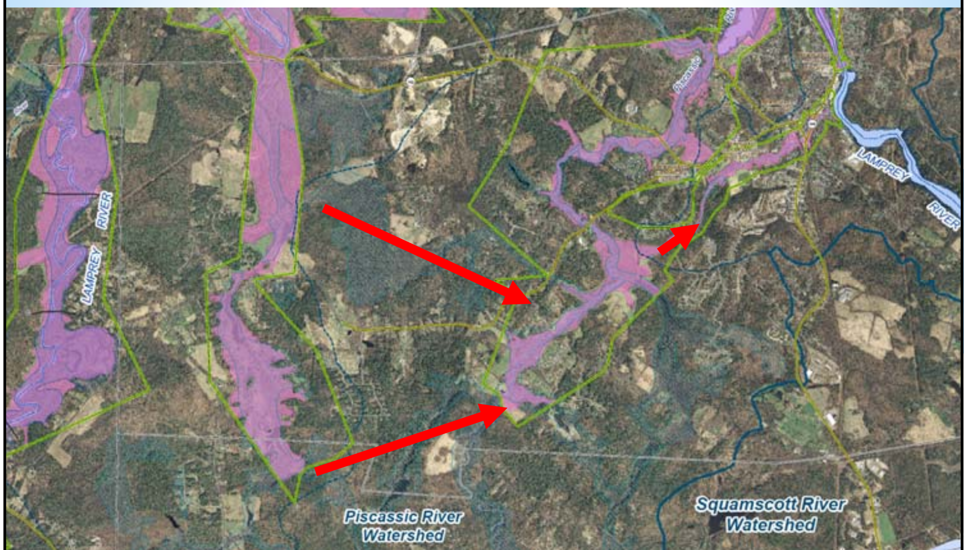
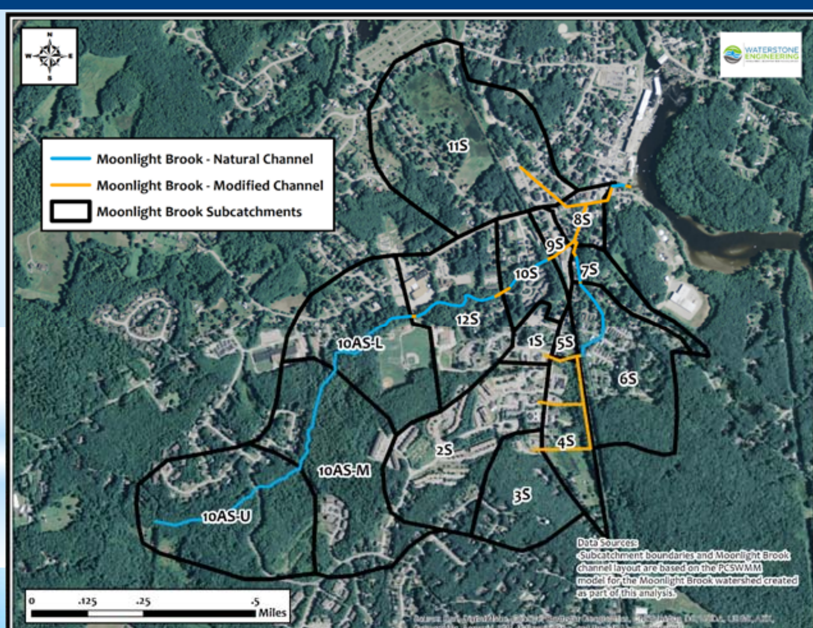
LAMPREY STUDY OF 2100 CONDITION



MOONLIGHT BROOK



INTRODUCTION OF SCENARIOS

SCENARIOS			
	With Piscassic Bypass	No-Piscassic	Design Storm Depth (Inches)
2005/2015	Current +307 CFS	Current	8.75
2005/2015	Current with New Road +307 CFS	Current without New Road	8.75
2050	LID/Conventional +307 CFS	LID/Conventional	8.75
2050	LID/Conventional +612 CFS	LID/Conventional	10.06*

*CRHC Recommendation for +15% of existing

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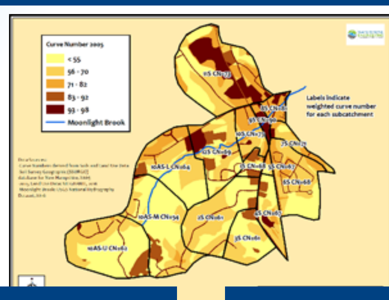
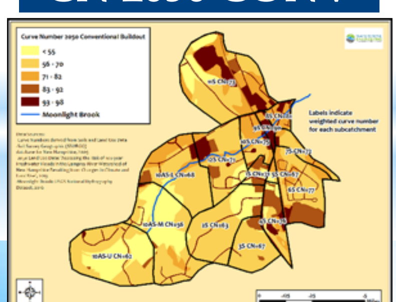
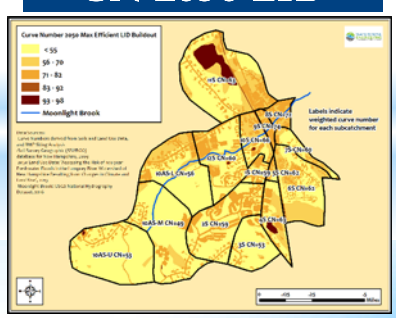
CURVE NUMBER CURRENT



CN 2050 CONV



CN 2050 LID



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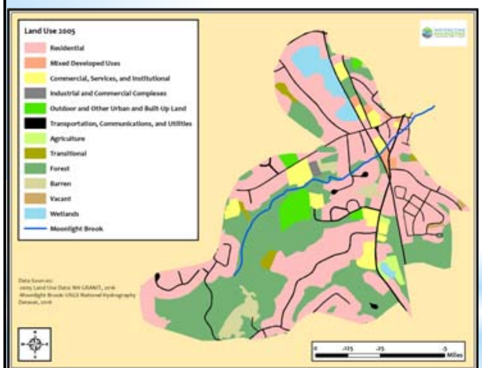
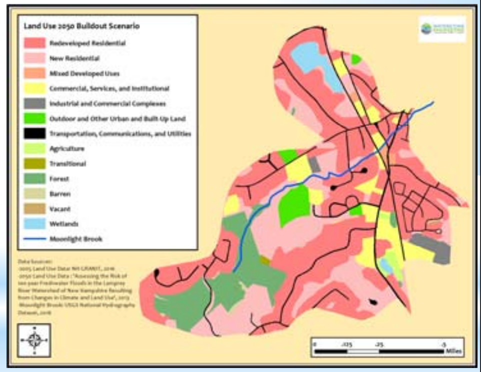
CHANGES IN LAND USE BY 2050





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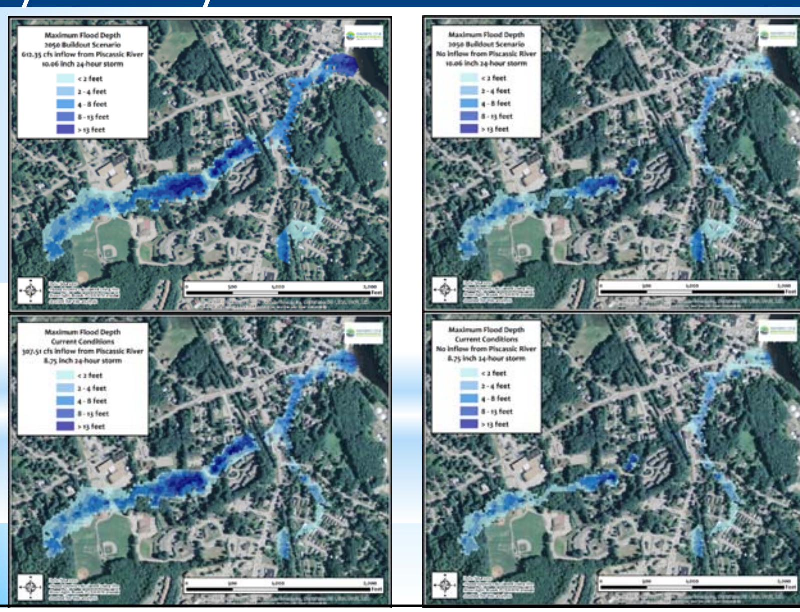
FLOOD CONDITIONS FOR CURRENT, W/ AND W/O PISCASSIC AND FUTURE



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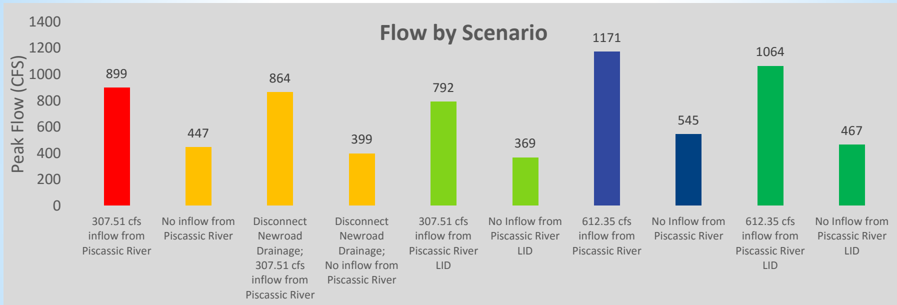
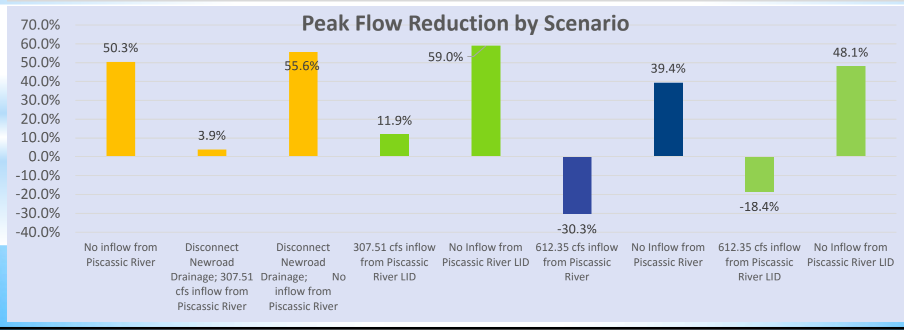
PEAK FLOW AND % REDUCTION





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FLOOD MITIGATION STRATEGIES AND BENEFITS

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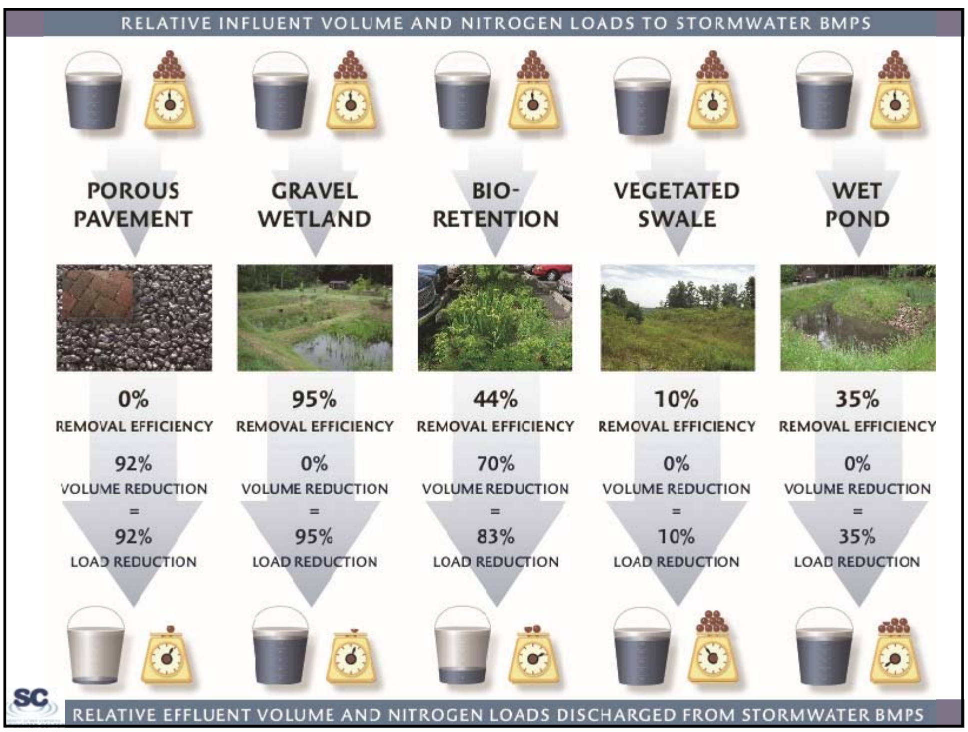
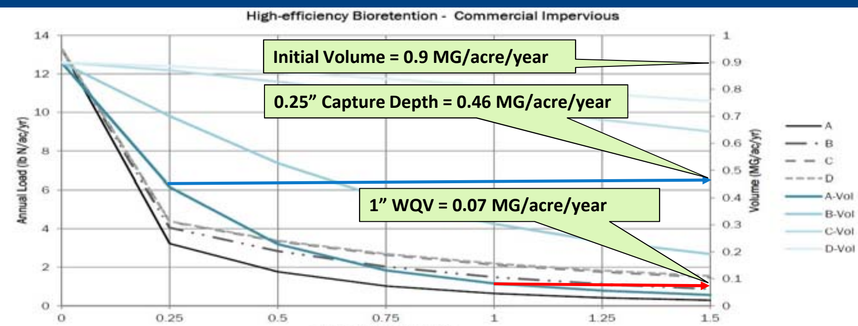
LID as a Climate Adaptation Tool



BMP OPTIMIZATION--VOL



BMP Sizing Example:

•1 system treating a 1" water quality volume for 1 acre will reduce runoff volume by approximately 0.83 MG/acre/year.

•4 smaller systems across 4 acres designed to treat 0.25" WQV/acre/yr will each reduce runoff volume by 0.44 MG/acre/year for a total of 1.76 MG per year.

•An additional 0.93 MG of runoff volume per year at nearly equivalent costs, or approximately 212% increase.

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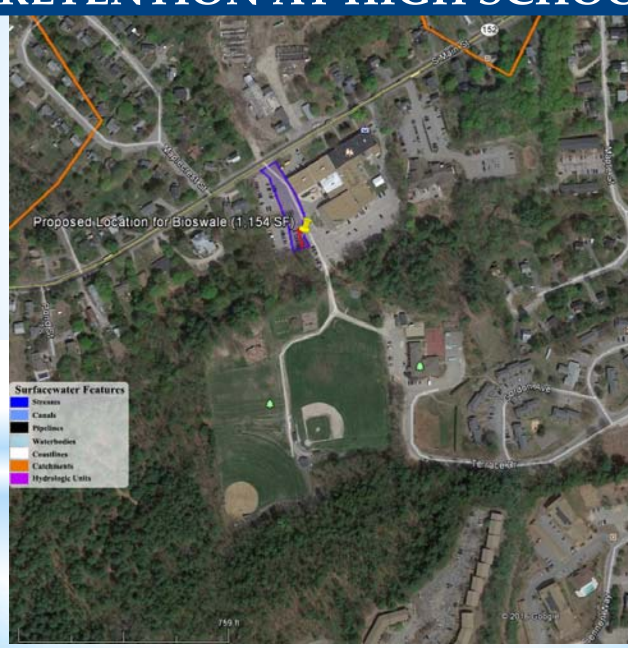
BIORETENTION AT HIGH SCHOOL



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BIORETENTION AT HIGH SCHOOL

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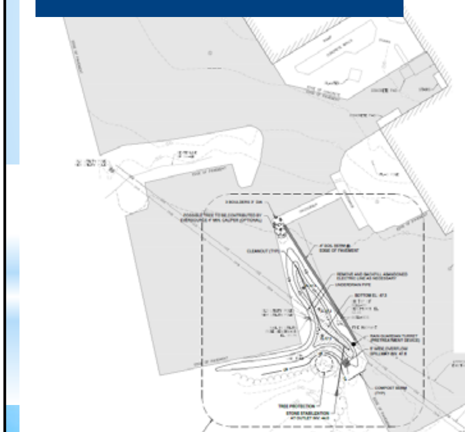
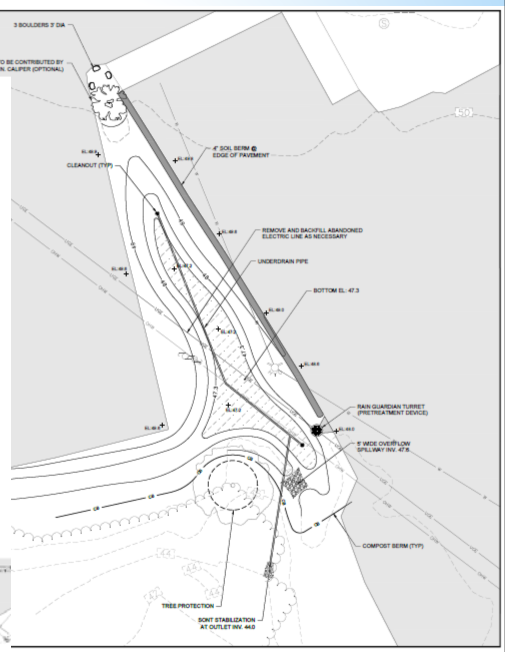
BIORETENTION AT HIGH SCHOOL





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RECOMMENDED BMPS

Total Present Value of NPS Management (including O&M): $7.5 M
Total Volume Reduction from NPS Management: 13.7 Million Gallons
Total Acres Treated: 417

Land Cover	BMP Type	BMP Size	Unit Runoff Reduction (MG / acre)	Recommended Acreage	Construction Cost ($/acre)	Unit Cost ($/MG)	Total Potential Runoff Reduction (MG)	Cost by Land Use ($$)
ROAD I	RAINGARDEN	1.5	0.029	189.31	$ 18,000	$ 621,000	5.49	$ 3,408,000
ROAD I	RAINGARDEN	1.5	0.03	44.86	$ 18,000	$ 600,000	1.35	$ 808,000
RESIDENTIAL R	RAINGARDEN	1.5	0.0325	41.73	$ 18,000	$ 554,000	1.36	$ 752,000
RESIDENTIAL I	RAINGARDEN	0.5	0.009	29.63	$ 7,000	$ 778,000	0.27	$ 208,000
RESIDENTIAL R	WET POND	1.5	0.063	18.85	$ 22,400	$ 356,000	1.19	$ 423,000
RESIDENTIAL C	RAINGARDEN	0.75	0.02275	16.95	$ 10,000	$ 440,000	0.39	$ 170,000
RESIDENTIAL D	RAINGARDEN	1.5	0.0325	12.02	$ 18,000	$ 554,000	0.39	$ 217,000
RESIDENTIAL B	GRAVEL WETLAND	1.5	0.049	9.04	$ 35,300	$ 721,000	0.44	$ 319,000
RESIDENTIAL A	WET POND	1.5	0.063	7.07	$ 22,400	$ 356,000	0.45	$ 159,000
OUTDOOR I	RAINGARDEN	1.5	0.03	6.23	$ 18,000	$ 600,000	0.19	$ 113,000
				417			13.7	$ 7,428,000

*Showing only areas totaling greater than 5 acres

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KEY FINDINGS

- **Piscassic Bypass is significant. To prevent bypass increases flood elevation 0.3- 1.0 ft in Piscassic and reduces peak flows by 50%**
- **New Road Drainage Reroute reduces peak flows by 14%**
- **LID benefit reduces runoff within watershed by 20%**
- **LID reduces peak flows by 12% but overwhelmed w/ Piscassic Bypass**
- **Combined reduction from Piscassic and New Road is 69%**
- **Combined reduction from Piscassic, New Road, and LID exceeds 80%**
- **LID benefits could accomplished in part with rezoning through redevelopment**
- **Nitrogen reduction for would be expected to be substantial ~50%, further analysis is required.**

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APPLICATIONS

- The new proposed small MS4 permits for NH and Final MA include a requirement for
  - BMP optimizing, and
  - Ranking of retrofits opportunities and target areas.
- Optimization at the watershed scale can significantly reduce costs for achieving load reduction targets for nitrogen, phosphorous, and other pollutants.
- Optimization can be conducted for volume reduction for climate resiliency.
- "Small Systems" can be a tremendous way to increase the cost effectiveness

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ASSUMPTIONS AND LIMITATIONS

1. Rough model calibration has been conducted using known high water marks observed during the April 2007 storms at the High School and in the Bowl area, in combination with assumptions made using the existing calibrated 2012 Lamprey HEC-RAS model. No additional calibration is planned as the project results are intended for a planning level analysis only.
2. Future climate precipitation for 2050 was based off of the Coastal Risk Hazard Commission recommendation for a 15% increase in existing rainfall depth. PCSWMM Model
3. Design storm rainfall volumes based on data from the NRCC for Newmarket, NH,
4. Steady-state inflow from Pisscassic River of 307 cfs for the current condition, 612 cfs for the 2050 condition
5. Subcatchment runoff characteristics for current conditions are based on 2005 land use data, the most current available data set
6. Subcatchment runoff characteristics for 2050 buildout are based on methodology outlined in the 2013 Lamprey study
7. Infiltration/runoff calculations are based on the least sophisticated method available in PCSWMM (CN vs. CN + Imp. Green-Ampt, or Horton methods)
8. Input/output flow volumes calculated using PCSWMM models designed primarily to calculate nutrient loads
9. Curve number adjustment calculations to develop curve numbers for the 2050 LID buildout condition are based on a slightly modified version of the methodology outlined in McCuen (2004)
10. Maximum treatment areas for each land use type assume that 100% of residential, commercial, institutional, industrial are suitable for LID controls

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Thank you for your time

Robert Roseen
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Waterstone Engineering

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NEXT STEPS

- New Road
- Beech Street

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SCENARIO RESULTS

Modeled Scenarios		Total Runoff (MG)	Total Inflow from Piscassic River (MG)	Peak Outflow into Lamprey River (cfs)		Total Outflow into Lamprey River (MG)	
				CFS	% Reduction	MG	% Reduction
2015 Land Use; 8.75 inch 24-hour storm	307.51 cfs inflow from Piscassic River	66.15	199	898.93	0	225	-
	No inflow from Piscassic River	66.15	0	446.8	50.3%	62.53	72.2%
	Disconnect Newroad Drainage; 307.51 cfs inflow from Piscassic River	66.15	199	775.11	13.8%	207.2	7.9%
	Disconnect Newroad Drainage; No inflow from Piscassic River	66.15	0	276.33	69.3%	42.59	81.1%
2050 LID Buildout; 8.75 inch 24-hour storm	307.51 cfs inflow from Piscassic River LID	52.46	199	791.97	11.9%	214.12	4.8%
	No Inflow from Piscassic River LID	52.46	0	369.31	58.9%	50.25	77.7%
2050 Buildout; 10.06 inch 24-hour storm	612.35 cfs inflow from Piscassic River	84.38	396	1171.39	-30.3%	366.36	-62.8%
	No Inflow from Piscassic River	84.38	0	544.61	39.4%	79.44	64.7%
2050 LID Buildout; 10.06 inch 24-hour storm	612.35 cfs inflow from Piscassic River LID	71.57	396	1064.43	-18.4%	355.48	-58.0%
	No Inflow from Piscassic River LID	71.57	0	467.12	48.0%	67.16	70.2%

*CRHC Recommendation for +15% of existing

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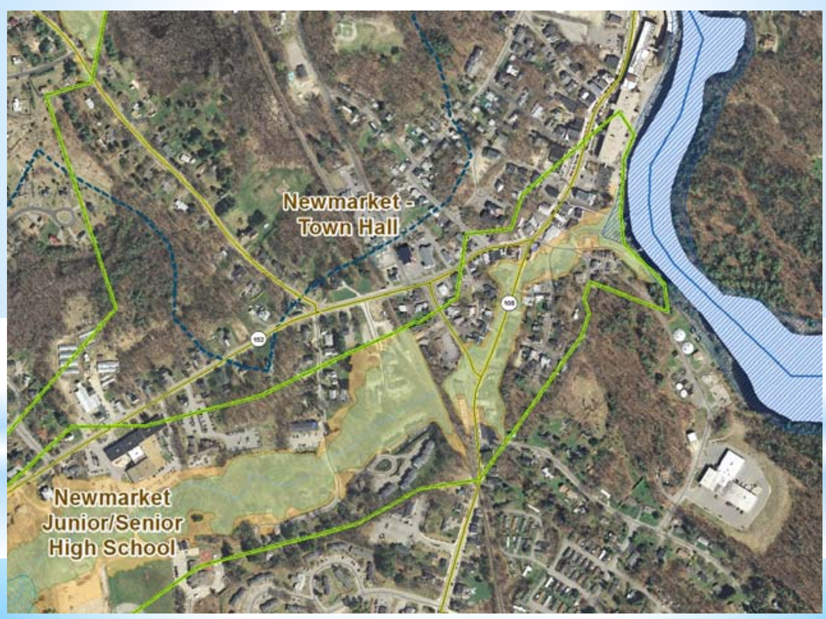
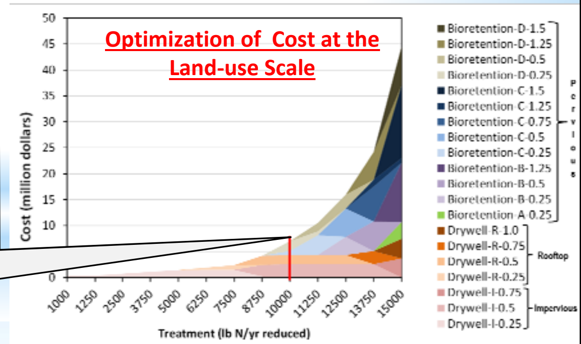


LAND USE SCALE OPTIMIZATION

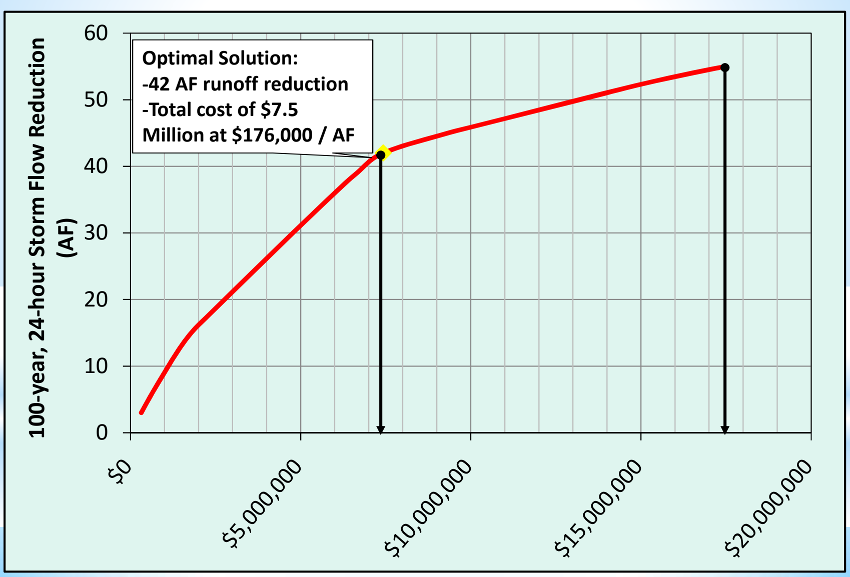
This process enables the identification of the **maximum extent practicable (MEP)**, or the point at which cost effectiveness is greatest and feasibility begins to decline.

To achieve **10,000 lbs** of reduction by treating residential land, use a mix of:

- Drywell/Infiltration trenches, 0.5" capture depth, treating runoff from driveways/sidewalks
- Drywells, 0.5" capture depth, treating roof runoff
- Bioretention (rain gardens), 0.25" capture depth, treating runoff from pervious C soils
- Bioretention (rain gardens), 0.25" capture depth, treating runoff from pervious D soils



WATERSHED OPTIMIZATION



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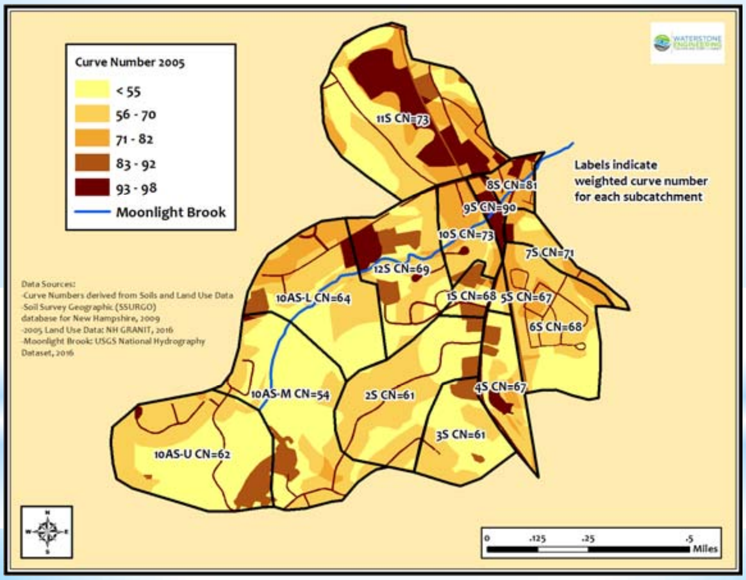
CURRENT CURVE NUMBER



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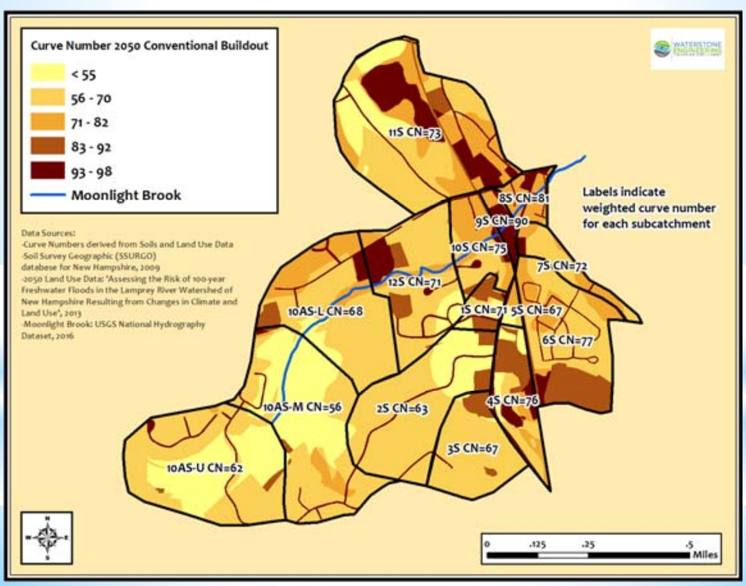
CHANGES IN CURVE NUMBER BY 2050



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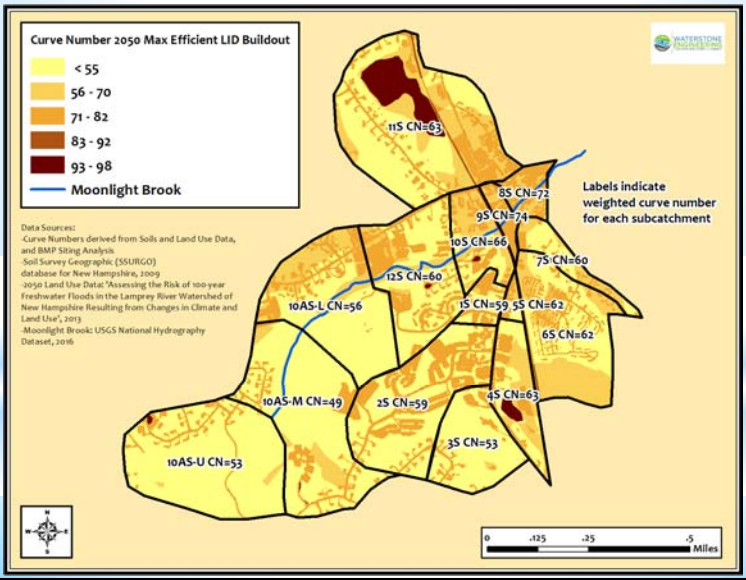
CHANGES IN CURVE NUMBER BY 2050 W/ LID



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CHANGES IN CURVE NUMBER BY 2050

		Weighted Curve Number		
Subcatchment	Area (acres)	2005 (Current Conditions)	2050 Conventional Buildout	2050 Efficient LID Buildout
10AS-L	50	65	69	57
10AS-M	62	55	57	50
10AS-U	62	62	62	54
10S	18	74	76	66
11S	80	73	73	63
12S	41	69	71	61
1S	7	68	71	60
2S	50	62	63	60
3S	27	62	67	54
4S	20	68	76	64
5S	3	68	68	62
6S	44	68	77	62
7S	11	71	73	61
8S	8	82	82	72
9S	5	90	90	75
Total MB Watershed	486	66	69	59

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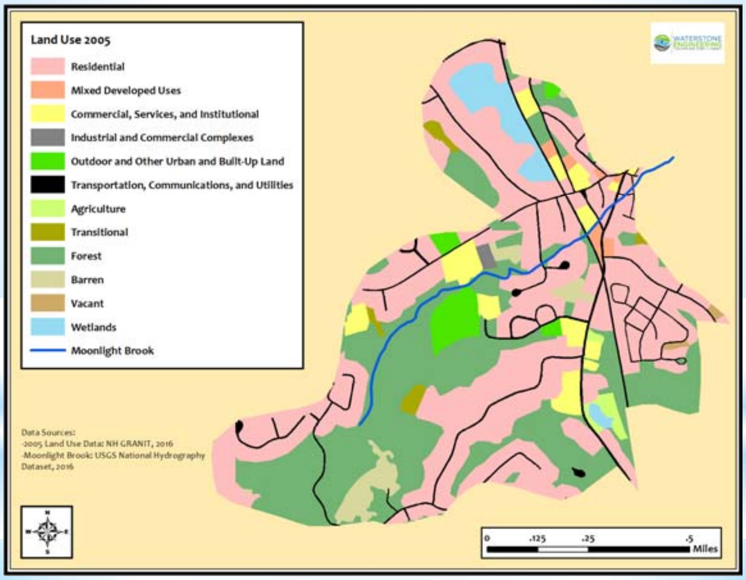
CURRENT LAND USE



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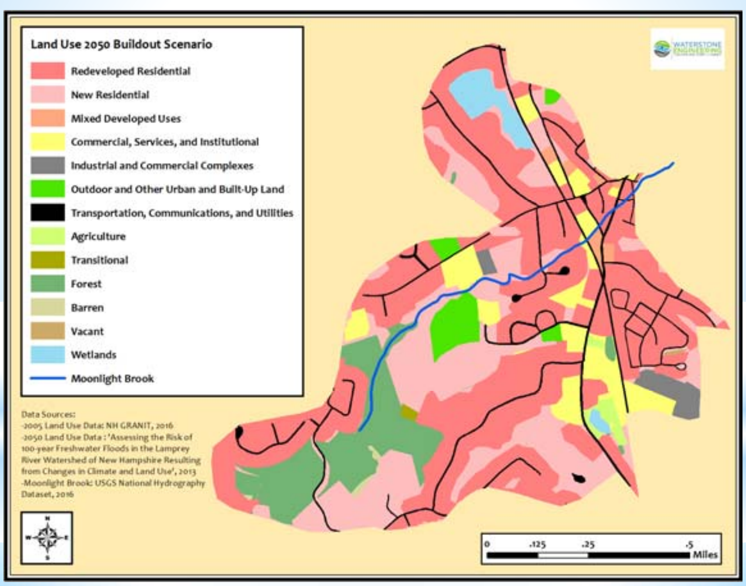
CHANGES IN LAND USE BY 2050



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CHANGES IN LAND USE BY 2050

	Acreage	
Land Use Type	**2005 (Current Conditions)**	**2050 Buildout Scenario**
Redeveloped Residential	N/A	228.53
New Residential	228.53	106.92
Mixed Developed Uses	3.91	3.91
Commercial, Services, and Institutional	22.7	35.39
Industrial and Commercial Complexes	1.33	7.66
Outdoor and Other Urban and Built-Up Land	12.4	12.4
Transportation, Communications, and Utilities	24.12	24.12
Agriculture	3.72	3.72
Transitional	4.47	0.71
Forest	155.13	50.03
Barren	12.59	1.11
Vacant	1.08	0.26
Wetlands	15.9	11.12
Moonlight Brook Watershed	485.88	485.88

1. All of 2005 commercial and industrial land use is redeveloped for 2050

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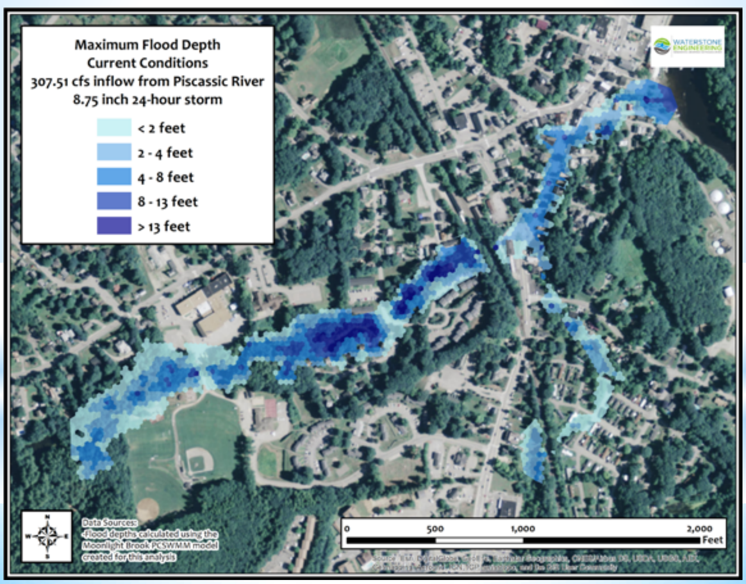
CURRENT FLOOD CONDITIONS W/ PISCASSIC



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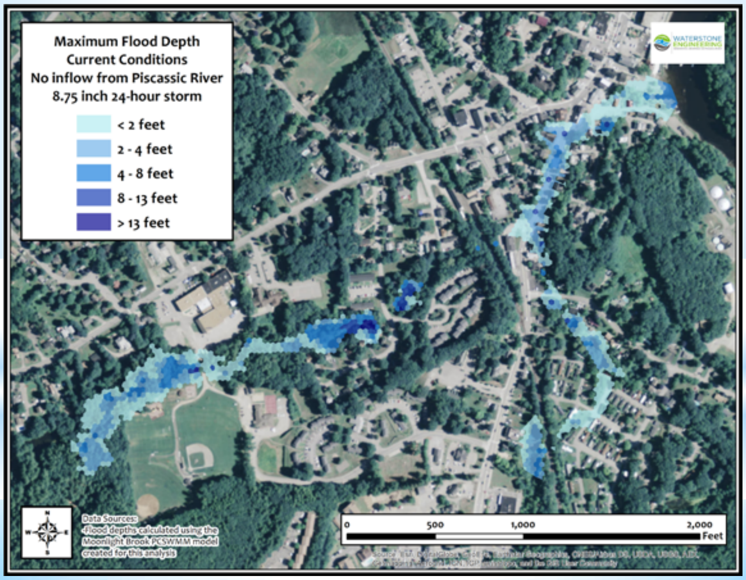
CURRENT FLOOD CONDITIONS W/O PISCASSIC +371CFS



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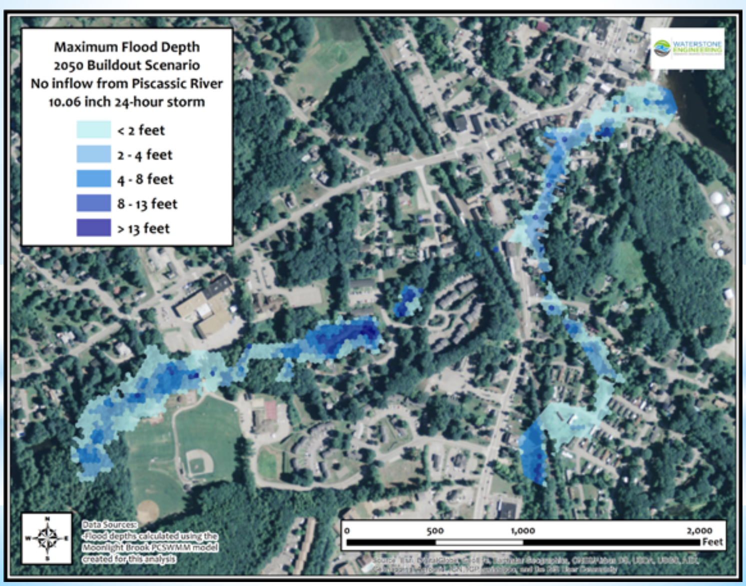
CHANGES IN FLOODING BY 2050 W/ O PISCASSIC



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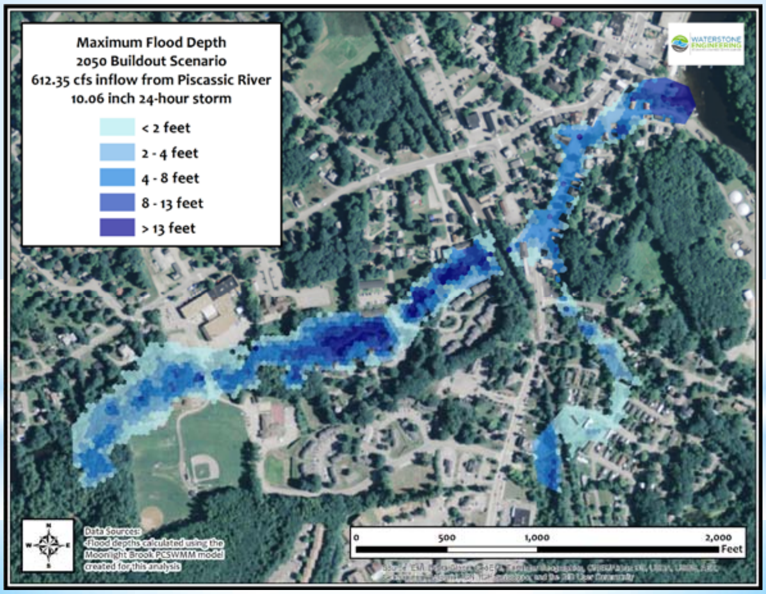
2050 W/ PISCASSIC + 612 CFS



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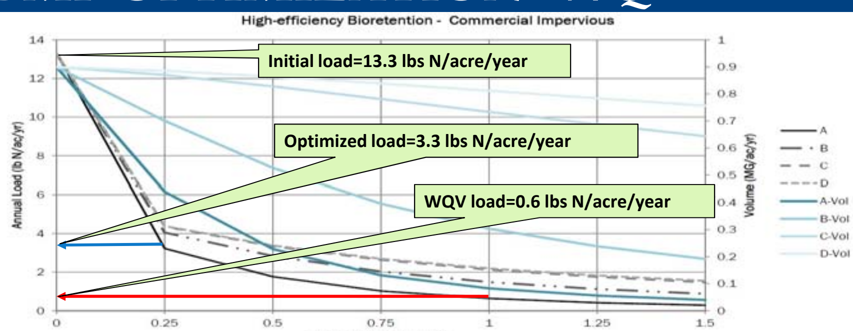
BMP OPTIMIZATION--WQ



BMP Sizing Example:

•1 system treating a 1” water quality volume for 1 acre will remove approximately 12.7 lbs N/acre/year.

•4 smaller systems across 4 acres designed to treat 0.25” WQV/acre/yr will each remove 10 lbs N/acre/year for a total of 40 lbs N per year.

•An additional 27 lbs of nitrogen per year at nearly equivalent costs, or approximately 315% increase.

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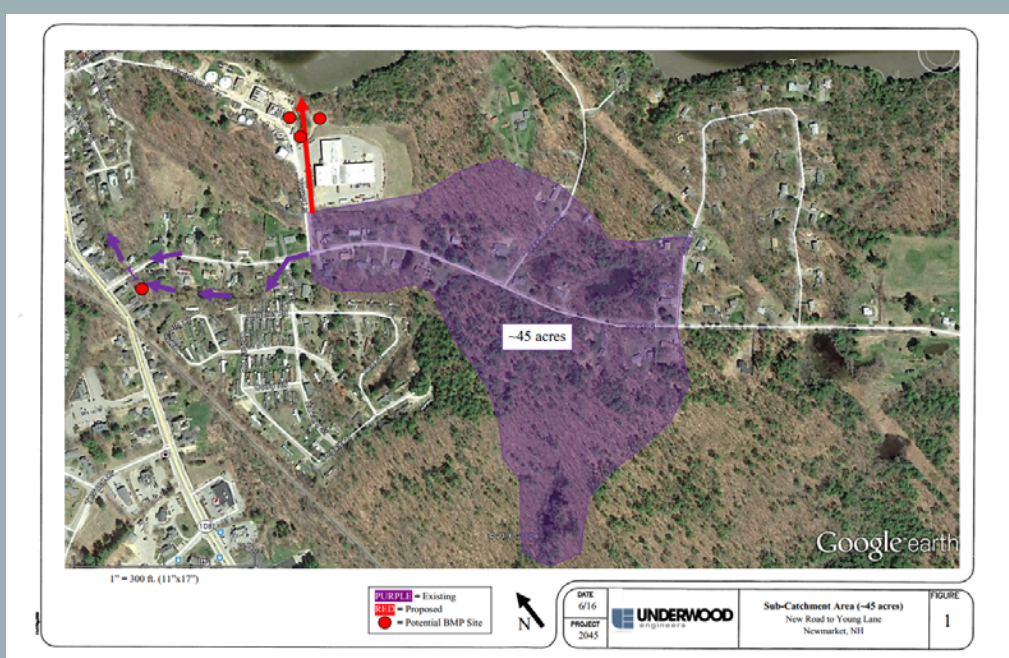
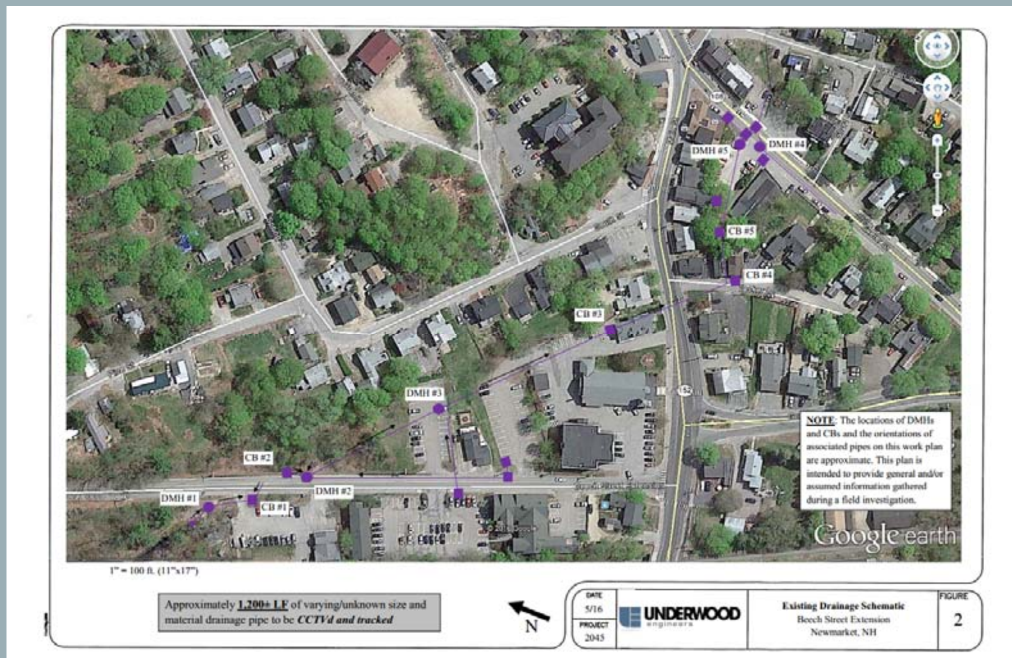
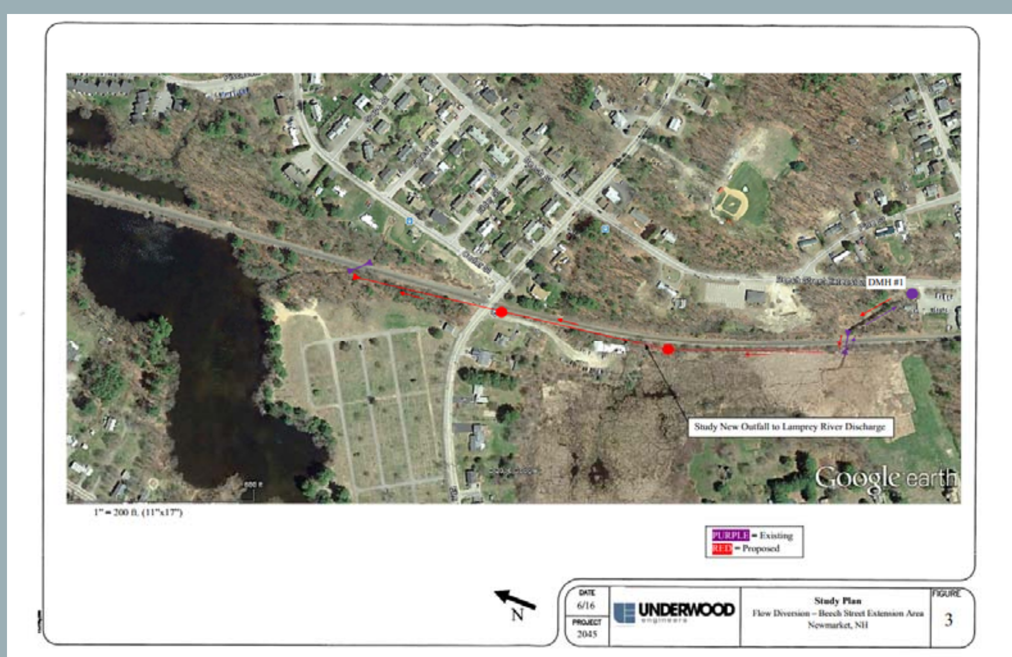
RELATED PROJECTS – ONGOING

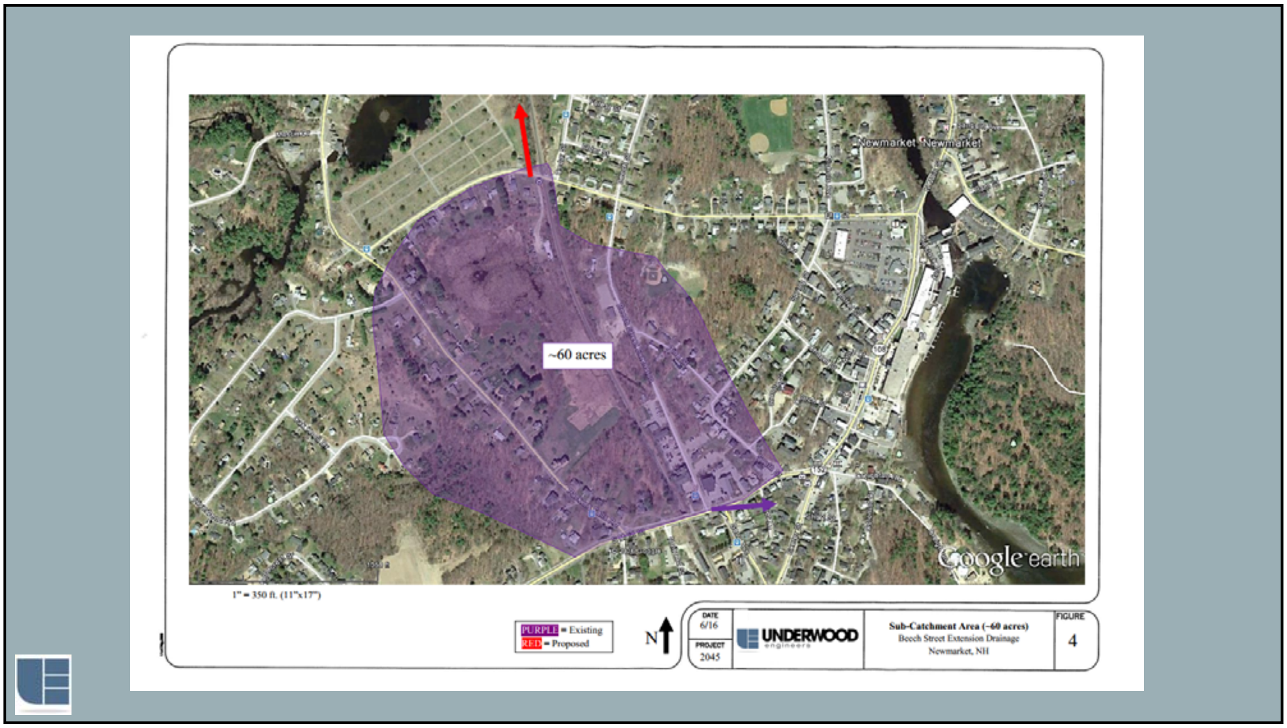
Drainage Improvements – New Road and Beech Street Extension

Underwood Engineers, Inc.




DMH #5
DMH #4
CB #5
CB #4
CB #3
DMH #3
CB #2
DMH #2
DMH #1
CB #1
NOTE: The locations of DMHs and CBs and the orientations of associated pipes on this work plan are approximate. This plan is intended to provide general and/or assumed information gathered during a field investigation.
Google earth
1" = 100 ft. (11"x17")
Approximately 1,200± LF of varying/unknown size and material drainage pipe to be CCTVd and tracked
N
DATE 5/16
PROJECT 2045
UNDERWOOD engineers
Existing Drainage Schematic
Beech Street Extension
Newmarket, NH
FIGURE 2


DMH #1
Study New Outfall to Lamprey River Discharge
Google earth
1" = 200 ft. (11"x17")
PURPLE = Existing
RED = Proposed
N
DATE 6/16
PROJECT 2045
UNDERWOOD engineers
Study Plan
Flow Diversion – Beech Street Extension Area
Newmarket, NH
FIGURE 3


Newmarket
~60 acres
Google earth
1" = 350 ft. (11"x17")
PURPLE = Existing
RED = Proposed
N
DATE
6/16
PROJECT
2045
UNDERWOOD
engineers
Sub-Catchment Area (~60 acres)
Beech Street Extension Drainage
Newmarket, NH
FIGURE
4

Climate Risk in the Seacoast

Assessing Vulnerability of Municipal Assets and Resources to Climate Change

Workshop on Climate Resiliency in Newmarket

Tuesday, June 28, 2016

Nathalie Morison, NHDES Coastal Program

Project Team

Project Applicant & Principle Project Manager

Steve Couture, Coastal Program Manager, NHDES

Project Partners

Tom Ballestero – UNH Stormwater Center
Joel Ballestero – UNH Stormwater Center
Julie LaBranche – Rockingham Planning Commission
Nathalie Morison - NHDES
Kyle Pimental – Strafford Regional Planning Commission
Fay Rubin – NH GRANIT

Project Introduction

FY2015 Project of Special Merit
- NOAA funding
- Awarded competitively
- Innovative projects that further enhancement area strategies and focus on national areas of importance

Project Goals
- Evaluate impacts from flooding to infrastructure and natural resources
- Assist municipalities with reviewing data and identify appropriate climate adaptation actions
- Comprehensive and coordinated shoreline management

Project Overview and Timeline

Provide maps and assessments of flooding impacts to infrastructure and natural resources in the coastal Great Bay region from projected increases in storm surge, sea level, and precipitation.

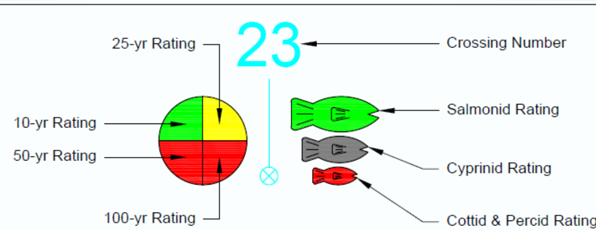
Project Components
- Culvert Analysis for each municipality (10 each)
- Mapping Flood Elevations (sea-level rise and storm surge)
- Vulnerability Assessment (statistical information and report)
- Hazard Mitigation Planning (unofficial amendment or scheduled update)

Timeline

Project Introduction & Regional Meetings April, 2016	Create Base Maps & Culvert Analysis March – April, 2016	Meetings with Municipal Decision Makers May – October, 2016	Vulnerability Analysis & Draft Assessment Reports August – October, 2016	Informational Workshops & Final Assessment Reports Dec. – January, 2017

Culvert Analysis

- Assess culvert hydrology, hydraulic capacity, and aquatic organism passage at various flows under projected climatic conditions
- Help identify and prioritize culverts for replacement



Hydraulic Rating Key

- 10-yr: Rating for the water's surface elevation at the inlet for the 10-yr flood flow
- 25-yr: Rating for the water's surface elevation at the inlet for the 25-yr flood flow
- 50-yr: Rating for the water's surface elevation at the inlet for the 50-yr flood flow
- 100-yr: Rating for the water's surface elevation at the inlet for the 100-yr flood flow

Pass: Headwater stage is below the lowest top of top of culvert at the site

Fail: Headwater stage overtops the road

Transitional: Headwater stage is between the lowest top of culvert and the top of the road

AOP Rating Key

- Top Fish: Salmonids; Salmon, Trout
- Middle Fish: Cyprinids; Carp, Minnow
- Bottom Fish: Cottids & Percids; Sculpin, Walleye, Perch

Pass: Species can navigate the culvert

Fail: Species cannot navigate the culvert

Indeterminate: Insufficient information to determine a rating

Mapping Flood Elevations

Sea level rise (SLR) and sea level rise combined with storm surge (SS) scenarios will be mapped for each municipality.

Scenario	1	2	3
SLR	1.7ft	4.0ft	6.3ft
SS	1.7ft + SS	4.0ft + SS	6.3ft + SS

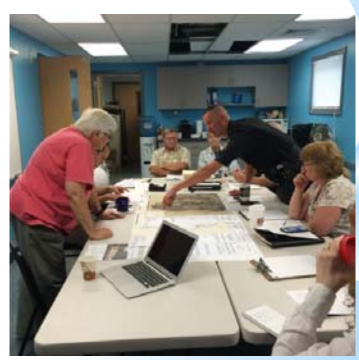
Sea-level rise scenarios from Tides to Storms Vulnerability Assessment (2015, Rockingham Planning Commission)

Vulnerability Assessments

- **Impacts to transportation systems, critical facilities and infrastructure, and natural resources**
- **Provide statistics and description of the potential risk and vulnerability of municipal assets and resources**
- **Customized report for each municipality**

Hazard Mitigation Planning

- **Vulnerability assessment report adopted as part of the Hazard Mitigation Plan ("unofficial")**
- **Vulnerability assessment report information incorporated in next scheduled update (a stand-alone chapter or dispersed throughout)**



Support for Planning Actions

- **Maps and assessment inform municipal decision makers about future flood risks**
- **Incorporate vulnerability assessment and adaptation strategies into other local planning efforts**
  - **Master Plan Chapter**
  - **Open Space/Land Conservation**
  - **Capital Improvement Plan**

Questions?

Contact:
Kyle Pimental, Principal Regional Planner
Tel. (603) 994-3500
Fax: (603) 994-3504
Email: kpimental@strafford.org

Strafford Regional Planning Commission
150 Wakefield Street, Suite 12
Rochester, NH 03867
www.strafford.org

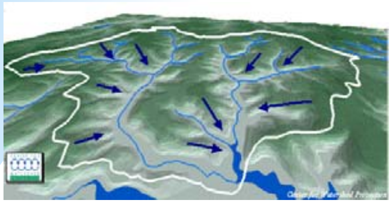
Strafford
REGIONAL PLANNING
COMMISSION

Methodology

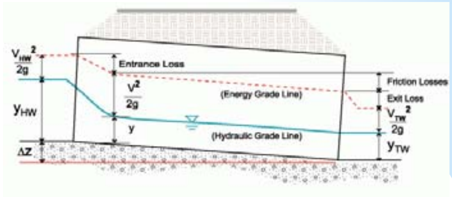
- Problem Culverts ID'd by each town
- Field survey at each culvert
- Locations to UNH GIS
- Watershed characteristics from GIS
- Hydrology (flows)
- Hydraulics (headwater depth)
- Aquatic organism passage (AOP)
- Map results

Modeling

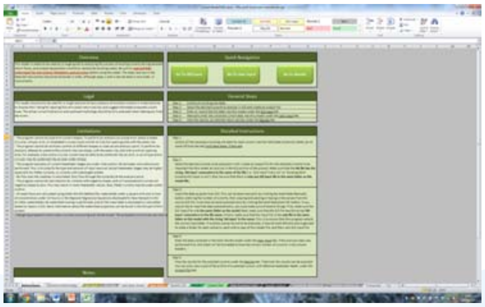
Hydrology



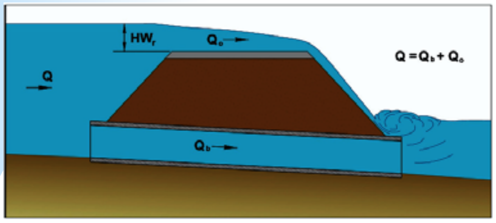
Hydraulics



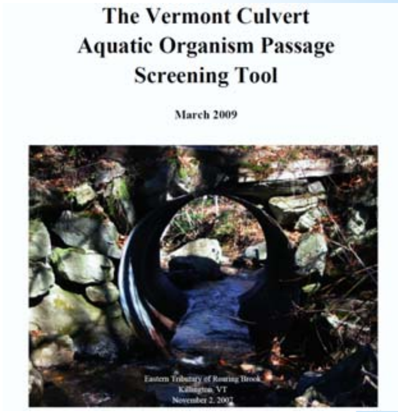
Excel Model



Suggested C-RiSe Classifications



- Hydraulics: Top of Culvert and Top of Road
- AOP: NH scheme



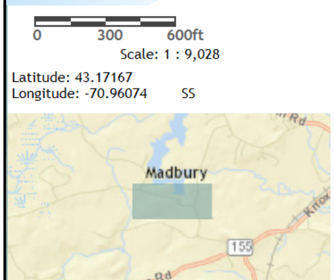
Aquatic Organism Passage (AOP)

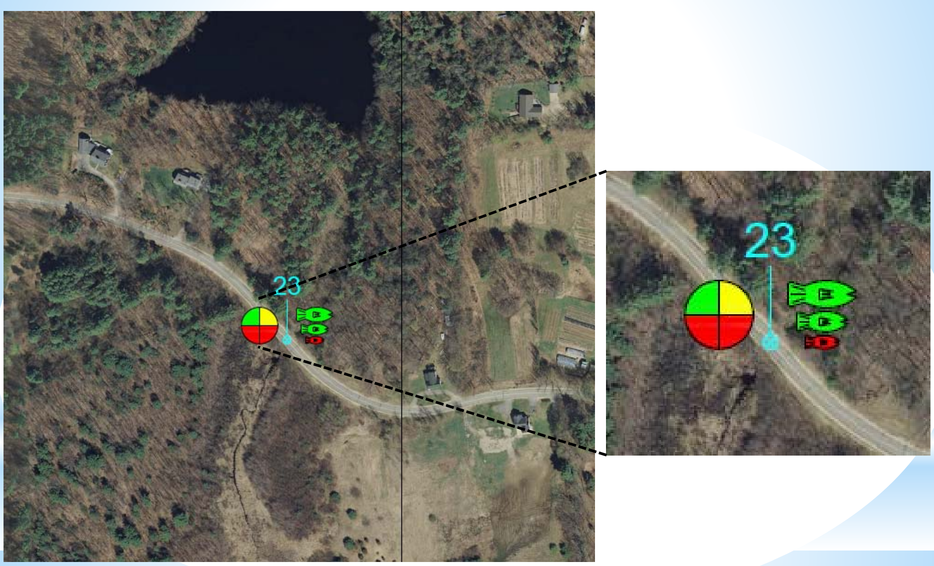
The AOP Coarse Screen

VT Aquatic Organism Passage Coarse Screen	Full AOP	Reduced AOP	No AOP			
Updated 2/25/2008	for all aquatic organisms	for all aquatic organisms	for all aquatic organisms except adult salmonids		for all aquatic organisms including adult salmonids	
AOP Function Variables / Values	**Green (if all are true)**	**Gray (if any are true)**	**Orange**		**Red**	
Culvert outlet invert type	at grade **OR** backwatered	cascade	free fall **AND**		free fall **AND**	
Outlet drop (ft)	= 0		> 0 , < 1 ft **OR**		≥ 1 ft **OR**	
Downstream pool present			= yes	(= yes **AND**	= no **OR**	(= yes **AND**
Downstream pool entrance depth / outlet drop			n/m	≥ 1)	n/a	< 1) **OR**
Water depth in culvert at outlet (ft)					< 0.3 ft	
Number of culverts at crossing	1	> 1				
Structure opening partially obstructed	= none	≠ none				
Sediment throughout structure	yes	no				

Example: Unnamed Brook on Hayes Road, Madbury

Watershed Delineation





NH Coastal Viewer – http://nhcoastalviewer.unh.edu

What it is:

On-line mapping and screening tool that provides access to spatial data about coastal resources and hazards for NH's 42 coastal watershed communities

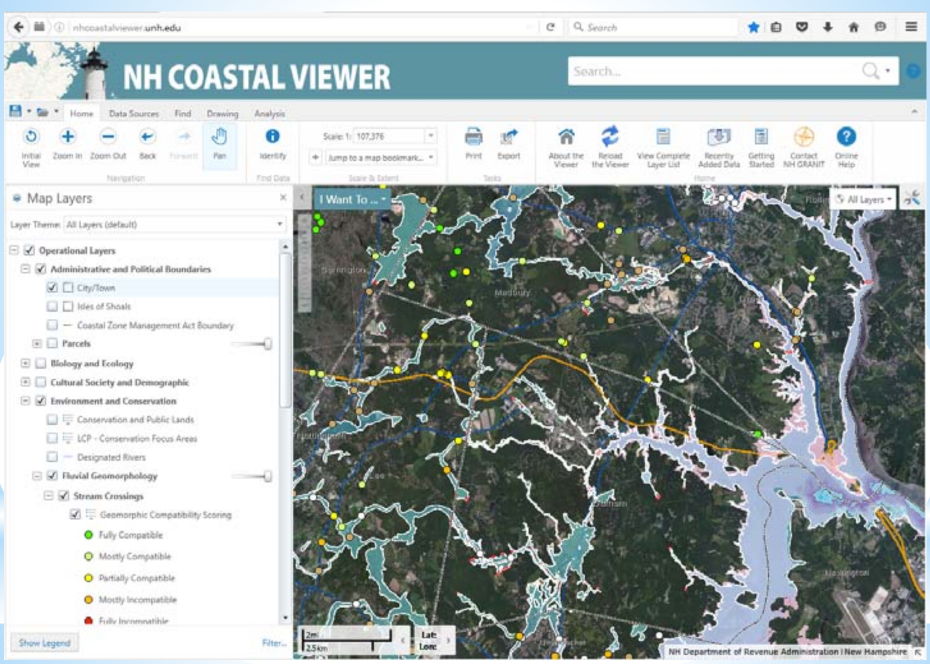
- Integrates data from many sources in single location
- Includes tools for users to interact with the data (with more to come …)

Audience:

Municipal staff, board members, consultants, business owners, state agency staff, researchers, volunteers, community members, and the public

Developed by:

NH GRANIT/University of New Hampshire with support from NH Coastal Program, NOAA



Design Solutions for Coastal Resilience
request for proposals

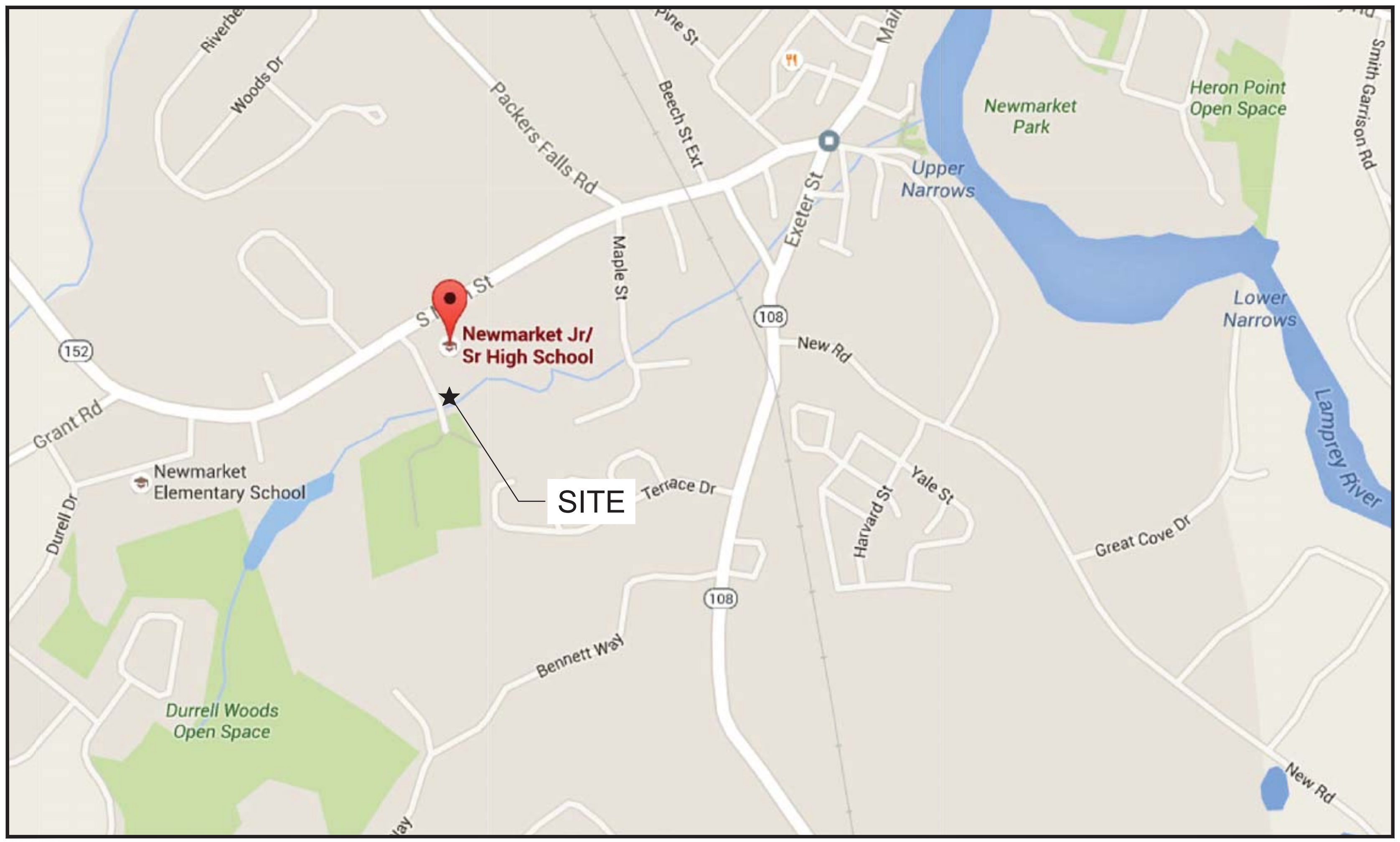
- **Due date: July 21, 2016**
- Purpose: enhance coastal resilience to current and future hazards
- Funding source: NHDES Coastal Program through NOAA
- Likely number of projects: 2-5
- Grant amount: $40,000-$100,000
- Match requirement: 1/3 total project cost
- 2 project types:
  - Creative Communications Solutions
  - Design & Construction Solutions
- Questions or submitting? Contact Kirsten Howard, NH Coastal Program, 559-0020 or kirsten.howard@des.nh.gov

Watershed Assistance Grants
Request for pre-proposals

- **Consultation due date: July 3, 2016**
- **Pre-proposal due date: July 17, 2016**
- Purpose: address nonpoint source pollution through development and implementation of watershed-based plans in priority watersheds
- Funding source: NHDES through EPA
- Likely number of projects: 5-8
- Grant amount: Total of $565,000 available
- Match requirement: 40% of total project cost
- Project types:
  - Planning projects
  - Implementation projects
- Contact: Sally Soule at 559-0032 and sally.soule@des.nh.gov

APPENDIX E. STORMWTER DEMONSTRATION PROJECT DRAWINGS

STORM WATER DEMONSTRATION PROJECT FINAL PLAN
NEWMARKET HIGH SCHOOL
213 S. MAIN ST. NEWMARKET, NH 03875
JUNE 2016



VICINITY MAP
Graphic Scale
1-inch = 300-feet

Sheet List Table

Sheet Number	Sheet Title
1	HW-COVER
2	NOTES & LEGEND
3	EXISTING CONDITIONS PLAN
4	GRADING AND DRAINAGE PLAN
5	CONSTRUCTION DETAILS (1)
6	PLANTING PLAN

Plan Set:
STORM WATER DEMONSTRATION
PROJECT FINAL PLAN
NEWMARKET HIGH SCHOOL
213 S. MAIN ST. NEWMARKET, NH 03875

Prepared For:
Town of Newmarket
186 Main St.
Newmarket, New Hampshire 03857

Prepared By:
Horsley Witten Group, Inc.
Sustainable Environmental Solutions
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Suite 403
Providence, RI 02906
(401) 272-1717 voice
(401) 439-8368 fax

113 R 2 Water Street,
Exeter, NH 03833
(508) 833-6600 voice
(508) 833-3150 fax

WATERSTONE ENGINEERING
INNOVATIVE STORMWATER MANAGEMENT
9 GRETAS WAY
STRATHAM, NH 03885
(603)-686-2488

Registration:

Revisions

Rev.	Date	By	Appr.	Description
△				
△				
△				
△				
△				
△				
△				

Project Number: 15091
Sheet Number: 1 of 6
Drawing Number: C - 1

last modified: 06/28/16 printed: 06/28/16 by mc H:\Projects\2015\15091 Newmarket Moonlight Brook\Drawings\15091 CV.dwg

GENERAL CONSTRUCTION NOTES

1. ALL SITE WORK TO COMPLETE THIS PROJECT AS INDICATED ON THE DRAWINGS AND IN THE SPECIFICATIONS IS THE SOLE RESPONSIBILITY OF THE CONTRACTOR.
2. UTILIZE ALL PRECAUTIONS AND MEASURES TO ENSURE THE SAFETY OF THE PUBLIC, ALL PERSONNEL AND PROPERTY DURING CONSTRUCTION IN ACCORDANCE WITH OSHA STANDARDS, INCLUDING THE INSTALLATION OF TEMPORARY FENCING BARRICADES, SAFETY LIGHTING, CONES, POLICE DETAIL AND/OR FLAGMEN AS DETERMINED NECESSARY BY THE TOWN/CITY/LOCAL MUNICIPALITY. THE CONTRACTOR IS RESPONSIBLE FOR THE COST OF POLICE DETAIL AND FOR COORDINATING WITH THE LOCAL OR STATE POLICE DEPARTMENT FOR ALL REQUIRED POLICE DETAIL.
3. MAKE ALL NECESSARY CONSTRUCTION NOTIFICATIONS AND APPLY FOR AND OBTAIN ALL NECESSARY CONSTRUCTION PERMITS, PAY ALL FEES INCLUDING POLICE DETAILS AND POST ALL BONDS, IF NECESSARY, ASSOCIATED WITH THE SAME, AND COORDINATE WITH THE OWNER AND THE ENGINEER.
4. ALL EXISTING CONDITIONS SHOWN ARE APPROXIMATE AND ARE BASED ON THE BEST INFORMATION AVAILABLE. PRIOR TO THE START CONSTRUCTION VERIFY THAT THE PROPOSED IMPROVEMENTS SHOWN ON THE PLANS DO NOT CONFLICT WITH ANY KNOWN EXISTING OR OTHER PROPOSED IMPROVEMENTS. IF ANY CONFLICTS ARE DISCOVERED, NOTIFY THE OWNER AND THE ENGINEER PRIOR TO INSTALLING ANY PORTION OF THE SITE WORK WHICH WOULD BE AFFECTED.
5. THE LOCATION AND/OR ELEVATION OF EXISTING UTILITIES AND STRUCTURES AS INDICATED ON THE DRAWINGS ARE BASED ON RECORDS OF VARIOUS UTILITY COMPANIES, AND WHEREVER POSSIBLE, MEASUREMENTS TAKEN IN THE FIELD. THIS INFORMATION IS NOT TO BE RELIED UPON AS BEING EXACT OR COMPLETE. VERIFY THE LOCATION OF ALL UNDERGROUND UTILITIES AND STRUCTURES IN THE FIELD PRIOR TO THE START OF CONSTRUCTION. CONTACT THE APPROPRIATE UTILITY COMPANY, ANY GOVERNING PERMITTING AUTHORITY IN THE TOWN, AND "DIGSAFE" (1-888-344-7233) AT LEAST THREE BUSINESS DAYS PRIOR TO ANY EXCAVATION WORK IN PREVIOUSLY UNALTERED AREAS TO REQUEST EXACT FIELD LOCATION OF UTILITIES. THE CONTRACTOR MUST RESOLVE CONFLICTS BETWEEN THE PROPOSED UTILITIES AND FIELD-LOCATED UTILITIES AND REPORT ANY DISCREPANCIES TO THE ENGINEER IMMEDIATELY. THE ENGINEER ASSUMES NO RESPONSIBILITY FOR DAMAGES INCURRED AS A RESULT OF UTILITIES OMITTED, INCOMPLETELY OR INACCURATELY SHOWN. THE CONTRACTOR MUST MAINTAIN ACCURATE RECORDS OF THE LOCATION AND ELEVATION OF ALL WORK INSTALLED AND EXISTING UTILITIES FOUND DURING CONSTRUCTION FOR THE PREPARATION OF THE AS-BUILT PLAN.
6. COORDINATE AND MAKE ALL CONNECTION ARRANGEMENTS WITH UTILITY COMPANIES, AS REQUIRED.
7. THE CONTRACTOR MUST MAINTAIN ALL EXISTING UTILITIES IN WORKING ORDER AND FREE FROM DAMAGE DURING THE ENTIRE DURATION OF THE PROJECT. REPAIR ANY DAMAGE TO EXISTING UTILITY LINES OR STRUCTURES INCURRED DURING CONSTRUCTION OPERATIONS AT NO COST TO THE OWNER. THE CONTRACTOR IS RESPONSIBLE FOR ALL COST RELATED TO THE REPAIR OF UTILITIES. EXCAVATION REQUIRED WITHIN THE PROXIMITY OF EXISTING UTILITY LINES MUST BE DONE BY HAND.
8. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO ESTABLISH AND MAINTAIN ALL CONTROL POINTS AND BENCHMARKS DURING CONSTRUCTION INCLUDING BENCHMARK LOCATIONS AND ELEVATIONS AT CRITICAL AREAS. COORDINATE WITH THE ENGINEER THE LOCATION OF ALL CONTROL POINTS AND BENCHMARKS.
9. SITE LAYOUT SURVEY REQUIRED FOR CONSTRUCTION MUST BE PROVIDED BY THE CONTRACTOR AND PERFORMED BY A NEW HAMPSHIRE REGISTERED PROFESSIONAL LAND SURVEYOR. THE CONTRACTOR IS RESPONSIBLE FOR COORDINATING WITH THE SURVEYOR FOR ALL SITE SURVEY WORK.
10. MAINTAIN ALL GRADE STAKES SET BY THE SURVEYOR. GRADE STAKES ARE TO REMAIN UNTIL A FINAL INSPECTION OF THE ITEM HAS BEEN COMPLETED BY THE ENGINEER. RE-STAKING OF PREVIOUSLY SURVEYED SITE FEATURES IS THE RESPONSIBILITY (INCLUDING COST) OF THE CONTRACTOR.
11. PROVIDE ALL CONSTRUCTION SERVICE IN ACCORDANCE WITH APPLICABLE LAWS AND REGULATIONS REGARDING NOISE, VIBRATION, DUST, SEDIMENTATION CONTAINMENT, AND TRENCH WORK.
12. COLLECT SOLID WASTES AND STORE IN A SECURED DUMPSTER. THE DUMPSTER MUST MEET ALL LOCAL AND STATE SOLID WASTE MANAGEMENT REGULATIONS.
13. RESTORE ALL SURFACES EQUAL TO THEIR ORIGINAL CONDITION AFTER CONSTRUCTION IS COMPLETE PER SPECIFICATIONS. LEAVE ALL AREAS NOT DISTURBED BY CONSTRUCTION IN THEIR NATURAL STATE. TAKE CARE TO PREVENT DAMAGE TO SHRUBS, TREES, OTHER LANDSCAPING AND/OR NATURAL FEATURES. WHEREAS THE PLANS DO NOT SHOW ALL LANDSCAPE FEATURES, EXISTING CONDITIONS MUST BE VERIFIED BY THE CONTRACTOR IN ADVANCE OF THE WORK.
14. LEDGE OR BOULDER EXCAVATION IS NOT ANTICIPATED FOR THIS SITE. HOWEVER, PROVIDE A UNIT PRICE COST IN CUBIC YARD MEASURE FOR LEDGE AND/OR BOULDER REMOVAL. LEDGE AND/OR BOULDERS LESS THAN 1 CUBIC YARD IN SIZE BASED ON THE AVERAGE DIMENSIONS WILL NOT BE CONSIDERED PAYABLE ROCK. PROVIDE UNIT PRICES FOR BOTH ON AND OFF SITE DISPOSAL. IF ADDITIONAL FILL MATERIAL IS REQUIRED INCLUDE THE COST OF ALL FILL MATERIAL.
15. REGULARLY INSPECT THE PERIMETER OF THE PROPERTY TO CLEAN UP AND REMOVE LOOSE CONSTRUCTION DEBRIS BEFORE IT LEAVES THE SITE. PROMPTLY REMOVE ALL DEMOLITION DEBRIS FROM THE SITE TO AN APPROVED DUMP SITE.
16. ALL TRUCKS LEAVING THE SITE MUST BE COVERED.
17. DO NOT WASH ANY CONCRETE TRUCKS ONSITE. REMOVE BY HAND ANY CEMENT OR CONCRETE DEBRIS LEFT IN THE DISTURBED AREA.
18. BURIAL OF ANY STUMPS, SOLID DEBRIS, AND/OR STONES/BOULDERS ONSITE IS PROHIBITED. DO NOT USE ROAD SALT OR OTHER DE-ICING CHEMICALS ON THE ACCESS ROADWAY.
19. IMMEDIATELY CONTACT AND COORDINATE WITH THE ENGINEER AND OWNER IF ANY DEVIATION OR ALTERATION OF THE WORK PROPOSED ON THESE DRAWINGS IS REQUIRED.
20. AT THE END OF CONSTRUCTION, REMOVE ALL CONSTRUCTION DEBRIS AND SURPLUS MATERIALS FROM THE SITE (AS INDICATED IN THE SPECIFICATIONS). PERFORM A THOROUGH INSPECTION OF THE WORK PERIMETER. COLLECT AND REMOVE ALL MATERIALS AND BLOWN OR WATER CARRIED DEBRIS FROM THE SITE.

GENERAL DEMOLITION NOTES

THIS PLAN SET DOES NOT INCLUDE DETAILS & SPECIFICATIONS FOR ALL DEMOLITION WORK REQUIRED WITHIN THE PROPOSED CONSTRUCTION LIMITS. IT IS THE CONTRACTOR'S RESPONSIBILITY TO COORDINATE WITH THE OWNER, PROJECT ARCHITECT, MECHANICAL ENGINEERS AND OTHER PROJECT ENGINEERS INVOLVED WITH THE PROPOSED NEW CONSTRUCTION TO DEVELOP A SUITABLE DEMOLITION PLAN, WHICH WILL ALLOW THE FACILITIES TO REMAIN IN OPERATION DURING THE ENTIRETY OF CONSTRUCTION.

1. UNLESS OTHERWISE NOTED, THE CONTRACTOR IS RESPONSIBLE FOR THE RELOCATION, DEMOLITION, REMOVAL AND DISPOSAL, IN A LOCATION APPROVED BY ALL GOVERNING AUTHORITIES, OF ALL EXISTING SITE ELEMENTS AND STRUCTURES INCLUDING, BUT NOT LIMITED TO, BUILDINGS, ROADWAYS, PARKING AREAS, PARKING ISLANDS, BITUMINOUS CONCRETE, CEMENT CONCRETE, GRAVEL, CURBS, WALKWAYS, SIDEWALKS, BERMS, FENCES, BOLLARDS, POSTS, PLANTING BEDS, TREES, SHRUBS, UTILITIES, DRAINAGE STRUCTURES AND ALL OTHER STRUCTURES SHOWN AND NOT SHOWN WITHIN CONSTRUCTION LIMITS, AND WHERE NEEDED, TO ALLOW FOR NEW CONSTRUCTION. ALL FACILITIES TO BE REMOVED ARE TO BE UNDERCUT TO SUITABLE MATERIAL AND BROUGHT TO GRADE WITH SUITABLE COMPACTED FILL MATERIAL PER SPECIFICATIONS.
2. REMOVE ALL DEBRIS FROM THE SITE AND DISPOSE OF THE DEBRIS IN A PROPER AND LEGAL MANNER.
3. OBTAIN ALL PERMITS REQUIRED FOR DEMOLITION AND DISPOSAL.
4. COORDINATE WITH RESPECTIVE UTILITY COMPANIES PRIOR TO THE REMOVAL AND/OR RELOCATION OF UTILITIES. COORDINATE WITH THE UTILITY COMPANIES CONCERNING PORTIONS OF THE WORK WHICH MAY BE PERFORMED BY THE UTILITY COMPANY AND ANY FEES WHICH ARE TO BE PAID TO THE UTILITY COMPANY FOR THEIR SERVICES. THE CONTRACTOR IS RESPONSIBLE FOR PAYING ALL FEES AND CHARGES.
5. PROVIDE NOTICE TO ALL UTILITY COMPANIES REGARDING DESTRUCTION AND REMOVAL OF ALL SERVICE LINES AND CAP ALL UTILITY LINES, AS REQUIRED, BEFORE PROCEEDING WITH THE WORK.
6. MAINTAIN CONTINUOUS ACCESS AND OPERATION FOR SURROUNDING FACILITIES, AS DEEMED BY THE OWNER, AT ALL TIMES DURING DEMOLITION OF THE EXISTING FACILITIES.
7. PRIOR TO DEMOLITION OCCURRING, ALL EROSION CONTROL DEVICES ARE TO BE INSTALLED.

BASIC CONSTRUCTION SEQUENCE

THE FOLLOWING CONSTRUCTION SEQUENCE IS TO BE USED AS A GENERAL GUIDELINE. COORDINATE WITH THE OWNER, ENGINEERS, AND LANDSCAPE ARCHITECTS AND SUBMIT A PROPOSED CONSTRUCTION SEQUENCE FOR REVIEW AND APPROVAL PRIOR TO CONSTRUCTION.

1. SURVEY AND STAKE THE PROPOSED LIMIT OF DISTURBANCE AND LIMIT OF SEDIMENTATION BARRIERS.
2. PLACE SEDIMENTATION BARRIERS (STRAWBALES, SILT FENCE, COMPOST BERM, ETC.) AS INDICATED ON DRAWINGS AND STAKED OUT IN THE FIELD. UNDER NO CIRCUMSTANCES IS THE LIMIT OF WORK TO EXTEND BEYOND THE SEDIMENTATION BARRIERS/LIMIT OF DISTURBANCE AS INDICATED ON DRAWINGS.
3. BEGIN CLEARING THE SITE AS REQUIRED.
4. SURVEY AND STAKE CENTERLINE OF THE PROPOSED ROADS, DRAINAGE BASINS, AND DRAINAGE LINES.
5. EXCAVATE AND ROUGH GRADE THE PROPOSED DRAINAGE BASINS AND ANY ADDITIONAL TEMPORARY BASINS NECESSARY TO CONTROL SITE RUNOFF AND SEDIMENTS. TEMPORARILY SEEDED PERMANENT DRAINAGE BASINS. COMPLETE PERMANENT DRAINAGE BASIN SEEDING AND PLANTING AFTER THE CONTRIBUTING AREA TO THE BASIN HAS REACHED A MINIMUM OF 80% STABILIZATION AND IS NO LONGER REQUIRED AS A CONSTRUCTION SEDIMENTATION BASIN.
6. BEGIN CLEARING AND GRUBBING THE AREAS OF ROADWAYS AND DRAINAGE BASINS. TOPSOIL IS TO BE STRIPPED FROM THE AREA OF THE PROPOSED ROADWAYS AND DRAINAGE BASINS AND STOCKPILED IN APPROVED LOCATIONS. TOPSOIL STOCKPILES MUST BE PROTECTED BY A SEDIMENT BARRIER.
7. INSTALL TEMPORARY CONVEYANCE DEVICES (SWALES, CHECK DAMS, PIPES, ETC.) AS NECESSARY TO CONVEY RUNOFF TO TREATMENT AREAS.
8. BEGIN ROUGH GRADING AREAS FOR ROADS, PARKING AND BUILDINGS. BRING ROUGH GRADING TO PROPER ELEVATIONS AS SOON AS PRACTICABLE. COORDINATE WORK TO MINIMIZE TIME SOILS ARE UN-STABILIZED.
9. INSTALL DRAINAGE PIPES, DRAINAGE MANHOLES, CATCH BASINS, AND UNDERGROUND DRAINAGE STRUCTURES. BEGIN WORK AT THE DRAINAGE BASINS AND PROGRESS UP-GRADIENT. PROTECT DISCHARGE OUTLETS WITH RIP-RAP APRONS. THE DRAINAGE BASIN(S) AND DRAINAGE NETWORK ARE TO BE PROTECTED FROM SEDIMENTATION WITH COMPOST BERM UNTIL ALL UN-STABILIZED AREAS ARE STABILIZED WITH STONE SUB-BASE OR VEGETATION. INSTALL SEDIMENT BARRIERS AT ALL POINTS OF ENTRY INTO THE DRAINAGE NETWORK. TAKE PARTICULAR CARE TO PROTECT THE UNDERGROUND DRAINAGE BASINS FROM SEDIMENT.
10. PERMANENTLY SEED ALL DISTURBED AREAS OUTSIDE OF THE AREA TO BE PAVED.
11. UPON COMPLETION OF UNDERGROUND UTILITIES INSTALLATION, PLACE COMPACTED GRAVEL FOUNDATION AND ROUGH GRADE THE ROADWAYS/PARKING AREAS IN ACCORDANCE WITH THE SITE PLANS AND IN ACCORDANCE WITH APPLICABLE STATE AND LOCAL REGULATIONS AS SOON AS POSSIBLE.
12. FINISH PERMANENT STABILIZATION. SWEEP THE ROADWAY TO REMOVE ALL SEDIMENTS. REPAIR DRAINAGE OUTLETS AND BASINS AS REQUIRED. CLEAN AND FLUSH THE DRAINAGE STRUCTURES AND PIPES AT THE END OF CONSTRUCTION AND REMOVE ALL ACCUMULATED SEDIMENTS IN THE DRAINAGE BASINS. CONTRACTOR MUST INSPECT THE DRAINAGE NETWORK AND REPAIR ANY DAMAGE IMMEDIATELY.
13. COMPLETE ALL REMAINING PLANTING AND SEEDING.
14. ENGINEER TO APPROVE THE REMOVAL OF ALL TEMPORARY SOIL EROSION AND SEDIMENTATION CONTROL MEASURES FOLLOWING VEGETATIVE ESTABLISHMENT OF ALL DISTURBED AREAS AND DETERMINE WHEN THE CONTRIBUTING AREA HAS REACHED A MINIMUM OF 80% STABILIZATION.

GENERAL GRADING AND DRAINAGE NOTES

1. ALL CUT AND FILL SLOPES SHALL BE 2:1 OR FLATTER UNLESS OTHERWISE NOTED.
2. EXISTING GRADE CONTOUR INTERVALS SHOWN AT 2 FOOT.
3. PROPOSED GRADE CONTOUR INTERVALS SHOWN AT 1 FOOT.
4. ADJUST AND/OR CUT EXISTING PAVEMENT AS NECESSARY TO ASSURE A SMOOTH FIT AND CONTINUOUS GRADE.
5. PROPOSED ELEVATIONS ARE SHOWN TO FINISH PAVEMENT OR GRADE UNLESS NOTED OTHERWISE.
6. ALL EARTHWORK AND SITE PREPARATION MUST BE DONE IN STRICT ACCORDANCE WITH THE RECOMMENDATIONS OF ANY SUBSURFACE INVESTIGATION OR GEOTECHNICAL REPORTS PREPARED FOR THIS SITE.

STORMWATER FACILITY OPERATION & MAINTENANCE:

THE CONTRACTOR IS RESPONSIBLE FOR THE PROPER INSPECTION AND MAINTENANCE OF ALL STORMWATER MANAGEMENT FACILITIES AS OUTLINED BELOW UNTIL SUCH TIME THAT THE ROADWAYS AND ASSOCIATED UTILITIES ARE ACCEPTED BY THE OWNER AND THE ENGINEER.

1. INSPECT AND RESTORE/CLEAN ALL FACILITIES (INLETS, MANHOLES, INFILTRATION BASINS, ETC.) OF SEDIMENT AND DEBRIS PRIOR TO THE OWNER'S ACCEPTANCE.
2. REMOVE AND DISPOSE ALL SEDIMENT AND DEBRIS TO A PRE-APPROVED LOCATION AS APPROVED BY THE TOWN.
3. INSPECT AFTER EVERY MAJOR RAINFALL EVENT FOR THE ENTIRE DURATION OF THE CONSTRUCTION PROJECT AND THE FIRST 3 MONTHS AFTER CONSTRUCTION TO ENSURE PROPER STABILIZATION AND CONSTRUCTION.
4. SPECIFIC ANNUAL MAINTENANCE REQUIRED AS FOLLOWS:
   A. DRAINAGE STRUCTURES (INLETS, MANHOLES & CATCHBASINS): ALL DRAINAGE STRUCTURES WILL BE INSPECTED ANNUALLY TO MONITOR FOR PROPER OPERATION, COLLECTION OF LITTER OR TRASH, AND STRUCTURAL DETERIORATION. THE BASINS WILL BE CLEANED OF SEDIMENT (INCLUDING SUMPS) AS NECESSARY, AND REPAIRED WHEN REQUIRED.
   B. RIP-RAP SLOPE PROTECTION: INSPECT ANNUALLY AND REPAIR AS NECESSARY.
   C. BIORETENTION SYSTEMS AND RAINGARDENS: INSPECT TWICE ANNUALLY FOR THE FIRST YEAR OF OPERATION AND ANNUALLY AFTER THE FIRST YEAR, AND AFTER STORM EVENTS GREATER THAN OR EQUAL TO THE 1-YEAR, 24-HOUR PRECIPITATION EVENT. GENERAL MAINTENANCE OF BIORETENTION SYSTEMS FALLS UNDER LANDSCAPING PRACTICES. MONITOR THE PLANTING SOIL BED FOR PROPER PH, EROSION, AND AERATION. REPLACE MULCH BI-ANNUALLY, AND REMOVE AND REPLACE ILL-ESTABLISHED, DEAD OR SEVERELY DISEASED PLANTS ANNUALLY. REMOVE SEDIMENT BUILD-UP FROM THE PEA GRAVEL DIAPHRAGM AS NEEDED, AND REPLACE THE DIAPHRAGM WHEN NECESSARY.
   D. ROUTINE MAINTENANCE: OTHER ROUTINE MAINTENANCE INCLUDES THE REMOVAL OF TRASH AND LITTER FROM PAVED AND PERIMETER AREAS, AND ANNUAL STREET AND PARKING LOT SWEEPING AFTER THE SPRING THAW TO AVOID EXCESSIVE ACCUMULATION OF SEDIMENT IN THE DRAINAGE SYSTEM. INSPECT THE PIPES DRAINING THE PROJECT ANNUALLY FOR PROPER FLOW.

NOTE: OPERATION AND MAINTENANCE CHECKLIST AVAILABLE UPON REQUEST

EROSION & SEDIMENT CONTROL NOTES

1. DESIGNATE THE SITE CONSTRUCTION FOREMAN AS THE ON-SITE PERSONNEL RESPONSIBLE FOR THE DAILY INSPECTION AND MAINTENANCE OF ALL SEDIMENT AND EROSION CONTROLS AND IMPLEMENTATION OF ALL NECESSARY MEASURES TO CONTROL EROSION AND PREVENT SEDIMENT FROM LEAVING THE SITE.
2. INSTALL ALL EROSION AND SEDIMENT CONTROL (ESC) MEASURES AS INDICATED ON DRAWINGS. INSPECT, MAINTAIN REPAIR AND REPLACE EROSION CONTROL MEASURES, AS NECESSARY, DURING THE ENTIRE CONSTRUCTION PERIOD OF THE PROJECT. THE SITE PERIMETER EROSION CONTROLS ARE THE DESIGNATED LIMIT OF WORK. INFORM ALL PERSONNEL WORKING ON THE PROJECT THAT NO CONSTRUCTION ACTIVITY IS TO OCCUR BEYOND THE LIMIT OF WORK AT ANY TIME THROUGHOUT THE CONSTRUCTION PERIOD.
3. MAINTAIN A MINIMUM SURPLUS OF 100 FEET OF EROSION CONTROL BARRIER (SILT FENCE, STRAWBALE, &/OR COMPOST BERM) ONSITE AT ALL TIMES.
4. PROTECT THE ADJACENT RESOURCE AREA FROM SEDIMENTATION DURING PROJECT CONSTRUCTION UNTIL ACCEPTANCE BY THE OWNER & IN CONFORMANCE WITH THE ORDER OF CONDITIONS.
5. KEEP THE LIMIT OF CLEARING, GRADING AND DISTURBANCES TO A MINIMUM WITHIN THE PROPOSED AREA OF CONSTRUCTION. PHASE THE SITE WORK IN A MANNER TO MINIMIZE AREAS OF EXPOSED SOIL. IF TREES ARE TO BE CUT ON THE ENTIRE SITE, CLEAR AND GRUB ONLY THOSE AREAS WHICH ARE ACTIVELY UNDER CONSTRUCTION. PROPERLY INSTALL THE SEDIMENTATION CONTROLS PRIOR TO BEGINNING ANY LAND CLEARING ACTIVITY AND/OR OTHER CONSTRUCTION RELATED WORK.
6. MONITOR LOCAL WEATHER REPORTS DURING CONSTRUCTION AND PRIOR TO SCHEDULING EARTHMOVING OR OTHER CONSTRUCTION ACTIVITIES WHICH LEAVE LARGE DISTURBED AREAS UNSTABILIZED. IF INCLEMENT WEATHER IS PREDICTED, USE BEST PROFESSIONAL JUDGEMENT AND GOOD CONSTRUCTION PRACTICES WHEN SCHEDULING CONSTRUCTION ACTIVITIES AND ENSURE THE NECESSARY EROSION CONTROL DEVICES ARE INSTALLED AND FUNCTIONING PROPERLY TO MINIMIZE EROSION FROM ANY IMPENDING WEATHER EVENTS.
7. INSPECT EROSION AND SEDIMENT CONTROL DEVICES AND STABILIZED SLOPES ON A WEEKLY BASIS AND AFTER EACH RAINFALL EVENT OF .25 INCH OR GREATER. REPAIR IDENTIFIED PROBLEMS WITHIN 24 HOURS TO ENSURE EROSION AND SEDIMENT CONTROLS ARE IN GOOD WORKING ORDER. RESET OR REPLACE MATERIALS AS REQUIRED.
8. SURROUND THE PERIMETER OF SOIL STOCKPILES WITH SILT COMPOST BERM, SILT FENCE, STRAWBALES, OR A COMBINATION OF SILT FENCE WITH STRAWBALE, AS DETERMINED NECESSARY.
9. DISTURBED AREAS AND SLOPES MUST NOT BE LEFT UNATTENDED OR EXPOSED FOR EXCESSIVE PERIODS OF TIME SUCH AS THE INACTIVE WINTER SEASON. PROVIDE APPROPRIATE STABILIZATION PRACTICES ON ALL DISTURBED AREAS AS SOON AS POSSIBLE BUT NOT MORE THAN 14 DAYS AFTER THE CONSTRUCTION ACTIVITY IN THAT AREA HAS TEMPORARILY OR PERMANENTLY CEASED. REINFORCE TEMPORARY AREAS HAVING A SLOPE GREATER THAN 4:1 WITH EROSION BLANKETS OR APPROVED EQUAL AND SITE TO BE PROPERLY STABILIZED. TEMPORARY SWALES MAY ALSO BE REQUIRED IF DETERMINED NECESSARY IN THE FIELD BY THE ENGINEER.
10. INSTALL A SILT SACK OR APPROVED EQUIVALENT IN EACH EXISTING CATCHBASIN RECEIVING RUNOFF FROM THE SITE. UPON THE INSTALLATION OF EACH CATCH BASIN, INSTALL A SILT SACK OR APPROVED EQUIVALENT. INSPECT SILT SACKS, AFTER EACH SIGNIFICANT STORM EVENT AND REMOVE AND EMPTY AS NEEDED FOR THE DURATION OF THE CONSTRUCTION PERIOD.
11. SMALL SEDIMENTATION BASINS MAY BE CONSTRUCTED ON AN AS-NEEDED BASIS DURING CONSTRUCTION TO AID IN THE CAPTURE OF SITE RUNOFF AND SEDIMENT. IT WILL BE THE RESPONSIBILITY OF THE SITE CONTRACTOR, IN CONSULTATION WITH THE ENGINEER, TO SIZE AND CREATE THESE BASINS IN APPROPRIATE LOCATIONS.
12. CONTAIN ALL SEDIMENT ONSITE. SWEEP ALL EXITS FROM THE SITE AS NECESSARY INCLUDING ANY SEDIMENT TRACKING. SWEEP PAVED AREAS AS NEEDED TO REMOVE SEDIMENT AND POTENTIAL POLLUTANTS ACCUMULATED DURING SITE CONSTRUCTION.
13. REMOVE ACCUMULATED SEDIMENT FROM ALL TEMPORARY PRACTICES AND DISPOSE OF IN A PRE-APPROVED LOCATION.
14. PROVIDE ON SITE OR MAKE READILY AVAILABLE THE NECESSARY EQUIPMENT AND SITE PERSONNEL DURING CONSTRUCTION HOURS FOR THE DURATION OF THE PROJECT TO ENSURE ALL EROSION AND SEDIMENTATION CONTROL DEVICES ARE PROPERLY MAINTAINED AND REPAIRED IN A TIMELY AND RESPONSIBLE MANNER. IF SITE WORK IS SUSPENDED DURING THE WINTER MONTHS THE CONTRACTOR MUST CONTINUE TO PROVIDE PERSONNEL AND EQUIPMENT EITHER ON SITE OR READILY AVAILABLE TO PROPERLY MAINTAIN AND REPAIR ALL EROSION AND SEDIMENTATION CONTROL DEVICES IN A TIMELY AND RESPONSIBLE MANNER.
15. PRIOR TO THE INSTALLATION OF FILTER FABRIC AND MEDIA WITHIN THE BIORETENTION AREAS, REMOVE AND PROPERLY DISPOSE OF SEDIMENT ACCUMULATED IN ANY PARTIALLY CONSTRUCTED OR TEMPORARY BIORETENTION/DRAINAGE AREA USED FOR SEDIMENT CONTROL DURING CONSTRUCTION. PROVIDE A SURFACE ELEVATION AT A MINIMUM 1-FOOT ABOVE THE BOTTOM OF MEDIA ELEVATION AS SHOWN IN THE BIORETENTION SCHEDULE FOR PARTIALLY CONSTRUCTED BIORETENTION AREAS. THIS ALLOWS FOR AN OVER-DIG OF THE COLLECTED SEDIMENT FROM WITHIN THE BIORETENTION AREA PRIOR TO MEDIA/FABRIC INSTALLATION.
16. CONTROL DUST BY WATERING OR OTHER APPROVED METHODS AS NECESSARY, OR AS DIRECTED BY THE ENGINEER.
17. THE CONTRACTOR IS RESPONSIBLE FOR THE INSPECTION AND MAINTENANCE DURING CONSTRUCTION OF ALL STORMWATER FACILITIES INSTALLED OR AFFECTED BY THE PROJECT. REMOVE SEDIMENT OR DEBRIS COLLECTED WITHIN THESE FACILITIES FROM THE PROJECT WORK PRIOR TO THE OWNER'S ACCEPTANCE.

BIORETENTION CONSTRUCTION SEQUENCE

THE FOLLOWING CONSTRUCTION SEQUENCE IS TO BE USED AS A GENERAL GUIDELINE. COORDINATE WITH THE OWNER, ENGINEERS, AND LANDSCAPE ARCHITECTS AND SUBMIT A PROPOSED CONSTRUCTION SEQUENCE FOR REVIEW AND APPROVAL PRIOR TO CONSTRUCTION.

1. CONDUCT A PRE-CONSTRUCTION MEETING.
2. CHECK FOR EXISTING UTILITIES PRIOR TO ANY EXCAVATION.
3. CLEAR AND GRUB THE PROPOSED BIORETENTION AREA.
4. ROUGH GRADE THE BIORETENTION AREA DURING GENERAL CONSTRUCTION.
5. EXCAVATE PRETREATMENT CELLS AND/OR SEDIMENT FOREBAYS PRIOR TO BIORETENTION CONSTRUCTION.
6. DO NOT CONSTRUCT THE BIORETENTION AREA UNTIL ALL DISTURBED AREAS WITHIN THE CONTRIBUTING DRAINAGE AREAS HAVE BEEN GRADED AND STABILIZED.
7. INSTALL TEMPORARY EROSION AND SEDIMENT CONTROLS TO DIVERT STORMWATER AWAY FROM THE BIORETENTION AREA.
8. EXCAVATE THE BIORETENTION FACILITY TO THE BOTTOM INVERT OF THE SUBDRAIN SYSTEM.
9. INSTALL THE FILTER FABRIC ALONG THE EXCAVATION SIDE WALLS. ENGINEER FIELD VISIT AND REPORT REQUIRED SEE NOTE (3) BELOW.
10. RIP THE BOTTOM SOILS TO A DEPTH OF SIX INCHES TO PROMOTE GREATER INFILTRATION.
11. INSTALL THE OVERFLOW OUTLET STRUCTURE AS SPECIFIED IN THE DRAWINGS.
12. INSTALL UNDERDRAIN AS INDICATED ON DRAWINGS. ENGINEER FIELD VISIT AND REPORT REQUIRED PRIOR TO COVERING THE UNDERDRAIN. SEE NOTE (3) BELOW.
13. INSTALL PEA GRAVEL LAYER AS INDICATED ON DRAWINGS.
14. DELIVER APPROVED BIORETENTION SOIL AND STORE ON ADJACENT IMPERVIOUS AREA OR PLASTIC SHEETING.
15. BACKFILL WITH APPROVED BIORETENTION SOIL TO THE DESIGN GRADE (UN-COMPACTED) AS INDICATED ON DRAWINGS. THE CONTRACTOR MUST SUBMIT A SOIL SAMPLE (1 GALLON) TO THE ENGINEER PRIOR TO SOIL DELIVERY TO THE SITE.
16. STABILIZE ALL REMAINING DISTURBED AREAS AND SIDE SLOPES WITH SEEDING, HYDROSEEDING, AND/OR EROSION CONTROL BLANKETS AS INDICATED ON DRAWINGS. ENGINEER FIELD VISIT AND REPORT REQUIRED SEE NOTE (3) BELOW.
17. INSTALL BIORETENTION PLANTINGS AS INDICATED ON DRAWINGS. DO NOT PLANT BEFORE THE REMAINING DISTURBED AREAS SURROUNDING THE FACILITY ARE STABILIZED.
18. INSTALL MULCH LAYER AS INDICATED ON DRAWINGS. THE CONTRACTOR MUST SUBMIT A MULCH SAMPLE (1 GALLON) TO THE ENGINEER PRIOR TO DELIVERY TO THE SITE.
19. CONDUCT FINAL CONSTRUCTION INSPECTION WITH ENGINEER. ENGINEER FIELD VISIT AND REPORT REQUIRED SEE NOTE (3) BELOW.
20. REMOVE REMAINING EROSION AND SEDIMENT CONTROLS ONLY AFTER SURROUNDING DISTURBED AREAS HAVE BEEN PROPERLY STABILIZED.

NOTES:
(1.) SEE GENERAL CONSTRUCTION NOTES FOR OVERALL CONSTRUCTION SEQUENCE.
(2.) SEE GENERAL NOTES/SPECIFICATIONS/CONSTRUCTION DETAILS FOR DETAILED CONSTRUCTION REQUIREMENTS.
(3.) MANDATORY NOTIFICATION/APPROVAL OF THE PROJECT ENGINEER IS REQUIRED PRIOR TO PROCEEDING WITH NEXT STAGE.

CONSTRUCTION NOTES

1. **EXAMINATION**
   A. VERIFY LAYOUT AND ORIENTATION OF BIORETENTION AREA AND CONNECTIONS.
   B. VERIFY EXCAVATION BASE IS READY TO RECEIVE WORK AND EXCAVATIONS, DIMENSIONS, AND ELEVATIONS ARE AS INDICATED ON DRAWINGS.
2. **PREPARATION**
   A. CALL **DIGSAFE** AT 1-888-DIG-SAFE (1-888-344-7233) NOT LESS THAN **THREE** BUSINESS DAYS BEFORE PERFORMING WORK.
   B. REQUEST UNDERGROUND UTILITIES TO BE LOCATED AND MARKED WITHIN AND SURROUNDING CONSTRUCTION AREAS.
   C. IDENTIFY REQUIRED LINES, LEVELS, CONTOURS, AND DATUM.
   D. CLEAR AND GRUB THE PROPOSED BIORETENTION AREA.
3. **EXCAVATION**
   A. EXCAVATE BIORETENTION AREA IN ACCORDANCE WITH GENERAL NOTES AND SPECIFICATIONS.
   B. TO MINIMIZE COMPACTION, WORK EXCAVATORS OR BACKHOES FROM THE SIDES TO EXCAVATE THE BIORETENTION AREA TO ITS APPROPRIATE DESIGN DEPTH AND DIMENSIONS. USE EXCAVATING EQUIPMENT WITH ADEQUATE REACH SO THEY DO NOT WORK IN THE FOOTPRINT OF THE BIORETENTION AREA. IF APPLICABLE AND PER THE ENGINEERS DIRECTION USE A CELL CONSTRUCTION APPROACH IN LARGER BIORETENTION BASINS, WHEREBY THE BASIN IS SPLIT INTO 500 TO 1000 SQUARE FOOT TEMPORARY CELLS WITH A 10 TO 15 FOOT EARTH BRIDGE IN BETWEEN, SO THAT CELLS CAN BE EXCAVATED FROM THE SIDE.
   C. EXCAVATE AND SEAL ANY PRETREATMENT CELLS AND/OR SEDIMENT FOREBAYS FIRST AND SEALED TO TRAP SEDIMENTS PER THE DRAWINGS.
   D. ROUGH GRADE THE BIORETENTION AREA DURING GENERAL CONSTRUCTION. EXCAVATE THE BIORETENTION FACILITIES TO WITHIN 1 FOOT OF UNDERDRAIN BOTTOM.
   E. IF THE BIORETENTION AREA IS TO BE USED AS A TEMPORARY DRAINAGE STORAGE BASIN DURING THE EARLY STAGES OF PROJECT CONSTRUCTION, THE SIDE SLOPES SHOULD BE TEMPORARILY STABILIZED AND SILT FENCE INSTALLED ALONG THE TOE OF THE ROUGH GRADED BIORETENTION SLOPES TO MINIMIZE EXCESSIVE SEDIMENTATION OF THE BIORETENTION FLOOR.
4. **COMPACTION**
   A. MINIMIZE COMPACTION OF BOTH THE BASE OF THE BIORETENTION AREA AND THE REQUIRED BACKFILL. COMPACTION WILL SIGNIFICANTLY CONTRIBUTE TO DESIGN FAILURE.
   B. USE EXCAVATOR OR BACKHOES TO EXCAVATE THE BIORETENTION AREA
   C. IF THE BIORETENTION AREA IS EXCAVATED USING A LOADER, USE ONLY WIDE TRACK OR MARSH TRACK EQUIPMENT, OR LIGHT EQUIPMENT WITH TURF TYPE TIRES. USE OF EQUIPMENT WITH NARROW TRACKS OR NARROW TIRES, RUBBER TIRES WITH LARGE LUGS, OR HIGH PRESSURE TIRES CAUSE EXCESSIVE COMPACTION RESULTING IN REDUCED INFILTRATION RATES AND STORAGE VOLUMES AND IS NOT ACCEPTABLE.
   D. COMPACTION CAN BE ALLEVIATED AT THE BASE OF THE BIORETENTION FACILITY BY USING A PRIMARY TILLING OPERATION SUCH AS A CHISEL PLOW, RIPPER, OR SUBSOILER. THESE TILLING OPERATIONS ARE PERFORMED TO REFRACTURE THE SOIL PROFILE THROUGH THE 12-INCH COMPACTION ZONE. SUBSTITUTE METHODS MUST BE APPROVED BY THE ENGINEER. ROTOILLERS TYPICALLY DO NOT TILL DEEP ENOUGH TO REDUCE THE EFFECTS OF COMPACTION FROM HEAVY EQUIPMENT.
   E. DO NOT COMPACT BIORETENTION SOIL WITH MECHANICAL EQUIPMENT.
5. **EMBANKMENT/BERM FILL**
   A. CONSTRUCT EMBANKMENT/BERM IN ACCORDANCE WITH SPECIFICATIONS AND AS INDICATED ON DRAWINGS.
6. **INSTALLATION**
   A. DO NOT CONSTRUCT THE BIORETENTION AREA UNTIL ALL DISTURBED AREAS WITHIN THE CONTRIBUTING DRAINAGE AREAS HAVE BEEN GRADED AND STABILIZED.
   B. REMOVE SEDIMENT ACCUMULATED ALONG THE EXCAVATION FLOOR DURING SITE CONSTRUCTION PRIOR TO CONTINUING WITH THE BIORETENTION FACILITY CONSTRUCTION.
   C. FORM BOTTOM OF EXCAVATION TO CORRECT ELEVATION.
   D. IF INFILTRATION IS PROMOTED, THEN RIP THE BOTTOM SOILS TO A DEPTH OF SIX INCHES TO PROMOTE GREATER INFILTRATION.
   E. INSTALL THE FILTER FABRIC ALONG THE EXCAVATION SIDE WALLS AS SPECIFIED IN THE DRAWINGS. IF FILTER FABRIC IS TO BE INSTALLED PLACE THE FILTER FABRIC ON THE SIDES OF THE BIORETENTION AREA WITH A MINIMUM SIX INCH OVERLAP AT ALL JOINTS.
   F. INSTALL ANY TEMPORARY EROSION AND SEDIMENT CONTROLS TO DIVERT STORMWATER AWAY FROM THE BIORETENTION AREA DURING FINAL CONSTRUCTION AND UNTIL IT IS COMPLETED. SPECIAL PROTECTION MEASURES SUCH AS EROSION CONTROL FABRICS MAY BE NEEDED TO PROTECT VULNERABLE SIDE SLOPES FROM EROSION DURING THE CONSTRUCTION PROCESS.
   G. ESTABLISH ELEVATIONS AND PIPE INVERTS FOR INLETS AND OUTLETS AS INDICATED ON DRAWINGS
   H. INSTALL THE OVERFLOW OUTLET STRUCTURE AS INDICATED ON DRAWINGS.
   I. INSTALL UNDERDRAIN, INCLUDING 4 INCH PERFORATED PIPE, GRAVEL AND FILTER FABRIC ON TOP OF THE UNDERDRAIN GRAVEL AS INDICATED ON DRAWINGS. PLACE GRAVEL AROUND THE UNDERDRAIN PIPE AS INDICATED IN THE DETAILS. OBSERVATION WELLS AND/OR CLEAN-OUT PIPES MUST BE PROVIDED (SEE PLANS FOR LOCATION).
   J. INSTALL PEA GRAVEL LAYER AS INDICATED ON DRAWINGS.
   K. DELIVER APPROVED BIORETENTION SOIL AND STORE ON ADJACENT IMPERVIOUS AREA OR PLASTIC SHEETING.
7. **BACKFILLING**
   A. BACKFILL WITH APPROVED BIORETENTION SOIL TO THE DESIGN GRADE AS SPECIFIED IN THE DRAWINGS.
   B. PLACE SOIL IN 12 INCH LIFTS UNTIL DESIRED TOP ELEVATION OF BIORETENTION SOIL IS ACHIEVED. DO NOT USE HEAVY EQUIPMENT WITHIN THE BIORETENTION BASIN. HEAVY EQUIPMENT CAN BE USED AROUND THE PERIMETER OF THE BASIN TO SUPPLY SOILS AND SAND. WAIT 3 DAYS TO CHECK FOR SETTLEMENT, AND ADD ADDITIONAL MEDIA AS NEEDED
   C. DO NOT COMPACT BIORETENTION SOIL WITH MECHANICAL EQUIPMENT.
   D. GRADE BIORETENTION MATERIALS WITH LIGHT EQUIPMENT SUCH AS A COMPACT LOADER OR A DOZER/LOADER WITH MARSH TRACKS.
   E. STABILIZE ALL REMAINING DISTURBED AREAS AND SIDE SLOPES WITH SEEDING, HYDROSEEDING, AND/OR EROSION CONTROL BLANKETS AS INDICATED ON DRAWINGS.

CONSTRUCTION NOTES (CONT.)

8. **PLANTING**
   A. PLANT BIORETENTION AREA IN ACCORDANCE WITH PLANTING PLANS AND SPECIFICATIONS.
   B. THE PRIMARY FUNCTION OF THE BIORETENTION STRUCTURE IS TO IMPROVE WATER QUALITY. DO NOT ADD FERTILIZERS OR OTHER SOIL AMENDMENTS TO THE BIORETENTION SOILS UNLESS INSTRUCTED BY THE ENGINEER. THE PLANTING SOIL SPECIFICATIONS PROVIDE ENOUGH ORGANIC MATERIAL TO ADEQUATELY SUPPLY NUTRIENTS FROM NATURAL CYCLING.
   C. INSTALL BIORETENTION PLANTINGS AS INDICATED ON DRAWINGS. WATER DURING WEEKS OF NO RAIN FOR THE FIRST TWO MONTHS.
   D. DO NOT PLANT BEFORE THE REMAINING DISTURBED AREAS SURROUNDING THE FACILITY ARE STABILIZED.
   E. REMOVE SEDIMENT ACCUMULATED IN THE BIORETENTION AREA DURING THE PLANTING PHASE.
   F. IF SUITABLE VEGETATIVE COVER HAS NOT BEEN ESTABLISHED ALONG THE BIORETENTION SIDE SLOPES PRIOR TO PLANTING, INSTALL A SILT FENCE PERIMETER AT THE TOE OF THE BIORETENTION SLOPES AND LEAVE IN PLACE UNTIL AN APPROVED VEGETATIVE COVER HAS BEEN ESTABLISHED.
   G. INSTALL MULCH LAYER AS INDICATED ON DRAWINGS. MIX APPROXIMATELY HALF OF THE SPECIFIED MULCH LAYER INTO THE BIORETENTION SOIL TO A DEPTH OF APPROXIMATELY 4 INCHES TO HELP FOSTER A HIGHLY ORGANIC SURFACE LAYER.
   H. REMOVE REMAINING EROSION AND SEDIMENT CONTROLS ONLY AFTER SURROUNDING DISTURBED AREAS HAVE BEEN PROPERLY STABILIZED.
   I. CONDUCT FINAL CONSTRUCTION INSPECTION WITH ENGINEER.
9. **CLEAN UP**
   A. AFTER COMPLETION OF THE WORK, REMOVE AND PROPERLY DISPOSE ALL DEBRIS, CONSTRUCTION MATERIALS, RUBBISH, EXCESS SOIL, ETC., FROM THE PROJECT SITE. REPAIR PROMPTLY ANY IDENTIFIED DEFICIENCIES AND LEAVE THE PROJECT SITE IN A CLEAN AND SATISFACTORY CONDITION.

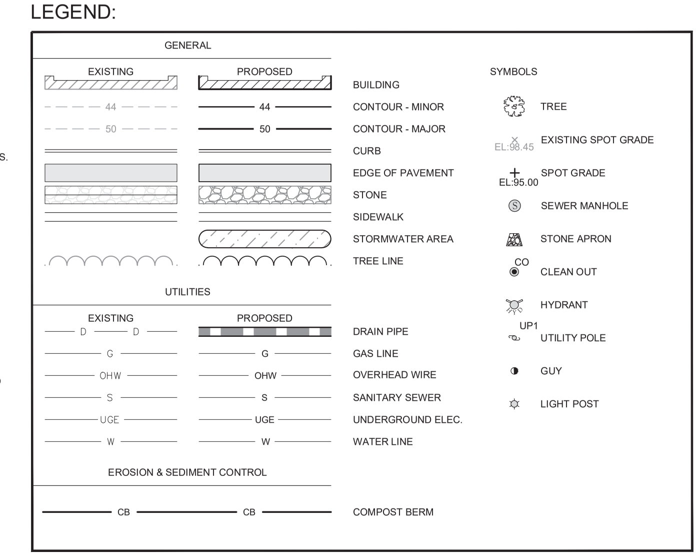
MATERIAL SPECIFICATIONS

1. **BIORETENTION SOIL**
   A. USDA UNIFIED SOIL CLASSIFICATION: LOAMY SAND CONSISTING OF A UNIFORM MIX, FREE OF NOXIOUS WEEDS AND FREE OF STONES, STUMPS, ROOTS OR OTHER SIMILAR OBJECTS LARGER THAN 1 INCH. A TEXTURAL ANALYSIS IS REQUIRED FOR CONFORMANCE TO THE SOIL COMPOSITION CRITERIA LISTED BELOW.
      85-88% MEDIUM SAND.
      8-12% SOIL FINES (< 2% CLAY).
      3% ORGANIC MATTER (WELL AGED (6-12 MONTHS), WELL AERATED, LEAF COMPOST OR APPROVED EQUIVALENT).
   B. PROVIDE A SOIL TEST OF THE BIORETENTION SOIL FOR CONFORMANCE TO THE FOLLOWING CRITERIA:

PH RANGE:	5.2-7.0.
MAGNESIUM:	MINIMUM 32 PPM.
PHOSPHOROUS (P2O5):	NOT TO EXCEED 69 PPM.
POTASSIUM (K2O):	MINIMUM 78 PPM.
SOLUBLE SALTS:	NOT TO EXCEED 500 PPM.

   IF THE SOIL PH IS NOT WITHIN THE ACCEPTABLE RANGE, AMEND WITH LIME TO RAISE THE PH OR WITH IRON SULFATE TO LOWER THE PH, AS NECESSARY. ALL TESTING SHOULD BE PERFORMED BY THE SAME TESTING FACILITY TO MAINTAIN CONSISTENT RESULTS. SUBMIT THE SOIL SAMPLE RESULTS TO THE ENGINEER REVIEW AND APPROVAL PRIOR TO DELIVERY TO THE PROJECT SITE.
   C. VOLUME OF FILTER MEDIA BASED ON 110% OF PLAN VOLUME TO ACCOUNT FOR SETTLING OR COMPACTION.
   D. DO NOT MIX, DUMP OR STORE ANY OTHER MATERIALS OR SUBSTANCES THAT MAY B E HARMFUL TO PLANT GROWTH OR PROVE A HINDRANCE TO THE PLANTING MAINTENANCE OR OPERATIONS WITHIN THE BIORETENTION AREA.
2. **MULCH**
   A. FINE SHREDDED WELL AGED (6 MONTH MINIMUM) HARDWOOD MULCH.
      HARDWOOD MULCH IS PREFERRED TO PREVENT FLOATING. IF HARDWOOD MULCH IS NOT AVAILABLE A FINELY DOUBLE SHREDDED WELL AGED, ORGANIC DARK PINE MULCH MAY BE ACCEPTABLE ON A CASE BY CASE BASIS PER SAMPLE SUBMITTAL AND ENGINEER REVIEW.
   B. A MULCH SAMPLE MUST BE SUBMITTED AND APPROVED BY THE ENGINEER PRIOR TO DELIVERY TO THE PROJECT SITE.
3. **FILTER FABRIC**
   A. NON-WOVEN GEOTEXTILE FABRIC WITH FLOW RATE OF > 110 GALLON/MINUTES/SQUARE FOOT.
   B. CLASS "C" APPARENT OPENING SIZE (ASTM-D-4751).
   C. GRAB TENSILE STRENGTH (ATSM-D-4632) BURST STRENGTH (ASTM-D-4833).
4. **PEA GRAVEL**
   A. 3/8" WASHED STONE
5. **UNDERDRAIN GRAVEL**
   A. 3/4" CRUSHED WASHED STONE, CLEAN AND FREE OF ALL FINES AND MEETING AASHTO M-43.
6. **PIPE**
   A. UNDERDRAIN
      4" RIGID SCHEDULE 40 PVC PIPE, WITH 3/8" PERFORATIONS @ 6" O.C. MEETING ASTMD 1785 OR AASHTO M-278. T'S AND Y'S FITTINGS AS REQUIRED FOR THE UNDERDRAIN CONFIGURATION INDICATED ON DRAWING.
   B. CONNECTIONS TO STORM DRAIN SYSTEM.
   C. UNDERDRAIN CLEANOUTS
      NON PERFORATED SCHEDULE 40 PVC PIPE, PVC ELBOW, CAP, AND ALL ASSOCIATED FITTINGS.
7. **EROSION CONTROL BLANKET (3:1 SIDE SLOPES ONLY)**
   A. WOVEN, 100% BIODEGRADABLE JUTE FIBER 7.70 LBS/1000 SQFT.
      BIONET S150BN OR APPROVED EQUIVALENT.
8. **PLANTS**
   A. AS INDICATED ON DRAWINGS.
9. **SEED (SIDE SLOPES ONLY)**
   A. NEW ENGLAND CONSERVATION/WILDLIFE/MIX OR APPROVED EQUIVALENT.
   B. APPLICATION RATE 25 LBS/ ACRES OR PER SEED MANUFACTURER'S REQUIREMENTS.
10. **OUTLET STRUCTURE**
   A. SIZE AS INDICATED ON DRAWINGS.
   B. FIBERGLASS REINFORCED PLASTIC MANHOLES OF SIZE INDICATED ON DRAWINGS.

LEGEND:



Revisions	
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Date:	Designed By:	Drawn By:	Checked By:
JUNE 2016	RAC	MJC	RAC

Plan Set:
STORM WATER DEMONSTRATION
PROJECT FINAL PLAN
NEWMARKET HIGH SCHOOL
213 S. MAIN ST. NEWMARKET, NH 03875

Plan Title:
NOTES & LEGEND

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Project Number:	Sheet:
15091	2 of 6

Sheet Number:
C - 2

last modified: 06/28/16 printed: 06/28/16 by mc

NOTES:

1. EXISTING CONDITIONS TAKEN FROM PLAN TITLED "PARTIAL EXISTING CONDITIONS PLAN" PREPARE FOR WATERSTONE ENGINEERING BY EMANUEL ENGINEERING CIVIL AND STRUCTURAL CONSULTANTS, LAND PLANNERS DATED MAY 23, 2016 AND IS NOT THE RESULT OF A LAND SURVEY BY THE HORSLEY WITTEN GROUP.

GRAPHIC SCALE

20 0 10 20 40 80

(in feet)
1 INCH = 20 FEET

WATERSTONE ENGINEERING
INNOVATIVE STORMWATER MANAGEMENT

Revisions

Rev.	Date	By	Appr.	Description

Horsley Witten Group, Inc.
Sustainable Environmental Solutions
www.horsleywitten.com
90 Route 6A
Sandwich, MA 02563
508-833-6600 voice
508-833-3150 fax

Date:	Designed By:	Drawn By:	Checked By:
JUNE 2016	RAC	MJC	RAC

Plan Set:
STORM WATER DEMONSTRATION
PROJECT FINAL PLAN
NEWMARKET HIGH SCHOOL
213 S. MAIN ST. NEWMARKET, NH 03875

Plan Title:
EXISTING CONDITIONS PLAN

Prepared For:
Town of Newmarket
186 Main St.
Newmarket, New Hampshire 03857
Phone:
Fax: ----

Survey Provided By:
Emanual Engineering
118 Portsmouth Ave. A202
Stratham New hampshire 03885
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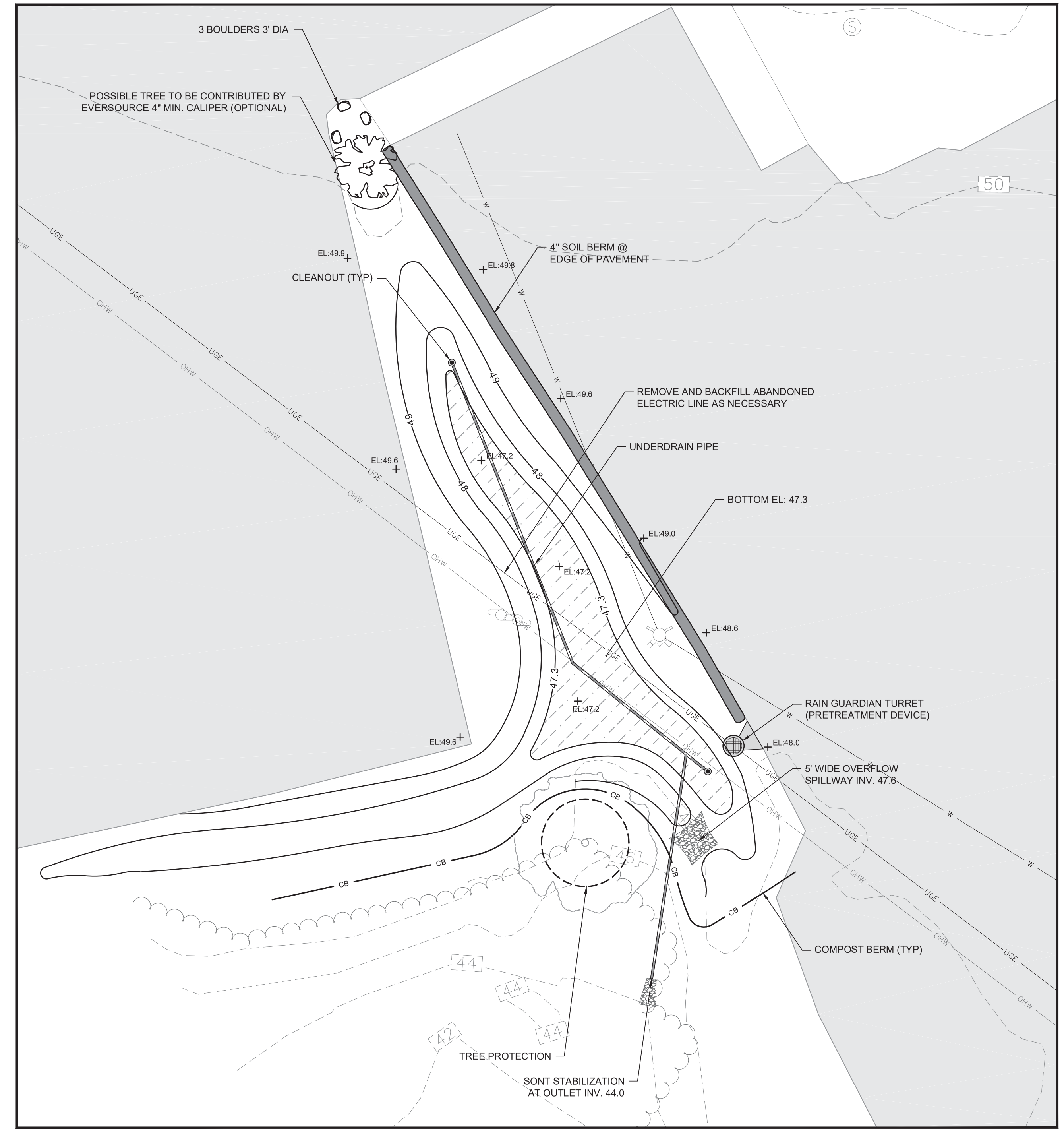
Fax: (603) 772-4487
Dated: May, 23, 2016

Registration:

Project Number: 15091
Sheet: 3 of 6
Sheet Number: C - 3

last modified: 06/27/16 printed: 06/28/16 by mc H:\Projects\2015\15091 Newmarket Moonlight Brook\Drawings\15091 EX.dwg



INSET "A"
SCALE: 1" = 10'

GRAPHIC SCALE
20 0 10 20 40 80
(in feet)
1 INCH = 20 FEET

WATERSTONE ENGINEERING
INNOVATIVE STORMWATER MANAGEMENT

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PROJECT FINAL PLAN
NEWMARKET HIGH SCHOOL
213 S. MAIN ST. NEWMARKET, NH 03875

Plan Title:
GRADING AND DRAINAGE PLAN

Prepared For:
Town of Newmarket
186 Main St.
Newmarket, New Hampshire 03857
Phone:
Fax: ----

Survey Provided By:
Emanual Engineering
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Stratham New hampshire 03885
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Dated: May, 23, 2016

Registration:

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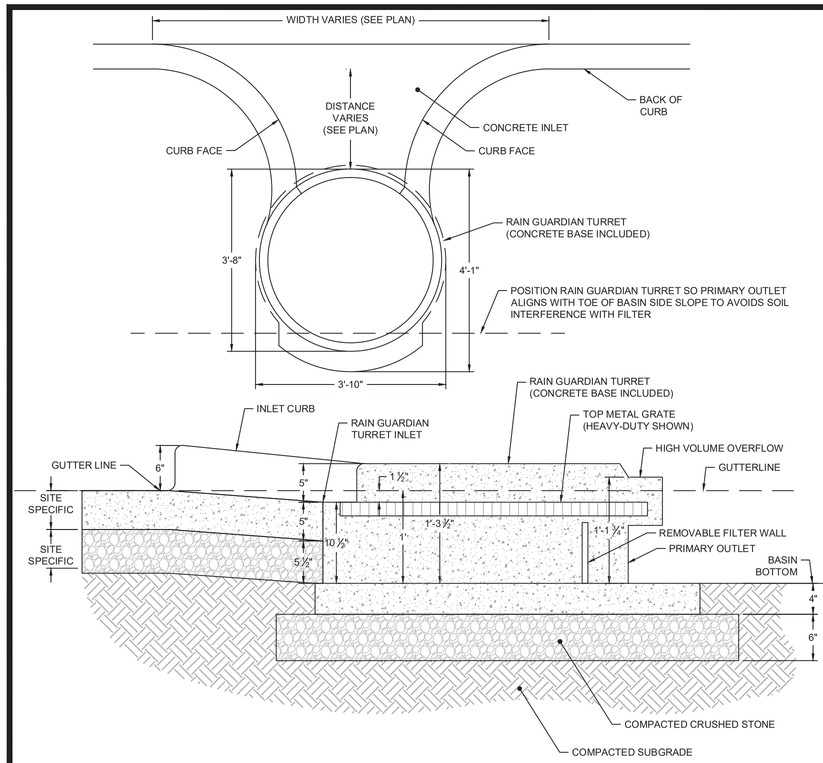
Sheet: 4 of 6
Sheet Number: C - 4

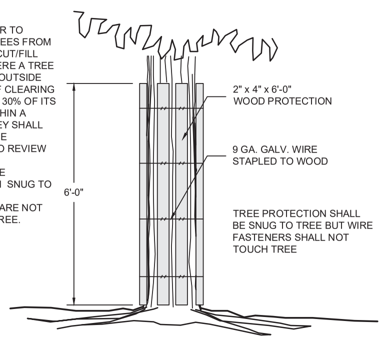


RAIN GUARDIAN TURRET DETAIL
NOT TO SCALE

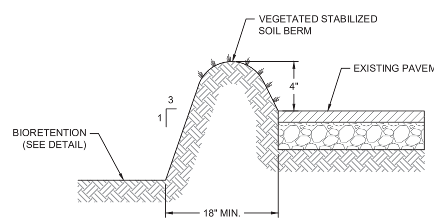
NOTES:

1. INSTALL THE CLASS 5 BASE (COMPACTED TO 95% STANDARD PROCTOR). THE DISTANCE FROM THE BACK OF THE CURB MAY VARY BASED ON SITE CONDITIONS, BUT CONSIDERATIONS SHOULD IN-CLUDE SLOPE OF THE INLET AND BASIN SIDE SLOPES ADJACENT TO THE RAIN GUARDIAN TURRET. POSITION RAIN GUARDIAN TURRET SO PRIMARY OUTLET ALIGNS WITH TOE OF BASIN SIDE SLOPE TO AVOID SOIL INTERFERENCE WITH REMOVABLE FILTER WALL. EXCAVATE 1' 10" BELOW THE GUTTERLINE ELEVATION (I.E. THE BIORETENTION OVERFLOW ELEVATION) TO ACCOMMODATE THE 1' PONDING DEPTH, 6" CLASS 5 AGGREGATE, AND 4" RAIN GUARDIAN TURRET BASE (INCLUDED). THEREFORE, THE TOP OF THE CLASS 5 COMPACTED BASE IS PRECISELY 1' 4" BELOW THE GUTTERLINE ELEVATION. THE TOP OF THE RAIN GUARDIAN TURRET METAL GRATE WILL BE 10-1/2" ABOVE THE TOP OF THE CONCRETE BASE AND 1-1/2" BELOW THE GUTTERLINE ELEVATION TO ACCOMMODATE A SLOPED INLET FROM THE GUTTER TO THE RAIN GUARDIAN TURRET.
2. THE RAIN GUARDIAN TURRET SHOULD BE SET ON THE PREPARED CLASS 5 BASE.
3. INSTALL FRAMING FOR INLET BETWEEN RAIN GUARDIAN TURRET AND BACK OF CURB. TOP ELEVATIONS OF THE FRAMING SHOULD MATCH THE TOP OF THE CURB ON THE STREET SIDE AND THE TOP OF THE RAIN GUARDIAN TURRET ON THE BIORETENTION SIDE.
4. USE EXPANSION JOINT MATERIAL BETWEEN RAIN GUARDIAN TUR-RET AND BIORETENTION INLET.
5. SIDE CURBS OF THE POURED INLET MUST HAVE AN INSURMOUNT-ABLE PROFILE TO PREVENT WATER FLOW FROM OVERTOPPING THE DOWNSTREAM SIDE OF THE INLET.
6. REMOVABLE FILTER WALL SHOULD BE INSTALLED WITH FILTER FABRIC FACING THE RAIN GUARDIAN TURRET INLET.

NOTES:
1. CONTRACTOR TO PROTECT TREES FROM EXCESSIVE CUT/FILL AREAS. WHERE A TREE IS LOCATED OUTSIDE THE LIMIT OF CLEARING & WILL HAVE 30% OF ITS CANOPY WITHIN A CUT/FILL THEY SHALL CONTACT THE ENGINEER TO REVIEW THE WORK.
2. INSTALL TREE PROTECTION SNUG TO TREE. WIRE FASTENERS ARE NOT TO TOUCH TREE.

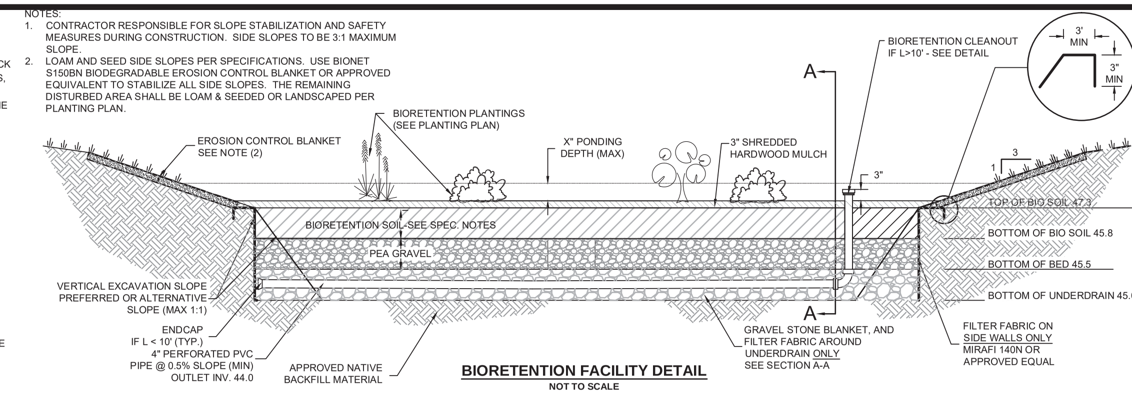


TREE PROTECTION DETAIL
NOT TO SCALE



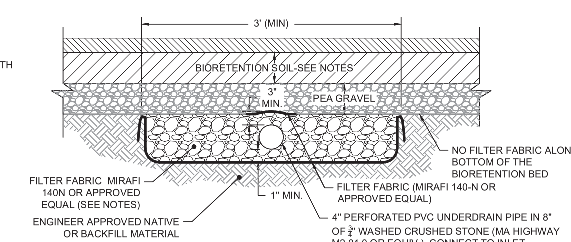
SOIL BERM DETAIL
NOT TO SCALE

NOTES:
1. CONTRACTOR RESPONSIBLE FOR SLOPE STABILIZATION AND SAFETY MEASURES DURING CONSTRUCTION. SIDE SLOPES TO BE 3:1 MAXIMUM SLOPE.
2. LOAM AND SEED SIDE SLOPES PER SPECIFICATIONS. USE BIONET S150BN BIODEGRADABLE EROSION CONTROL BLANKET OR APPROVED EQUIVALENT TO STABILIZE ALL SIDE SLOPES. THE REMAINING DISTURBED AREA SHALL BE LOAM & SEEDED OR LANDSCAPED PER PLANTING PLAN.

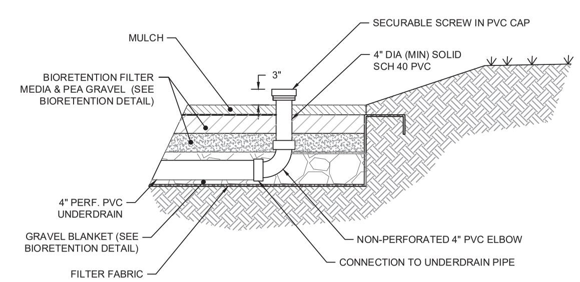


BIORETENTION FACILITY DETAIL
NOT TO SCALE

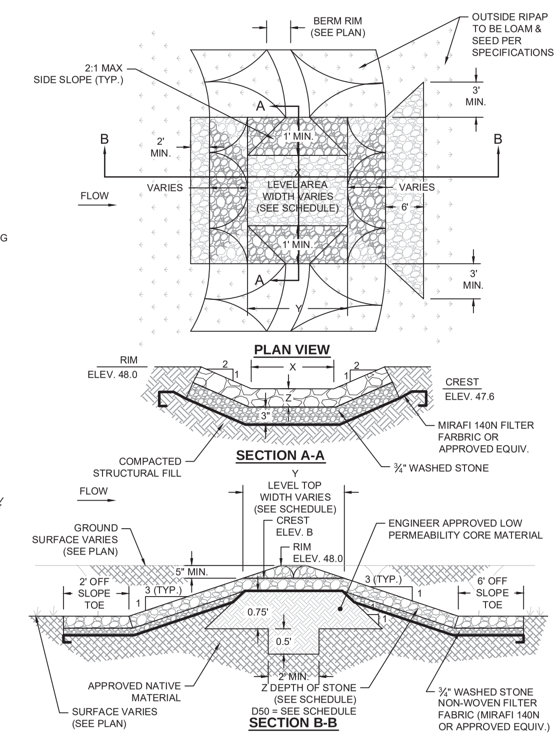
NOTES:
1. FILTER FABRIC AT BOTTOM OF UNDERDRAIN ONLY.
2. FILTER FABRIC ABOVE UNDERDRAIN SHALL EXTEND VERTICALLY 1-INCH± INTO THE PEA GRAVEL LAYER & HORIZONTALLY 1-FOOT OFF THE CENTER OF THE UNDERDRAIN PIPE.



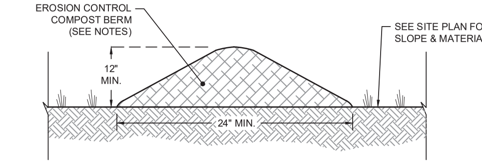
BIORETENTION FACILITY SECTION A-A
NOT TO SCALE



TYPICAL BIORETENTION CLEANOUT DETAIL
NOT TO SCALE

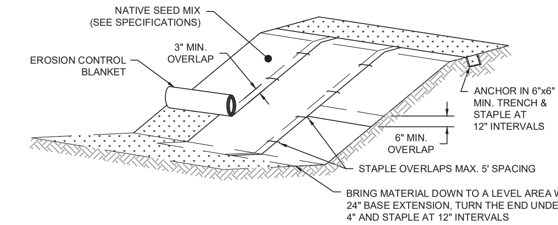


TYPICAL SPILLWAY DETAIL
NOT TO SCALE



NOTES:
1. EROSION CONTROL COMPOST BERMS CAN BE MANUFACTURED ON OR OFF THE PROJECT SITE. IT MUST CONSIST PRIMARILY OF ORGANIC MATERIAL, SEPARATED AT THE POINT OF GENERATION, AND MAY INCLUDE: WOOD SHIP, SHREDDED BARK, STUMP GRINDINGS, OR ACCEPTABLE MANUFACTURED PRODUCTS. WOOD AND BARK CHIPS, GROUND CONSTRUCTION DEBRIS OR REPROCESSED WOOD PRODUCTS WILL NOT BE ACCEPTABLE AS THE ORGANIC COMPONENT OF THE MIX.

COMPOST BERM DETAIL
NOT TO SCALE



NOTES:
1. EROSION CONTROL BLANKET TO BE ALL NATURAL MATERIAL SUITABLE FOR TEMPORARY STABILIZATION - NORTH AMERICAN GREEN BIONET S150BN OR APPROVED EQUIVALENT.
2. SLOPE SURFACE SHALL BE SMOOTH BEFORE PLACEMENT FOR PROPER SOIL CONTACT.
3. STAPLING PATTERN AS PER MANUFACTURER'S RECOMMENDATIONS.
4. DO NOT STRETCH BLANKETS/MATTINGS TIGHT. ALLOW THE ROLLS TO MOLD TO ANY IRREGULARITIES.
5. FOR SLOPES LESS THAN 3H:1V, ROLLS MAY BE PLACED IN HORIZONTAL STRIPS.
6. LIME, FERTILIZE AND SEED BEFORE INSTALLATION. PLANTING OF SHRUBS, TREES, ETC. SHOULD OCCUR AFTER INSTALLATION.

EROSION CONTROL BLANKET DETAIL
NOT TO SCALE

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Plan Set: STORM WATER DEMONSTRATION PROJECT FINAL PLAN NEWMARKET HIGH SCHOOL 213 S. MAIN ST. NEWMARKET, NH 03875

Plan Title: CONSTRUCTION DETAILS

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Newmarket, New Hampshire 03857
Phone:
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WATERSTONE ENGINEERING
INNOVATIVE STORMWATER MANAGEMENT

Project Number: 15091
Sheet: 5 of 6
Sheet Number: C - 5

last modified: 06/27/16 printed: 06/28/16 by mc H:\Projects\2015\15091 Newmarket Moonlight Brook\Drawings\15091 DE.dwg

GENERAL PLANTING NOTES:

1. THE FOLLOWING NOTES ARE PROVIDED AS GENERAL PLANTING GUIDELINES ONLY. THOROUGHLY REVIEW THE PROJECT SPECIFICATIONS FOR ALL LANDSCAPE REQUIREMENTS PRIOR TO THE COMMENCEMENT OF ANY LANDSCAPE WORK. SUBMIT IN WRITING TO THE LANDSCAPE ARCHITECT ANY QUESTIONS OR CLARIFICATIONS REQUIRED AT A MINIMUM OF 30 DAYS PRIOR TO ORDERING ANY MATERIALS OR BEGINNING ANY LANDSCAPE CONSTRUCTION.
2. SUBMIT TO THE LANDSCAPE ARCHITECT FOR REVIEW AND APPROVAL ALL REQUIRED LANDSCAPE SUBMITTALS AS DESCRIBED IN THE SPECIFICATIONS INCLUDING A PLANT LIST WITH PLANT SIZE AND QUANTITIES TO BE ORDERED PRIOR TO DELIVERY TO THE PROJECT SITE.\
3. FURNISH AND INSTALL ALL PLANTS AS SHOWN ON THE DRAWINGS AND IN THE SIZE AND QUANTITIES SPECIFIED ON THE PLANTING SCHEDULE. PLANT SUBSTITUTION SELECTION MUST BE APPROVED BY BIOLOGIST OR LANDSCAPE ARCHITECT PRIOR TO INSTALLATION.
4. ALL PLANTS TO COMPLY WITH APPLICABLE REQUIREMENTS OF ANSI Z60.1 "AMERICAN STANDARD FOR NURSERY STOCK." LATEST EDITION, PUBLISHED BY THE AMERICAN NURSERY AND LANDSCAPE ASSOCIATION INC.
5. PLANTS TO BE GROWN UNDER CLIMATIC CONDITIONS SIMILAR TO THOSE IN THE LOCALITY OF THE PROJECT FOR AT LEAST TWO (2) YEARS. USE HEALTHY NURSERY GROWN PLANTS, FREE OF DISEASE, INSECTS, AND PESTS. EGGS OR LARVAE, AND HAVE A WELL DEVELOPED ROOT SYSTEM.
6. INSTALL PLANTS WITHIN ONE (1) WEEK OF PURCHASE. IF PLANTS ARE TO BE STORED AT THE SITE PRIOR TO PLANTING, IT IS THE CONTRACTOR'S RESPONSIBILITY TO ENSURE THEY ARE PROPERLY MAINTAINED, WATERED, AND REMAIN HEALTHY.
7. PROCEED WITH PLANTING ONLY WHEN EXISTING AND FORECASTED WEATHER CONDITIONS PERMIT. SUBMIT TO THE LANDSCAPE ARCHITECT IN WRITING THE PROPOSED PLANTING SCHEDULE. OBTAIN APPROVAL OF PLANTING SCHEDULE FROM THE LANDSCAPE ARCHITECT PRIOR TO PERFORMING ANY WORK.
8. SEASONS FOR PLANTING:

SPRING:	DECIDUOUS:	APRIL 1 TO JUNE 15
	EVERGREEN:	APRIL 1 TO JUNE 15
	PERENNIALS:	APRIL 15 TO JUNE 1
	GROUNDCOVERS:	APRIL 15 TO JUNE 1
FALL:	DECIDUOUS:	SEPTEMBER 15 TO NOVEMBER 15
	EVERGREEN:	SEPTEMBER 15 TO NOVEMBER 15
	PERENNIALS:	SEPTEMBER 15 TO NOVEMBER 15
	GROUNDCOVERS:	SEPTEMBER 15 TO NOVEMBER 15

LIVE STAKES: PLANTS WHILE DORMANT FROM DECEMBER 1ST THROUGH MARCH 31ST

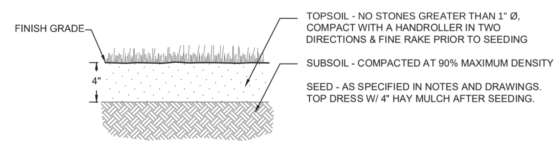
9. PLANTING UNDER FROZEN CONDITIONS IN EITHER THE SPRING OR FALL WILL NOT BE PERMITTED . PLANTING BEFORE OR AFTER THE ABOVE REFERENCED PLANTING DATES WILL INCREASE THE LIKELIHOOD OF PLANT OR GRASS SEED ESTABLISHMENT FAILURE. ANY DEVIATION FROM THE ABOVE REFERENCED PLANTING DATES IS UNDERTAKEN AT SOLE RISK OF THE CONTRACTOR AND IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO PROVIDE ANY ADDITIONAL MAINTENANCE AND WATERING WHICH MAY BE REQUIRED TO ENSURE SATISFACTORY PLANT AND SEED ESTABLISHMENT.
10. FURNISH ONE YEAR MANUFACTURER WARRANTY FOR TREES, PLANTS, AND GROUND COVER AGAINST DEFECTS INCLUDING DEATH AND UNSATISFACTORY GROWTH, EXCEPT FOR DEFECTS RESULTING FROM LACK OF ADEQUATE MAINTENANCE, NEGLECT, OR ABUSE BY OWNER, OR ABNORMAL WEATHER CONDITIONS UNUSUAL FOR WARRANTY PERIOD. THE DATE OF FINAL ACCEPTANCE OF ALL COMPLETED PLANTING WORK ESTABLISHES THE END OF INSTALLATION AND INITIAL MAINTENANCE PERIOD AND THE COMMENCEMENT OF THE GUARANTEE PERIOD.
11. ALL TREES WITHIN 5'-0" OF WALKWAYS AND SIDEWALKS TO HAVE A 6'-8" STANDARD BRANCHING HEIGHT.
12. INSPECT ALL AREAS TO BE PLANTED OR SEEDED PRIOR TO STARTING ANY LANDSCAPE WORK. REPORT ANY DEFECTS SUCH AS INCORRECT GRADING, INCORRECT SUBGRADE ELEVATIONS OR DRAINAGE PROBLEMS, ETC. TO THE LANDSCAPE ARCHITECT AND ENGINEER PRIOR TO BEGINNING WORK. COMMENCEMENT OF WORK INDICATES ACCEPTANCE OF SUBGRADE AREAS TO BE PLANTED, AND THE LANDSCAPE CONTRACTOR ASSUMES RESPONSIBILITY FOR ALL LANDSCAPE WORK.
13. PROVIDE PROPER PREPARATION OF ALL PROPOSED PLANTED AND SEEDED AREAS PER THE NOTES AND SPECIFICATIONS.
14. ALL PLANT LAYOUT AND ACTUAL PLANTING LOCATIONS ARE TO BE FIELD VERIFIED BY LANDSCAPE ARCHITECT PRIOR TO PLANTING. NOTIFY THE LANDSCAPE ARCHITECT AT A MINIMUM OF 48 HOURS IN ADVANCE PRIOR TO SCHEDULING ANY FIELD INSPECTIONS.
15. BALL AND BURLAP: REMOVE BURLAP AND WIRE BASKETS FROM TOPS OF BALLS AND FROM TOP HALF OF ROOTBALL AS INDICATED ON DRAWINGS. REMOVE PALLETS, IF ANY, BEFORE SETTING.
16. POTTED PLANTS: REMOVE THE PLANT FROM THE POT AND LOOSEN OR SCORE THE ROOTS BEFORE PLANTING TO PROMOTE OUTWARDS ROOT GROWTH INTO THE SOIL.
17. PLUGS: PLANT UPRIGHT AND NOT AT AN ANGLE. DIG PLANTING HOLES LARGE ENOUGH AND DEEP ENOUGH TO ACCOMMODATE THE ENTIRE ROOT MASS. PLANT PLUGS WITH NO TWISTED OR BALLED ROOTS AND WITH NO ROOTS EXPOSED ABOVE THE GRADE LINE. HAND PACK THE SOIL AROUND THE ENTIRE PLUG ROOT MASS.
18. DIG THE THE PLANTING HOLE TO THE SAME DEPTH AS THE ROOT BALL AND TWO TO THREE TIMES WIDER. SCORE ALL SIDES OF THE HOLE. PLACE THE PLANT IN THE HOLE SO THE TOP OF ROOT BALL IS EVEN WITH SOIL SURFACE. FILL THE HOLE HALFWAY AND THEN ADD WATER ALLOWING IT TO SEEP INTO BACK FILLED MATERIAL. BE SURE TO REMOVE ALL AIR POCKETS FROM BACK FILLED SOIL. DO NOT SPREAD SOIL ON TOP OF THE ROOTBALL. IF SOIL IS EXTREMELY POOR, REPLACE BACK FILL WITH GOOD QUALITY TOP SOIL. AMEND THE SOIL, AS NECESSARY.
19. CREATE A 2" TO 4" BERM AROUND THE EDGE OF PLANTING HOLE WITH REMAINING SOIL TO RETAIN WATER.
20. REMOVE ALL PLANT TAGS AND FLAGS FROM THE PLANTS.
21. MULCH ALL PLANTING BEDS AS INDICATED ON DRAWINGS. UNLESS NOTED OTHERWISE, ALL PLANTS TO RECEIVE 2-3 INCHES OF MULCH. DO NOT PILE OR MOUND MULCH AROUND THE PLANT STEMS OR TRUNK.
22. TRIM BROKEN AND DEAD BRANCHES FROM TREES AND SHRUBS AFTER PLANTING. NEVER CUT A LEADER.

WATERING NOTES:

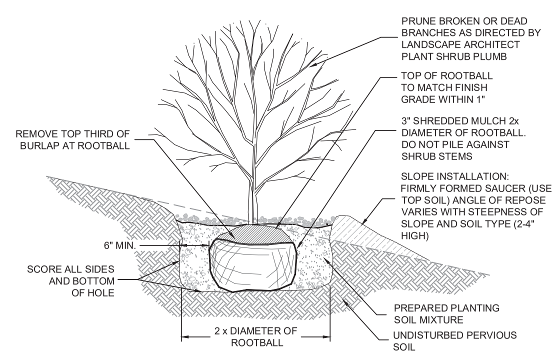
1. PROVIDE PROPER PLANT CARE, MAINTENANCE AND WATERING ON SITE UNTIL SUCH TIME AS THE LANDSCAPING IS ACCEPTED BY THE PROPERTY OWNER AS SATISFACTORY PER THE SPECIFICATIONS OR AS DETERMINED BY ANY WRITTEN AGREEMENTS BETWEEN THE CONTRACTOR AND PROPERTY OWNER.
2. ESTABLISH AN APPROPRIATE WATERING SCHEDULE FOR ALL PLANT MATERIAL BASED UPON PLANT SPECIES REQUIREMENTS AND PROVIDE IN WRITING TO THE LANDSCAPE ARCHITECT AND OWNER FOR REVIEW AND APPROVAL. ADHERE TO THE APPROVED SCHEDULE UNTIL PLANTS ARE FULLY ESTABLISHED.
3. AT A MINIMUM THE NEWLY SEEDED AND/OR HYDROSEEDED LAWNS SHOULD BE WATERED 2-3 TIMES A DAY. SPECIAL CARE SHOULD BE TAKEN TO ENSURE THAT THE LAWN IS NOT SATURATED DURING WATERING. IF AN IRRIGATION SYSTEM IS NOT PROVIDED, A TEMPORARY IRRIGATION SYSTEM OR HANDHELD GARDEN HOSE SHALL BE USED FOR WATERING SEEDED AREAS. THE AREA MUST BE MAINTAINED CONSISTENTLY MOIST FOR THE BEST GERMINATION RESULTS. ADDITIONAL WATERING WILL BE REQUIRED IF PLANTING AND SEEDING OCCUR OUTSIDE OF THE RECOMMENDED PLANTING SEASONS.

GENERAL SEEDING NOTES:

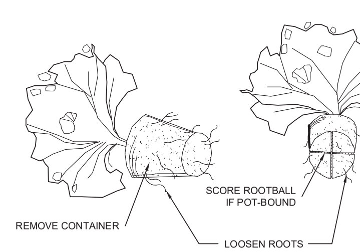
1. SEND A REPRESENTATIVE SAMPLE OF THE TOPSOIL TO A TESTING LABORATORY FOR STANDARD SOIL ANALYSIS AS DESCRIBED IN THE SPECIFICATIONS. SUBMIT TO THE LANDSCAPE ARCHITECT AND ENGINEER TEST RESULTS WITH RECOMMENDED SOIL TREATMENTS TO PROMOTE PLANT AND GRASS GROWTH. CORRECT DEFICIENCIES IN THE LOAM AND STOCKPILED TOPSOIL AS DIRECTED BY THE TESTING AGENCY.
2. ALL AREAS THAT ARE DISTURBED AND/OR GRADED DURING CONSTRUCTION ARE TO BE BROUGHT TO FINISHED GRADE WITH AT LEAST 4" MINIMUM DEPTH OF GOOD QUALITY LOAM AND SEEDED WITH A QUICK GERMINATING GRASS SEED SUCH AS NEW ENGLAND EROSION CONTROL RESTORATION MIX OR AS SPECIFIED ON THE PLANS.
3. PRIOR TO THE PLACEMENT OF TOP SOIL, LOOSEN THE SUBGRADE OF ALL PROPOSED SEEDED AREAS TO A DEPTH OF 6" AND RAKE TO REMOVE STONES LARGER THAN 1 INCH, STICKS, ROOTS, RUBBISH AND OTHER EXTRANEOUS MATTER AND LEGALLY DISPOSE TO AN OFF SITE LOCATION.
4. DO NOT SPREAD TOPSOIL IF THE SUBGRADE IS FROZEN, EXCESSIVELY WET, COMPACTED OR NOT PROPERLY PREPARED PER THE NOTES AND SPECIFICATIONS.



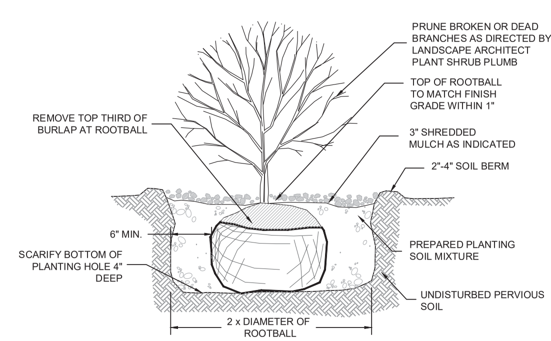
LOAM AND SEED DETAIL
NOT TO SCALE



SHRUB PLANTING DETAIL
NOT TO SCALE



CONTAINER PLANT ROOTBALL TREATMENT
NOT TO SCALE



SHRUB PLANTING DETAIL
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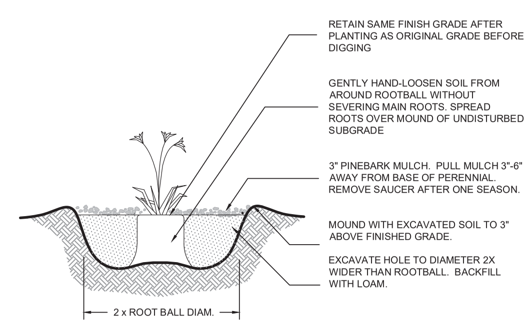

PERENNIAL PLANTING DETAIL
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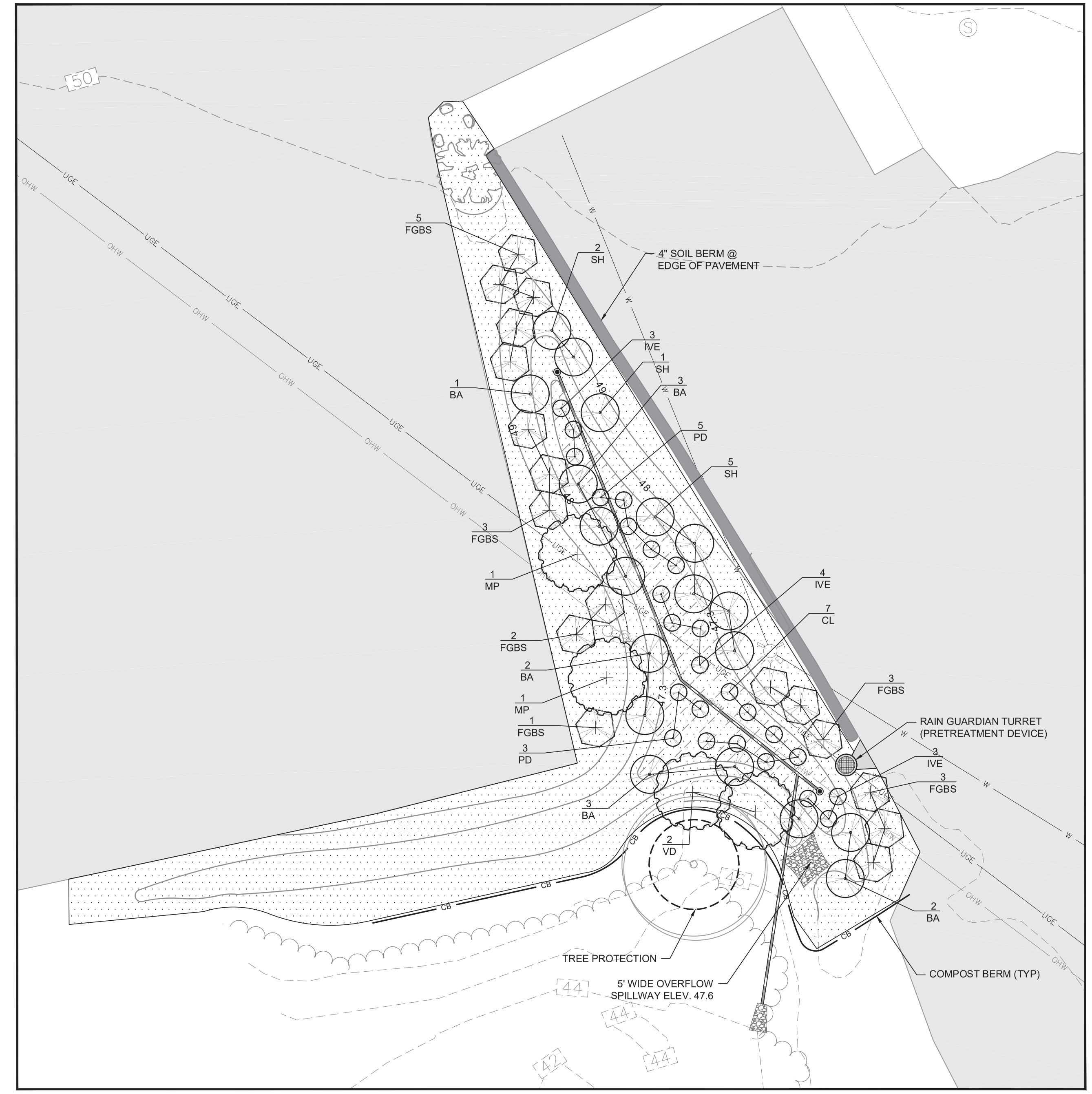

Plant Schedule

Key		Botanical Name	Common Name	Size	Spacing
		Shrubs			
FGBS	17	*Fothergilla gardenii*	Dwarf Fothergilla	#3	As Shown
MP	2	*Myrica pensylvanica*	Northern Bayberry	#3	As Shown
VD	2	*Viburnum dentatum*	Arrowwood Viburnum	#3	As Shown
		Ground Cover/Grasses/Perennials			
BA	11	*Baptisia australis*	Blue False Indigo	#1	36" O.C.
CL	7	*Chasmanthium latifolium*	Northern Sea Oats	#1	3' O.C.
IVE	10	*Iris versicolor*	Blue Flag	#1	18" O.C.
PD	8	*Penstemon digitalis*	Beardtongue	#1	18" O.C.
SH	8	*Sporobolus heterolepis*	Prarie Dropseed	#1	30" O.C.

SEED MIX 1 - MOW AS NEEDED
COLONIAL SEED - STABILIZER MIX

WAVY HAIR GRASS
LITTLE BLUESTEM
BIG BLUESTEM
UPLAND BENT GRASS
HARD FESCUES
CANADA WILD RYE
SWAN SEDGE
GOLDENROD
BUTTERFLY MILKWEED
LANCE LEAVED COREOPSIS
PARTRIDGE PEA
TICK-TREFOIL

WATERSTONE ENGINEERING
INNOVATIVE STORMWATER MANAGEMENT

GRAPHIC SCALE
10 0 5 10 20 40
(in feet)
1 INCH = 10 FEET

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JUNE 2016	BAL	BAL	RAC

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NEWMARKET HIGH SCHOOL
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