Mitigation Localized Flooding - Development of a Green Infrastructure Master Plan in the Lower Rio Grande Valley

Ahmed Mahmoud¹, Javier Guerrero², and Andrew Ernest³

¹, ³ Civil Engineering Department University of Texas Rio Grande Valley
², ³ RATES (Research Applied Technology and Education Services) RGV
Stormwater Runoff

- Urban stormwater runoff is a primary source of water quality impairment in receiving streams and water bodies.
- It is discharged into surface water untreated carrying numerous pollutants causing decline in aquatic biota and degradation of water quality.
- Typical pollutants in stormwater runoff are generally categorized as:

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS (Total Suspended solids)</td>
<td>Erosion of soil surfaces and dust deposition</td>
</tr>
<tr>
<td>Nutrients</td>
<td>Plant fertilizers, detergent and animal waste</td>
</tr>
<tr>
<td>Pesticides</td>
<td>control weeds and insects</td>
</tr>
<tr>
<td>Organic Compounds</td>
<td>use of petroleum products</td>
</tr>
<tr>
<td>Heavy metal (Pb, Cu, Zn, Cd and Ni)</td>
<td>associated with transportation</td>
</tr>
<tr>
<td>Pathogenic microorganisms</td>
<td>feces of domestic animals and wildlife or human</td>
</tr>
</tbody>
</table>
Gray Infrastructure

- Gray stormwater infrastructure—conventional piped drainage and water treatment systems—is designed to move urban stormwater away from the built environment.

Green Infrastructure (GI)

• Is an ecologically-based storm-water management approach favoring soft engineering to manage rain fall on the site through vegetated treatment network.

• The goal is to reduce or eliminate the contaminants collected by stormwater as it moves into streams and rivers.

• **Green Infrastructure (GI)** attempts to includes as much green space as possible in urban planning and aims to maximize the benefit from these green spaces.

• GI are an integral component of sustainable communities, help communities protect the environment through minimize pollutant production and water recycling.
Showing the difference in the surface water runoff between pervious (15%) and impervious surface (55-70% carrying pollutants) that drain in the surface water bodies

Green Infrastructure (GI) in LRGV

Wetland (Weslaco, LRGV TX)

Bio-swale, (Brownsville, LRGV TX)

Rain Harvesting system (Weslaco, TX)

Bioretention (McAllen, LRGV TX)

Green Roof (San Juan, LRGV TX)

Permeable Pavement (La Feria, LRGV TX)
Permeable Pavements

• Permeable pavement systems were developed for infiltration of surface runoff by passing through porous surface, allowing capturing and recycling of storm water on site.

• Effective reducing runoff besides removing various nutrients and pollutants loads associated to the streams in compared to impervious surfaces as asphalt to including:
  - Total Kjeldhal Nitrogen (TKN),
  - Total suspended solids,
  - Total phosphorus,
  - Heavy metals.

Permeable Pavements

Surface of monitored pavements in different LRGV parking lots: (a) Monte Bella Park - PCP, (b) Cameron County Drainage District #1 - PICP, and (c) La Feria Recreational Center – IBPG, (d) Monte Bella Park - TAP, and (e) La Feria Recreational Center – TBP

Cross section (as built) of three types of monitored permeable pavement installations in LRGV parking lots: (a) COB - PCP, (b) CCDD#1 - PICP, and (c) COLF-IBPG.
A Comparison of Three Types of Permeable Pavements for Urban Runoff Mitigation in the Semi-Arid South Texas, U.S.A

by Trufiql Alom, Ahmed Mahmoud, Kim D. Jones, Juan César Bezares-Cruz, and Javier Guerrero

1 Department of Environmental Engineering, Texas A&M University-Kingsville, Kingsville, TX 78363, USA
2 Department of Civil Engineering, University of Texas Rio Grande Valley, Edinburg, TX 78539, USA
3 Research, Applied, Technology, Education and Service, Inc., Rio Grande Valley, Edinburg, TX 78540, USA
* Author to whom correspondence should be addressed.

Water 2019, 11(10), 1992; doi:10.3390/w11101992
Received: 30 July 2019 / Revised: 20 September 2019 / Accepted: 23 September 2019 / Published: 24 September 2019
(This article belongs to the Special Issue Advances of Low Impact Development Practices in Urban Watershed)

Abstract

This study examines the hydrologic and environmental performance of three types of permeable pavement designs: Porous Concrete Pavement (PCP), Permeable Interlocking Concrete (PICP), and Interlocking Block Pavement with Gravel (IBPG) in the semi-arid South Texas. Outflow rate, storage, Normalized Volume Reduction (NVR), Normalized Load Reductions (NLR) of Total Suspended Solids (TSS), and Biochemical Oxygen Demand (BOD₅) were compared to results obtained from adjacent traditional pavements at different regional parking lots. A notable percentage of peak flow attenuation of approximately 31–100% was observed when permeable pavements were constructed and implemented. IBPG was capable of holding runoff from rainfall depths up to 136 mm prior to flooding. PCP was the most satisfactory in reducing surface runoff (NVR: 2.91 x 10⁻³ ± 0.67 x 10⁻³ m³ mm⁻¹ mm⁻¹), which was significantly (p < 0.05) higher (98%) than the traditional pavement. PCP was also very effective in TSS removal (NLR: 244 x 10⁻⁵ ± 143 x 10⁻⁵ kg m⁻² mm⁻¹), which was an increase of over 80% removal compared to traditional pavement. IBPG (NLR: 7.14 x 10⁻⁵ ± 1.79 x 10⁻⁵ kg m⁻² mm⁻¹) showed a significantly (p < 0.05) higher (46%) BOD₅ removal over traditional pavement. These results demonstrate that the type of permeable pavement and the underlying media can significantly influence the runoff reduction and infiltration in this climatic region. View Full-Text

Keywords: urban runoff, water quality, Low Impact Development (LID), permeable pavement, stormwater management

View Figures
New Orleans mandates permeable pavement to control stormwater runoff

David Wagman | September 12, 2019

New surface parking areas in New Orleans will need to be built using water-permeable materials as a result of a new ordinance passed by council members in early September.

The ordinance is intended to reduce stormwater runoff into Lake Ponchartrain and mitigate soil subsidence in the city. During heavy rainstorms the city’s drainage system can become overwhelmed and result in local flooding. Porous surfaces will allow rain water to soak into the ground where it falls.

Under the new ordinance, concrete bases and mortar are prohibited from new parking areas. Permitted materials include pervious concrete, porous asphalt, aggregate if stabilized with a grid system that prevents compaction and washout and permeable pavement such as open-jointed blocks, pavers or bricks.

Once in place, the paving is subject to water infiltration testing based on ASTM International C1701 or C1781 standards. Pavement must maintain a minimum infiltration rate of 200 in per hour, the ordinance said.

The ordinance also requires new paving installations to have a minimum aggregate subbase of 24 in, measured from the base of the permeable pavement system.

More broadly, the City of New Orleans was awarded $141 million through the U.S. Department of Housing...
Bioretention

- Bioretention is an infiltration practice through porous media; that uses a biologically active filtration bed to remove contaminants.
- One of the most commonly used GI practices.
- Significant reduction of runoff volume provided by the bioretention cells with water quality improvement by substantially reducing the various pollutants.

https://www.hydrologystudio.com/help/bioretention-ponds.htm
Runoff water is captured in a shallow depression and infiltrates through selected bioretention media, where physical, chemical and biological processes and mechanisms are employed for pollutant removal and runoff reduction.
STC Bioretention (McAllen)
The main objectives of the GI Master Plan that the City wants to implement are to:

1) **Minimize** the environmental impact of the rainwater,
2) **Avoid** localized flooding,
3) **Stop** the **contamination** of the water and
4) **Integrate** it to the construction projects through the development of natural drainages.
Green Infrastructure Master Plan

**Task 1** - Inventory of City-Owned property (right-of-ways, corner clips, parks, bus stops, other)

**Task 2** - Identify areas of localized flooding that occur with small storm events (< 2” of rain)

**Task 3** - Conceptually design green infrastructure facilities, primarily bioretention systems

**Task 4** - Provide outreach to promote strategy

**Task 5** - Incorporate GI in local stormwater
Rainfall Data

The closest rainfall monitoring station for NOAA was located in Harlingen International Airport with station ID (USW00012904).

June and September with an average value of $3.2 \pm 3.6$ and $5.49 \pm 4.68$ inches

The total rainfall value 2013 and 2018 was 32.9 and 34.8 inches; respectively

- Most precipitation occurs from April through June and from August through October
- June 1\textsuperscript{st} through November 30\textsuperscript{th} is hurricane season
City of Mercedes has some ditches and drainage lines with inlets to properly divert rain & flood waters.

HCDD#1, USIBWC and Irrigation District No. 9
Mercedes adopted its first Storm Water Management Plan in February 2008, obtained an individual NPDES permits for its stormwater discharges.

According to the city subdivision ordinance (link), in Section 30 which includes the storm drainage policy, it is stated that: “Storm drainage shall be installed at the expense of the developer. It shall be designed by the Rational Method or other methods as approved by the Planning Commission and a copy of the design computations shall be submitted along with plans. Run-off Computations - To determine the runoff rates for the various areas, the standard rational method may be used utilizing the formula

\[ Q = CIA, \]

where \( Q \) - rate of runoff in cubic feet per second,
\( C \) = runoff coefficient, \( I \) = rainfall intensity for the particular duration in inches per hour and \( A \) = the drainage area in acres.

The runoff factor \( C \) I used in the design of storm drainage shall be a minimum of 1.3 cubic feet per acre for a minimum time concentration of ten\(^\circ\) (10) minutes.”
• Priority Areas (19 locations)

Majority in Texas, Ohio, Illinois Avenues and Capisallo St
Priority Sites List

<table>
<thead>
<tr>
<th>Area</th>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>300 E Expressway 83, Mercedes, Tx 78570</td>
<td>area east of Exxon</td>
</tr>
<tr>
<td>2</td>
<td>208 Starr St, Mercedes, TX 78570</td>
<td>area south of Childrens Clinic, intersection of Start St and Cameron St</td>
</tr>
<tr>
<td>3</td>
<td>300 N Ohio Ave, Mercedes, TX 78570</td>
<td>area south of Family Dentistry, along Cameron St</td>
</tr>
<tr>
<td>4</td>
<td>307 Starr St, Mercedes, TX 78570</td>
<td>area south of post office, along Cameron St</td>
</tr>
<tr>
<td>5</td>
<td>331 N Texas Ave, Mercedes, TX 78570</td>
<td>area south of Juanitos Restaurant, along Acmeron St</td>
</tr>
<tr>
<td>6</td>
<td>215 N Illinois Ave, Mercedes, TX 78570</td>
<td>area south of Area 2, intersection of Cameron St and Illinois Ave</td>
</tr>
<tr>
<td>7</td>
<td>105 N Ohio Ave, Mercedes, TX 78570</td>
<td>Mercedes Fire Station</td>
</tr>
<tr>
<td>8</td>
<td>150 N Ohio Ave, Mercedes, TX 78570</td>
<td>parking area south of Knights of Columbus</td>
</tr>
<tr>
<td>9</td>
<td>129 N Texas Ave, Mercedes, TX 78570</td>
<td>parking area north of Atlas Credit Co</td>
</tr>
<tr>
<td>10</td>
<td>100 N Ohio Ave, Mercedes, TX 78570</td>
<td>area east of Dollar General, intersection of S. Illinois Ave and Capisallo St.</td>
</tr>
<tr>
<td>11</td>
<td>111 S Ohio Ave, Mercedes, TX 78570</td>
<td>My Secret Closet clothing store</td>
</tr>
<tr>
<td>12</td>
<td>325 W 3rd St, Mercedes, TX 78570</td>
<td>parking lot south of Eye Care Center</td>
</tr>
<tr>
<td>13</td>
<td>333 S Ohio Ave, Mercedes, TX 78570</td>
<td>property along intersection of S Ohio Ave and W 4th St</td>
</tr>
<tr>
<td>14</td>
<td>417 S Ohio Ave, Mercedes, TX 78570</td>
<td>parking area north of Mercedes Development Corporation</td>
</tr>
<tr>
<td>15</td>
<td>316 S Ohio Ave, Mercedes, TX 78570</td>
<td>Mercedes Police Department</td>
</tr>
<tr>
<td>16</td>
<td>321 S Ohio Ave, Mercedes, TX 78570</td>
<td>area east of Police Department</td>
</tr>
<tr>
<td>17</td>
<td>400 S Ohio Ave, Mercedes, TX 78570</td>
<td>Mercedes City Hall and Public Library</td>
</tr>
<tr>
<td>18</td>
<td>202 US-83 BUS, Mercedes, TX 78570</td>
<td>area east of Health &amp; Human Services Dept</td>
</tr>
<tr>
<td>19</td>
<td>203 US-83 BUS, Mercedes, TX 78570</td>
<td>area east of Area 18</td>
</tr>
</tbody>
</table>

Developed a list and visited each site to assess and evaluate causes of flooding and possible installation of GI systems.
Priority Sites

Most of the flooding sites evaluated during the field visit, showed the presence of impervious parking areas which will increase overall volume and velocity of runoff into city drainage system.
Priority Sites

Switching the impervious parking areas to permeable pavements, can reduce the amount of stormwater runoff from a site, and improve water quality.

Site #5 Parking at Juanitos Restaurant
Priority Sites

Bioretention areas can be incorporated into the city commercial areas to capture roof runoff and parking lot runoff on private property.
## PROJECT

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Permeable pavement/sidewalk</th>
<th>Bioretention/Bioswale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site #1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Site 2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Site 3</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Site 4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Site 5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Site 6</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Site 7</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Site 8</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Site 9</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Site 10</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Site 11</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>29</strong></td>
<td><strong>24</strong></td>
</tr>
</tbody>
</table>
Two Priority Sites

The first site located in Kennedy-Collier Park in Mathis Street.
Two Priority Sites

The second location is the intersection between the fifth and Illinois streets.
Permeable Pavement Design

**Diagram A:**
- **Illinois Avenue**
- **Prop Type 5 Ramp**
- **Prop Type Curb Ramp**
- **Existing Curb**
- **5th Street**
- **Prop Type 10 Ramp**
- **Prop Type Curb**
- **Prop Type Existing**
- **Existing Soils to Be Moisture Conditioned Per Geotechnical Recommendation (Slope to Drain)**

**Diagram B:**
- **4" Thick Porous Concrete Sidewalk**
- **2" Thick Bedding** (ASTM No. 8 or No. 9 Aggregate Stone)
- **X" Thick Open-Graded Base** (ASTM No. 57 Aggregate Stone)
- **4" Ads Triple Wall Perforated Pipe** (Install at Center of Sidewalk, Slope to Drain)
- **Geotextile Fabric** (XXXXXXX)
- **Existing Soil to Be Moisture Conditioned Per Geotechnical Recommendation (Slope to Drain)**
During Construction

After Construction
Outreach and Educational

MITIGATING LOCALIZED FLOODING: DEVELOPMENT OF A GREEN INFRASTRUCTURE MASTER PLAN IN THE LOWER RIO GRANDE VALLEY

Background Information

The City of Mercedes (City) in partnership with the Lower Rio Grande Valley (LRGV) and The University of Texas Rio Grande Valley (UTRGV) proposes to develop a demonstration green infrastructure (GI) master plan to mitigate localized flooding in a high priority region within the City limits of the City. Local governments in the LRGV control localized flooding and stormwater runoff by adopting strict drainage design policies. During the course of this project, participating local governments and the project team will review drainage policies. The project team will identify those that already incorporate GI language, will provide GI related information to the local government staffers and will provide recommendations for policy enhancement. The flat terrain characteristic of the LRGV provides stormwater engineers with complicated flow, detention and flood design problems.

Outreach and Educational

• The project team gave a technical presentation on the scope of the GI Master plan for the City of Mercedes in the 2019 EPA Region 6 Stormwater Conference, July 28 - August 1, 2019, Denton, Texas.

• Two UTRGV undergraduate students presented the project in the 21st Annual Lower Rio Grande Valley Water Management & Planning Conference, May 21-24, 2019, South Padre Island, Texas.
Recommendations

• Work with owners on construction and installation of the GI systems at the priority sites

• Change the drainage policy to convey more runoff from the sites

• Quantifying estimated pollutant load reductions for the GI Master Plan.

• Explore additional funding streams to facilitate widespread implementation
Recommendations

Project Funded by North America Development Bank (NADBank) Broder 2020 Program (TAA:18-007/PID: 20323)

NADBank Project Manager: Jorge Hernandez
Mercedes Project Manager: Jose Figueroa
RATES: Javier Guerrero, M.S., E.I.T
UTRGV PI: Andy Ernest, Ph.D., P.E.
UTRGV Co-PI: Ahmed Mahmoud, Ph.D.
Bioretention basin at Water Street in Plymouth Center, Massachusetts.
https://capecodgreenguide.wordpress.com/bio-retention/


Thanks

Questions?