Assessing the Performance of Bioretention and Sand Filter Basins in a Single Full-scale Low Impact Development (LID) Testbed

Michelle Barkley, Abtin Shahrokh Hamedani, Maya Abounasr,
Dr. Hanieh Soleimanifar, Dr. Heather Shipley, and Dr. Marcio Giacomoni
Department of Civil and Environmental Engineering, University of Texas at San Antonio (UTSA)

Abstract

Urbanization changes the natural land cover to impervious surfaces, which results in decreased infiltration, increased runoff and increased washed off pollutants in the stormwater runoff. Stormwater management strategies such as Low Impact Development (LID) are control measures designed to restore the hydrologic flow regime and enhance the quality of stormwater. The performance of LID systems is highly dependent of design parameters such as the filtration media, and local conditions such as climate. To compare performance of three different LID designs under same conditions, a full-scale LID testbed was designed and implemented at the University of Texas at San Antonio (UTSA) main campus.

Introduction and Background

San Antonio is one of the fastest growing cities in the United states and is located on top of the **Edwards Aquifer** recharge zone, which

- is the main water supply for south-central Texas
- is under extreme pressure due to increased water demands and prolonged droughts
- provides habitant for endangered species
- is listed in the top ten endangered karst ecosystems

Sand filter basins and bioretention areas are the most-commonly used LID practices to mitigate negative impacts of urbanization on the Edwards aquifer, however their performance is limited and impacted by various factors.

Sand Filter Basins - Physical Treatment

+ Reduce peak runoff, runoff volume
+ Remove particulate pollutants

– Non-aesthetic and unattractive
– Not effective in removal of dissolved pollutants


Sand filter basin

Bioretention Basins - Physical & Biochemical Treatment

+ Enhanced water quality
+ Removal of dissolved pollutants
+ Aesthetic and habitant for pollinators and particular bird species

– Requires careful construction
– High maintenance and costly

Rain Garden

Objectives

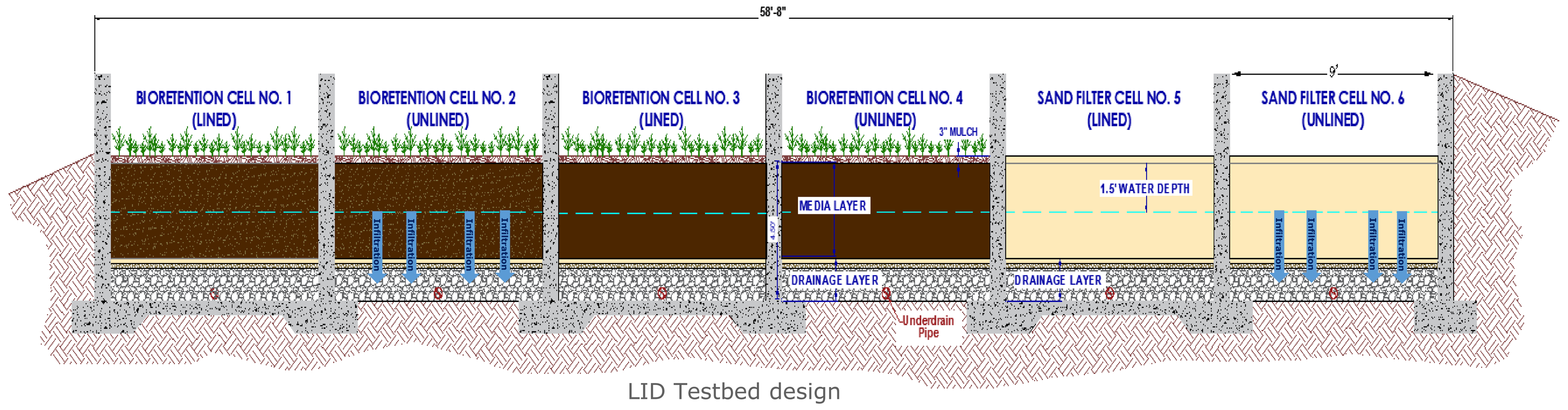
- **Develop extensive datasets on stormwater characteristics and performance of LID systems that will enable us to**
- Comparative evaluation of hydrologic and treatment performance of sand filter and bioretention basins under same conditions
- Inclusive comparison of lined and unlined LID designs
- Identify enhanced LID designs that provide effective stormwater control and allow safe and sufficient recharge of the aquifer.
- Develop models to study the soil-plant interaction, flow path and fate transport

LID Testbed Design

The LID testbed is composed of six parallel cells (9ft*30ft*4.5ft) filled with three different filtration media

- **Innovative limestone mixture (limestone sandy loam)** (cells 1 & 2)
  Limestone sand (85-88%), fines (8-12%) and organics (2-5%)
- **Standard biofiltration mixture (sandy loam)** (Cells 3 & 4)
  Regular sand (85-88%), fines (8-12%) and organics (2-5%)
- **Regular sand** (Cells 5 & 6)

It drains approximately 2.67 acres of parking lots, rooftops and landscapes with overall runoff coefficient of 0.69 and time of concentration of 21.5 minutes.



LID Testbed design

The three LID designs are tested in duplicates - with and without impermeable liner - to investigate the impact of liners on the potential impacts of the direct infiltration on water quality and aquifer recharge.

Bioretention Cells are vegetated with three native plants:

Pink Muhly

Inland Sea Oats

Frogfruit

LID testbed Monitoring

Testbed Monitoring

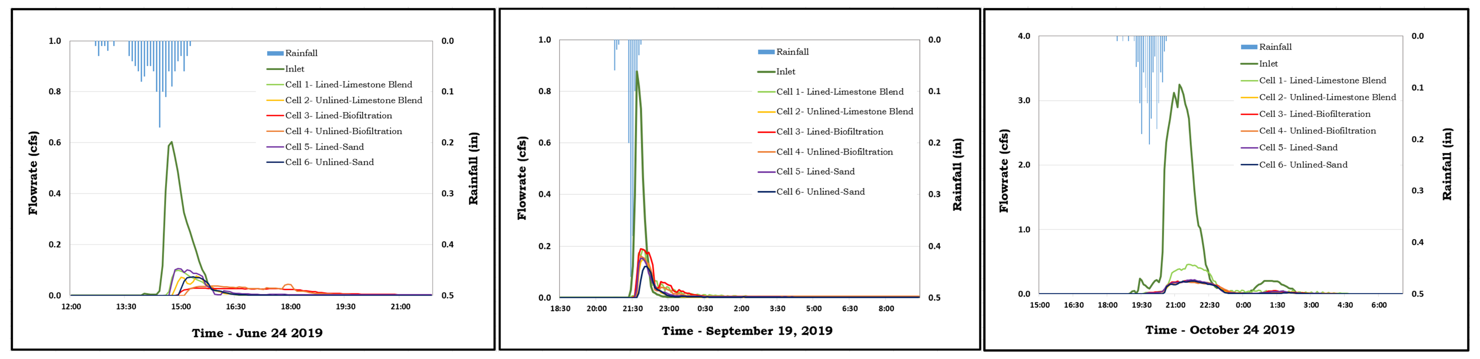
- One-year pre-construction monitoring of the inlet
- Two-year post-construction monitoring of the testbed

▪ **Stormwater Quantity**
Monitoring the rainfall, flowrate, water level and soil moisture

▪ **Stormwater Quality**
Flow-paced sampling at the inlet and six outlets to assess the removal efficiencies of:

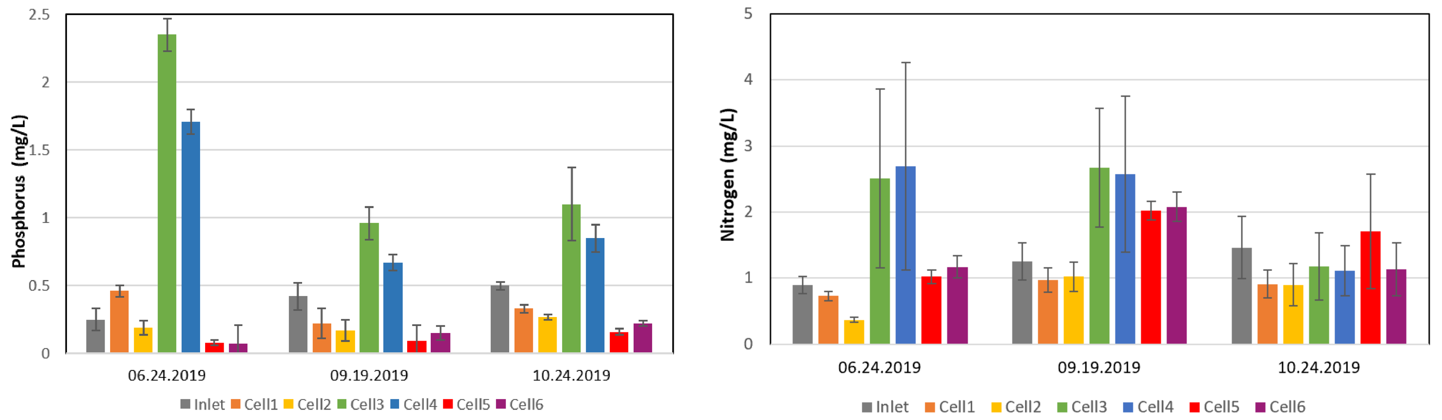
Total and Volatile Suspended Solids (TSS&VSS-mg/L)
Total coliform bacteria and E.Coli (CFU)
Dissolved and total Nitrogen concentration (mg/L)
Dissolved and total Phosphorus concentration (mg/L)
Dissolved and total heavy metals (Lead, Zinc and Copper) concentration (µg/L)

Monitoring Data 2019



Event Date	Number of Inlet Samples	Number of outlet Samples	Storm Duration (min)	Total Rainfall Depth (in)	Total Runoff volume (ft^3)
06/24/2019	24	29	100	1.44	1480
09/19/2019	18	50	60	1.33	1197
10/24/2019	24	153	85	2.32	7989

- Impact of rainfall regime on the hydrologic and treatment performance is evident
- Poor hydrologic and treatment performance for short intense rainfall events
- On average 20-50% infiltration increase in the unlined cells



- Enhanced removal of pollutants for the limestone mixture (cells 1 and 2) compared to the standard biofiltration media
- Plants increased the removal of nutrients after the roots were established for September and October events
- Intense storm events lead to higher effluent concentrations due to the reduced contact time and flushing effects