EA Project Summaries and Findings Report Project

Project 3 – Implementation of a Low Impact Development Test Bed at The University of Texas at San Antonio Main Campus

Project Summary

Author: UTSA

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Funding Amount

$1,069,113

Stated objectives of the study - *Provide regulatory agencies information about benefits and risks of LID features through investigation of the liner requirement, differences between sand filter and bioretention treatments, and optimal combination of soil types and plants in bioretention for the San Antonio region through construction of LID test beds at UTSA Main Campus.*

Justification for the study – *Low Impact Development (LID) is a strategy to mitigate the impacts of urbanization on Edwards Aquifer water quality. Even though LID features, such as bioretention and sand filters, can enhance significantly the quality of urban stormwater, there are still barriers to their widespread use in new and retrofitted urban environments. The barriers are technical, economical, educational, and regulatory. This project will answer four main questions for our region related to the barriers:*

- *What are the water quality differences between treating stormwater with sand filters and bioretention basins?*
- *What are the water quality differences between treating stormwater with and without liners?*
- *How much recharge can be generated in an unlined LID feature?*
- *What is the best design for bioretention basins in terms of soils and plants for the San Antonio region?*

1 Summary

This project evaluated the performance of different types of low impact development (LID) systems, including sand filters and bioretention basins. The project evaluated the effectiveness of different LID configurations to treat pollutants typically found in stormwater, including nutrients, metals, bacteria, and solids. The researchers also evaluated how different design features impact LID performance for quality and quantity. These include:

- Presence of impermeable liners,
- Media (sand and bioretention), and
- Presence of internal water storage.

The project involved three phases including a pilot-scale study of soil columns and synthetic stormwater, a test bed field study using real storm events, and a watershed model to simulate long term performance of different system configurations. The test bed was located on the UTSA campus and received stormwater from a 2.67-acre drainage area. Figure 1 shows a closeup of the test bed.

Results showed that adding limestone sand to sand filters and bioretention basins can improve pollutant removal, especially for dissolved nutrients and organic matter. Results also showed that nutrient concentrations in bioretention basins may be higher in the discharge which warrants further investigation. Finally, unlined LID features allowed infiltration which reduced peak flows and runoff volume. The sand filter and bioretention basins that were unlined and allowed internal water storage (IWS) had the best performance for volume reduction and for all pollutant treatment except for nutrients.

The authors suggest careful selection of bioretention soil media with low initial nutrient, metal, and organic content, as well as regular maintenance. They also encourage the use of unlined LID features with IWS for improved treatment and volume reduction.

Figure 1 – Aerial view of the LID testbed, water movement and monitoring locations.

1.1 Methods

The three-phase study included a pilot-scale study with soil columns and synthetic stormwater, a test bed field study using real storm events draining a 2.67 acre site on the UTSA campus, and a watershed model to simulate long term performance of different system configurations.

In Phase I, a pilot-scale study, soil columns were created, each containing different compositions of sand, bioretention soil media, limestone, and other materials. The additional materials selected had previously shown positive performance in other studies and could provide some material cost savings. A synthetic stormwater was also created that contained typical pollutant concentrations that are found in the San Antonio area. The synthetic stormwater (or influent) was then applied to the columns and the effluent, or outflow, from the columns was collected and analyzed to see which provided the best removal of these pollutants. Statistical analyses were performed to determine if the differences in concentrations before and after treatment were statistically significant. The results of this phase were used to develop the LID features in the second phase.

In Phase II, a test bed with six cells (see Figure 1) was created and each cell contained a different LID feature. These included two sand filters, one lined and one unlined, and four bioretention cells: 1) lined 2) unlined, 3) lined with limestone added to the soil media, and 4) unlined with limestone added to the soil media. The bioretention cells were populated with three native plant species. The land use of the 2.67 acre area of UTSA campus draining to the test bed was comprised of parking lots, buildings, and some grassy and vegetated space. The influent and effluent stormwater from multiple storms over several years was analyzed for flow, volume, and standard water quality pollutants, such as suspended solids, bacteria, nutrients, and metals. There was particular focus to see if unlined cells, which allow infiltration, produced better performance than lined cells. The analysis was repeated with a new configuration that allowed internal water storage within each cell. The results were analyzed for the total load of each pollutant for the entire storm as well as the event mean concentration (EMC) of each storm event, which is a weighted average based on flow during the entire storm event that allows comparison between storm events of different sizes.

Phase III included the development of a watershed model to evaluate the performance of different LID features over a 15-year period. The watershed model evaluated the long-term performance of sand filters and bioretention basins and the impacts of lined systems and systems with internal water storage.

1.2 Findings

Results of the pilot and test bed studies showed that adding limestone sand, either alone or as part of the bioretention soil media, improves treatment performance especially for dissolved nutrients and organic matter. The bioretention media without the limestone addition resulted in increased concentrations for several pollutants in the discharge, especially for nutrients. The researchers suggest that this may be due to a few factors such as chemical processes in the soil, the higher nutrient content of the soil, and seasonal fluctuations in leaf litter. Overall, there was not a substantial performance difference between the bioretention cells and sand filters.

The unlined cells had lower peak flows and runoff volumes for both LID types since stormwater was able to infiltrate directly. The cells with internal water storage (IWS) had even greater reductions in peak flow and runoff volume. Pollutant removal in these cells was improved for solids, bacteria and metals, but worse for nutrients. The authors emphasized the importance of maintenance to ensure continued performance of the bioretention basins. The study also involved a cost benefit analysis which shows that bioretention without limestone was the least cost effective due to its maintenance requirements and limited pollutant removal, while the unlined LID features were shown to the be the most cost effective.

The watershed model evaluated the long-term performance of sand filters and bioretention basins with and without lining as well as with and without IWS. The results suggest a reduction in discharge volume with unlined cells via direct infiltration which is further increased when the LID feature allows for internal water storage. The infiltration volume was even higher for unlined bioretention basins and sand filters that also allowed for internal water storage.

The water quality database developed from this study can be utilized for multiple additional investigations and statistical analysis on the performance effectiveness of different LID types and features. The majority of the analysis focused on EMCs which allows comparison of storm events of different sizes, but additional detailed analysis of pollutant load reductions in different storm events can yield valuable insights into the overall performance of BMPs whose goal is to reduce the load of pollutants in surface and ground waters. Additional study would also be useful to assess the cost-benefit of liners and level of protection they may or may not provide to the aquifer.

1.3 Challenges and Limitations

During Phase I, the authors note some challenges in keeping a consistent concentration of total suspended solids in their synthetic stormwater. During Phase II, storm event sampling had its inherent challenges due to the unpredictability of storm event timings and magnitude. The watershed model in Phase III had several overarching assumptions that limit the ability to draw broad conclusions and the authors suggest a more detailed model be developed in future study.

2 Benefits

This project provides water quality benefits, additional data, analysis, and public education / outreach for water quality treatment efforts in the Edwards Aquifer Recharge Zone (EARZ). In addition, the study provides valuable information on maintenance needs and the cost benefit of different LID feature configurations.

The benefits of the project include:

- The project provides insight into pollutants of concern and potential treatment design opportunities in urban developments within the EARZ.
- This project serves as a local example to generate interest on the effectiveness of LID for future implementation in the region.
- The LID test bed improved water quality on the UTSA campus.
- Through Phase I and II of the study, the researchers collected a tremendous dataset that can be utilized for additional data analysis and studies on the pollutant removal effectiveness and volume effectiveness of LID features.
- The findings about bioretention soil media being a potential source of pollutants are important and warrant further investigation.
- The pollutant removal benefits of adding limestone-based media to any type of LID feature are important for designers and regulators.
- The cost benefit analysis is useful for selecting LID features and configurations.
- The project included the development of materials and a valuable resource to educate students. The project team has already used these for classes.

Project Deliverables:

Giacomoni, M. H., Hamedani, A. S., Shipley, H. (2022). Implementation of a low impact development test bed at The University of Texas at San Antonio main campus. The University of Texas at San Antonio.

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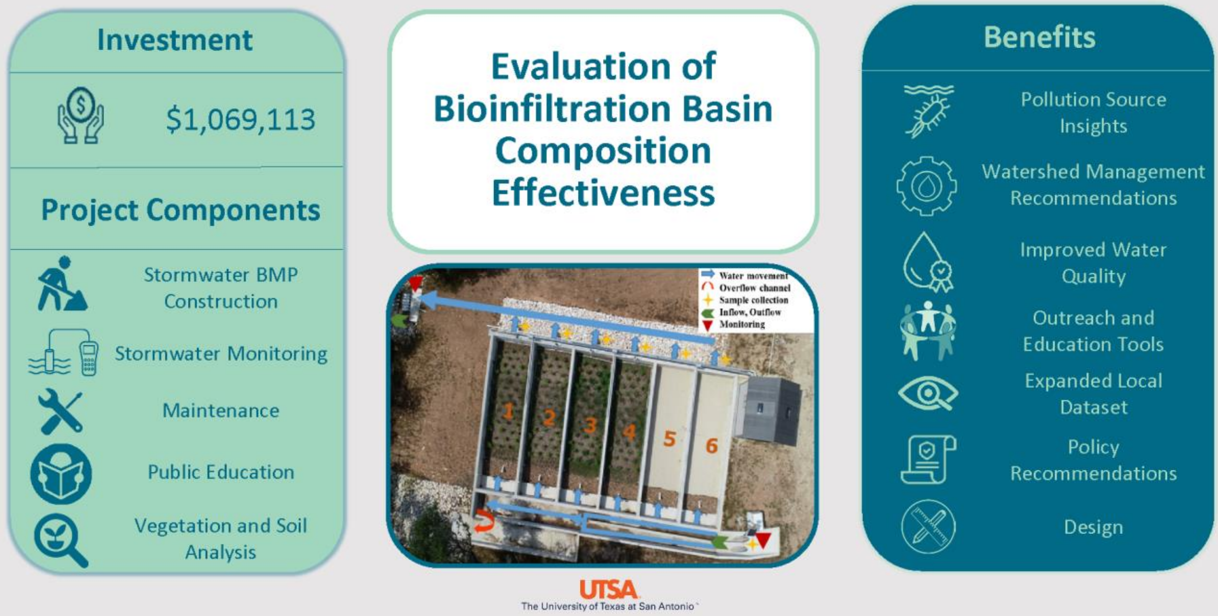
Project 3 – Implementation of a Low Impact Development Test Bed at The University of Texas at San Antonio Main Campus

Fact Sheet

Project 3 – Implementation of a Low Impact Development Test Bed at the University of Texas at San Antonio (UTSA) Main Campus



Benefits

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Project Graphic

Project 3 - Implementation of a Low Impact Development Test Bed at The University of Texas at San Antonio (UTSA) Main Campus

Study to compare the effectiveness of several low impact development feature components in reducing flooding and pollutant transport in stormwater runoff.