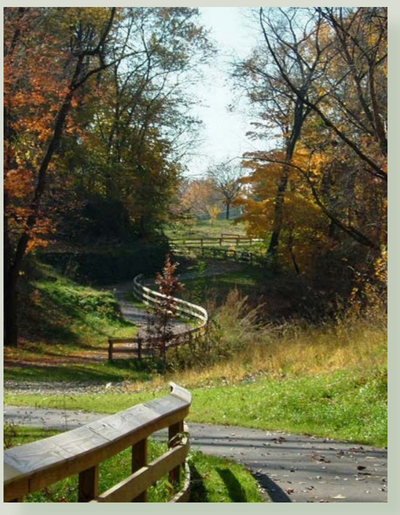
Using Green Infrastructure and Low Impact Development to Address Impacts of Climate Change



CAPTION
LOCATION, NH

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Advantages of Incorporating Climate Change Projections into the Design of Stormwater Management (SWM) Systems

Stormwater infrastructure designs are based traditionally on rainfall, land use and sea level data modeled after historical trends and conditions.

Infrastructure decisions and investments should consider future conditions in order to remain functional and able to respond to more frequent severe weather events. These decisions should promote design and management capacities that will improve community resilience—the ability of natural systems and physical structures to recover quickly from changes in environmental conditions by accommodating future temperature, rainfall and drought projections and the effects of land development.

IMPROVING DESIGN AND PERFORMANCE OF SWM SYSTEMS

Climate change is expected to affect traditional stormwater management system design calculations by:

- increasing rainfall intensity and frequency;
- raising moisture levels in soils; and
- incresing the average amount of water contained in storage ponds.

New or retrofitted SWM systems need to account for the anticipated intensity of future rainfall events, which could affect system design, lifecycle, performance, and timing of upgrades.

Traditional stormwater models may need to be updated to get a better picture of SWM system performance under future climate conditions. These components may include: changes in mean temperature; changes in mean rainfall (which affects soil moisture saturation); increases in total rainfall for storm events; and increases in wind.

ENHANCING THE RESILIANCY OF SWM SYSTEMS

Poorly managed stormwater runoff can lead to:

- higher mobility and transport of pollutants into surface and ground water;
- increased erosion potential, causing loss of property, aquatic habitat and organism passage, and damage to infrastructure; and
- increases in nutrients, leading to algae blooms, reduced dissolved oxygen levels, and the possible loss of sensitive aquatic species.

Climate projections can be incorporated into measures to improve water supplies, sanitation services, drainage systems, building codes, and flood-proofing of infrastructure.

PROTECTING HUMAN HEALTH

Direct health and safety impacts may include injury and disease from flooding, and contamination of drinking water. Standing water caused by floods and higher temperatures dramatically increase the risk of diseases transmitted by food, air, water, insects, and ticks. Resource-intensive disaster response and recovery efforts will be constrained by diminishing local, state and federal budgets.

REDUCING COSTS BY REDUCING IMPACTS

NH's most densely-populated and developed areas occur along or in river floodplains, making riverine flooding the most common and costly disaster event in NH. Continued damage to infrastructure represents a serious drain on the economy. Better predictions of changing climate may lessen the need to repair and replace stormwater infrastructure. Expanding protection for and use of natural stormwater management assets, like wetlands and forests, will further reduce these costs.

Local officials can use climate projections to estimate long-term operation, maintenance, and investments in stormwater conveyance and drainage networks that can withstand changing conditions.

HELPING COMMUNITY LEADERS MAKE DECISIONS UNDER CONDITIONS OF UNCERTAINTY

It is challenging to pinpoint exactly when and where climate impacts will occur, but there is sufficient evidence that climate adaptation can no longer be responsibly postponed until all uncertainty is eliminated. Proactive and cost-effective methods can be identified to address lingering uncertainty and provide local leaders with support for implementing infrastructure adaptation programs.

Municipalities can begin directing funds toward protecting infrastructure prior to flooding impacts by incorporating climate projections into their planning decisions. Assessing community risks and identifying specific assets that might be vulnerable will help local officials prepare a range of appropriate responses prior to impact.

Applying climate projections in stormwater planning ensures that the future safety of communities is considered. Climate data can be used to identify areas that can sustain future economic development and population growth.

PROTECTING WATER QUALITY AND QUANTITY

Increased rainfall predicted for the northeast U.S. will alter the region's hydrology, which is deemed to be a primary cause of water quality degradation. Communities may need to reassess the capacity of their reservoirs to withstand longer periods of drought. This can impact drinking water supplies and agricultural networks to support specific crops due to decreased water tables.

Benefits of Using Green Infrastructure and Low Impact Development to Adapt to Climate Change

Compared with conventional SWM systems, Green Infrastructure (GI) and Low Impact Development (LID) are easily adapted to most sites and environmentally friendly.

These approaches can:

- add water storage to the built landscape,
- provide open space allowing stormwater to naturally infiltrate soils,
- contribute to social and ecological resiliency,
- reduce the amount of polluted runoff reaching surface and ground waters,
- use to retrofit existing development,
- help maintain natural stream channel functions and habitat.

GI and LID minimize impervious surfaces and use natural landscape features to create functional and appealing drainage features that allow rain water and snow melt to soak into the ground.

Broad use of LID across a watershed can:

- reduce the urban heat island effect (by shading and minimizing impervious surfaces),
- address impacts from climate change by allowing plants to capture carbon dioxide,
- reduce energy use by installing green roofs and trees, and avoided water treatment,
- reduce air pollution by avoiding power plant emissions and reducing ground-level ozone,
- combat drought by increasing groundwater recharge.

GREAT BAY NATIONAL ESTUARINE RESEARCH RESERVE

This project is funded by the **National Estuarine Research Reserve Science Collaborative** and the **National Oceanic and Atmospheric Administration (NOAA)**

The Legal Basis in New Hampshire:

Adopting Stormwater Zoning Ordinances and Land Development Regulations

FEDERAL LAW

CLEAN WATER ACT

The Clean Water Act (CWA) originated as the Federal Water Pollution Control Act of 1972 in response to unchecked dumping of pollution into the nation's surface waters. At that time, about $^{2}/_{3}$ of U.S. waters had been declared unsafe for fishing and swimming. The CWA provides the basic structure for:

1) regulating discharges of pollution into the waters of the United States, and
2) regulating quality standards for the nation's surface waters. Its objective is "to restore and maintain the chemical, physical, and biological integrity of the nation's waters."

The U.S. Environmental Protection Agency (EPA) administers the CWA and enforces its provisions. The EPA is authorized to implement water pollution control programs, like setting water quality standards for all surface waters (streams, lakes and coastal waters).

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)

The CWA made it illegal to discharge any pollutant from a point source into navigable waters without an NPDES permit. The NPDES Storm Water Program addresses non-agricultural sources of stormwater discharges. The program's permitting mechanism requires dischargers to implement control measures that prevent pollution from being washed into surface waters by stormwater runoff. Control measures, like stormwater management programs, must use best management practices. The NPDES gives permitting authorities guidance on meeting stormwater pollution control goals as cost-effectively as possible. The CWA also requires NPDES permits to be consistent with applicable state water quality standards.

NPDES AND EPA

Through the Phase 1 and Phase 2 NPDES programs EPA sets water quality standards for point source and wastewater discharge permits. EPA administers NH's NPDES permit program and permits for stormwater and sewer overflow discharges. Individual homes that are connected to a municipal system, use a septic system, or do not produce surface discharge do not need an NPDES permit. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.

NPDES STORMWATER PERMIT TYPES

The NPDES permit regulations cover 3 main classes of stormwater and wastewater discharges.

Municipal Separate Storm Sewer Systems (MS4s) Permits

EPA administers its Stormwater Program in two phases. Generally, under Phase I of the program, EPA issues NPDES permits for:

A) "medium MS4s" and "large MS4s"
B) certain construction activities; and
C) multiple categories of industrial activity.

Phase II extends coverage of the program nationwide to:

1) automatically include "small MS4s" in urbanized areas; and
2) include on a case-by-case basis small MS4s outside of EPA-designated urbanized areas.

MS4 permits are generally required for small, medium and large MS4s in urbanized areas. Any MS4 permit may include additional EPA requirements for pollution control. MS4 permits may be issued for a specific storm sewer system or an entire jurisdiction. MS4 permits prohibit non-stormwater discharges into storm sewers and require implementation of pollution reduction controls to the "maximum extent practicable" (MEP) using best management practices (BMPs). The lack of a precise definition of MEP allows small MS4s flexibility in tailoring their programs to their actual needs.

The MEP standard requires small MS4s to satisfy the following six "minimum control measures":

1) Public Education and Outreach
2) Public Participation
3) Illicit Discharge Detection and Elimination (IDDE) Program
4) Construction Site Runoff Controls
5) Post-Construction Runoff Controls
6) Good House Keeping and Pollution Prevention for Municipal Operations

Construction Activities Permits

All construction activities 1 acre or larger must obtain a permit, and those less than 1 acre must obtain a permit if they are part of a larger common development plan or sale that totals at least 1 acre. Small construction activities (less than 5 acres) may qualify for a waiver. In NH, where EPA is the permitting authority, operators must meet EPA's Construction General Permit requirements.

Industrial Activities Permits

Industrial facilities (as defined by the facility's Standard Industrial Classification code) that discharge to an MS4 or to waters of the U.S. must obtain a permit. Operators (excepting construction) may qualify for a waiver by certifying to a condition of "no exposure" if their industrial materials and operations are not exposed to stormwater. NH operators must meet the requirements of EPA's Multi-Sector General Permit.

OTHER FEDERAL LAWS THAT MAY AFFECT NPDES PERMITS

Four federal acts apply to the EPA's issuance of an NPDES permit to an MS4: the Endangered Species Act, the National Historic Preservation Act, the Magnuson-Stevens Fishery Conservation and Management Act, and the Coastal Zone Management Act.

STATE LAW

Although many larger sites are subject to NH's Alteration of Terrain permit requirements and the EPA's stormwater management requirements under the CWA, local zoning ordinances and land development regulations provide municipalities the authority to act independently to address local problems and issues relating to water quality impacts and water resource management on a case-by-case basis. Often federal and state regulations apply to only the largest development projects and lack the oversight and enforcement for which municipalities are ultimately responsible.

NH statutes provide the authority and legal mechanisms for municipalities to enforce standards for land use, the environment, and protection of life and property.

GENERAL AUTHORITY AND ADMINISTRATION

RSA 149-I:1-25 Sewers, RSA 432:3 State Plan, RSA 483-B:8 Municipal Authority, RSA 485-A:13 Water Discharge Permits, RSA 674:20 Districts, RSA 674:21-a Development Restriction Enforceable

REGULATORY/PLANNING

RSA 483:10 Rivers Corridor Management Plans, RSA 485-A:17 Terrain Alteration, RSA 674:2 Master Plan Purpose and Description, RSA 674:3 Master Plan Preparation, RSA 674:17 Purposes of Zoning Ordinances, RSA 674:44 Site Plan Review Regulations, RSA 674:36 Subdivision Regulations, RSA 674:16 Grant of Power

ENVIRONMENTAL

RSA 483-B:9 Minimum Shoreland Protection Standards, RSA 674:21 Innovative Land Use Controls, RSA 674:55 Wetlands, RSA 674:57 FEMA Flood Insurance Rate Maps (and 44 C.F.R. 67.5), RSA 674:56(II) Flood Hazards: Fluvial Erosion Hazard Zoning, RSA 674:56(I) Flood Hazards: Floodplain Zoning

MUNICIPAL LAW

Vermont Law School Study: New Floodplain Maps for a Coastal New Hampshire Watershed and Questions of Legal Authority, Measures and Consequences

The Vermont Law School Study assessed the level of legal risk communities may face if they choose to adopt regulations and policies based on new floodplain maps that utilize projected future conditions. The study concluded that the level of risk of being successfully sued is very low, as long as the typical procedures and precautions are taken. The study may be found at **http://100yearfloods.org/resources.**

The following sections outline the questions addressed by the Vermont Law School Study pertaining to the legal basis for adopting municipal zoning ordinances and land development regulations.

MUNICIPAL LIABILITY

What is the potential liability of a governmental entity that fails to take steps to reduce the vulnerability of its landowners and other citizens to flooding risks and storm damage as revealed by UNH's research efforts and mapping information?

Answer: Municipalities are very unlikely to be held liable for actions related to adopting new floodplain maps.

Recommendations: At a minimum, always abide by the "reasonable person" standard – i.e., what a reasonable person would do under same circumstances. There is no need to take action related to municipal liability for failing to adopt floodplain maps. Acknowledge the unpredictability of future flood hazards in plans while emphasizing importance of taking action to protect the public despite uncertainty. Give the public meaningful opportunities to participate in the planning process.

LEGAL AUTHORITY

Do New Hampshire communities have the legal authority under state planning and zoning enabling legislation, or other state legislation, to design and implement regulatory controls based on current and predicted environmental conditions, specifically projected flooding levels?

Answer: Whether towns have the requisite enabling authority depends on the type of regulation being imposed; municipalities must clearly identify the enabling statute that allows the enactment of the ordinance or regulation.

Recommendations: Clearly identify the enabling statute(s) authorizing the ordinance/regulation. Check the language of the statute to make sure specific authorizations are not being exceeded. Show that your decision is reasonable by drawing from supporting data and documentation from trusted sources, like academic, state and federal reports and studies. When enacting new ordinances related to or referencing new floodplain maps, use the previous list of potential enabling statutes as a resource.

USE OF PROJECTED DATA AND MAPS AS EVIDENCE

What legal standard of scientific and technical reliability must planners and other officials meet in order to support regulatory measures that are based on current and projected future – as opposed to past – environmental conditions?

Answer: Scientific evidence is generally not needed to justify the enactment of ordinances or regulations.

Recommendations: To ensure the use of future climate conditions and related floodplain maps stands up in court, clearly identify and define in the ordinance the reason you are adopting or referencing the maps. Only use maps generated from reliable science. **Note:** Projected future conditions may include land conversion and impervious surface cover using a buildout analysis, or projected changes in environmental parameters such as precipitation or sea level rise.

TAKINGS

What is the potential regulatory takings exposure of New Hampshire communities if they impose regulatory controls that are designed at least in part to address anticipated future environmental conditions?

Answer: Though most takings are determined on a case-by-case basis, it is unlikely that a municipality could be successfully sued on the basis of a taking suit for imposing regulatory controls intended to reduce the risk of harm from future flooding events. Courts are much more likely to hold that a "harm preventing" (versus "benefit-conferring") regulation does not constitute a compensable taking.

Recommendations: Enact regulations in a way that preserves some economically viable use of the land, such as for agricultural and recreational activities. Indicate that the purpose of the regulation is to promote hazard mitigation to protect the public health, safety and welfare, and make this clear in the master plan. Include a variance option to deal with requests on a case-by-case basis. Be sure that the potential harm of flooding to the community outweighs the regulatory restrictions. Use the principle of No Adverse Impact (NAI) as a standard when creating floodplain regulations (or to prevent harm to a body of water held in public trust). NAI is the principle that the action of one property owner may not adversely impact the flooding risk for other property owners. Stay consistent with the existing regulatory scheme to the extent possible; when the regulation aims to correct an unforeseen problem, existing landowners will have a much stronger argument for a taking.

REFERENCES

Vermont Law School Land Use Clinic. *New Floodplain Maps for a Coastal New Hampshire Watershed and Questions of Legal Authority, Measures and Consequences.* South Royalton, VT: National Sea Grant Law Center Grants Program, University of Mississippi, June 2012.

Southeast Watershed Alliance. *Model Stormwater Standards for Coastal Watershed Communities.* Exeter, NH: University of New Hampshire Stormwater Center and Rockingham Planning Commission, December 2012 draft.

This project is funded by the
National Estuarine Research Reserve Science Collaborative
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Overcoming Barriers to Green Infrastructure

Green infrastructure is an approach to water resource management that incorporates vegetation, soils, and natural processes into the built environment to manage stormwater, mitigate the impacts of climate change, and maintain healthy and sustainable communities.

Green infrastructure's ability to capture, absorb, and filter stormwater before it flows into groundwater or surface waters has provided economic, social, and environmental benefits to numerous communities. Nonetheless, the approach is still relatively new and many still have questions.

As the benefits of green infrastructure have become more widely known, barriers still often block the adoption of green infrastructure approaches. These barriers can occur throughout the planning and development process, and can take many forms.

The barriers to green infrastructure typically fall into four main categories:

1. Technical and Physical Barriers
2. Legal and Regulatory Barriers
3. Financial Barriers
4. Community and Institutional Barriers

Many of the barriers in these categories are due to unfamiliarity with green infrastructure; however, there are strategies to overcome these barriers.

BARRIERS IN NH AND STRATEGIES USED TO OVERCOME THEM

In 2013, a working session was held with local decision makers to identify the existing barriers to the implementation of green infrastructure projects in New Hampshire. Participants included municipal staff, volunteer board members, and elected and appointed officials. In addition to identifying local barriers, participants also developed specific strategies and approaches to address them. What follows is an overview of the results of this working session.

Technical and Physical Barriers

Technical and physical barriers to green infrastructure at the local level include limited or no maintenance of existing infrastructure, unfamiliarity with green infrastructure, little or no trust in the science and technology behind it, and a lack of understanding how green infrastructure is relevant to local stormwater issues.

Conventional Stormwater Infrastructure

Some of the specific technical and physical barriers include:

- The practice is new, not widely understood, and unproven,
- The limited ability of local DPWs to maintain existing infrastructure
- Existing maintenance and capital improvement priorities.

Many of the technical and physical barriers at the local level are the result of limited outreach and education, limited resources, competing interests, and a lack of confidence in local government.

To overcome these barriers, local governments and municipalities need to:

- Develop training programs for staff
- Increase training opportunities for staff
- Improve documentation of maintenance activities.


Bioretention System, Stratham, NH

Legal and Regulatory Barriers

Legal and regulatory barriers at the local level include resistance to new rules and regulations, perceived adverse impacts to property owners, and an inability to understand its importance.

Some of the specific legal and regulatory barriers include:

- overly prescriptive, inflexible, and conflicting rules,
- complications associated with property rights, and
- lack of a clear regulatory framework.

The acceptance and implementation of green infrastructure projects is dependent on the leadership, knowledge, and support by local officials.

To overcome the legal and regulatory barriers, local governments and municipalities need to:

- ensure and maintain local control rather than allow state and federal agencies to mandate standards,
- ensure that property rights are not adversely impacted, and
- make available cost benefit analyses showing the cost effectiveness of green infrastructure and its positive impacts on the local economy.

Financial Barriers

Currently, most local governments and municipalities are experiencing a time of fiscal constraint where limited resources and funds are available for infrastructure projects. Therefore, in order to implement green infrastructure projects local governments and municipalities must find innovative ways to fund these projects. Even without current fiscal constraints, a number of financial barriers remain.

Some financial barriers include:

- a perception that the community cannot afford green infrastructure investments,
- a low priority for green infrastructure projects compared to other infrastructure projects, and
- the perception that green infrastructure may be an unfunded mandate from state and federal governments.

Green infrastructure can be less costly over its operational life span and has the ability to meet multiple development and stormwater management objectives. Therefore, it can be an efficient and cost effective alternative compared to conventional stormwater infrastructure.

In order to overcome perceived financial barriers:

- local governments are encouraged to share with the public the multiple benefits and avoided costs associated with green infrastructure
- local officials need to consider providing incentives that encourage the use of green infrastructure over conventional infrastructure.

Community and Institutional Barriers

Community and institutional barriers at the local level are a considerable constraint to green infrastructure projects. The characteristics and values of a community significantly influence a community's acceptance of green infrastructure and may represent critical barriers to its implementation. These barriers include public knowledge and perception, landowner preferences, development plans, resistance to change, and a lack of political commitment and leadership.

Barriers in this category include:

- insufficient and inaccessible information about green infrastructure and its benefits for political leaders, administrators, agency staff, developers, builders, landscapers, and others, including the public,
- a lack of integration of green infrastructure in local rules and regulations,
- a lack of understanding concerning the interconnectedness of our water resources, and
- resistance by developers to integrate and use green infrastructure.

Overcoming these barriers will require local governments to:

- generate public understanding and potential support,
- conduct education and outreach, and
- ensure broad stakeholder participation.

This can be most easily achieved if local government leaders gain a better understanding about opportunities, funding, benefits, and avoided costs associated with green infrastructure.

For more information about Green Infrastructure for NH Coastal Watershed Communities and the Green Infrastructure approach, please visit the following resources:

STORMWATER FOR COASTAL COMMUNITIES
southeastwatershedalliance.org/wordpress

UNH STORMWATER CENTER
www.unh.edu/unhsc

WATER: POLLUTION PREVENTION AND CONTROL
water.epa.gov/polwaste

HOW CAN I OVERCOME BARRIERS TO GREEN INFRASTRUCTURE?
water.epa.gov/infrastructure/greeninfrastructure/gi_barrier.cfm

NERRS SCIENCE COLLABORATIVE
www.nerrs.noaa.gov/ScienceCollaborative. aspx

The Green Infrastructure Project provides resources and technical support for communities to improve stormwater management. We support pilot projects and provide workshops, fact sheets and other resources to help communities protect water resources.

Improving the Brickyard Pond Residential Watershed

Exeter, New Hampshire

What Is Green Infrastructure?

Green infrastructure is the utilization of natural processes to help control rain runoff.

This can include **constructed systems** such as **raingardens** or **buffers** along streams that treat runoff by filtering the water.

There are also **non-structural strategies** such as **incentives** or **education** to encourage homeowners to protect water quality, and **regulations** that require better stormwater control for new construction.

A **complete community approach** uses green infrastructure throughout all aspects of community planning.

THE PROBLEM

Brickyard Pond, once a community gathering place and natural playground, has deteriorated steadily over the years. As excess fertilizer, soil, oils, salt, and other components of stormwater pollution flow through stormdrains from a neighboring community and enter the pond, a food smorgasbord is created for unwanted plants and algae. The plants and algae grow in excess, reducing the overall water quality and degrading the habitat for fish.

THE SOLUTION

Neighbors in the Marshall Farms community expressed their concerns. Working with the town and with support from a Green Infrastructure grant, they learned what small changes they could make on their property to work toward improving the pond's condition. Their focus was on making these changes using three Green Infrastructure tools: **Lawn Care, Rain Barrels** and **Rain Gardens.**

Improving the Brickyard Pond Residential Watershed

Exeter, New Hampshire

The town of Exeter and residents living near Brickyard Pond participated in an education program that was followed by implementation of several residential stormwater treatment systems. The project combined education with water treatment and monitoring and engaged a wide range of stakeholders. In the initial stages of this program, seven rain barrels and rain gardens were installed and, most importantly, a relationship was established between residents and the town to resolve issues with stormwater and the health of Brickyard Pond.

LAWN CARE

In a neighborhood workshop, residents learned about the importance of letting soil conditions, not past habits, dictate what their lawns need for fertilizer. By committing to the Happy Lawns-Blue Waters campaign, residents agreed to opt for slow release, phosphorus-free fertilizers unless soil tests indicate otherwise. In addition, they committed to cleaning up after their pets, reducing yet another source of excess nutrients. When mowing lawns, they would cut to three inches or higher to encourage stronger grass root growth and leave the cut grass on the lawn to take advantage of the free fertilizer provided as clippings decompose.

RAIN BARRELS

Residents were offered the opportunity to purchase SkyJuice rain barrels at a discounted rate. Rain barrels capture clean water from rooftops through gutter downspouts and store it for use whenever houseplants, gardens, or flowerbeds need watering. The result is not only a free water source for the residents, but a reduction in the amount of stormwater that leaves the property. So how much water can you save? A half-inch rainfall falling on a 1,000 square foot roof will provide 300 gallons of water.

RAIN GARDENS

A rain garden in its simplest form is a depression in your yard that uses soil, mulch, and plants to capture, absorb, and treat stormwater. This helps reduce the amount of stormwater coming from your property and to recharge groundwater.

Two neighborhood rain gardens were installed in this community. They were designed by Ironwood Design Group LLC with donations and assistance from Rye Beach Landscaping and Churchill's Gardens. Residents were invited to participate in construction to gain hands-on experience. They then applied their newly acquired skills to construct a rain garden on their own property.

Why Do We Care About Stormwater And How Does Green Infrastructure Help?

Stormwater is **rain runoff** that flows across parking lots, roads or other hard surfaces. The runoff contributes to **flooding** and can carry **pollutants** including road salt and nitrogen into our rivers, lakes and the Great Bay.

Existing stormwater management systems designed to control runoff and protect life and property are not always able to handle the large **storm events** that New Hampshire has experienced over the last several years. Better water resource management will reduce infrastructure costs and help to alleviate flooding.

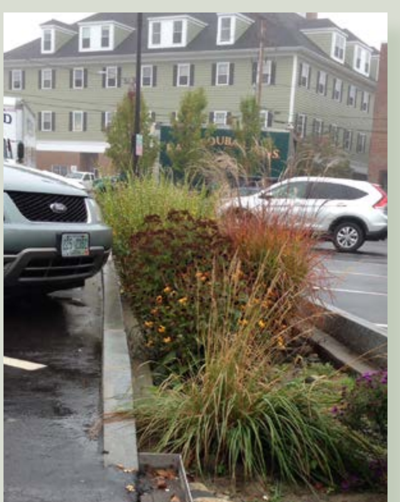
This project is funded by the **NERRs Science Collaborative** to a project team led by the **University of New Hampshire Stormwater Center** and the **Great Bay National Estuarine Research Reserve.** It supports Green Infrastructure implementation with local municipal, non-profit and private sector partners.

For more information please visit **southeastwatershedalliance.org/green-infrastructure**

The Up Side of Implementing Green Infrastructure and Low Impact Development Practices

PROVEN PRACTICES

POROUS PAVEMENT
STRATHAM, NH

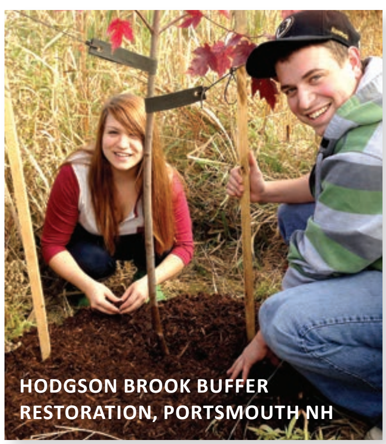


BIORETENTION SYSTEM
DURHAM, NH

Low impact development (LID) and green infrastructure (GI) are approaches to stormwater management that can improve water and air quality, enhance recreational opportunities, improve quality-of-life, protect ecosystem function, save energy, reduce the urban heat island effect, and alleviate the effects of climate change. These goals are advanced by LID and GI in ways that traditional "grey" infrastructure cannot match.

WHAT IS LOW IMPACT DEVELOPMENT?

Low impact development practices manage runoff in ways that reduce the impact of built areas and promote the natural movement of water within soils, ecosystems or a watershed. Applied on a broad scale, LID can maintain or restore a watershed's hydrologic and ecological functions. LID employs principles such as preserving and restoring natural landscape features and minimizing impervious surfaces to create functional and appealing site drainage systems that treat stormwater as a resource rather than a waste product.



HODGSON BROOK BUFFER RESTORATION, PORTSMOUTH NH

WHAT IS GREEN INFRASTRUCTURE?

Green infrastructure practices (also a low impact development tool) serve to manage runoff as an integrated part of the developed landscape by capturing runoff close to its source and weaving natural processes into the built environment. Practices use vegetation and soils to absorb and infiltrate excess runoff and remove pollutants. Implementing stormwater standards for development and protecting existing natural areas and land in river corridors are also part of the green infrastructure approach.

TREE FILTER
PORTSMOUTH, NH

Benefits for Communities

URBAN HEAT ISLAND EFFECT REDUCTION

The urban heat island (UHI) effect occurs when built-up urban areas become warmer than nearby areas due to the amount of "hard surfaces" such as buildings, roads and parking lots. The UHI effect is of particular concern in summer, when higher surface air temperatures and solar radiation heat exposed surfaces. UHI can increase electricity demand, air pollution, and heat–related mortality and illness. **LID and GI can mitigate the UHI effect through added shade and evapotranspiration in urban areas.**

ENERGY CONSERVATION AND CLIMATE CHANGE OFFSETS

Green infrastructure can be adapted to address site-specific conditions to meet the anticipated challenges of climate change. Properly placed trees and natural vegetation can provide shade in summer and reduce wind speeds in winter, reducing the energy needed for heating and cooling. **Trees and vegetation help to offset carbon dioxide emissions by removing pollutants from and cooling the air.** Unlike some traditional grey infrastructure, GI installations do not need electricity to operate, so they do not produce greenhouse gas emissions.

IMPROVED AIR QUALITY

LID and GI improve air quality by incorporating vegetated areas that absorb pollutants, like ozone and nitrogen dioxide, intercept airborne particles, like dust, smoke, and pollen, and decrease carbon dioxide levels and increase oxygen levels. LID and GI help ponds, swamps and other water bodies from becoming toxic by limiting inflows of nutrients that cause massive algal blooms, the decay of which can create strong odors and rob the waters of life-sustaining dissolved oxygen.

ENHANCED PROPERTY VALUES, RECREATION AND QUALITY OF LIFE

GI and LID enhance neighborhood livability, in turn elevating property values, by beautifying yards and streets, increasing privacy, reducing noise pollution, providing urban agriculture opportunities, and creating or expanding attractive outdoor spaces. **Healthy environments can promote community development and foster stronger community connections** (via community tree planting programs, recreational activities, and social gatherings) that can reduce community costs for emergency response, crime, transportation, and water supply restoration.

Properties in LID neighborhoods have been shown to sell faster and for higher amounts than those in competing areas not using LID, in part due to proximity to open space and high-quality waterways. The significant improvements in water quality yielded by GI and LID can increase market value by 15% for properties bordering the water body. Similarly, LID has been shown to generate higher rents and lower vacancy and turnover rates. Therefore, **protecting water quality helps boost tax revenues by enhancing local real estate values.**

PROTECTED ECOSYSTEMS

GI and LID protect wildlife and habitats by enabling the ecosystem to perform its natural functions, like water restoration, nutrient recycling, and the capture and storage of carbon dioxide from the atmosphere. **GI's enhancement of native vegetation along streams keeps stream ecosystems healthy.** The natural areas near streams, or "riparian buffers," provide a number of ecological and water quality benefits by: filtering sediments and pollutants out of runoff before reaching streams; slowing runoff to allow it to soak into and be filtered by the soil; reducing erosion and stabilizing stream channels; allowing plants to absorb flood waters; providing shade that keeps stream water cool in summer so that it can hold more oxygen for use by fish and other aquatic species; and providing food and habitat for a number of land and water species. On a smaller scale, street trees and green roofs can provide nesting, migratory, and feeding habitat for a variety of birds, butterflies, bees, and other pollinating insects.

OPERATION AND MAINTENANCE BENEFITS

Natural systems are lower-maintenance, compared with conventional systems. **LID uses small, cost-effective landscape features throughout developed areas to slow runoff, delay peak flows, increase evaporation, remove sediment, and remove pollutants.** This maximizes water quality treatment and reduces the dangerous and damaging erosional forces of fast-moving waters. Protecting water quality through GI and LID practices is usually less expensive than cleaning contaminated water. LID's decentralized approach reduces municipalities' stormwater management costs by letting private landowners handle rain as it falls on their properties. This extends the useful life of central and underground infrastructure while reducing chemical, energy, and maintenance costs at treatment plants.

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