Ipswich River Targeted Watershed Grant
Fact Sheet:

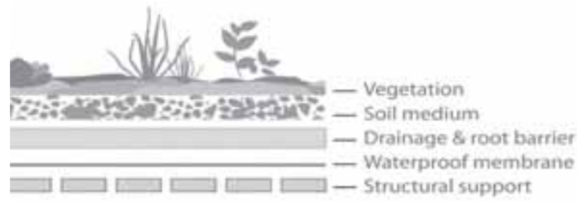
Green Roof Case Study

Prepared by:

Massachusetts Department of Conservation and Recreation and
The Ipswich River Watershed Association

What is a green roof?

A green roof is a rooftop that is covered with plants. Most green roofs involve a layered system that commonly includes (from bottom to top): a waterproof membrane; a drainage layer and root barrier; lightweight soil; and hardy, drought-resistant plants. Different types of green roofs may be chosen, depending on the steepness of the roof, the building's ability to sustain the added weight, the primary purpose of the green roof, and the maintenance requirements of the plants. Plantings can include trees and shrubs, especially where the green roof is intended to be used as garden space, but more often lighter-weight and lower-maintenance plants - such as Sedums, grasses, and mosses - are selected because they are drought tolerant, able to grow in shallower soil depths, and do well in sunny locations.



Dominated by succulent Sedums, green roofs need very little water or fertilizer and can survive temperature extremes.

What does a green roof do?

Rain water soaks into green roof soils. From there it is either taken up by plants, evaporates to the air, or slowly drains off the roof. In contrast, rain on conventional roofs drains off quickly and in larger amounts, typically picking up contaminants from the roof before it is discharged to the ground. Once on the ground, large runoff volumes from conventional roofs can cause flooding, erode soil, pick up more pollutants, destabilize river banks and slopes, and deposit sediment and other contaminants in lakes and streams. The lower volumes and slower release of runoff from green roofs greatly reduce these problems.

Green roofs serve many other functions. They insulate buildings from heat loss in the winter and heat gain in the summer, which in turn reduces the heating and cooling costs of the buildings. Green roofs can also extend the life of the underlying roofing materials by protecting them from ultraviolet light, temperature extremes, and harsh weather. In urban areas, green roofs can help reduce air temperatures during very hot days because green roofs absorb less solar energy than traditional black roofs. The plants can also trap the harmful contaminants found in dust particles. Finally, green roofs are attractive and provide natural habitat for birds, butterflies, and other small wildlife.

Despite the many benefits of green roofs, they are heavy, usually adding a minimum of 15 lbs per square foot, but possibly adding as much as 150 lbs per square foot, if larger trees and shrubs are planted. As a result, green roofs must have stronger structural support than a conventional roof. Additionally, green roofs are likely to require some maintenance over their life, especially during the first few years, as the plants establish.

Ipswich green roof case study

The case-study green roof was constructed in September 2006 on an existing roof (top) and is home to at least 10 species of flowering plants (bottom). The roof area is 3,000 ft^2 and the weight is 20 lbs. per ft^2 (saturated).

As part of a demonstration project funded by the United States Environmental Protection Agency (USEPA) under a cooperative agreement, the Massachusetts Department of Conservation and Recreation worked with the North Shore Housing Trust (now Harborlight Community Partners) to construct a green roof in the town of Ipswich, Massachusetts. The building was historically used both as a factory and a school, and the North Shore Housing Trust had undertaken the effort of renovating the building and converting it to affordable senior housing. With assistance from the cooperative agreement, the green roof was incorporated into the redevelopment plans. For more information about the cooperative agreement, funded under the USEPA Targeted Watersheds Grant Program, please see the last page of this publication.

The 3,000-square-foot green roof was constructed with the following layers: a waterproof membrane, a plastic drainage layer, a fabric root barrier, and a 3-inch layer of specially engineered soil (crushed clay and organic matter). Low-growing, drought-tolerant species were planted, including 8 varieties of Sedum (*Sedum spp*.), chive (*Allium schoenoprasum*) and fame flower (*Talinum calycinum*). The structure of the original roof was sufficiently strong to bear the added weight of this green roof, without the need for structural enhancements.

Project Lead: Massachusetts Department of Conservation and Recreation (MA DCR)
Project Funding: U.S. Environmental Protection Agency (USEPA)
Project Host/Partner: The North Shore Housing Trust (subsequently merged with Harborlight Community Partners)
Project Design: K. J. Savoie Architecture
Project Installation: Magco Inc., A TectaAmerica Company
Green Roof Maintenance: Apex Green Roofs
Data Collection and Analysis: U.S. Geological Survey (USGS)

Monitoring study and research question

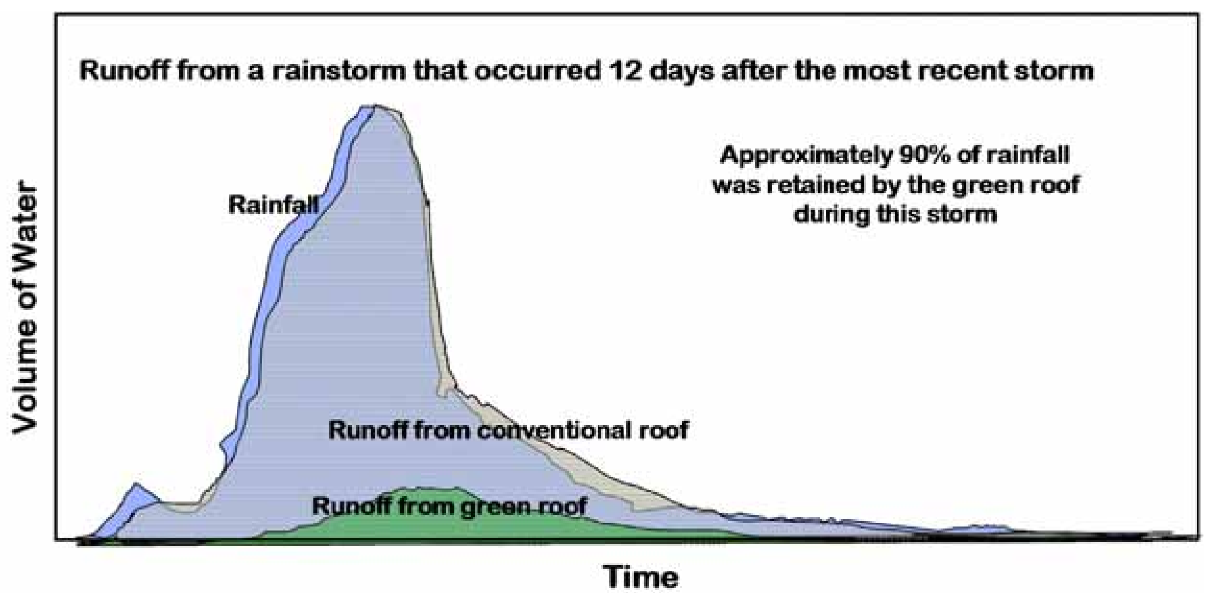
Does the demonstration green roof reduce stormwater runoff and pollution?

DCR contracted with the U.S. Geological Survey (USGS) to compare the quality and the quantity of the stormwater running off the green roof to that running off the conventional rubber roof on the adjacent building, Ipswich Town Hall. Both the green roof and the Ipswich Town Hall roof were fitted with flow gauges (to measure the rate and volume of runoff) and water quality samplers (to collect runoff for chemical analysis). A rain gauge was also installed on the Ipswich Town Hall roof to collect rainfall and keep track of total rainfall amounts. Rainfall and runoff from the two roofs were monitored for 18 months over 2007 and 2008. In all, 70 storms were analyzed for runoff volume, and 5 storms were analyzed for water quality. Contaminants investigated included nitrogen and phosphorus compounds and heavy metals.

Water quality monitoring station below the green roof— Photo: DCR

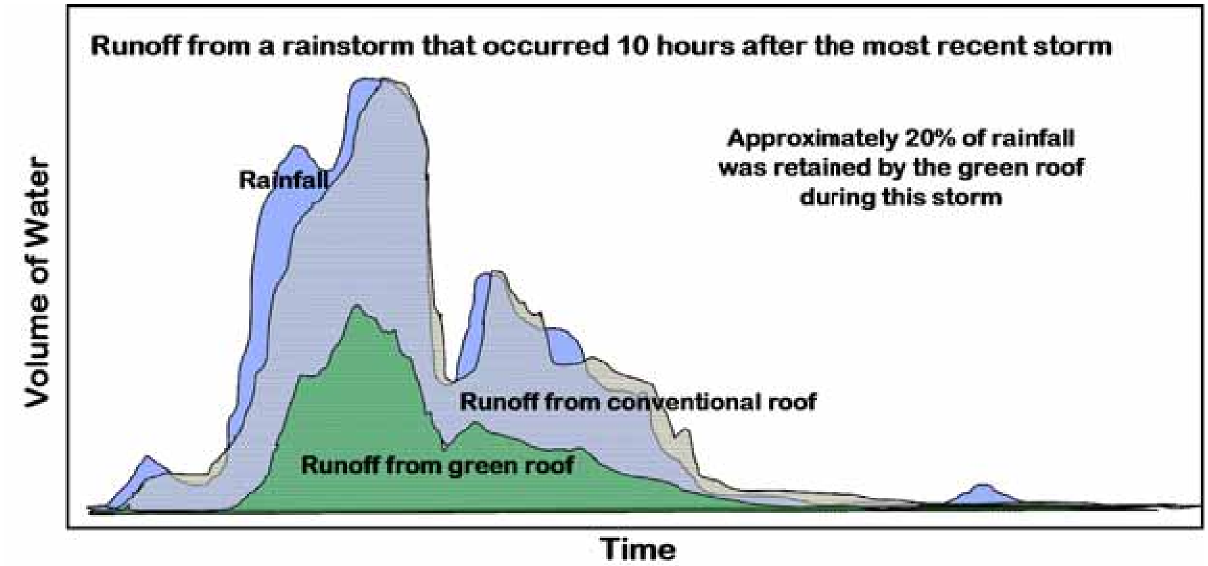
Water quantity findings

Overall, the green roof was very successful at capturing and holding water. Almost 100% of the rain falling on the Town Hall roof ran off quickly, whereas the green roof captured anywhere from 20% to 100% of rainfall in the soil, where it was taken up by plants or evaporated. The amount of rain captured by the green roof varied depending on how long it had been since the last storm. The longer the period of dry weather before a rainstorm, the drier the soil and the greater the volume of rainwater the green roof could absorb. Overall, the green roof retained over 50% of the rainfall from most storms. The green roof also delayed and slowed down the rate of runoff, releasing water slowly over several hours. Even when the green roof was still wet from a previous storm and could not hold much more water, runoff from new storms was often delayed by an hour or more. This type of delay and slow release reduces erosion and helps moderate spikes in flows that can damage stream channels and increase flooding.



This unitless conceptual graph shows that 90% of rainfall was retained by the green roof during a storm that occurred 12 days after the most recent storm. The amount of rainfall retained by green roofs depends, in part, on the period of dry weather preceding the storm.

Water quantity findings (continued)



This unitless conceptual graph shows that only 20% of rainfall was retained by the green roof during a storm that occurred 10 hours after the most recent storm. The green roof retained less rainwater in this case, because the soil was still holding water from the previous storm.

Water quality findings

Nutrients: Both the green roof and Town Hall roof runoff had measurable levels of nitrogen and phosphorus. Likely sources of these compounds include dust particles in the air ("atmospheric deposition"), leaves and pollen from nearby trees, and bird and insect droppings. Runoff from the green roof, however, tended to have higher levels of phosphorus compounds than the Town Hall roof, suggesting that organic matter in the green roof soil and the fertilizer that was applied to help the plants establish may have served as additional sources of phosphorus. Though fertilizer was applied at the time of construction and the following two summers, it is not expected to be used once the plants are fully developed.

Nitrogen and phosphorus compounds are called "nutrients" because they aid in plant growth. They are considered pollutants because when high levels of these nutrients are washed into water bodies, they lead to an overgrowth of plants and algae, which can reduce water clarity and the amount of oxygen available for fish and aquatic wildlife.

Metals: The amounts of heavy metals detected in the runoff from the two roofs seemed to reflect differences in roofing and drainpipe materials on each roof. For example, the building with the green roof retained the original copper flashing, and the runoff from this roof contained high levels of copper. Similarly, the older drainpipes used at Town Hall are suspected to contain lead, and the runoff from the Town Hall roof had high levels of lead. While these results do not necessarily help us understand the effect of green roofs on heavy metal contamination in general, they do highlight the importance of building materials as contributors of heavy metals in stormwater. The soil used on the green roof was also found to contain trace amounts of copper and zinc, elements which were found in this study.

Overall: The greatest water quality benefit of green roofs comes from stormwater retention—when the annual volume of rainfall that runs off a roof is reduced, the contaminants associated with that rainwater are also reduced. The findings from this study suggest that pollutant loads from green roofs may be even further reduced by selecting appropriate roofing and soil materials and using fertilizers sparingly.

Things to keep in mind

Groundwater recharge: In some areas, the primary danger to streams and wetlands is groundwater levels becoming too low. Groundwater replenishes streams and wetlands between rain storms, and when levels drop significantly, stream flow can drop too low to support fish and wildlife. Dropping groundwater levels can also lead to the drying of wetlands, which provide critical habitat to many species of plants and animals. Such conditions can occur when not enough rainfall is able to soak into the ground, because of extensive areas of pavement and rooftops. In these areas, rather than retain rain water on roof tops through green roofs, it can help the nearby streams and wetlands more to direct roof runoff to areas where it can soak into the ground, "recharging" groundwater levels. **Green roofs are most appropriate in areas where the primary dangers to streams and wetlands are flooding, erosion, and pollution.**

New versus existing buildings: Because of the increased weight of a green roof, buildings require greater structural support for a green roof than for many conventional roofs. Installing sufficient structural support at the time a building is being constructed can be more practical and less expensive than increasing the structural capacity of a roof already in place. **Therefore, from a cost perspective, green roofs are generally most appropriate in either new construction projects or on existing buildings that already have sufficient structural capacity for a green roof.**

Choosing the right system: Green roof technologies range from pre-planted modular systems to roofs in which the membrane, soil, and plants are assembled on site. The costs and practicality of different technologies depend on the roof size and slope, as well as installation and maintenance constraints. The following factors can also play a role: public access and safety, aesthetics, building codes, and historic designation. **A system should be chosen and designed based on the particular needs and opportunities of a site.**

Fertilization: While fertilization may be necessary in the first few years to establish the plants, care should be taken to minimize fertilizer application and choose fertilization techniques that minimize runoff of excess nutrients. **Green roofs should ideally be designed to thrive without any added fertilizers, once plants are established.**

The Ipswich River Targeted Watershed Grant

In 2004, through its Targeted Watersheds Grant Program, the United States Environmental Protection Agency (EPA) provided $1 million through a cooperative agreement to the Massachusetts Department of Conservation and Recreation (DCR) to demonstrate and study practices to help conserve water, reduce storm water pollution, and increase groundwater recharge throughout the Ipswich River watershed, in northeastern Massachusetts. Under this cooperative agreement, four low impact development (LID) and five water conservation projects were undertaken by DCR in cooperation with EPA, the United States Geological Survey (USGS), eight municipalities, the Ipswich River Watershed Association, and other cooperating partners. The projects were designed to (1) implement and quantify the benefits of LID and water-conservation techniques and (2) evaluate the impact of wide-spread application of these techniques throughout the watershed, using computer modeling simulations. Additional funding for this work was provided by DCR; USGS; the Ipswich River Watershed Association; and the towns of North Reading, Reading, Topsfield, and Wilmington. In-kind support was provided by DCR; the towns of Hamilton, Ipswich, Middleton, North Reading, Reading, Topsfield, Wilmington, and the city of Peabody; AquaSave LLC; the Martins Companies; the North Shore Housing Trust (since merged with Harborlight Community Partners); and Rainwater Recovery.

This is one in a series of three fact sheets that describes the work conducted under the cooperative agreement. The complete series includes:

- **Ipswich River Targeted Watershed Grant Fact Sheet: Green Roof Case Study**
- **Ipswich River Targeted Watershed Grant Fact Sheet: Water Conservation Case Studies**
- **Ipswich River Targeted Watershed Grant Fact Sheet: Three Low-Impact Development Case Studies**

For more information on the Ipswich River Targeted Watershed Grant, including links to study results and other publications, please visit:

http://www.mass.gov/dcr/watersupply/ipswichriver/index.htm.

The Massachusetts Department of Conservation and Recreation (DCR), an agency of the Executive Office of Energy and Environmental Affairs, oversees 450,000 acres of parks and forests, beaches, bike trails, watersheds, and dams, whose mission is to protect, promote, and enhance our common wealth of natural, cultural, and recreational resources. To learn more about DCR, our facilities, and our programs, please visit www.mass.gov/dcr. Contact us at mass.parks@state.ma.us.

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Department of Conservation and Recreation

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