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# Low Impact Storm Water Management Projects at the University of New Hampshire

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# Low Impact
# Storm Water Management Projects
# at the University of New Hampshire

A Final Report to

the New Hampshire Estuaries Project

Submitted by

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## I. Project Summary

The University of New Hampshire has become increasingly concerned with storm water management on the Durham campus. Due to Federal regulations many regional municipalities are feeling pressure to enhance and increase management of storm water to reduce impacts to surface waters. The specific objective of this proposal is to demonstrate reductions in the discharge of storm water runoff from UNH-Durham campus properties. The construction and use of three Low Impact Development (LID) integrated management systems on UNH property will help UNH and the UNH Stormwater Center to champion innovative approaches in the state and region for reducing storm water runoff and improving the health of coastal watershed areas.

## II. Project Description

LID is a storm water best management practice (BMP) involving the use of small-scale storm water management controls that are placed at strategic points to control the impacts of contaminants generated from storm water runoff from transportation infrastructure. These sustainable management measures are designed to filter pollutants, control peak flow rates, and reduce the total volume of rainfall runoff.

The project site was the University of New Hampshire (UNH), located in Durham, New Hampshire. The primary campus is comprised of 300+ buildings located on 1,100+ acres of predominantly developed land, including impermeable roof and ground surface. The ongoing concern about managing storm water at UNH was in harmony with a number of NHEP highest priority action items. The project was an excellent opportunity to demonstrate how to confront coastal storm water problems common to UNH and coastal municipalities by using LID strategies in effective, yet low-cost and easily adoptable ways. Specific project objectives achieved through this project include the following:

- Construction of demonstration-level BMP’s at two high profile locations on the UNH campus.
- Creation of self-guided descriptions of and outreach material for the three innovative storm water management BMP’s installed.
- Development and initiation of an outreach and education program
- Estimations of runoff volume reduction and pollutant load reduction from BMP’s.

## III. Project Site Selection

Collaborations between NHEP, the UNH Jackson Estuarine Laboratory, UNH Environmental Hazard and Safety Office (EHS), UNH Facilities, UNH Stormwater Center, and SkyJuice New England all contributed to successful completion of the project. In order to maximize visibility and outreach impact two high profile locations were chosen.

a.) UNH Stormwater Center

The UNH Stormwater Center had several areas that could accommodate additional LID systems beyond those involved as pilot systems in experiments. One area was the on-site building that houses the monitoring equipment for the pilot systems. The installation of a rainwater runoff cistern and irrigation system would serve to minimize the impact of the roof runoff on nearby systems.

In addition, specific attributes of the UNH Stormwater Center made it a compelling location for fulfillment of project objections. First, it is the University's storm water research headquarters and was already the site for research on a variety of LID applications. Second, the center plays host to hundreds of storm water technology end-users through on-going technical workshops. The backgrounds of workshop participants are wide ranging and include town council, planning and conservation board members, consulting engineers, watershed alliances, state (MA, NH, VT, ME) and federal DOT environmental agencies federal Coastal Training Programs, NEIWPCC, NEWWA, NHWWA, NHEP, MACZM, local municipal officials, town engineers, and other researchers involved or interested in BMP design and stormwater management. Increasingly organizations such as the New England Water Works Association are choosing to host annual meetings, technical workshops, and conference venues at UNH in order to demonstrate first hand the research products of the center. These outreach and education efforts are critical to the success of any program. All of these attributes provided a high exposure venue for introduction, demonstration, and reporting on appropriate source control BMP's that can be incorporated in storm water management plans.

b.) UNH Jackson Estuarine Laboratory

This UNH Jackson Estuarine Laboratory (JEL) is a prime location for LID demonstrational techniques. Governors, congressmen, researchers, outdoor enthusiasts, educators, school children, researchers and college UNH classes and individual students visit JEL throughout the year, making it a great educational opportunity. The lab is built at the edge of the Great Bay Estuary. This critical receiving water would obviously benefit from integrated LID strategies that intercept and treat storm water runoff from surrounding impervious surfaces. In addition, the well that serves JEL freshwater needs occasionally is inadequate for meeting demands, and augmentation of freshwater supply would benefit the ongoing research projects at the lab.

The conditions at the Jackson Estuarine Laboratory prior to the project resulted in large volumes of runoff from the parking lot and building surfaces that flowed over small, steep-sloping shoreline areas and unimpeded into the estuary. The project focused on two of the most critical areas, the parking lot and associated runoff that flowed down the paved walkway stairs, and the roof runoff that fell onto the narrow area of lawn between the lab building and the shoreline riparian zone. The intent was to construct a LID to intercept runoff from flowing off the parking lot and down the walkway, and to intercept some of the rainfall runoff from the roof on the side facing the water to enable re-use. The two installed project BMPs currently help treat runoff from the 8,750 square feet of impervious roof footage and runoff from the impervious land area covered by the parking lot and access road.

## IV. Project Outcomes

a.) Rainwater storage: UNH Stormwater Center and UNH JEL

Rain water runoff cisterns are roof water management devices that provide on-site storm water retention capacity. On-site storage combined with later reuse of storm water provides an opportunity for water conservation with significant reduction of utility costs, and can help to mitigate impacts of runoff in fragile riparian areas.

A 550 gallon cistern was installed at each site location. Each cistern is 48" x 72" HDPE plastic and is green in color to minimize light penetration and limit algae growth. All system require low maintenance regimes that include annual inspection for leaks and built up sediments and winterization, or emptying prior to freezing conditions.

A. at JEL: 1) gutter serving 400 $ft^2$ of roof; 2) hooked up to cistern via a 20 ft length of downspout with a valved shut off; 3) overflow pipe; 4) a ¾ HP jet pump with pressure tank to supply pressurized output to an adjacent spigot.
B. at SC: 1) gutter serving 200 $ft^2$ of roof; 2) hooked up to cistern via a 5 ft length of downspout; 3) overflow pipe; 4) a ¾ HP jet pump with pressure tank to supply pressurized output to an adjacent spigot.
C. At SC: 500 ft of drip irrigation tape was installed with a pressure reducer and inline filter to efficiently water existing landscaping at the site.

See appendix A for unit specifications. The attachment is part of an informational package that is delivered to all visitors of technical demonstration workshops for the UNH SC.

b.) Tree filter bioretention cell: UNH JEL

A tree filter bioretention cell is a storm water management technology that treats storm water through manufactured soil and conditioned planting of biologic retention materials and landscaping. The bioretention concept is designed to detain and filter storm water runoff before it is conveyed to local receiving waters. A tree filter bioretention cell was installed at the UNH JEL to treat runoff from the lab's parking area. The system also served to eliminate erosion that had been occurring bordering the walkway and weathering of walkway materials. The Bioretention Tree Filter Cell is composed of a 6' diameter 4' deep concrete catchbasin with an internal 8" by-pass and an 8" underdrain. The catchbasin is open bottomed to facility infiltration and ground water recharge. The underdrain and sub-base in bedded in 1' of ¾" crushed stone and the catchbasin was backfilled with a constructed soil media mix consisting of 80% sand, 10% hardwood chips, and 10% compost. To develop a vegetative biotic root zone, a native shrub, Viburnum Opulus 'Roseum' was planted along with perennial rye grass. The tree filter was designed to treat a one inch rainfall event (92% recurrence interval) off of 0.14 acres of impervious parking area with a peak flow of 0.1 cfs. Storms larger than 1 inch will ultimately by-pass however the first 1 inch, or "first flush" of a large rainfall event is still treated. The system requires low maintenance regimes that include annual inspection for vegetation health, evidence of internal and external erosion, and built up trapped sediments.

See appendix A for unit specifications. The attachment is part of an informational package that is delivered to all visitors of technical demonstration workshops for the UNH SC.

c.) Self-guided descriptions of innovative storm water management BMP's
An important component of this project was to introduce potential beneficiaries, including municipal, UNH, and state environmental managers to LID approaches to storm water management. To facilitate this, self-guided informational exhibits have been designed and installed at each demonstration facility in accordance with UNH policies. The exhibits consist of a steel stand and laminated data sheets describing project objectives, technical design, treatment summaries and contact information, re: UNH Stormwater center. The signage also acknowledged the NHEP support and the UNH partners. The exhibits inform interested parties of the scientific rationale, regional impact, and strategic significance of LID storm water management techniques.

d.) Outreach and education program
LID storm water management pilots pose an educational opportunity for many UNH academic program participants. University undergraduate and graduate students have been directly involved in LID construction, hydrological assessments, and native plant selection. Two environment and engineering classes have visited the demonstration sites so far. The number of participants exposed to project results through UNH Stormwater Center technical workshops have been tracked and total over 860 participants since 2004 as of August 31, 2006.

## V. Estimation of Runoff Volume and Pollutant Load Reduction

Low technology, easily adoptable LID storm water management strategies are a recent phenomenon. Scientific data validating the adoption of such logical strategies must be documented. A hydrological assessment and estimation of the regional impact is necessary to the continued adoption of such approaches and is provided in this report.

a.) Volume Reduction
To quantify rainfall volume reduction, rainfall runoff curves were used and compared with three months of rainwater catchment/re-use data collected at the UNH Stormwater Center facility. In general one inch of precipitation on one square foot of impervious surface yields 0.6233 gallons of runoff. Thus 1,000 $ft^2$ of impervious surface will yield an average of 623 gallons of water. A 10% initial reduction collectable runoff volume is generally assumed to account for initial abstraction and loss due to inefficiency in conveyance systems. The calculation used to determine total runoff catchment potential is thus:

$$\text{Runoff} = \frac{\text{Area } (ft^{2}) \times \text{Rainfall (in)} \times 561}{1000}$$

Collection at the UNH Stormwater Center:

Rainfall conditions, water collection and reuse were measured over a 3-month period at the Stormwater Center installation (Table 1). The collection area for the 550-gallon cistern installation was 200 $ft^2$. Due to the small, demonstration size of the facility all rainfall any rainfall collected was subsequently used for drip irrigation reuse.

| Month | Rainfall (in) | Runoff (gallons) | Rainfall Collected | Runoff Reduction |
|---|---|---|---|---|
| June | 4.45 | 499 | 499 | 100% |
| July | 2.53 | 284 | 284 | 100% |
| August | 2.39 | 268 | 268 | 100% |

Table 1: Measured water collection and re-use for the UNH SC installation

Collection at the UNH Jackson Estuarine Laboratory:

The 550 gallon cistern was installed just prior to winter 2005/2006. The collection area consisted of a 10 ft length of gutter installed on the far southern rear corner of the laboratory building yielding a relative collection area of 400 $ft^2$. Due to the small, demonstration size of the facility all rainfall any rainfall collected (Table 2) was subsequently used for non-potable water needs.

| Month | Rainfall (in) | Runoff (gallons) | Rainfall Collected | Runoff Reduction |
|---|---|---|---|---|
| June | 4.45 | 998 | 998 | 100% |
| July | 2.53 | 568 | 568 | 100% |
| August | 2.39 | 536 | 536 | 100% |

Table 2: Estimated water collection and re-use for the UNH JEL installation

b.) Pollutant Load Reduction

The impervious watershed treatment area for the JEL Bioretention tree filter consists of 6,086 $ft^2$ of impervious surface. Pollutant loading calculations are determined using the EPA spreadsheet method (EPA, 2005) with NURP contaminant loading rate estimations (EPA, 1983). Bioretention tree filter removal efficiencies have been calculated using existing field data collected by the UNH Stormwater Center (Table 3).

| | **TSS (mg/L)** | **NO3 (mg/L)** | **Zn (mg/L)** |
|---|---|---|---|
| Loading | 253.7 | 3.22 | 1.14 |
| Removal | 248.6 | 1.54 | 1.13 |
| Effluent load | 5.07 | 1.67 | 0.01 |
| **% Reduction** | **98%** | **48%** | **99%** |

Table 3: Pollutant BioretentionTree Filter Pollutant Load Reduction

## V Conclusions

This project demonstrates the effectiveness and efficacy of low technology LID strategies for stormwater management and control on the UNH campus. The demonstration projects have already been a feature in many important site visits and on-going local programs including visits from Governor Lynch, NHEP funded estuary cruises, and UNH SC technical workshops. Many of these educational programs are on-going and will continue to benefit from the functionality of the demonstrational installations developed through this project.

The source and runoff reduction strategies represented by the rainwater harvesting cisterns and drip irrigation system proved to be effective strategies to control runoff at its source. Many impervious surfaces provide great opportunities for runoff collection and reuse strategies. In the JEL cistern installation, the quantity of rooftop runoff was only limited by the size of the collection system. Opportunities for the expansion of such source reduction strategies can be supported by the findings in this study. The augmentation of the JEL freshwater supply for non-potable uses was also a critical benefit for this remote facility that depends on well water.

The biorention tree filter installation at the UNH JEL facility remains the only stormater management device employed at the facility. Its potential for contaminant removal and educational impact has been well established and will remain an asset for years to come. As the plants, including the grass and Viburnum shrub, mature, more effective filtration of contaminants and uptake of nutrients is expected. The immediate benefit of reducing flow down the walkway stairs has eliminated erosion problems and decreased the weathering of walkway materials, both of which will reduce maintenance costs. The installation has also eliminated most of the runoff from the parking lot from reaching the estuarine waters.

## VI References

U.S. EPA (2005). "Handbook for Developing Watershed Plans To Restore and Protect Our Waters." U.S. Environmental Protection Agency, Washington, DC. www.epa.gov/nps/watershed_handbook/pdf/ch09.pdf

U.S. EPA (1983). "Results of the Nationwide Urban Runoff Program Volume I – Final Report. Water Planning Division." U.S. Environmental Protection Agency, Washington, DC.

## APPENDIX A

The following specification documents are part of an informational package that is delivered to all visitors of technical demonstration workshops for the UNH SC.

## Rainwater Harvesting

Rainwater harvesting is an ancient technique increasingly recognized as an effective Low Impact Development (LID) strategy due to its potential to control the generation of stormwater runoff and water's inherent usefulness as a local resource. Rainwater harvesting systems can be sized for any application. They can be as simple as a 55 gallon rain barrel for garden irrigation at the end of a downspout, or as complex as a commercial potable supply system. Key design considerations should include total capture area, catchment overflow and a first flush roof washing system depending on local pollutant loading conditions.

550 gallon cistern installation collecting rainfall runoff from a guttered roof.

| Coastal New Englan Rain Catchment Potentials | | |
|---|---|---|
| Roof Size (square feet) | Gallons per 1 inch of rain | Annual total (based on 44 inch annual average) |
| 1,000 | 562 | 24,728 |
| 1,100 | 618 | 27,201 |
| 1,200 | 674 | 29,674 |
| 1,300 | 731 | 32,146 |
| 1,400 | 787 | 34,619 |
| 1,500 | 843 | 37,092 |
| 1,600 | 899 | 39,565 |
| 1,700 | 955 | 42,038 |
| 1,800 | 1,012 | 44,510 |
| 1,900 | 1,068 | 46,983 |
| 2,000 | 1,124 | 49,456 |
| 2,100 | 1,180 | 51,929 |
| 2,200 | 1,236 | 54,402 |
| 2,300 | 1,293 | 56,874 |
| 2,400 | 1,349 | 59,347 |
| 2,500 | 1,405 | 61,820 |

### WQ Treatment and Stormwater Benefits

Advantages and benefits of rainwater harvesting are plentiful. The water is typically free; rainwater harvesting reduces flow to stormwater drains and in turn reduces non-point source pollution. Rainwater harvesting can help utilities reduce demands and delay expansion of existing water treatment plants. Rainwater is captured and used locally so it can also serve to replenish groundwater levels and recharge local aquifers.

**Category Type**
Source Control

**BMP Type**
Low Impact Design

**Design Source**
UNH Stormwater Center

**Dimensions**
550 gallon capacity
48" wide x 72" tall

**Treatment Functions**
Source Control and water reuse.
Prevention of rainfall runoff, efficient utilization of water resources and minimization of water input needs

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## Bioretention Tree Box Filter

A tree box filter consists of an open bottom concrete vault filled with a porous soil media planted with vegetation and underlain by an underdrain in crushed gravel. Stormwater runoff enters the device from streetside and passes through the media into the subgrade and underdrain. The underdrain carries the treated runoff to either a surface discharge location or to the stormwater sewer system. The tree box filter used at this 0.1 acre site is an economical 6 foot diameter concrete manhole riser filled with a two feet thick sand-compost mix (76% sand/ 24% compost). The mix was designed to maximize permeability while providing a minimum organic matter of 10 percent to sustain tree health and adsorb pollutants. At the surface, there is a two-inch mulch layer and gravel pad where flow enters to dissipate energy. A two-inch caliper inundation-tolerant ash tree planted is planted in the center. An overflow is set approximately six inches above the sand-compost mix. Flows that pass through the filter media and into the overflow are collected in an underdrain that eventually discharges onto a riprap pad and swale. This unit features a bottomless unit that allows for infiltration of water pooled in the 12 inches of high porosity crushed gravel below the underdrain. Maintenance is anticipated to consist of occasional trash removal and raking of surface to maintain permeability. The life of the tree is expected to be 5 to 10 years, similar to standard street trees. The surface can optionally be planted with inundation-tolerant and hardy shrubs and herbaceous vegetation.

Bioretention tree box filter after installation (left). Close-up of the coarse sand-compost media used in the tree box filter. This 76% coarse sand/24% compost mixture has 10% organic matter and infiltrates water at a rate of 14.6 inches/hour in the laboratory (right).

**Category Type**
Filtration, Infiltration

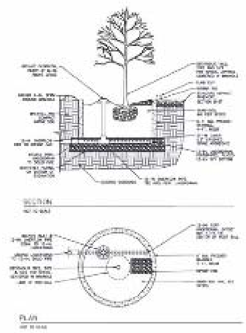
**BMP Type**
Low Impact Design

**Design Source**
UNH Stormwater Center

**Dimensions**
Diameter: 6 ft
Depth: 4 ft

**Specifications**
Catchment Area: 0.14 acre
Peak flow: 0.1 cfs
Treatment Volume: 425 cf
Vegetation: Viburnum Opulus ëRoseumí

**Treatment Functions**
Physical-Chemical and Biological, Filtration



### Water Quality Treatment Process

The tree box filter is designed primarily for water quality treatment. Tree box filters can be ideal solutions for new construction or for retrofits to existing catch basin inlets, especially in urban environments where space and cost are primary concerns. Water quality treatment occurs through filtration and adsorption in the sand-compost mix. Some biological treatment is expected within the microbe rich soil-root matrix. This research will examine water quality treatment performance. For bottomless units, there will be some runoff retention and groundwater recharge, especially on sites where high permeability soils underlie the tree box filter. Tree box filters can be combined with a downstream manhole that provides additional settling of solids. An alternative patented design made by AmeriCast and called the Filterra have sealed bottoms so infiltration and recharge do not occur, which may be desirable if highly contaminated stormwater is anticipated and/or the subgrade has a low infiltration rate.

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