Rice Urban Laboratory for the Environment (RULE):
A Summary of the New Low Impact Development Laboratory on the Rice University Campus

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The Civil and Environmental Engineering (CEE) department, in partnership with the Administrative Center for Sustainability and Energy Management (ACSEM) and Facilities Engineering and Planning (FE&P), has created the Rice Urban Laboratory for the Environment (RULE) to study the hydrologic and water quality impacts of green infrastructure systems in Houston. RULE focuses on the design, construction, and monitoring of Low Impact Development (LID) features for stormwater management on the Rice Campus.

Background:

Harris County Flood Control defines LID as: a comprehensive land planning and engineering design approach with the goal of maintaining, as the minimum, the pre-development hydrologic regime in a watershed without solely using conventional development and detention basin techniques to satisfy drainage and flood mitigation requirements. LID features include vegetated conveyance channels, retention basins, and green roofs which function to slow, filter, and limit the overall flow of rainwater runoff into municipal stormwater systems. National awareness about the benefits of Low Impact Development has been growing over the past decade, largely due to the research initiatives at universities. LID research labs at the University of Maryland, Villanova University, North Carolina State University, and Drexel University, amongst others, have all directly influenced city and county-wide adoption of low-impact stormwater management practices through significant contributions to performance analysis and improved design methods for LID in their respective regions. Although LID implementation and effectiveness has been well documented in the Northeast and East Coast regions, little is known about the capacity for these strategies to be effectively transferred to other climatologically varied regions, specifically regions with high-intensity rainfall events and low-permeability soils, such as Houston.

The LID features associated with the implementation of RULE on the Rice Campus provide three main benefits:

1. Reduce impervious surfaces on the campus in order to reduce the flooding hazards due to increased infiltration and retention and to improve water quality of storm runoff through the filtration of pollutants
2. Provide Rice University researchers and students the educational opportunity to monitor LID features in real-time rain events and simulated events to better understand functionality for design, modeling, and implementation
3. Provide public outreach and education to the community about the effectiveness of LID in Houston and provide opportunities for outside industry and partners to utilize the features as learning tools and test facilities for LID engineering products
Flooding and Water Quality:

The benefit of implementing different LID features on the Rice campus through the RULE program is the reduction of total volume and intensity of stormwater runoff, an issue that currently plagues many areas of the campus and surrounding community. In addition to providing pervious area for infiltration of water and retention of some volume of water, the RULE features also help to improve the quality of the water that does enter the storm sewer network below campus and eventually Brays Bayou.

Rice University Educational Opportunities and Research:

The RULE on-campus laboratory provides the invaluable opportunity to monitor LID features and collect data on water storage capabilities, water quality parameters, and provide data that can be used to calibrate models of LID features both individually and on a watershed scale. The ability to model LID effectively in the Houston region is a great tool for future development plans not only on the Rice campus but for the Houston community. Water quality parameters such as bacteria (E.coli) and nutrients (Phosphorus and Nitrogen) present in runoff are key measurements necessary to understanding the performance of LID features. Current LID features installed around the city were designed based on data from other climatic and topographic regions and have not been verified for performance after their construction. Understanding the performance of these features in a local climate rather than through its design standards allows for Rice and the greater Houston community to utilize these features for stormwater management in a more effective manner through better design and planning.

Public Outreach and Industry Collaboration:

In addition to providing a living laboratory for much-needed research on green infrastructure performance, RULE offers the opportunity for community partnerships for the education and engagement of government and consulting groups on the topic of green infrastructure. Conferences and seminars are held regularly, giving the campus community and outside parties the opportunity to learn about LID features in a safe and controlled environment. Displays at each feature provide the opportunity for passive education; as pedestrians and students pass the features, they can learn about the science and engineering behind the feature and about the monitoring activities that take place at the feature. RULE also provides companies specializing in LID feature products and media the opportunity to use our laboratory features to test and analyze their individual products, such as different engineered soil or filtration membranes. This collaboration not only benefits the RULE features by providing technology, but results of controlled monitoring activities can be used to inform the company on the effectiveness of their product. The continued outreach of the RULE features to the public and outside industry provides a benefit to Rice and the RULE initiative through potential funding sources, short-term applicability to industry development, and long-term education of the community on flooding issues and solutions in Houston.
Appendix A: Potential location for new LID features

1: Glasscock School of Continuing Studies

Brief Description of the location:

The LID feature would be situated in front of the newly built school.

Type of LID feature(s) to be installed: bioswale, tree boxes

Why this is a good location for feature?

As one of the newly constructed buildings on campus, it has its own small detention feature in the front of the building. This detention feature could be updated to become a vegetated swale with native plant species and engineered soils (see appendix A for description of vegetated swale). This location will also be ideal for educational material around the feature since by nature people are coming there to expand their knowledge.

2: Anderson Lab

Brief Description of the location: This is behind Anderson Lab and in front of the Weiss Building for Natural Sciences.

Type of LID feature to be installed: bioswale with underground storage

Why this is a good location for feature?

This is an isolated location with very little foot traffic. It would also allow for collaboration with the ecology department on native species and with the earth science department to study soil properties.

3: Engineering Quad

Brief Description of the location: In front of Mechanical Laboratory Building

Type of LID feature to be installed: vegetated swale, bioswale, tree boxes

Why this is a good location for feature: Since the center would be based out of the CEE department to have features in front of the CEE bldg. is ideal. It is also a very central place on campus that would allow for people to see these features and learn about them. It would also allow for more direct access to the features for monitoring. It would be a great tool for professors in the department.

4: Central Quad

Brief description of the location:

Type of LID feature to be installed: vegetated swale, tree boxes

Why this is a good location for feature: An area with a lot of traffic. This location would be ideal for the educational component of this project.
5: IM fields
Brief Description of the location: The deep ditches located on each side of the IM fields 6 and 7 near Weiss.

Type of LID feature to be installed: vegetated swale, tree boxes

Why this is a good location for feature: Already there are very deep ditches that carry water these could be retrofitted to have more native species and bioengineered soil.

6: Anderson School of Architecture:
Brief Description of the location: the side of the building facing the inner loop.

Type of LID feature to be installed: vegetated swale

Why this is a good location for feature: Being located on the inner loop, this spot is primed for flooding whenever it rains. Also being in front of the Architecture school, it allows students interested in landscape architecture to help design and monitor the LID feature.

7: Herzstein building
Brief Description of location: Located in the academic quad, this is one of the first buildings that was built on campus. The area surrounding it is often flooded during storm events.

Type of LID feature to be installed: vegetated swale

Why this is a good location for feature: An area known for holding water and the vegetation there is currently not doing much. It would allow for water to be held there and not flood the academic quad.

8: West Lot Parking Lot

Brief Description of location: In between the Sheppard School of Music and the stadium.

Type of LID feature to be installed: vegetated swale

Why this is a good location for feature: This area can become very dangerous when it floods, having small swales in between rows of cars would allow for some control of water.
Enhancing Current LID Features

Rice University is currently home to several LID features. Very little to no monitoring has been performed on these features. The Rice Urban Lab recognizes the benefit they bring to campus by assessing their performance in stormwater control and water quality improvements. Retrofitting these features for monitoring is not costly and could be done quickly.

Filter Strips

Green Roofs
APPENDIX B:  
DESCRIPTION OF PROPOSED LID FEATURES

Vegetated Swale:  
A vegetated swale (also known as a “grass swale”) is a shallow stormwater conveyance channel typically lined with turf or other native vegetation that can be used to replace a conventional curb and gutter system. The increased roughness of the vegetated channel has the ability to both slow the flow of runoff, thus decreasing the time of concentration and peak discharge, and to filter gross stormwater pollutants. Vegetated swales vary in size depending upon catchment area, but are commonly used to treat and collect low-velocity runoff from roadways or other small, low-sloping catchment areas. Ordinary grassed swales are relatively inexpensive and easy to retrofit (USDOT 1996).

Sedimentation is the primary pollutant-removal mechanism in vegetated swales. The effectiveness of these features depends largely on swale dimensions (slope, depth of flow, vegetation density)

Figure 1: Perspective cutaway view of a typical vegetated swale (Source: Harris County LID Design Guide)

Figure 2: Grassed Parking Lot Swale in Veneta, OR (Source: greengirlpdx.com)
Bioretention systems:
The term “bioswale” is used to refer to a hybrid LID feature that functions as both a bioretention system and a conveyance swale. It can also be thought of as an enhanced vegetated swale that uses the chemical, biological, and physical biofiltration properties of microbes, soils, and plants to treat, store, and convey runoff. Bioswales have similar water quantity benefits to vegetated swales, but are generally designed to remove a wider range of pollutants to a higher degree. Bioswales, especially in regions with low-permeability soils, are often designed with extra below-ground storage capacity to prevent surface ponding as well as an underdrain and overflow/bypass system for larger storm events. Retention is possible with a bioretention system if the outlet opening can be controlled to store or release water. Bioswales are generally constructed with engineered soil materials to improve treatment and infiltration capacity and planted with native vegetation with specific filtration properties. These features can be connected downstream of vegetated swales or filter strips in a “treatment train” configuration.

Figure 3: Section view of a typical bioswale (Source: Harris County LID Design Guide)

Figure 4: Upstream (left) and downstream (right) views of Birnamwood Dr. bioswale located in northern Harris County
**Tree Box Filter:**
Tree box filters are small-scale compartmentalized bioretention systems which utilize the space around and below street trees to filter and retain stormwater runoff from paved surfaces. Tree box filters are typically planted in series in the public right of way along roadways and consist of concrete-enclosed “pits” of mulch or engineered soil mixture. Runoff from impervious surfaces is directed into the tree box where it is infiltrated and filtered into an underdrain system which empties into the municipal storm-sewer system.

![Figure 5: Schematic of a typical tree box filter (Source: Harris County LID Design Guide)](image)

![Figure 6: Tree filter boxes in Milton, MA (Source: Neponset River Watershed Association)](image)

**Summary:**

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Effect or Function:
- **Slow Runoff:** Reduces runoff volume
- **Filtration:** Filters contaminants from stormwater
- **Retention:** Stores stormwater temporarily
- **Detention:** Delays stormwater flow to downstream systems
- **Evaporation:** Evaporates stormwater
- **Water Quality:** Improves stormwater quality
References:


