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

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Draft Final Report

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UTRGV College of Engineering & Computer Science

city of mercedes It Starts Here!

Rio Grande Valley Stormwater Management

BORDER 2020 FRONTERA 2020

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1- Background and Identified Problem

The City of Mercedes in partnership with the Lower Rio Grande Valley (LRGV) and The University of Texas Rio Grande Valley (UTRGV) proposed 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 in local governments and the project team reviewed the city drainage policy. The project team identified those that already incorporate GI language, provided GI related information to the local government staffers and recommendations for policy enhancement. The flat terrain characteristic of the LRGV provides stormwater engineers with complicated flow, detention and flood design problems. The GI Master Plan can provide a unique innovative strategy that will be used as a demonstration tool that can be duplicated throughout the region. Through the GI Master Plan, the City intends to establish the general and specific guidelines for the management and treatment of rainwater to diminish its impact and to apply the strategies that allow the construction of "green" structures. Of the twenty-one (21) LRGV Stormwater Task Force members (SWTF), solely the City of Weslaco has GI language in its drainage policy, primarily stating that the GI strategies can be used in managing stormwater runoff. Through this project, the City of Mercedes and other participating local governments assessed GI facilities and considered providing language that encourages GI in their policies. The GI Master Plan is an approach for land development that works with nature to manage rainwater and it's based on the preservation and recreation of natural landscape characteristics, minimizing impervious surfaces to create functional drainage. The idea is that rainwater can be integrated as a natural attraction of urbanism instead of being considered a discarded product, therefore avoiding the creation of ponds and future contamination.

The GI Master Plan can benefit the public and the environment by providing innovative and emerging information to the region in order to meet the challenging requirements of water quality, flooding and public safety. Improving water quality, reducing localized flooding, and identifying sustainable, economical and innovative stormwater management strategies is a key benefit that can result from the development of the GI Master Plan. Although this project will be implemented in the City of Mercedes, UTRGV is partnering with the LRGV TPDES Stormwater Task Force (SWTF) and the Coastal Cities Task Force (CTF) in the promotion of the GI Master Plan to the region. The coalitions are comprised of thirty-three (33) local governments, a population of over 750,000. The institutionalization of GI Infrastructure strategies, the introduction of low impact development programs, and the implementation of innovative planning, management and engineering approaches to water programs will not only benefit communities but the environment. The successful institutionalization of innovative stormwater management programs can reduce NPS pollutants, mitigate localized flooding in urban, colonia, and rural settings, and improve water quality BMP’s utilized by residential, commercial and industrial stakeholders.

2. Stormwater Runoff and Green Infrastructure

The Lower Rio Grande Valley (LRGV) in southernmost Texas has been experiencing a population book and currently consists of 1.2 million people. It also consists of rapidly expanding urbanized areas and is subject to periods of extreme rainfall. The LRGV only contains four major drainage outfalls, three of which are under the control of the International Boundary and Water Commission, a binational organization. Despite economic growth in the area, the LRGV remains one of the poorest per-capita areas in the US.

Resulting communities along the US-Mexico border region disproportionately experience environmental threats, associated adverse health outcomes and a lack of environmental information (Byrd et al., 2001; Zuniga Carrillo et al., 2009). From an economic viewpoint, rapid population growth and the development of manufacturing facilities has put pressure on air, water and land resources in the border region (USEPA, 2016). Aging and/or lack of infrastructure to address solid waste generation/disposal and water treatment and sanitation also contribute greatly to concerns among border residents regarding environmental exposures and water quality and safety. Unincorporated areas or areas that lack municipal water supplies and infrastructure also increase the risk of adverse health outcomes associated with chemical and water hazards. Growing urbanization, increasing population size, and the lack of aging infrastructure contribute to regional conditions that limit the ability for stormwater systems to cope.

According to the United States Census Bureau, urban growth rates exceeding 10 percent per decade and more than 80 percent of the U.S. population lives in urban areas (Johnson and Hunt, 2016). The more apparent effects of climate change in addition to the vast increase in urbanization around the world are considered the two major contributors to excessive runoff that cannot adequately be handled by the stormwater management system (Eckart et al., 2017).

Urbanization produces numerous changes in the natural environment through disturbing lands and replacing natural vegetation with impervious surfaces such as roads, driveways, parking areas, and building roofs and compact soils. Thus, modifying the hydrological cycle by eliminating interception reduces surface retention and reducing evapotranspiration (ET) and rainfall filtration into the ground. Result in increasing the runoff volume and flooding with a significant reduction in groundwater recharge (Pazwash, 2016; Winston et al., 2016).

Furthermore, 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 various pollutants including sediments, nutrients, pathogenic bacteria, pesticide and herbicides and heavy metals such as zinc, copper, lead, and nickel causing a decline in aquatic biota and degradation of water quality (Bean, E. et al., 2007; Liu et al., 2014). Accordingly, the U.S. Environmental Protection Agency (EPA) in 2000 ranked stormwater runoff among the top three sources of surface water pollution (Hunt et al., 2006).

The management of stormwater and areas prone to flooding in the LGRV is imperative. The Gulf Coast is largely characterized by a warm, subtropical climate. The climate in south Texas has been described as atypical, indeed both wet and dry. It is classified as subtropical, sub-humid to semiarid type (Hernandez and Uddameri, 2014). These conditions, along with extreme poverty and frequent and periodic exposure to climate and environmental hazards (e.g. hurricanes, flooding), leave border populations vulnerable to neglected tropical diseases (Hotez et al., 2014). Moreover, stormwater runoff as nonpoint source pollution is one of the major threats to water quality in the United States and is linked to chronic and acute illnesses from exposure through drinking water, seafood, and contact recreation. The pooling of stormwater due to the impervious surfaces, increasing mosquito's production, including species capable of transmitting the disease such as dengue hemorrhagic fever, West Nile virus, and other infectious diseases (Gaffield et al., 2003).

Low Impact Development (LID) or Green Infrastructure (GI) are structural Best Management Practices (BMPs) - ecologically-based stormwater management approaches to manage rainfall on the site favoring soft engineering through a vegetated or biologically based treatment network (Eckart et al., 2017). The basic idea behind GI is to manage and control urban stormwater runoff by keeping as much stormwater runoff as possible on-site to give the water a chance to infiltrate into the soil or receive treatment. This can be achieved using on-site measures such as vegetated swales, rain gardens, green roofs, porous pavement and larger-scale practices such as retention ponds. The goal of a GI structure is to reduce or eliminate the contaminants collected by stormwater before its drains into streams and rivers. GI has several ecological benefits; one of the major benefits is its ability to reduce water pollution thereby assisting with the regulation of biogeochemical cycles. GI studies demonstrate that it also be used to reduce concentrations of metals, bacteria and other pollutants associated with the runoff (Mahmoud et al., 2019).

GI practices offer an innovative way to integrate stormwater management through reduction of the runoff volume and peak discharge, increasing infiltration, groundwater recharge, stream protection, and water quality improvement through different removal mechanisms as filtration, chemical sorption and biological processes (Ahiablame et al., 2012). For example, one of the commonly used GI practices for managing stormwater runoff is bioretention or rain garden systems which is an infiltration practice through biologically-based porous media; designed to encourage percolation and volume reduction by capturing and storage of stormwater runoff (Dorman et al., 2013; Liu et al., 2014). Bioretention systems are unique among the installed GI practices that can meet both landscape aesthetics objectives and water quality improvements

(Mahmoud et al., 2019). Runoff water typically is captured in a shallow depression and infiltrates through a combination of selected bioretention engineered soil media, where physical, chemical and biological processes and mechanisms are employed at various depths for pollutant removal and runoff reduction as shown in Figure 1 (Dorman et al., 2013; Winston et al., 2016). By comparing different water quality parameters of influents and effluents through bioretention, studies have demonstrated concentration reductions for heavy metals, total suspended solids (TSS), oil and grease, biological oxygen demand (BOD), nitrogen and phosphorus species, and pathogenic bacteria indicator species (Liu et al., 2014).

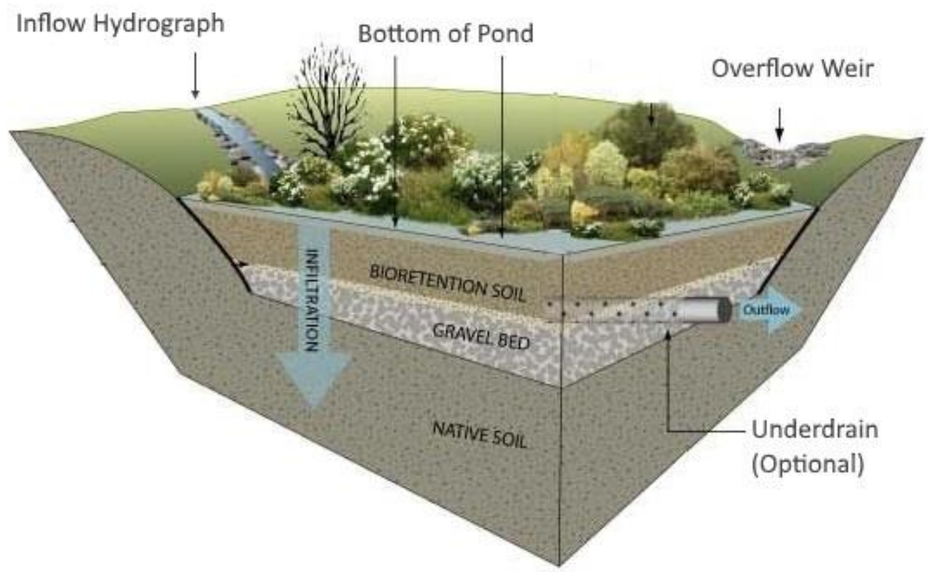

Figure 1. Typical bioretention systems structure (https://www.hydrologystudio.com/help/bioretention-ponds.htm).

Permeable Pavement (PP) systems are a key in GI technology, developed for infiltration of surface runoff by passing through porous surface, allowing capturing and recycling of stormwater on site instead of traditional ways focusing on treatment with an end of pipe system (Bean, E. et al., 2007; Scholz and Grabowiecki, 2007). Previous studies have found permeable pavements to be effective in reducing surface runoff besides removing various nutrients and associated pollutant loads into streams (Brattebo and Booth, 2003). The hydraulic performance of permeable pavements systems for peak flow attenuation and runoff volume reduction systems are well documented (Kia et al., 2017). Besides reducing the runoff, various pollutants associated with the runoff are reduced to a certain degree. Permeable pavements capture particulates including Total Kjeldahl Nitrogen (TKN), ammonia, total suspended solids, total phosphorus, heavy metals, nitrite and nitrate associated with stormwater runoff through mechanical filtration in the base layers (Drake et al., 2014).

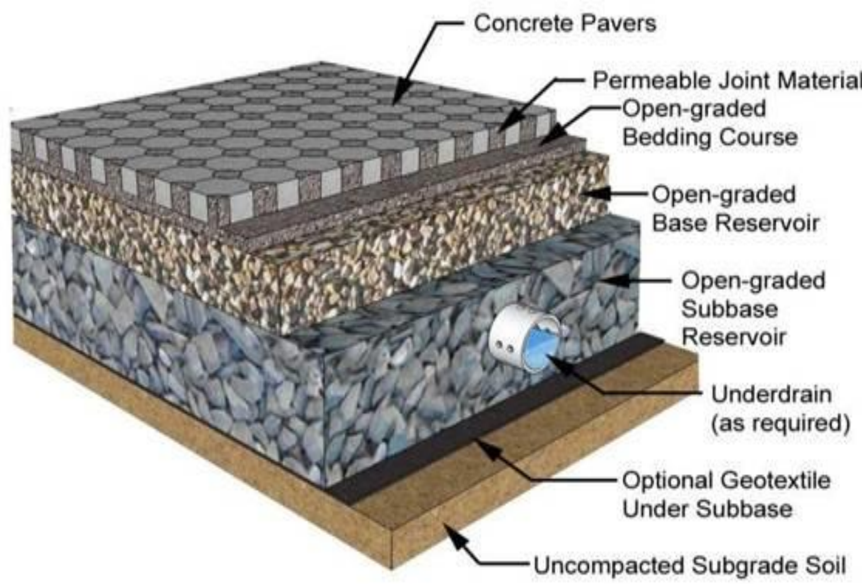

Figure 2. Permeable Pavement System (PPS) sectional layout (Source: Virgina DEQ Stormwater Design Specification, No.7, Permeable Pavement)

3- Project Objectives

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. The project meets the requirements of Goal 2 under Objective 2, Type 2 project classification. Goal 2 is fulfilled by the project content which will include educational and research topics associated with stormwater management. Goal 2 was fulfilled by the educational outreach activities that were required by the project in order to promote the GI stormwater runoff management strategies to local school district officials, colonias, institutes of higher education, city and county officials, water professionals, professional organizations and water-related organizations.

The goals of this GI Master Plan are as follows:

- Provide an understanding of drainage concepts and patterns in the community
- Describe the properties and tendencies of the major watersheds in the region
- Explain precipitation patterns and the concept of percentiles, zero runoff approaches, and the importance of water quality
- Explain detention and promote alternatives to conventional design
- Engage residential, commercial and educational stakeholders
- Promote topics that will educate residential, commercial and educational stakeholders
- Change the mindset of water professionals by promoting a new engineering paradigm

4- Methods or work description:

The project consists of three (3) key components, namely planning, design, and outreach and education. UTRGV researchers, students and staff collaborated with city planners, city engineers and city public works directors to identify and discuss issues, concerns and local policies. Previous studies conducted by the UTRGV team show that 90% of the storms in the LRGV are 2-inch rain events. The project team limited the information and input data of this project to parameters associated with these storm events.

Each component of the project consists of tasks assigned to project team members with an associated deliverable, budget and timeline. During the planning stage, the project team has three (3) tasks. Task 1 require the project team to identify at least two (2) regions within the city limits that exhibit extreme localized flooding during target storm events. City staff worked with the project team in identifying key regions of the city, which will include downtown, commercial and/or residential regions. Each region was assessed using historical data, staff experience and community input. UTRGV uses various precipitation databases. Project team worked with UTRGV in identifying key data needed for this project. Localized flooding within local communities can be at times best identified by residents, city workers and business owners. The project team conducted interviews, review available data (as-builts, precipitation data, etc.). If necessary, the project team will conduct community input sessions.

Task 2 was to identify specific locations within each region to be categorized, prioritized, and assessed for cost benefits. The project team provided recommendations, and the City selected one site location for implementation of one of the suggested LID systems in the GI Master Plan. The City constructed a permeable pavement in one LID facility, identified in the Master Plan. Task 3 was to compile information and developing a GI Master Plan for the selected region. The project team shared the LID Master Plan with the City of Mercedes. The interlocal agreement between the City and UTRGV was approved through Council, which included a brief overview of the project.

During the design stage, the City selected one (1) location within the target region, of highest priority preferably, to be designed using LID technology. During this task, the project team reviewed bioretention design guidance, geotechnical data, identify available local materials and resources, and reviewed local design policies. As part of the grant's scope of work, at a minimum, the GI Master Plan will be accompanied by design guidance, design typicals, and technical depictions of GI facilities.

The third stage was related to outreach, education and training. The workshop announcements will be solicited through utility mailouts, e-mail databases, regulatory list servers, professional organizations, ISDs, public television, and other delivery tools. The marketing activities was conducted by the Task Force and UTRGV. This will maximize the outreach area. UTRGV will facilitate these activities. The GI Master Plan can benefit residential, commercial, industrial educational, professional and government stakeholders through the delivery of innovative information, by providing a venue with opportunities to disseminate and share knowledge between stakeholders and by engaging young professionals, students, and educators with new science and engineering paradigms. UTRGV will continue to engage the local communities to attempt to have a similar tool adopted and institutionalized into the regional stormwater management programs. UTRGV presented the scope of the GI Master Plan at local conferences and at regional conferences. UTRGV presented the GI Master Plan project at one (1) local conference and one (1) regional conference during the grant period.

5- Results

5.1 City of Mercedes Rainfall Patterns and Drainage Network

To start developing the GI Master plan for the city, the hydrology of the region should be studied first to provide a better insight into the rainfall pattern changes for the region. The project time downloaded the rainfall data from The National Oceanic and Atmospheric Administration (NOAA). Data was requested from the website to include the last nine years starting from 2010 till 2018. The closest rainfall monitoring station for NOAA was located in Harlingen International Airport with station ID (USW00012904). Figures 3 and 4 are representing the average rainfall data for each month and year; respectively. The monthly rainfall average was found to be in June and September with an average value of 3.2 ± 3.6 and 5.49 ± 4.68 inches; respectively. The large variation of rainfall data that is reflected in the standard deviation is due to the pronounced dry and wet years that were observed in the available data. For example, the total rainfall depth was shown to be substantially high in both the years of 2013 and 2018. The total rainfall value was 32.9 and 34.8 inches; respectively. On the other hand, certain years showed very low total rainfall depth such as 2011 and 2013; the total rainfall value was 8.05 and 14.07 inches; respectively. It is worth mention that the change of rainfall patterns in the recent was an alert for the cities in the region to adopt more strict drainage policy especially after the flooding that happened less than two years ago. In June 2018, Hidalgo and Cameron's counties located in LRGV were declared as major disaster areas by Federal Emergency Management Agency (FEMA) due to severe storm and flooding that struck the region, most areas received between 5 to 15 inches during 72 hour period according to the National Weather Service website (https://www.weather.gov/crp/june_2018_heavy_rain). The city of Mercedes received 10.76 inches during this flood event, which was considered the highest in the last nine years.

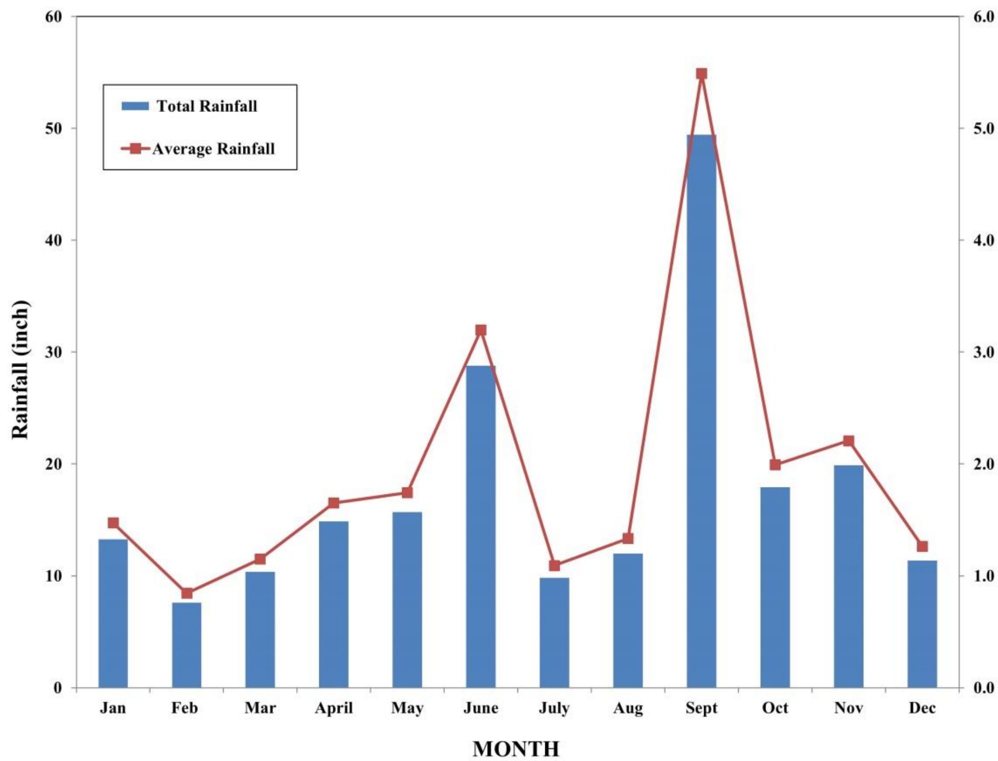

Figure 3. Total and average rainfall depth for each month for available data in the last nine years starting from 2010 till 2018

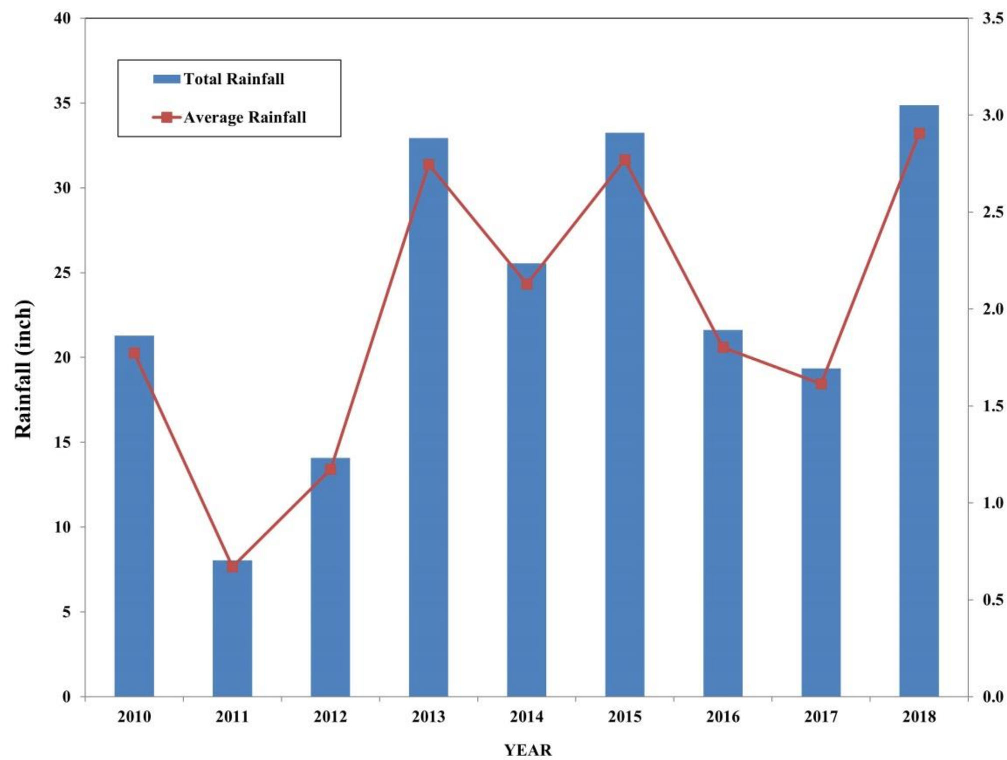

Figure 4. Total and average rainfall depth per year for available data in the last nine years starting from 2010 till 2018

Most precipitation occurs from April through June and from August through October. Spring precipitation is the result of inflowing warm, moist air from the Gulf of Mexico and the Pacific Ocean which generates thunderstorms. June 1st through November 30th is hurricane season, during which Atlantic and Gulf storms may move ashore along the Texas or Upper Mexican Gulf Coast. These storms can generate tremendous amounts of rainfall over short periods and provide a large portion of the surface water run-off captured in water supply reservoirs within the Rio Grande Basin.

Mercedes relies on drainage ditches owned and managed by Hidalgo and Cameron County Irrigation District No. 9 and Hidalgo County Drainage District No. 1 for much of its drainage infrastructure. Irrigation District No. 9 owns and manages many miles of canals, pipelines, and ditches. The Irrigation District is organized primarily to handle the irrigation and drainage needs of agriculture. Currently, the City and Irrigation District have a cooperative relationship in keeping the drainage ditches cleared. As the City continues to grow, it should be expected that the Irrigation District and the City will want to formalize an agreement regarding the maintenance of the ditches. It will also be important to explore and work cooperatively with the Irrigation District over the long term if the great promise of passive recreation use on or adjacent to drainage and irrigation right-of-way is to ever become a reality. The drainage network for the city was delineated as shown in figure 5 to show the main drainage system within the city of Mercedes according to Hidalgo County Drainage District (HCDD#1) Geographic Information System (GIS) data layer on the county website (link)

The City of Mercedes discharges stormwater to the Arroyo Colorado and subsequently to Laguna Madre Bay. To prevent polluted stormwater from being discharged into the Arroyo and subsequently, Laguna Madre, Mercedes adopted its first Storm Water Management Plan in

February 2008. The city obtained an individual National Pollution Discharge Elimination System permits for its stormwater discharges. The federal EPA began to regulate small "MS4s" in 1999. An "MS4" is a system owned by a municipality that is designed or used to collect or convey stormwater run-off. The definition of an "MS4" includes streets, stormwater sewers, and drainage ditches. Each regulated MS4 is required to develop and implement a stormwater management program (SWMP) to reduce the contamination of stormwater runoff and prohibit illicit discharges. In Texas, small MS4s are regulated under a general permit issued to TCEQ, General Permit TX04000. Because the City conveys its stormwater to the Arroyo via Hidalgo County Drainage District No. 1, the City entered an interlocal agreement with that entity to share efforts through a common stormwater management plan.

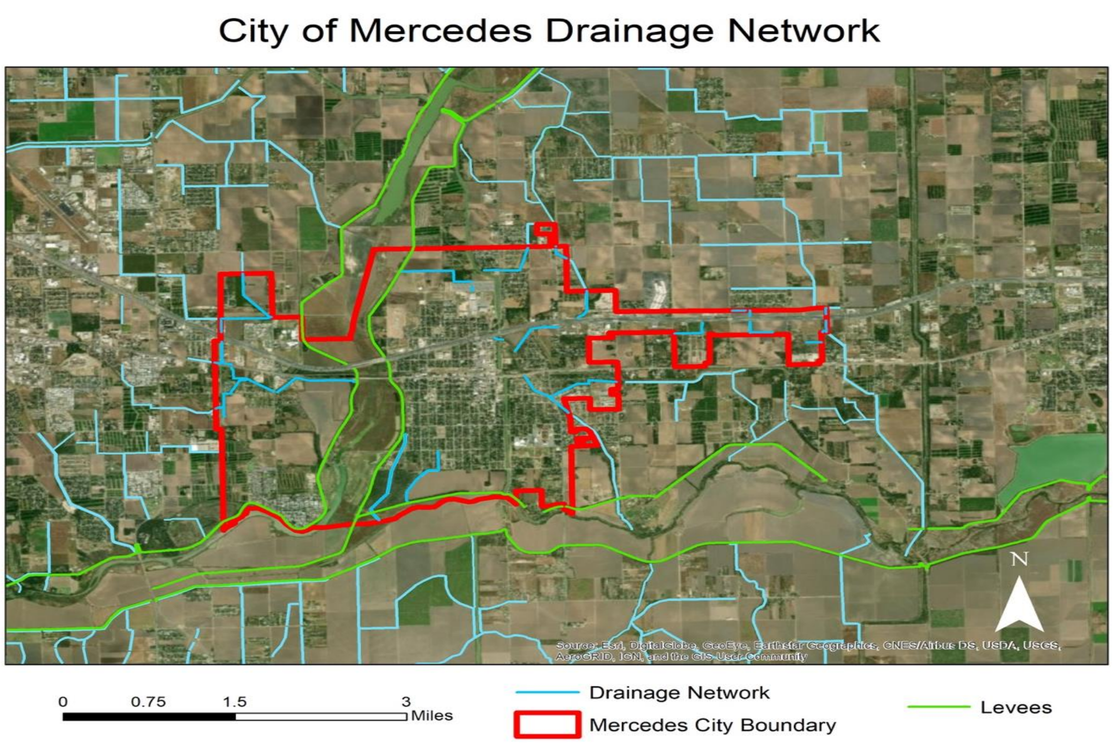

Figure 5. The drainage network for the city of Mercedes (Source: Hidalgo County Drainage District (HCDD1) Website)

In addition, the storm drainage policy was discussed with the city for the BMP or subdivision design ordinances. 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 A - 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 (10) minutes."

5.2 Identifying Priority Region within the City limits

Given the City's location on the delta of the Rio Grande, approximately 40' above mean sea elevation, and the episodic torrential rains that occur, it is not surprising that certain locations in the City are prone to flooding. It should also be no surprise that drainage vies with streets as the number one concern and priority of city residents.

Several meetings were arranged between the city of Mercedes and the UTRGV project to discuss the priority regions within the city. The meetings include from the city of Mercedes Sergio Zavala (City Manager), Jose Figueroa (Director of Public Works) and Israel Gaona (City Engineer) and from UTRGV Ahmed Mahmoud and Javier Guerrero. The city provided the UTRGV project team with a list of the locations that may suffer from flooding and runoff accumulation depending on the rainfall depth. Figure 6 and Table 1 show the location and address for each site of the priority areas within the city; respectively. Some of the areas where periodic flooding occurs include Melton Park Estates #2, Capisallo Terrace Subdivision, Marion Drive, the east-bound and west-bound Expressway Frontage Roads, Business 83, Texas Blvd. near Business 83, and Valley de Palmas. Melton Park, recorded in 1962, was apparently constructed without any stormwater drains, and, according to the Flood Insurance Rate Map (FIRM) prepared by FEMA, is in or adjacent to a special flood hazard area. Drainage at Capisallo Terrace was a key topic for that subdivision and was reviewed by the drainage district manager for development. Marion Drive is also identified as a special flood hazard area. The expansion of U.S. Expressway 83 worsened drainage along the Frontage Roads and in other areas in the City as run-off from the expanded roadway overwhelmed the capacity of the local drainage system. The drainage and flooding problems that exist in these areas can be prevented by avoiding development in flood-prone areas and implementing modern planning and engineering standards and methodologies for all development.

Table 1. Locations of localized flooding area that LID conceptual design within the city of Mercedes

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

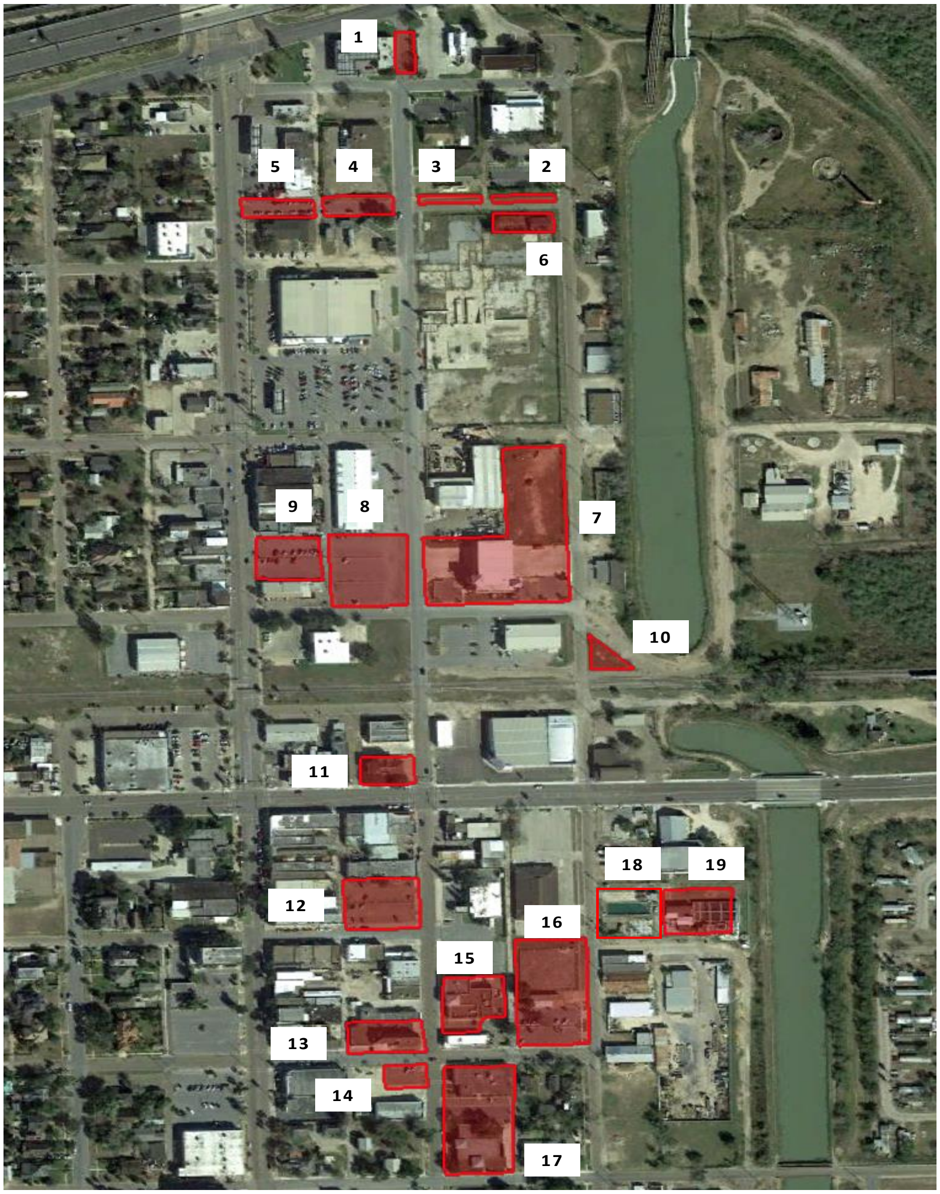

Figure 6. The drainage network for the city of Mercedes (Source: Hidalgo County Drainage District (HCDD1) Website)

5.3 Identifying Priority Region within the City limits

A group of students and researchers from UTRGV visited each site mentioned in the previous section to evaluate and investigate the causes of flooding and how to manage it. It was obvious that most of the visited sites were located in the urbanized areas and mainly the historical downtown for the city. The team assessed each site separately and discussed the proposed BMP system installation to prevent any further flooding. To meet the project and design goals discussed above, the team identified a set of green infrastructure practices appropriate for the priority areas redevelopment. These practices manage stormwater at the source and provide neighborhood amenities by integrating planning and multifunctional stormwater practices into the planned development. Table 2 shows the number of proposed GI practices to be installed within the selected sites. Multiple green infrastructure practices can be incorporated into the City of Mercedes flooding areas to complement and enhance the proposed layout while also providing water quality treatment and volume reduction. The proposed green infrastructure programmatic approaches are well suited for the City and will help meet green infrastructure goals. It is important for the City to keep in mind when considering any of these approaches that green infrastructure is more likely to be accepted in the community if plans encourage and the code allows such best management practices (BMPs) to be in required open space, recreation, and landscaped areas.

Table 2. Number of proposed LID practices that can be installed with the flooding area within the city of Mercedes

Site Number	Permeable pavement/sidewalk	Bioretention/Bioswale
Site #1	1	3
Site 2	2	3
Site 3	7	1
Site 4	1	4
Site 5	3	3
Site 6	-	1
Site 7	1	2
Site 8	4	2
Site 9	5	2
Site 10	3	3
Site 11	2	-
Total	29	24

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. Switching the impervious parking areas to permeable pavements such as porous concrete or permeable interlocking concrete pavements along with reducing such dimensions can, therefore, minimize the effective impervious cover, reduce the amount of stormwater runoff from a site, and improve water quality. In contrast to traditional pavements, permeable pavements contain small voids that allow water to drain through the pavement to an aggregate reservoir and then infiltrate into the soil beneath impervious surfaces. Permeable pavement can be developed using modular paving systems (e.g., concrete pavers, grass pavers, or gravel pavers) or pour-in-place solutions (e.g., pervious concrete or permeable asphalt). Permeable pavements are most often used in constructing pedestrian walkways, sidewalks, driveways, low-volume roadways and parking areas of office buildings, recreational facilities, and shopping centers. Incorporating the regulations and incentives into parking space requirements in the overlay city will create the opportunity to meet with less impervious cover. However, composite designs using conventional asphalt or concrete in high-traffic areas adjacent to permeable pavements along shoulders or in parking areas can provide a more cost-effective solution for achieving both transportation and stormwater management goals. In addition, including the following green infrastructure practices into the overlay district's parking lot design standards will further reduce the environmental impact of parking required within the city, could afford additional community benefits by providing shade and, if appropriately placed, creating natural barriers between pedestrians and cars. These implementation options are recommended throughout the overlay district; however, they are specifically suited and recommended for the parking courtyards with common green space proposed for the multi-family residential housing developments.

Bioretention is well suited for removing stormwater pollutants from runoff, particularly for smaller (water quality) storm events, and can be used to partially or completely meet stormwater management requirements on smaller sites. Bioretention areas can be incorporated into the city commercial areas to capture roof runoff and parking lot runoff on private property such as the multi-family residential units proposed in the vegetated areas and within rights-of-way to capture sidewalk and street runoff. These types of bioretention areas can also serve green streets hoping to attract pedestrian traffic on the main roads of the downtown area such as Texas Avenue.

Figure 7. Proposed BMP implementation and location for Site#1

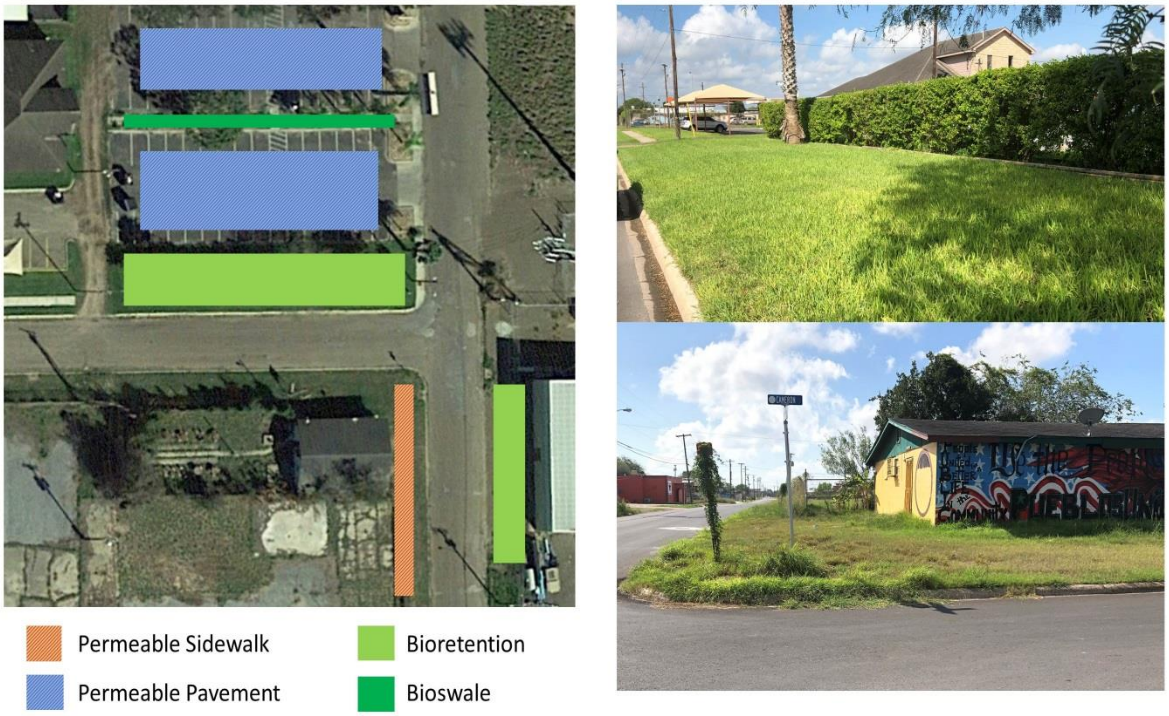

Figure 8. Proposed BMP implementation and location for Site #2

Figure 9. Proposed BMP implementation and location for Site #3

Figure 10. Proposed BMP implementation and location for Site #4

Figure 11. Proposed BMP implementation and location for Site #5

Figure 12. Proposed BMP implementation and location for Site #6

Figure 13. Proposed BMP implementation and location for Site #7

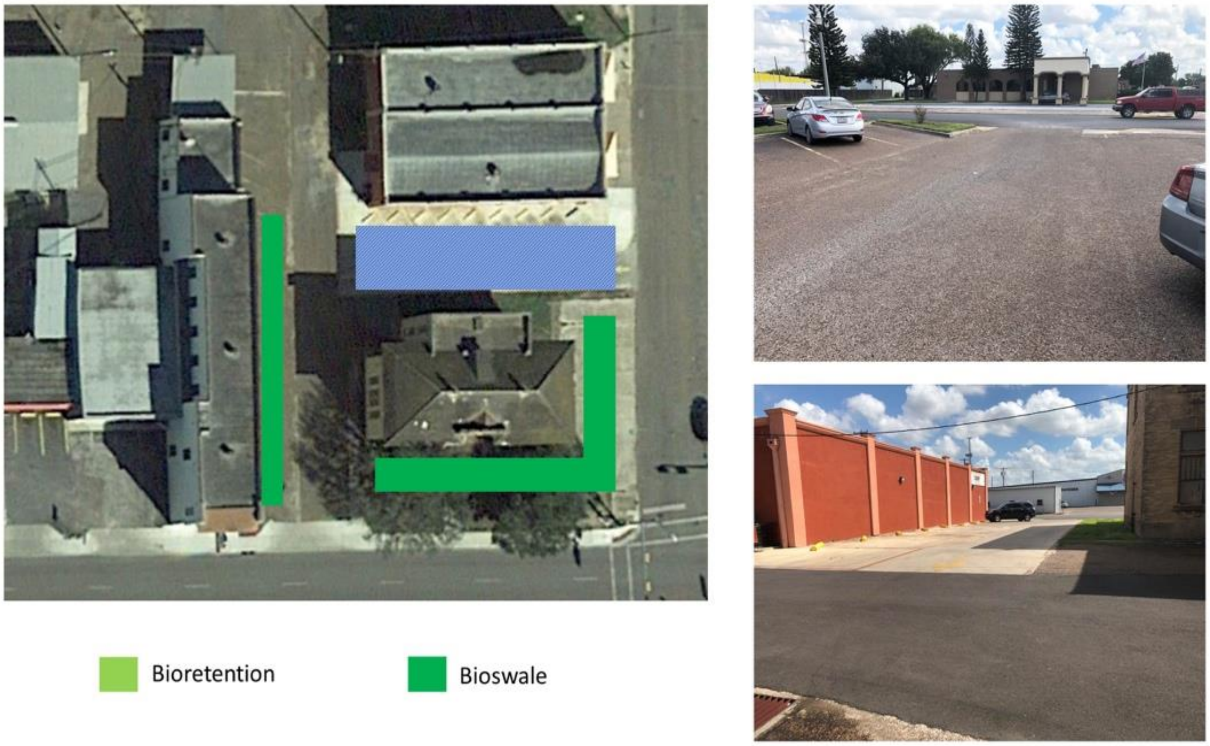

Figure 14. Proposed BMP implementation and location for Site #8

Figure 15. Proposed BMP implementation and location for Site #9

Figure 16. Proposed BMP implementation and location for Site #10

Figure 17. Proposed BMP implementation and location for Site #11

5.4 LID Site Selection and Design

Two locations were identified by the city as a high priority and the LID technology can help in reducing the runoff impacts on each site. The first site located in Kennedy-Collier Park in Mathis Street. The park produces a large amount of runoff that only can be collected by a drainage ditch found on the west side of the park. Additionally, the city mentioned that several times they have to provide a pump for transferring the water from the ditch to create a pathway for the water pooling in the park. The second location is the intersection between the fifth and Illinois streets. The city identified this site as a priority region due to its proximity to Mercedes Independent School District, where the students and their families pass daily through this location across the bridge. However, there is no sidewalk the pedestrian can use and they have to walk on a vegetated strip which is inconvenient to use especially after rainfall events. In addition, the location receives large amounts of runoff from the surrounding area which makes it unsafe to be used. The project team suggested installing a wetland in the first site and a permeable sidewalk on the second. Due to the budget constraints and safety issues, the project team decided to select the site located in the intersection between the fifth and Illinois streets close to the downtown area for installation of the permeable sidewalk (Figure 16). Also, the selection of the site to be close to the school district can be a good educational material for the students passing by. UTRGV assisted the city of Mercedes in the permeable pavement planning and design through several meetings to engage students and provide project information and technical guidance. The planning and design activities for this project were conducted through the participation of:

- City of Mercedes: Project leader
- UTRGV: subcontractor, civil design team and technical advisors.
- LRGV SWTF: technical advisors.
- MEG Engineering Consultants: Geotechnical consultants

Figure 16. Site selected from the permeable pavement design and construction

UTRGV and the city of Mercedes coordinated a geotechnical study to test the infiltration capacity of natural soils at the site. For the study, it was found that the project location soil characteristic is sandy lean clay (Geotech Engineering Report, Appendix A). Using the soil characterization and the survey conducted by the city of Mercedes, UTRGV developed the engineering design of the permeable sidewalk system. UTRGV and the city designed the permeable sidewalk which consists of two sections; first one is on the fifth street while the other section on Illinois street (Civil Engineering Design, Appendix B). A cross-section of the permeable sidewalk is shown in Figure 17. Each pavement section has a top layer of permeable pavement with joints filled with gravels (Figure 21) to allow surface runoff infiltration. Followed the top layer there is a bedding layer and high porous aggregates that serve as a drainage layer to store and hold the stormwater runoff for a period of time before infiltration to the native soil or collected in the perforated underdrain to discharge it to the detention system. In December 2019, the city finished the construction based on a design developed by UTRGV and approved by the city. Figures 18-20 shows the permeable sidewalk before, during and after the construction

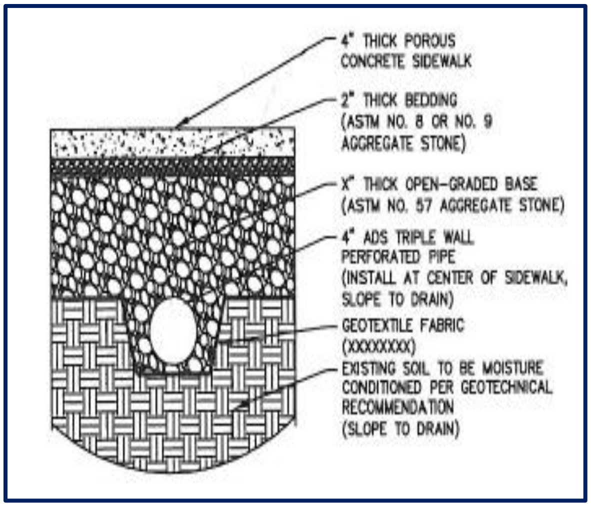

Figure 17. Cross Section of the permeable pavement design

Figure 18. Site selected for the permeable pavement before construction

Figure 19. Construction of the permeable pavement

Figure 20. The two sides of the Permeable pavement after the construction

Figure 21. The permeable pavement joints filled with gravel to increase the runoff infiltration

5.5 Outreach and Education

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. The presentation was listed in the Advancing Resiliency and Green Infrastructure session (Conference Agenda), see Appendix C for the presentation slides. UTRGV undergraduate and graduate students helped in the development of the literature review related to the project. 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. The student poster was awarded the second place in the poster competition, see Appendix D. At these two conferences, the project team provided the GI Master Plan outreach and information to a host of municipal managers, technical staff, consultants, and other interested parties. The project team developed an online website which includes the project scope, technical presentations and project information, the website link is (Project Website), see also Appendix C.

A final workshop was held in the City of Mercedes on the January 30, 2020, to discuss the final report and GI Master Plan results with the City Commissioner and Public Utilities Director , in addition to UTRGV students and stormwater local partners. The slides and attendance sheet are attached in Appendix E. The workshop includes the proposed GI installation with the city to prevent the flooding and recommendations to the city.

5. Discussion and Recommendations

The conceptual GI Master Plan for the stormwater management developed for the City of Mercedes project demonstrates how green infrastructure approaches can complement smart growth principles— providing innovative stormwater management while accommodating and mixed-used development and affordable housing. The next steps are:

1- Work with owners on construction and installation of the GI systems at the priority sites,

2- Make additional enhancements to the GI Master Plan,

3- Change the drainage policy to convey more runoff from the sites,

4- To assist more City of Mercedes jurisdictions in using the tools to create GI plans, and

5- To explore additional funding streams to facilitate widespread implementation.

UTRGV will arrange future meetings with the city of Mercedes to help identify and prioritize upgrades, likely focused on quantifying estimated pollutant load reductions and maintaining simplicity without losing functionality.

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Appendix A
(Geotech Engineering Report Sample)

MEG GEOTECHNICAL ENGINEERING REPORT

PROPOSED
PERMEABLE SIDEWALK
AT South Illinois Avenue and West 5th Street, Mercedes, Texas

MERCEDES, HIDALGO COUNTY, TEXAS

Geotechnical Engineering • Construction Materials Engineering & Testing
Environmental • Consulting • Forensics

GEOTECHNICAL ENGINEERING REPORT
PAVEMENT RECOMMENDATIONS
PROPOSED PERMEABLE SIDEWALK
AT South Illinois Avenue and West 5th Street, Mercedes, Texas
MERCEDES, HIDALGO COUNTY, TEXAS

Prepared For
Richard LeFevre, PE, CFM

MEG Report No. 01-19-29111

February 6, 2019

Millennium Engineers Group
MEG ENGINEERS
Consultants - Geotechnical - Testing

16 2001 - 2017 MEG ENGINEERS

MILLENNIUM ENGINEERS GROUP, INC.
TBPE FIRM NO. F-3913
5804 N. GUMWOOD AVENUE
PHARR, TEXAS 78577
TEL:956-702-8500
FAX:956-702-8140
WWW.MEGENGINEERS.COM

MEG ENGINEERS
Millennium Engineers Group
Consultants - Geotechnical - Testing

February 6, 2019

Richard LeFevre, PE, CFM
LEMC, LLC
320 S. Texas Ave.
Mercedes, Texas, 78570
(956) 687-5362
richard@lemc-llc.com

Subject: **Geotechnical Engineering Report**
MEG Report No. 01-19-29111
Sidewalk Recommendations
PROPOSED PERMEABLE SIDEWALK
AT South Illinois Avenue and West 5th Street
Mercedes, Hidalgo County, Texas

Dear Mr. LeFevre:

Millennium Engineers Group, Inc. is pleased to submit the enclosed geotechnical engineering report that was prepared for the above subject project. This report addresses the procedures and findings of our geotechnical engineering study. Our recommendations should be incorporated into the design and construction documents for the proposed development.

We want to emphasize the importance that all our recommendations presented in this report and/or addendums to this report be followed. We look forward to continuing our involvement in the project by providing construction monitoring in accordance with the report recommendations and materials testing services during construction. We strongly recommend that we be a part of the preconstruction meeting to address any specific issues that are pertinent to this project.

Thank you for the opportunity to be of service to you in this phase of the project and we would like the opportunity to assist you in the upcoming phases of the project. If you have any questions, please contact our office at the address, telephone, fax or electronic address listed below.

STATE OF TEXAS
RAUL PALMA
65656
LICENSED
PROFESSIONAL ENGINEER

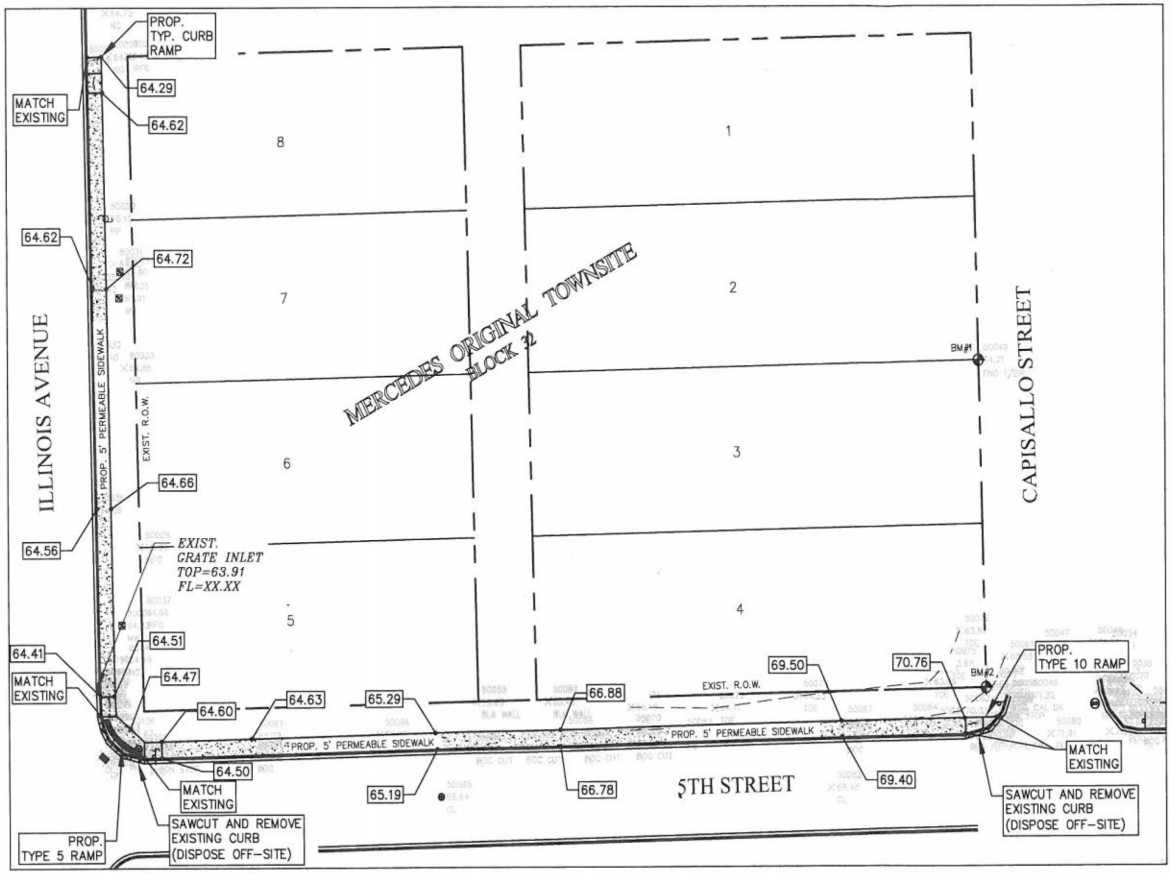
Cordially,
Millennium Engineers Group, Inc.
TBPE Firm No. F-3913

Raul Palma, P.E.
President

The seal appearing on this document was authorized by Raul Palma, P.E. 65656 on February 6, 2019. Alteration of a sealed document without proper notification to the responsible engineer is an offence under the Texas Engineering Practice Act

Cc: 1 Original and PDF Document

Appendix B
(Permeable Sidewalk Deisgn)

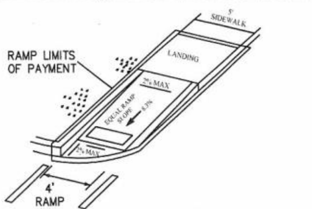


LEGEND

ATT	COMMUNICATION SIGN
	POWER POLE
	WATER METER
TMH	TELEPHONE MANHOLE
	SIGN
	GRATE INLET
	5' PERMEABLE CONCRETE SIDEWALK
	SAWCUT
	CONCRETE CURB AND GUTTER
00.00	PROPOSED SPOT ELEVATIONS
	PERFORATED PIPE
× 86.86	EXISTING SPOT ELEVATIONS

GRADING NOTES:

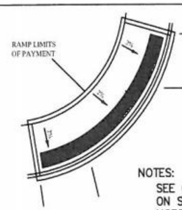
1. ALL MATERIALS AND CONSTRUCTION SHALL CONFORM TO THE PLANS AND SPECIFICATIONS, EXCEPT AS NOTED HEREIN AND APPROVED BY THE CITY.
2. CONTRACTOR SHALL BE RESPONSIBLE FOR MAINTAINING TRENCH SAFETY REQUIREMENTS IN ACCORDANCE WITH CITY STANDARDS, TEXAS LAW, AND O.S.H.A. STANDARDS FOR ALL EXCAVATION IN EXCESS OF FIVE FEET IN DEPTH.
3. THE LOCATION OF ALL UTILITIES LOCATED ON THESE PLANS ARE TAKEN FROM EXISTING PUBLIC RECORDS. THE EXACT LOCATION AND ELEVATION OF ALL PUBLIC UTILITIES MUST BE DETERMINED BY THE CONTRACTOR. IT SHALL BE THE DUTY OF THE CONTRACTOR TO ASCERTAIN WHETHER ANY ADDITIONAL FACILITIES OTHER THAN THOSE SHOWN ON THE PLANS MAY BE PRESENT.
4. IT WILL BE THE RESPONSIBILITY OF THE CONTRACTOR TO PROTECT ALL PUBLIC UTILITIES IN THE CONSTRUCTION OF THIS PROJECT. ALL MANHOLES, CLEAN-OUTS, VALVE BOXES, FIRE HYDRANTS, ETC. MUST BE ADJUSTED TO PROPER LINE AND GRADE BY THE CONTRACTOR PRIOR TO AND AFTER THE PLACING OF PERMANENT PAVING. UTILITIES MUST BE MAINTAINED TO PROPER LINE AND GRADE DURING CONSTRUCTION OF THE PAVING FOR THIS DEVELOPMENT.
5. DRAINAGE SHOULD BE MAINTAINED AWAY FROM THE FOUNDATIONS, BOTH DURING AND AFTER CONSTRUCTION.
6. BACKFILL FOR UTILITY LINES SHOULD BE CAREFULLY PLACED SO THAT THEY WILL BE STABLE. WHERE UTILITY LINES PASS THROUGH THE PARKING LOT, THE TOP 6" SHOULD BE COMPACTED SIMILARLY TO THE REMAINDER OF THE LOT. UTILITY DITCHES SHOULD BE VISUALLY INSPECTED DURING THE EXCAVATION PROCESS TO ENSURE THE UNDESIRABLE FILL IS NOT USED.
7. ALL EARTHWORK OPERATIONS SHALL CONFORM TO THE RECOMMENDATIONS PER THE GEO-TECHNICAL REPORT.
8. ALL PROPOSED SPOT SHOTS ARE GUTTER/TOP OF PAVEMENT/FINISHED GRADE ELEVATIONS UNLESS OTHERWISE SPECIFIED.
9. UPON COMPLETION OF CONSTRUCTION ALL DISTURBED AREAS SHALL BE SEEDED IN ACCORDANCE WITH SPECIFICATION.



** DENOTES PLANTING OR NON-WALKING SURFACE.

DIRECTIONAL RAMP WITHIN RADIUS
(SIDEWALK ADJACENT TO CURB)

HANDICAP RAMP, DETAIL
TYPE 10

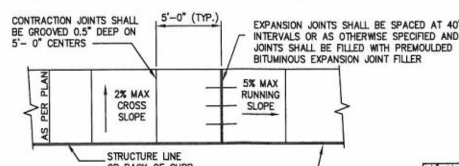


NOTES:
SEE GENERAL NOTES ON SHEET 2 OF 4 FOR MORE INFORMATION.

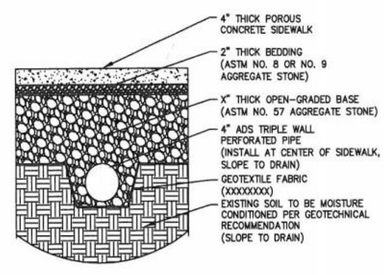
FLUSH LANDING

** DENOTES PLANTING OR NON-WALKING SURFACE.

HANDICAP RAMP, DETAIL
TYPE 5



TYPICAL SIDEWALK DETAIL



PERMEABLE SIDEWALK DETAIL

BENCHMARKS

BM#1:

FOUND 1 1/2 " IRON ROD AT THE NORTH EAST CORNER OF MERCEDES ORIGINAL TOWNSITE LOTS 2-3-4 N 20' BLK 32

N:16579342.8330
E:1177798.9410
ELEV. 64.71

BM#2:

FOUND 1 1/2 " IRON ROD AT THE SOUTH EAST CORNER OF MERCEDES ORIGINAL TOWNSITE LOTS 2-3-4 N 20' BLK 32

N:16579242.8710
E:1177801.1370
ELEV. 69.82

811
Know what's below.
Call before you dig.
(@ least 48 hours prior to digging)

No.	Date	Revision Description

PROJECT NO.: P216

CITY OF MERCEDES PUBLIC IMPROVEMENT PROJECT
PERMEABLE SIDEWALK - 5TH ST. AND ILLINOIS AVE.
MERCEDES, TEXAS

SIDEWALK AND GRADING PLAN

PRELIMINARY
FOR REVIEW ONLY

CIVIL ENGINEERING
ENVIRONMENTAL ENGINEERING
PLANNING
PROJECT MANAGEMENT

LEMC, LLC
RIO GRANDE VALLEY - DALLAS/FORT WORTH
WWW.LEMC-LLC.COM

SHEET NO.
C1.0

Appendix C
(EPA Region 6 Conference Presentation)

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

Ahmed Mahmoud, Ph.D.
Civil Engineering Department
University of Texas Rio Grande Valley

1

Introduction

- LRGV was severely impacted by storm events causing flooding within the cities in the region
- UTRGV is working with one of local cities to solve the problem through incorporation of Green Infrastructure Plan within the city limits

- Topics covered in the presentation:
  1- Effect of stormwater in the LRGV area
  2- GI project in the LRGV
  3- Results of GI project
  4- GI Master plan

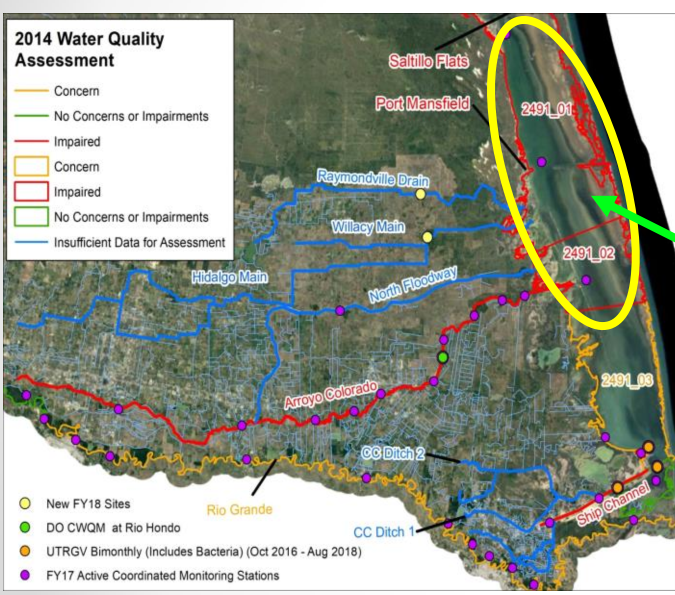
2

Lower Rio Grande Valley

- Located on the southernmost tip of South Texas.
- The economy has revolved around agriculture activities.
- Recently, LRGV is considered One of the fastest growing areas in the United States.
- The climate has been classified as subtropical and sub-humid to semi-arid in some areas

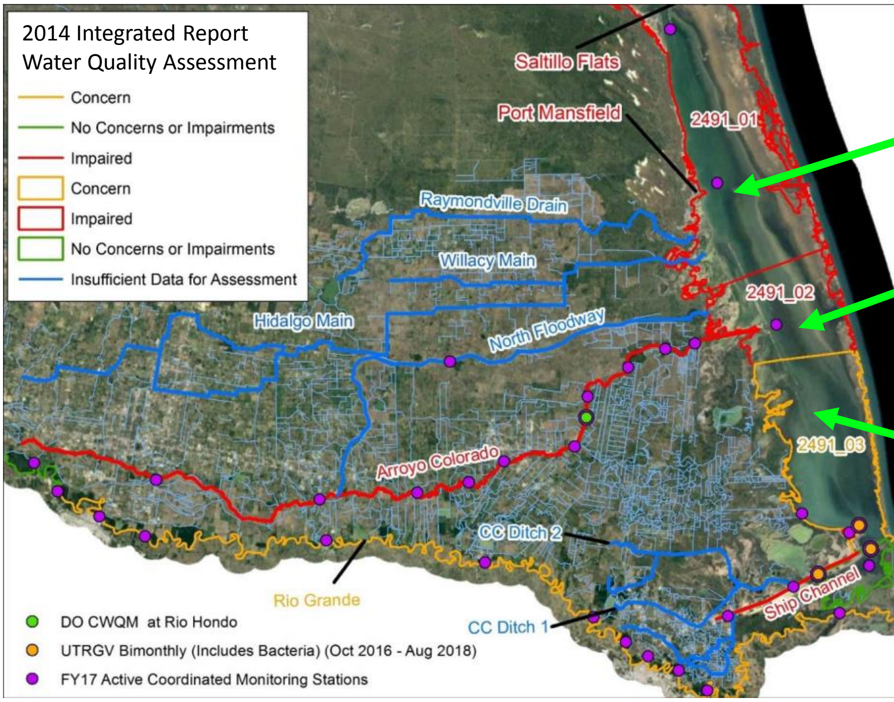
3

Lower Laguna Madre



- The Laguna Madre is one of only five hypersaline in the world (Unique ecosystem).
- Due to its location in semi-arid South Texas, its waters generally evaporate more than freshwater flows into it.
- Lower Laguna Madre Segment 2491 (2941_01, 2941_02 and 2941_03).
- Laguna Madre is impaired for low dissolved oxygen and bacteria

4



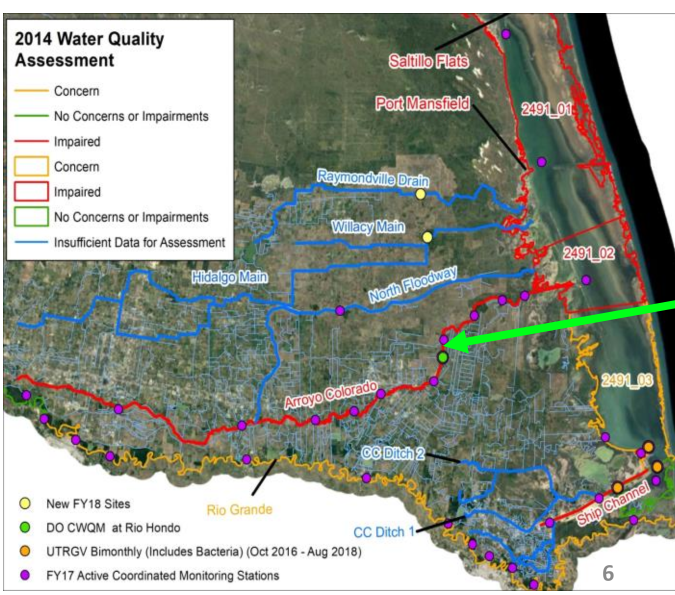
Laguna Madre (2491)

Low Dissolved Oxygen
Chlorophyll-a

Low Dissolved Oxygen
Bacteria
Ammonia
Nitrate
Chlorophyll-a

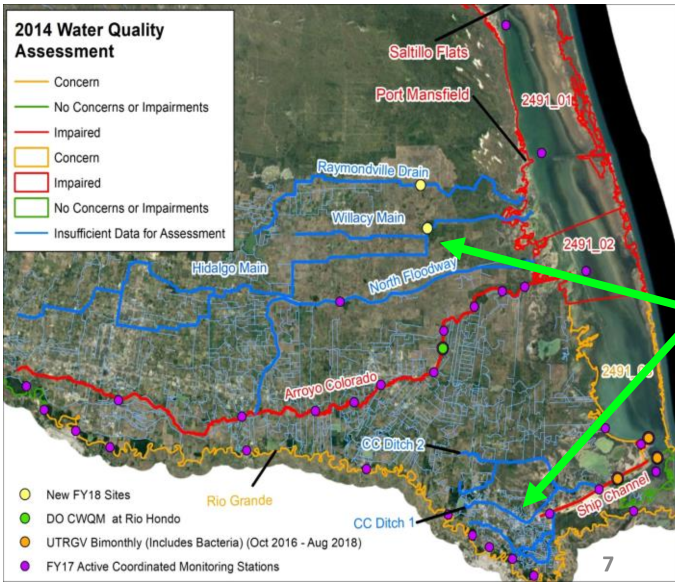
Low Dissolved Oxygen

Arroyo Colorado Watershed



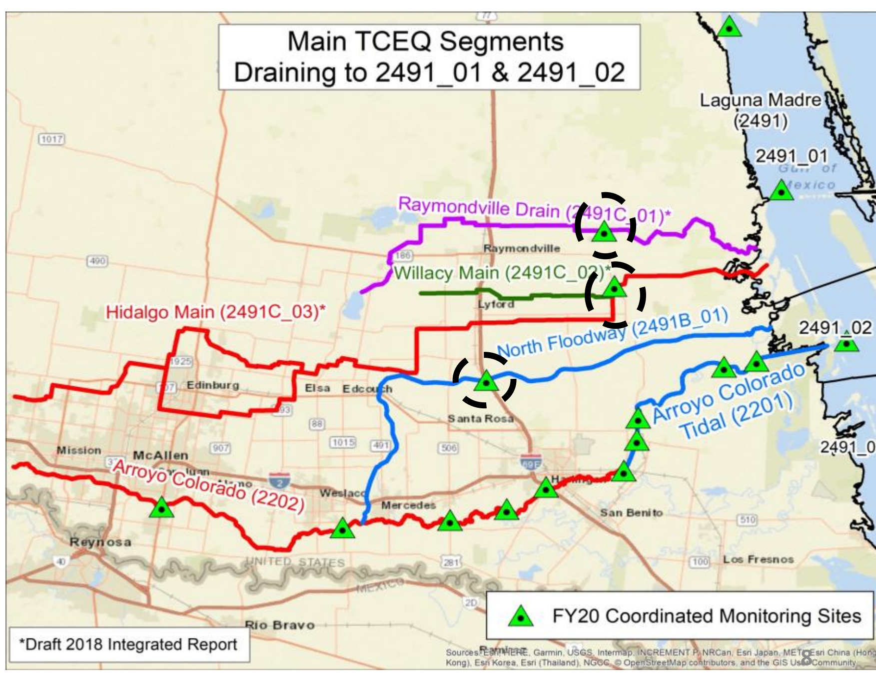
- The stream flow is primarily sustained by wastewater discharges, agricultural irrigation return flows and urban runoff.
- Impaired waterway Does not meet the State's ambient water quality standards
- Elevated levels of fecal coliform bacteria and low dissolved oxygen
- TCEQ, From 1990 to 2004, an estimated 26 million fish died

North and South Arroyo Colorado Watershed



- North and south waterways collects agricultural irrigation and urban runoff.
- Limited data available to assess the flow and water quality

Water Quality Monitoring Stations



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:

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

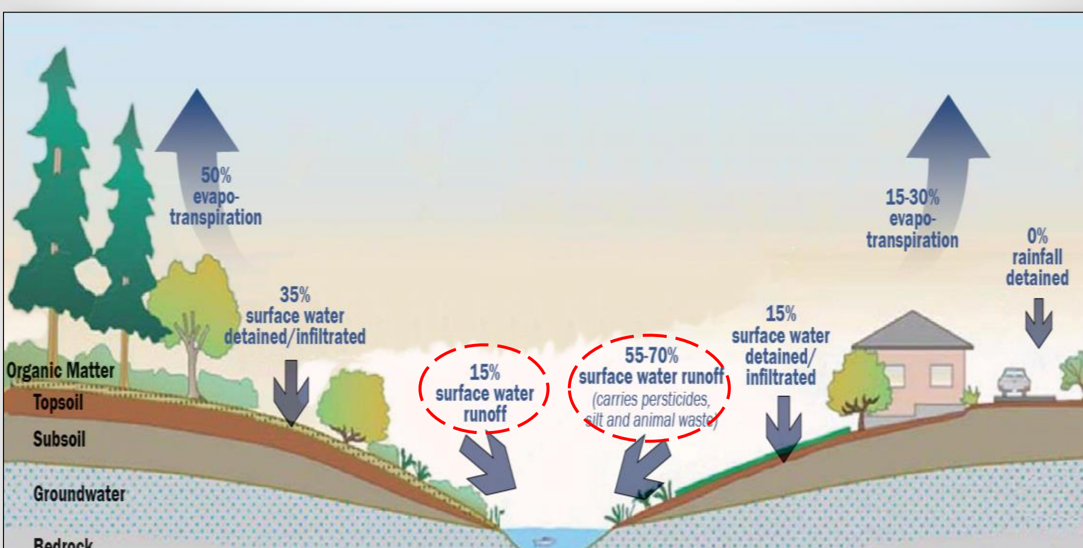
Gray Infrastructure

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

http://niepe.com.au/wp-content/uploads/2017/06/Headwall-Photo-2-resized-1000x663.jpg

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
http://www.kirklandwa.gov/Assets/!Global+PDFs/LID+Residential+Stormwater.pdf

GI Performance

- Green Infrastructure (GI) can be very location dependent.
- Performance generally rely on infiltration and evapotranspiration
- GI effectiveness will be impacted by such things as:

  Soil type/conditions, (Clay, sandy clay loam, other)

  what types of plants will grow,

  the amount of sunlight,

  rainfall patterns,

  land use types (Commercial, Residential, other) and

  other meteorological and hydrological properties.

13

Wetland (Weslaco, LRGV TX)

Bio-swale, (Brownsville, LRGV TX)

Rain Harvesting system (Weslaco, TX)

Green Infrastructure (GI) in LRGV

Bio-retention (McAllen, LRGV TX)

Green Roof (San Juan, LRGV TX)

Permeable Pavement (La Feria, LRGV TX)

Permeable Pavements

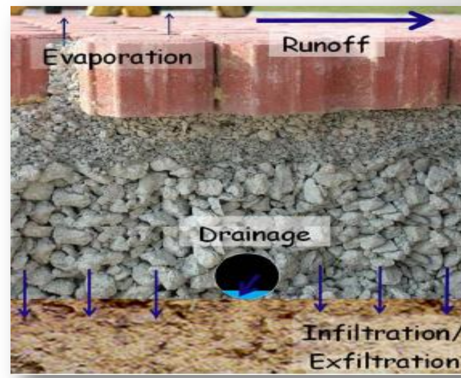
- Permeable pavement systems were developed for infiltration of surface runoff by passing through porous surface, allowing capturing and recycling of storm water on site.
- Effective reducing runoff besides removing various nutrients and pollutants loads associated to the streams in compared to impervious surfaces as asphalt to including :

  Total Kjeldhal Nitrogen (TKN),

  Total suspended solids,

  Total phosphorus,

  Heavy metals.

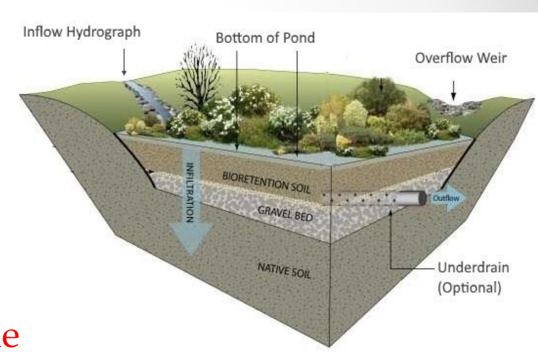


http://www.bae.ncsu.edu/stormwater/PublicationFiles/PermPave2008.pdf

15

Bioretention

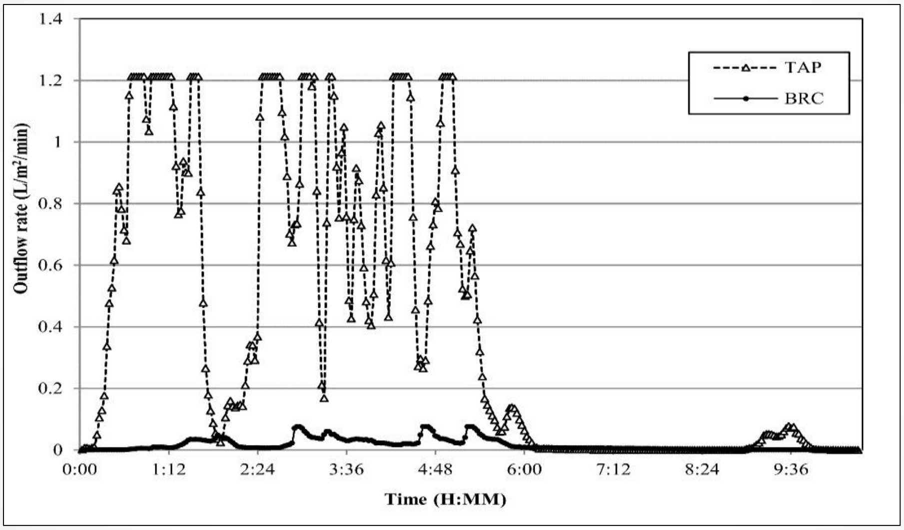
- Bioretention is an infiltration practice through porous media; that uses a biologically active filtration bed to remove contaminants.
- One of the most commonly used GI practices.
- Significant reduction of runoff volume provided by the bioretention cells with water quality improvement by substantially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



https://www.hydrologystudio.com/help/bioretention-ponds.htm

16

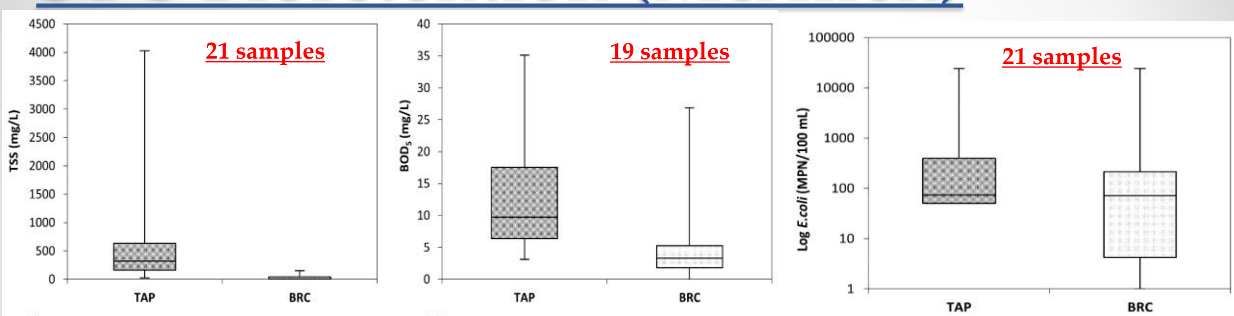
STC Bioretention (McAllen)

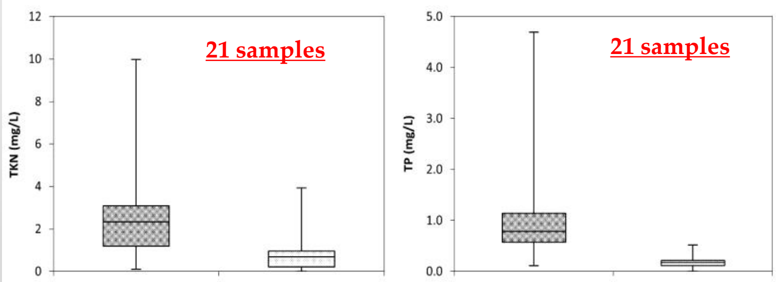


Runoff hydrographs for 10 hours March 3, 2017, rain event totaling 38.3 mm (1.51 inches)

17

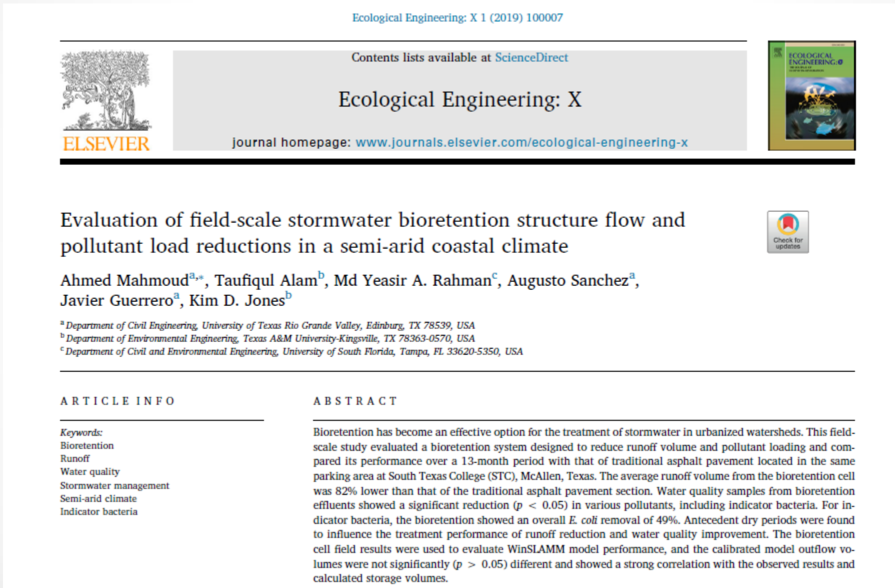
STC Bioretention (McAllen)





18

STC Bioretention (McAllen)



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ELSEVIER

Evaluation of field-scale stormwater bioretention structure flow and pollutant load reductions in a semi-arid coastal climate

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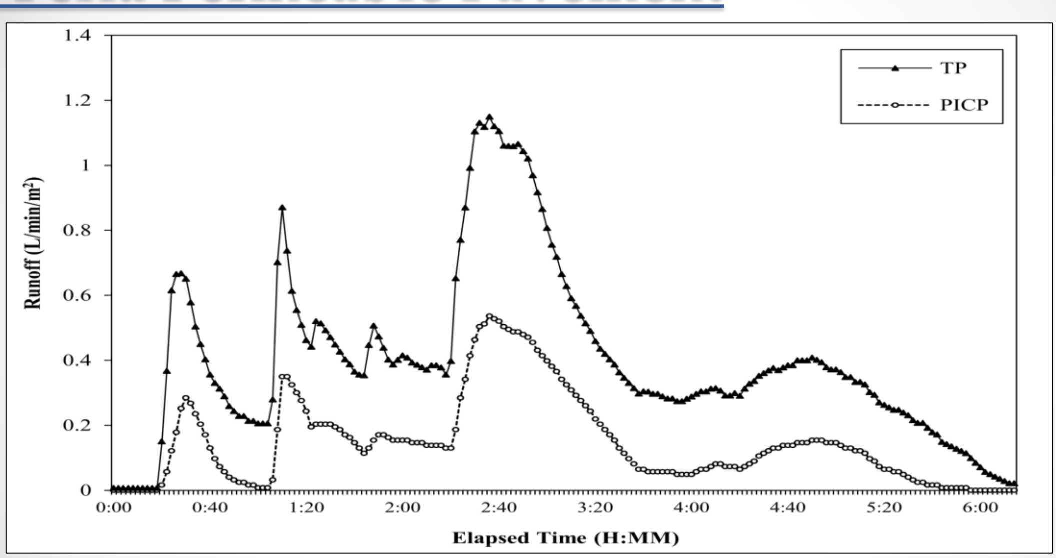
Semi-arid climate
Indicator bacteria

ABSTRACT

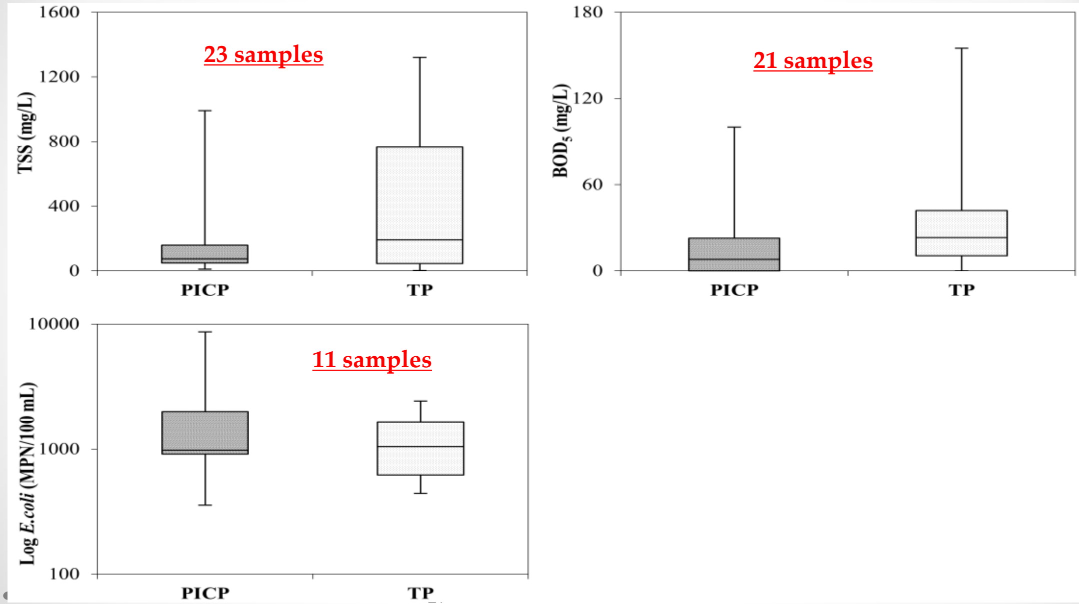
Bioretention has become an effective option for the treatment of stormwater in urbanized watersheds. This field-scale study evaluated a bioretention system designed to reduce runoff volume and pollutant loading and compared its performance over a 13-month period with that of traditional asphalt pavement located in the same parking area at South Texas College (STC), McAllen, Texas. The average runoff volume from the bioretention cell was 82% lower than that of the traditional asphalt pavement section. Water quality samples from bioretention effluents showed a significant reduction ($p < 0.05$) in various pollutants, including indicator bacteria. For indicator bacteria, the bioretention showed an overall *E. coli* removal of 49%. Antecedent dry periods were found to influence the treatment performance of runoff reduction and water quality improvement. The bioretention cell field results were used to evaluate WinSLAMM model performance, and the calibrated model outflow volumes were not significantly ($p > 0.05$) different and showed a strong correlation with the observed results and calculated storage volumes.

La Feria Permeable Pavement

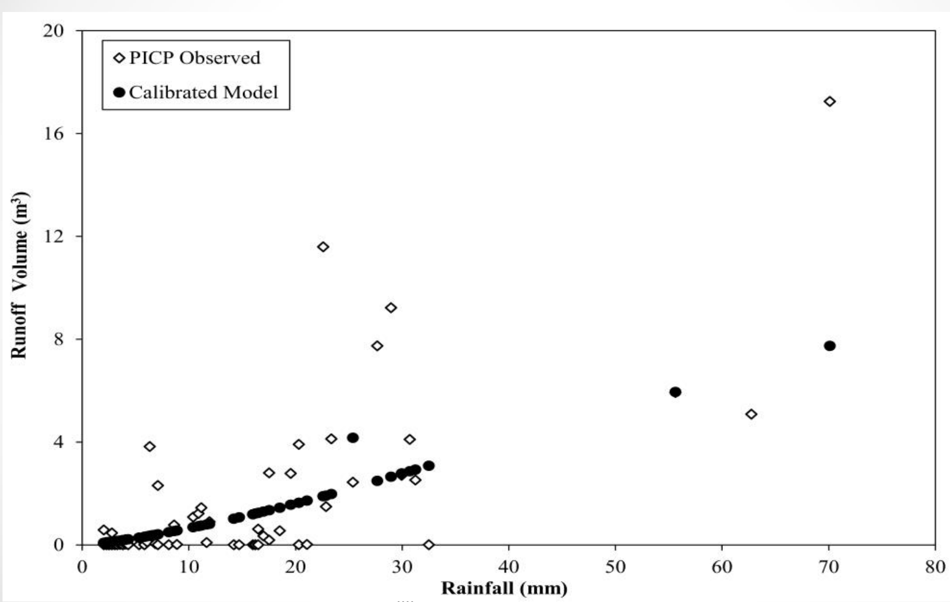


Runoff hydrographs for 6 hours September 13, 2014, rain event totaling 22.6 mm (0.89 inches)

La Feria Permeable Pavement



La Feria Permeable Pavement WinSLAMM Modeling



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Green Infrastructure Master Plan

- City of Mercedes and UTRGV developed a demonstration green infrastructure (GI) master plan to mitigate localized flooding in a high priority region within the city limits.
- The GI Master Plan will provide a unique innovative strategy that will be used as a demonstration tool that can be duplicated throughout the region

Green Infrastructure Master Plan

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

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PROJECT

Project will map the following:

- Inventory (7 city Parks)

PROJECT

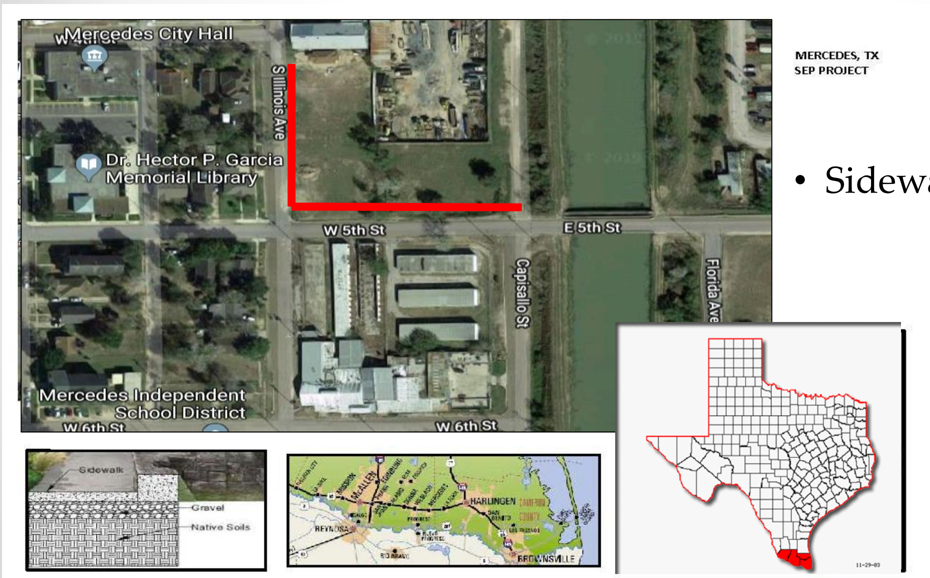
Project will map the following:

• Priority Areas (17 locations)

MERCEDES PROPERTIES (DOWNTOWN)

GI Master Plan

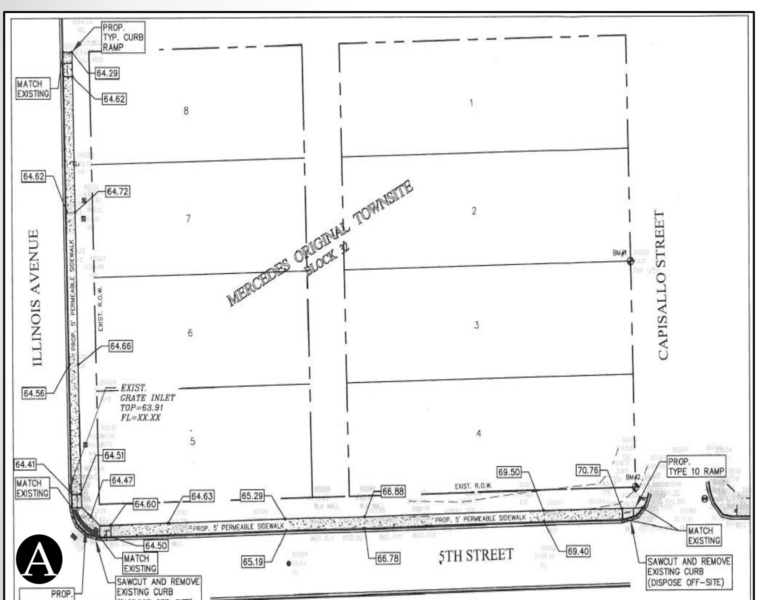
GI Master Plan

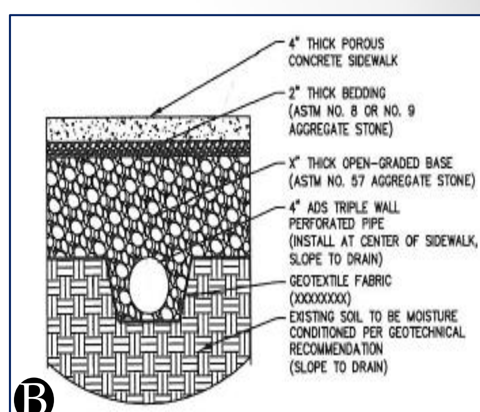


MERCEDES, TX
SEP PROJECT

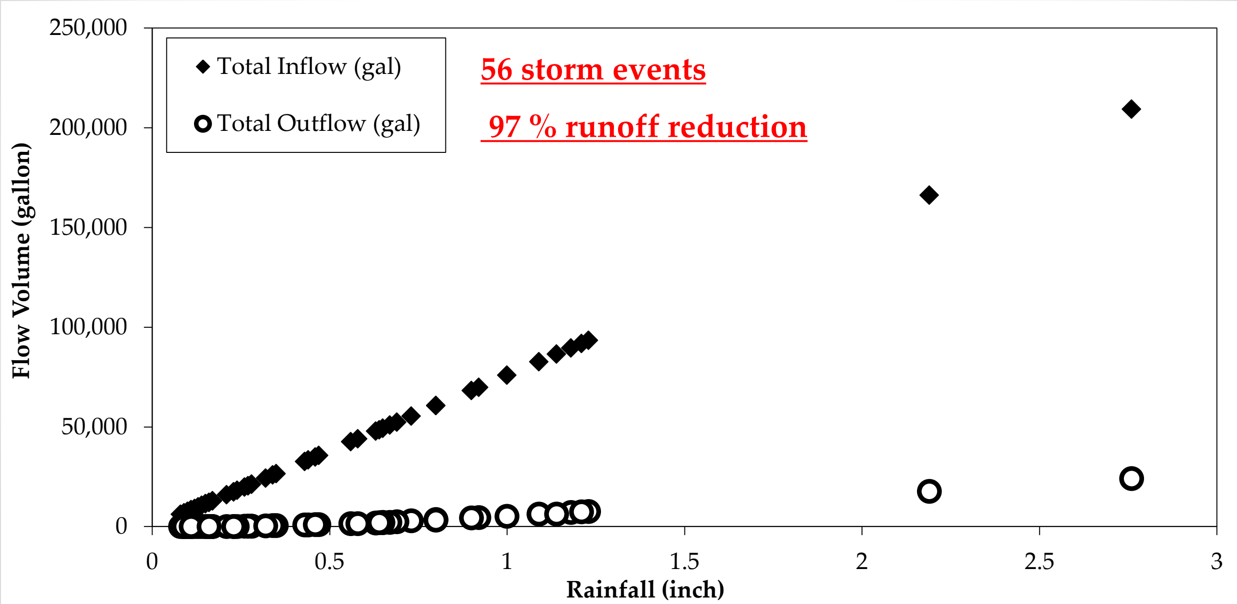
- Sidewalk under design

GI Master Plan

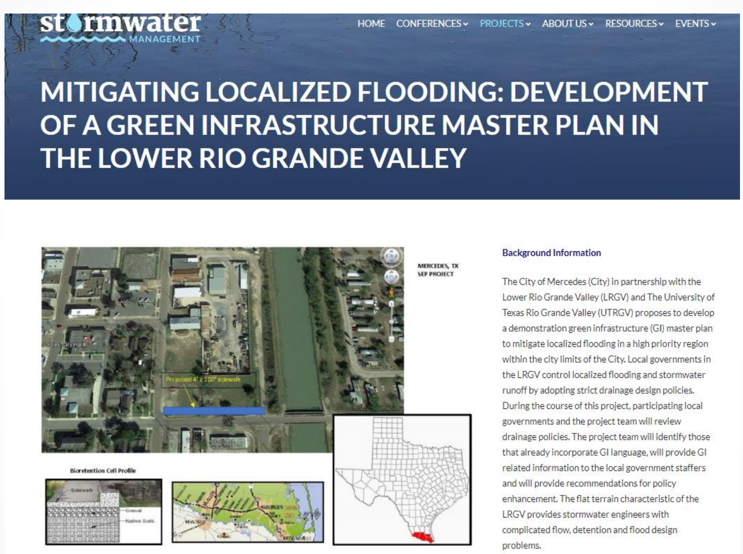




Porous Concrete WinSLAMM Model



Project Website



- https://rgvstormwater.org/projects/mitigating-localized-flooding-development-of-a-green-infrastructure-master-plan-in-the-lower-rio-grande-valley/

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Questions?

- **Project Funded by North America Development Bank (NADB) Broder 2020 Program (TAA:18-007/PID: 20323)**
- **NADB Project Manager** : Jorge Hernandez
- **Mercedes Project Manager:** Jose Figueroa
- **PI :** Andy Ernest, Ph.D., P.E., BCEE, D. WRE
- **Co-PI:** Ahmed Mahmoud, Ph.D.

Appendix D
(Stormwater Conference Poster)

Evaluation of Permeable Pavement for Mitigation of Stormwater Runoff in The City of Mercedes

The University of Texas Rio Grande Valley

Linda Navarro; Samantha Reyna; Javier Guerrero M.S., E.I.T.; Ahmed Mahmoud Ph.D.

city of mercedes It Starts Here!

Abstract

Recent South Texas hazardous flooding events have affected communities along the Lower Rio Grande Valley (LRGV). Permeable Pavement (PP) designs will allow runoff filtration and will reduce pollutants from runoff through filtration and retention. The purpose of this study is to mitigate stormwater runoff by implementing a Low Impact Development (LID) project which will consist of a porous concrete design. The City of Mercedes is partnership with the LRGV stormwater taskforce and the University of Texas Rio Grande Valley (UTRGV) to develop the LID project which will be executed within the city limits. Following the construction of the project, UTRGV students will start monitoring the porous concrete pavement design for runoff volume and pollutant load reduction. The porous concrete will introduce the use of green infrastructures (GI) which are beneficial for areas with flooding. The implementation will benefit both the community and the environment and introduce the GI Master Plan in the region.

Permeable Pavement Design

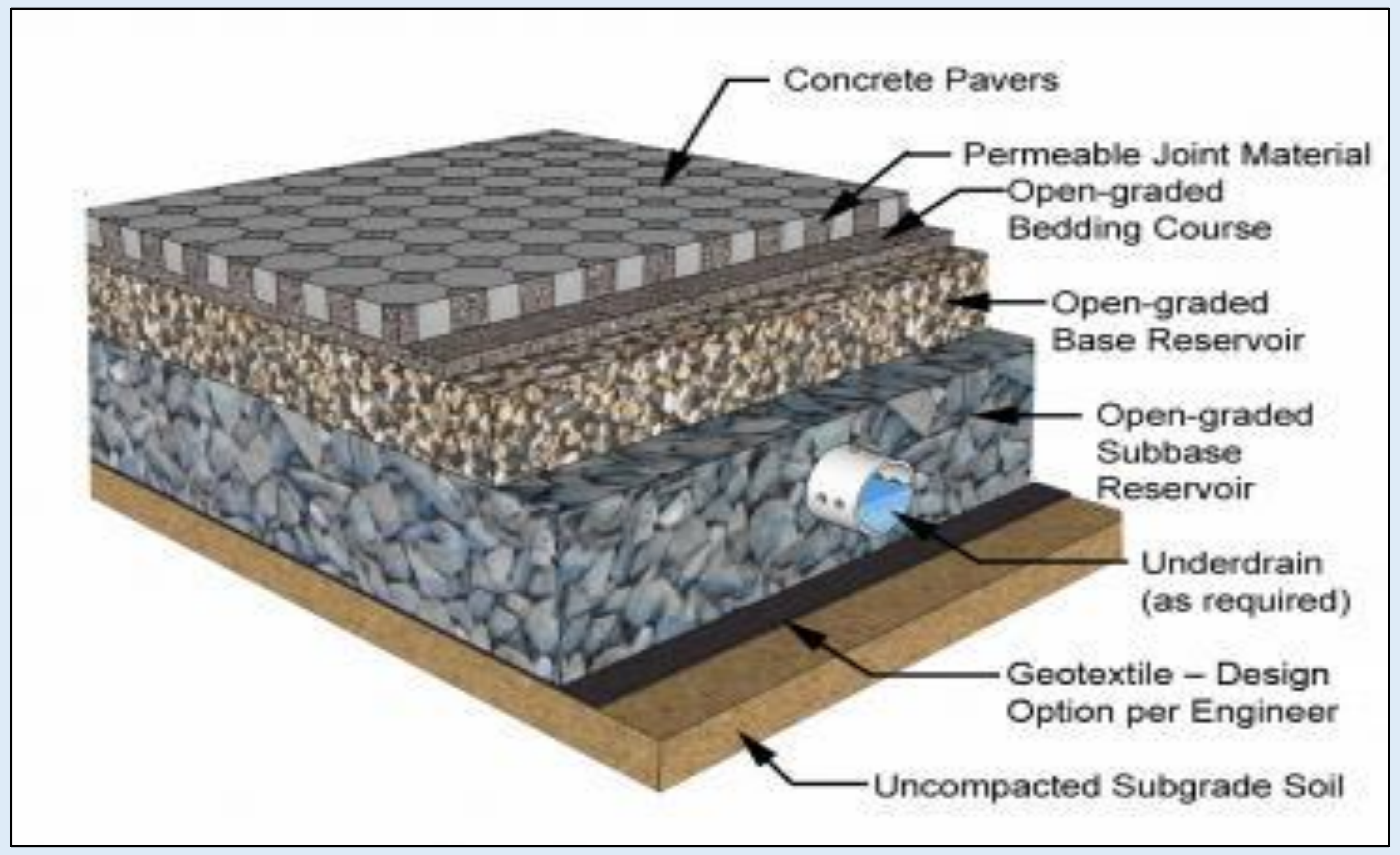

Figure 2: A typical Permeable Pavement design showing the different layers it consists of.
Reference: http://www.stormwater.allianceforthebay.org/take-action/installations/pervious-pavers

Design Model

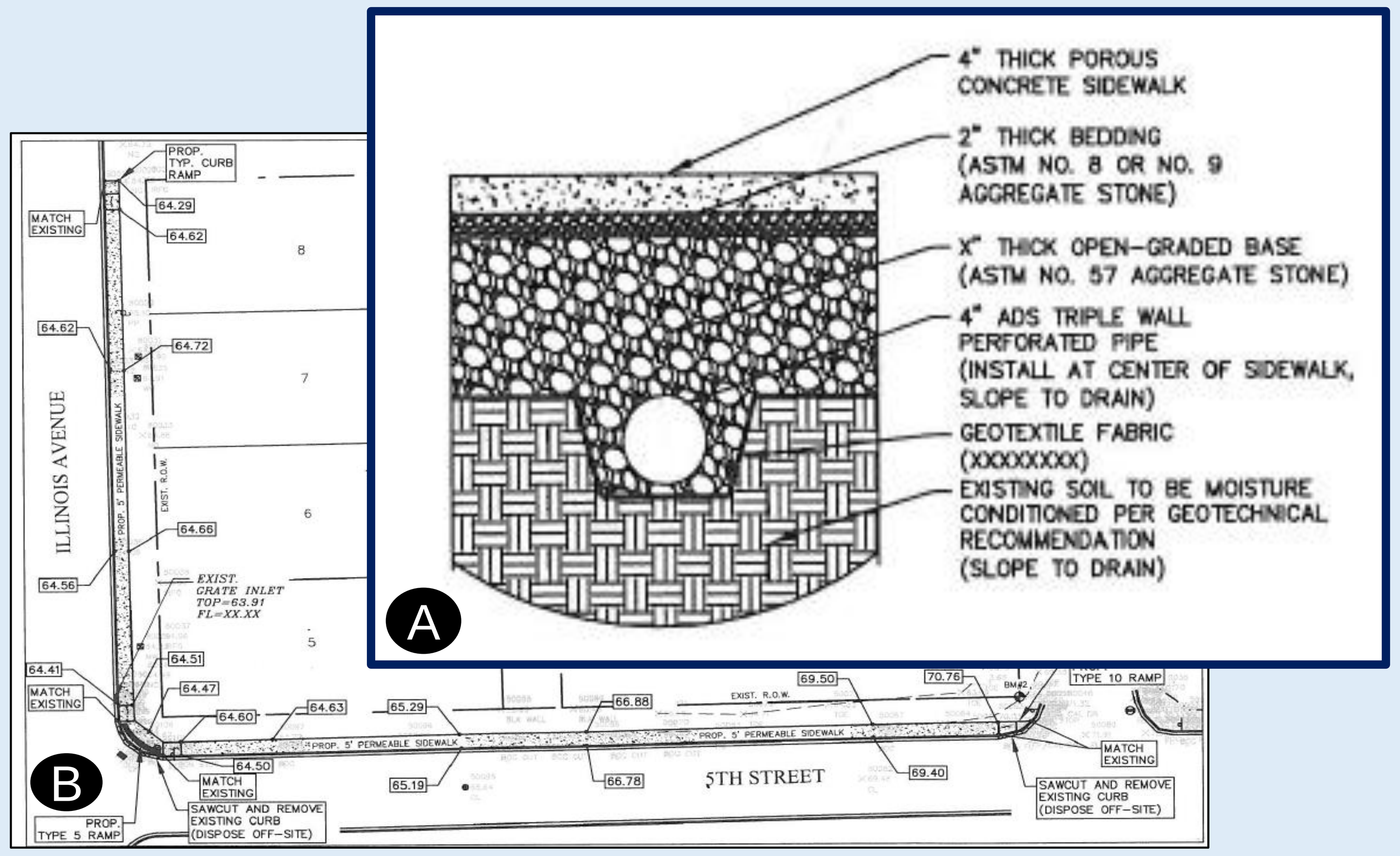

Figure 4: Figure A shows the cross-section of the porous concrete design model. Figure B shows the civil engineering drawing of the design in the project site .

Scope of Work

Permeable pavements (PP) are effective in reducing water volume, improving water quality, removing pollutants, and filtration of water into a reservoir until water runoff is collected by an under drain pipe. There are four main kinds of PPs these include porous concrete, permeable asphalt, concrete grid pavers, and permeable interlocking grid pavers. Among the different types of PPs, porous concrete was chosen due to its proved effectiveness based on previous studies. One of the studies was conducted in the City of Brownsville and showed expected results of porous concrete in reduction of water quantity and improved quality.

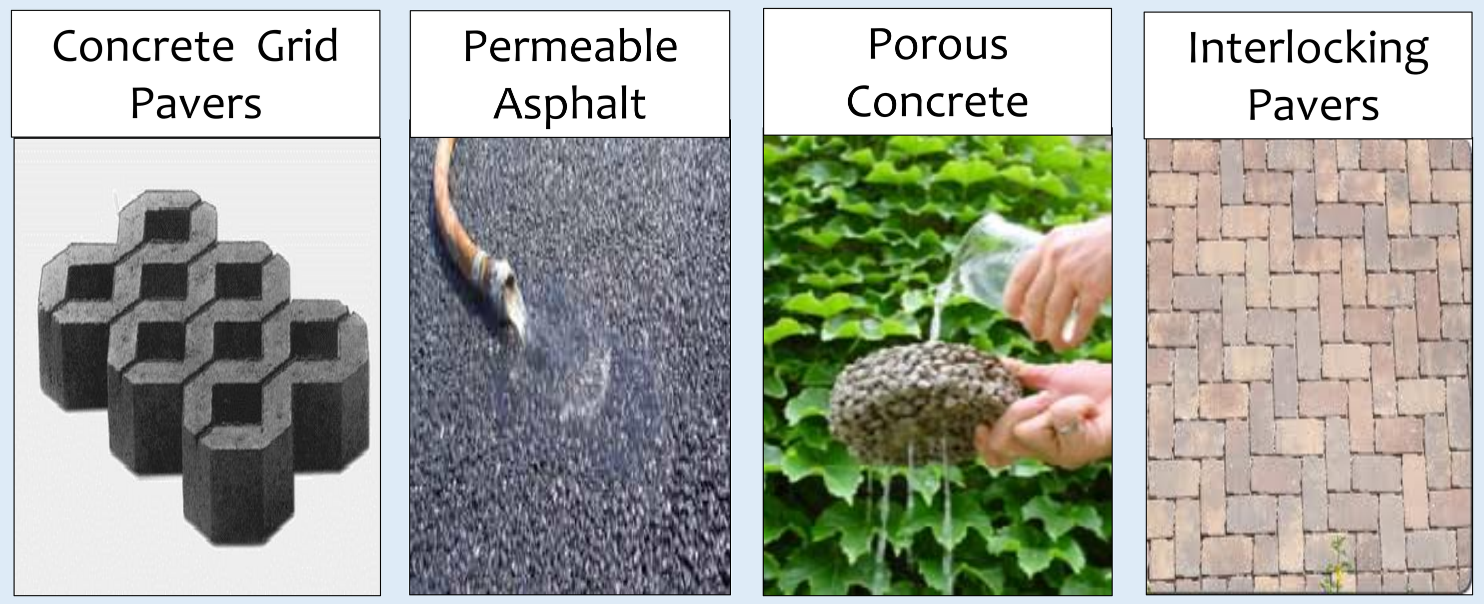

Figure 1: the different types Permeable Pavement

Project Site

Figure 3: Aerial picture shows project site in City of Mercedes

The purpose of this project is to provide a sidewalk for Mercedes City Hall , Bridge and a School. The project will be implemented in S. Illinois Ave and W 5 street. The site location was selected to provide a path for the people and students which will serves as stormwater control system for the urban runoff.

Future Work

UTRGV stormwater faculty and students will be evaluating the performance of the porous concrete pavement in reducing stormwater runoff volume and enhancing water quality.

Monitoring equipment will be installed (Figure 5) for measuring the outflow volume and pollutant concentration.

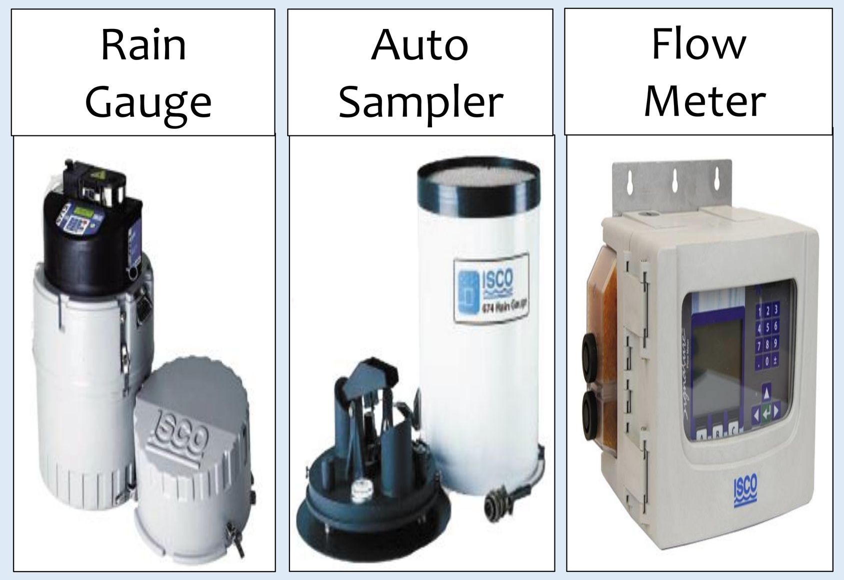

Figure 5: Monitoring equipment to measure rain stormwater runoff volume and collecting samples.

Acknowledgements

This project was funded by TCEQ as a part of the Supplemental Environmental project in the city and NADBank Border 2020 for development of a green infrastructure master plan in the Lower Rio Grande Valley.

Appendix F
(Final Workshop)

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

Ahmed Mahmoud[1], Javier Guerrero[2], and Andrew Ernest[3]
[1, 3] Civil Engineering Department University of Texas Rio Grande Valley
[2, 3] RATES (Research Applied Technology and Education Services) RGV

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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:

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

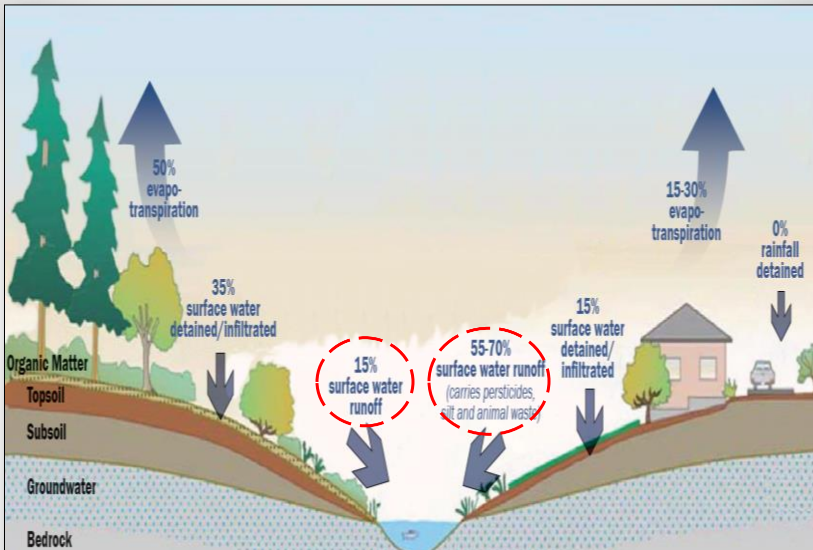
Gray Infrastructure

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

http://niepe.com.au/wp-content/uploads/2017/06/Headwall-Photo-2-resized-1000x663.jpg

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

- http://www.kirklandwa.gov/Assets/!Global+PDFs/LID+Residential+Stormwater.pdf

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Wetland (Weslaco, LRGV TX)

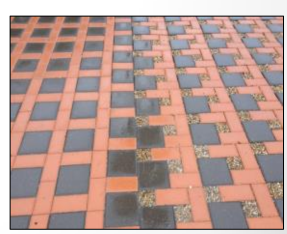
Bio-swale, (Brownsville, LRGV TX)

Rain Harvesting system (Weslaco, TX)

Green Infrastructure (GI) in LRGV

Bioretention (McAllen, LRGV TX)

Green Roof (San Juan, LRGV TX)



Permeable Pavement (La Feria, LRGV TX)

Permeable Pavements

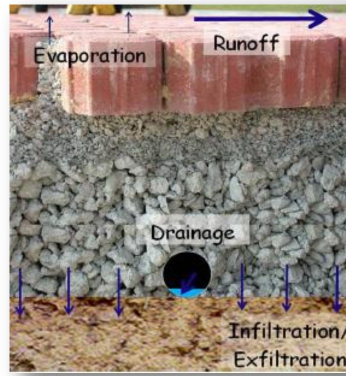
- Permeable pavement systems were developed for infiltration of surface runoff by passing through porous surface, allowing capturing and recycling of storm water on site.
- Effective reducing runoff besides removing various nutrients and pollutants loads associated to the streams in compared to impervious surfaces as asphalt to including :

  Total Kjeldhal Nitrogen (TKN),

  Total suspended solids,

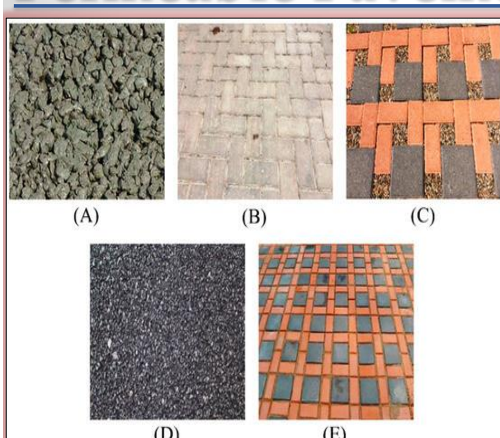
  Total phosphorus,

  Heavy metals.

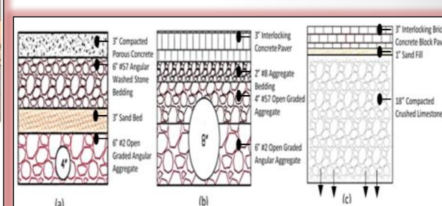


http://www.bae.ncsu.edu/stormwater/PublicationFiles/PermPave2008.pdf

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 water

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A Comparison of Three Types of Permeable Pavements for Urban Runoff Mitigation in the Semi-Arid South Texas, U.S.A

by Taufiqul Alam [1], Ahmed Mahmoud [2], Kim D. Jones [1], Juan César Bezares-Cruz [1,*] and Javier Guerrero [3]

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[2] Department of Civil Engineering, University of Texas Rio Grande Valley, Edinburg, TX 78539, USA
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(This article belongs to the Special Issue Advances of Low Impact Development Practices in Urban Watershed)

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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 (BOD_5) 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 to hold runoff from rainfall depths up to 136 mm prior to flooding. PCP was the most satisfactory in reducing surface runoff (NVR: $2.81 \times 10^{-3} \pm 0.67 \times 10^{-3}$ $m^3/m^2/mm$), which was significantly ($p < 0.05$) higher (98%) than the traditional pavement. PCP was also very effective in TSS removal (NLR: $244 \times 10^{-5} \pm 143 \times 10^{-5}$ $kg/m^2/mm$), which was an increase of over 80% removal than traditional pavement. IBPG (NLR: $7.14 \times 10^{-5} \pm 7.19 \times 10^{-5}$ $kg/m^2/mm$) showed a significantly ($p < 0.05$) higher (46%) BOD_5 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

▼ Show Figures

Permeable Pavements

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New Orleans mandates permeable pavement to control stormwater runoff

David Wagman | September 12, 2019

Permeable paving allows stormwater to drain into the soil rather than flow into drainage systems. Source: Wikipedia

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.

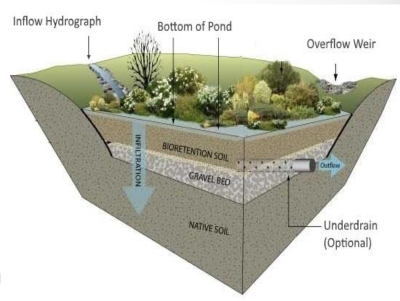
Once in place, the paving is subject to water infiltration testing based on ASTM International C1701 or C1781 standards. Pavement must maintain a minimum infiltration rate of 200 in per hour, the ordinance said.

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

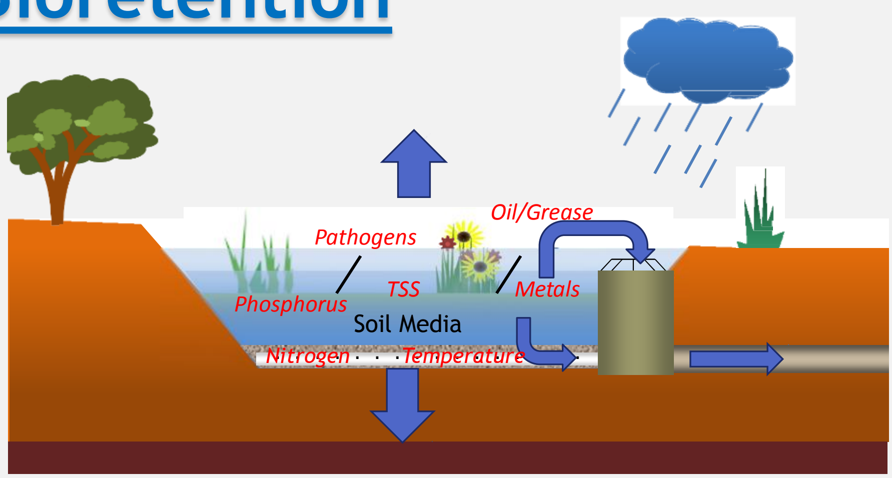
Bioretention

- 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.



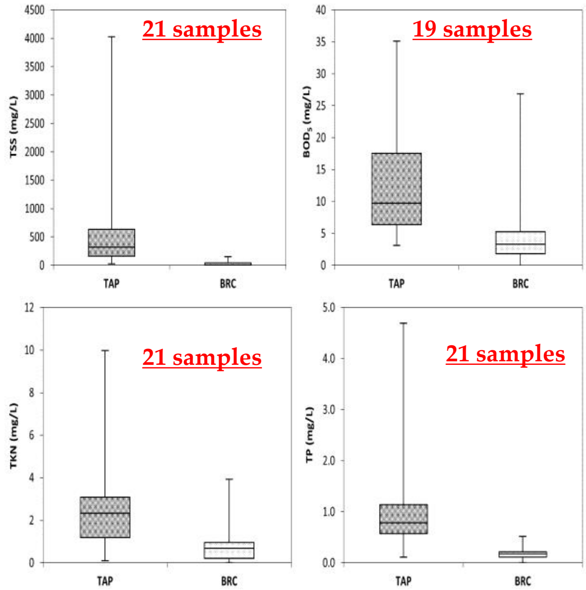
https://www.hydrologystudio.com/help/bioretention-ponds.htm

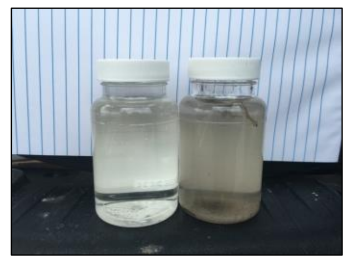
Bioretention



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)





- https://www.sciencedirect.com/science/article/pii/S2590290319300070

Green Infrastructure Master Plan

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2) Avoid localized flooding,
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4) Integrate it to the construction projects through the development of natural drainages.

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

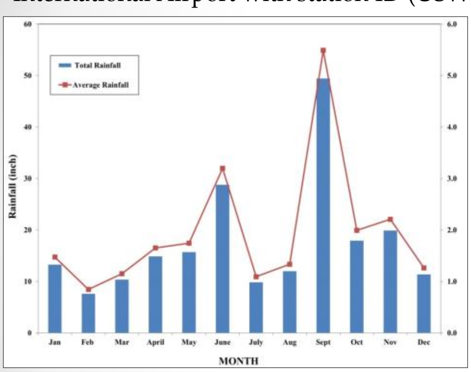
Task 3- Conceptually design green infrastructure facilities, primarily bioretention systems

Task 4- Provide outreach to promote strategy

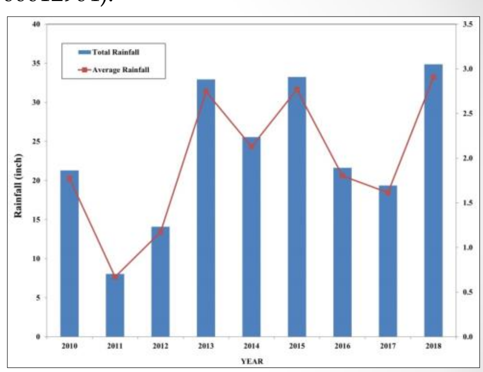
Task 5- Incorporate GI in local stormwater

Rainfall Data

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

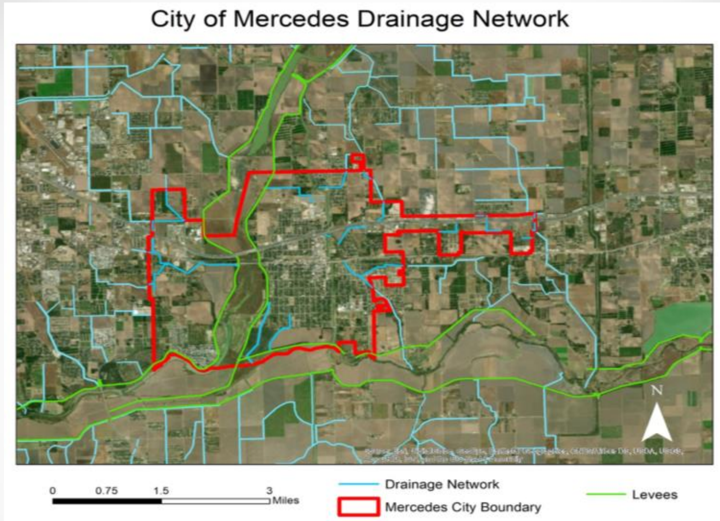


June and September with an average value of 3.2 ± 3.6 and 5.49 ± 4.68 inches



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 1st through November 30th 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

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Storm Drainage Policy

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 (10) minutes."

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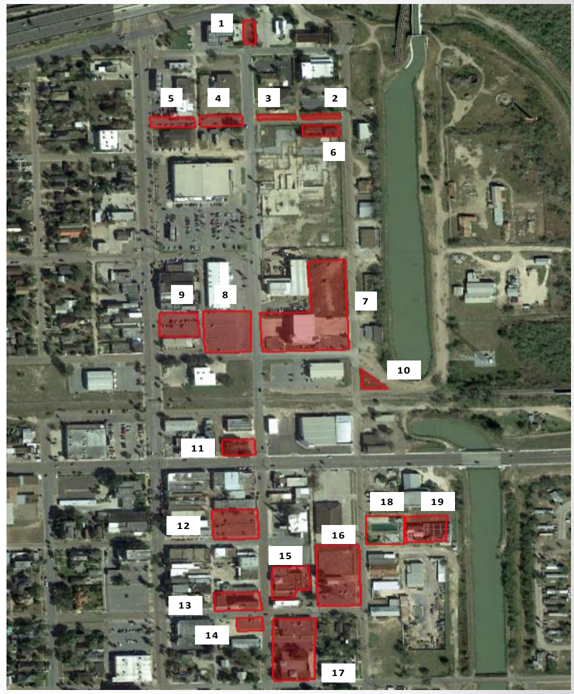
PROJECT

- Priority Areas (19 locations)

Majority in Texas, Ohio, Illinoi Avenues and Capisallo St



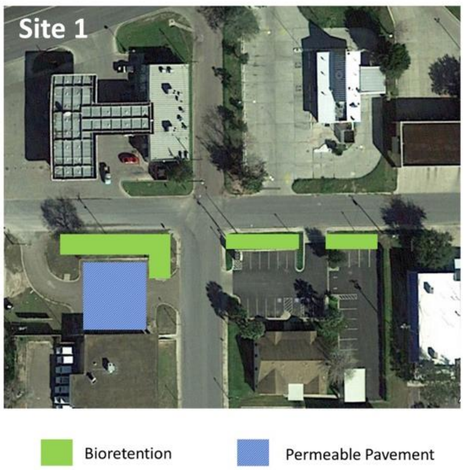
Priority Sites List

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

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

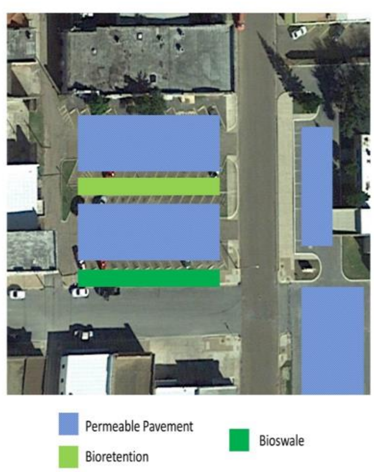
Priority Sites

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

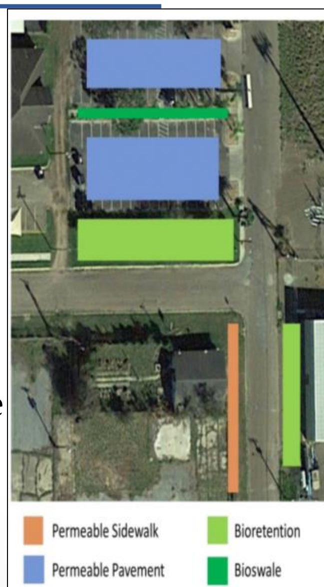
Switching the impervious parking areas to permeable pavements, can reduce the amount of stormwater runoff from a site, and improve water quality.

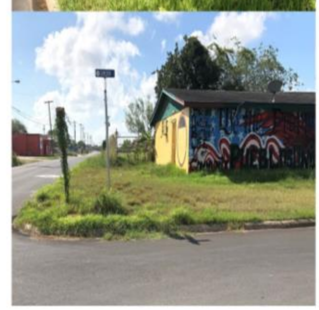


Site #5 Parking at Juanitos Restaurant

Priority Sites

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





PROJECT

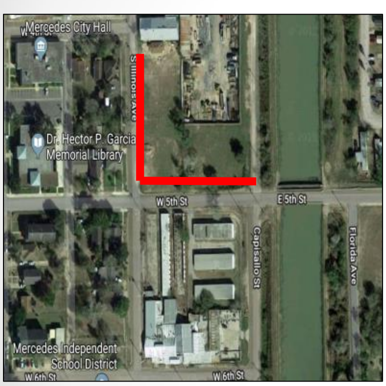
Site Number	Permeable pavement/sidewalk	Bioretention/Bioswale
Site #1	1	3
Site 2	2	3
Site 3	7	1
Site 4	1	4
Site 5	3	3
Site 6	-	1
Site 7	1	2
Site 8	4	2
Site 9	5	2
Site 10	3	3
Site 11	2	-
Total	**29**	**24**

Two Priority Sites

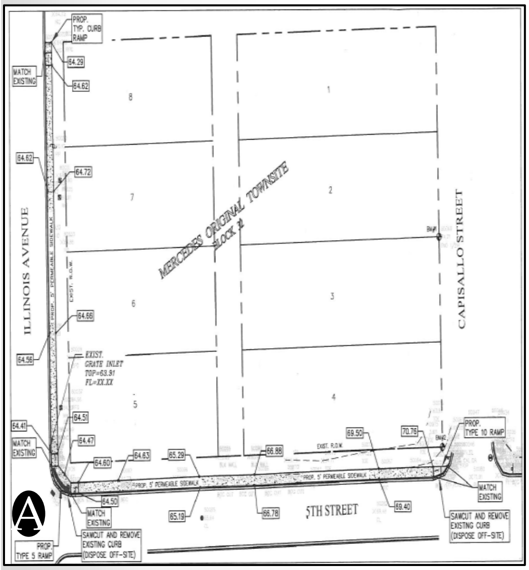
The first site located in Kennedy-Collier Park in Mathis Street.

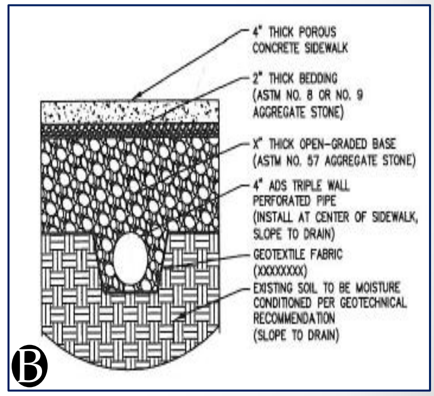
Two Priority Sites

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



Permeable Pavement Design



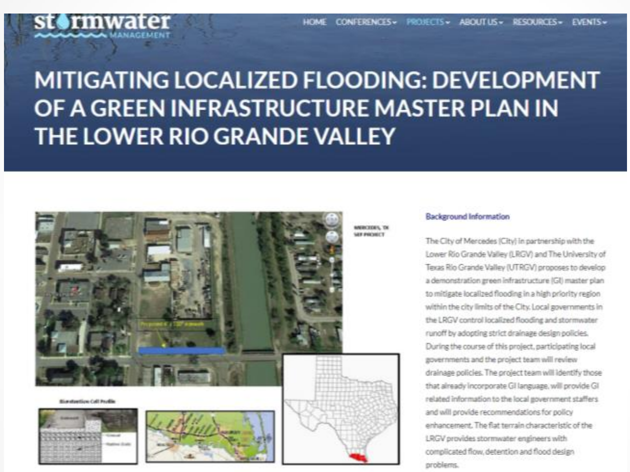


During Construction

After Construction

Permeable Pavement Design

Outreach and Educational

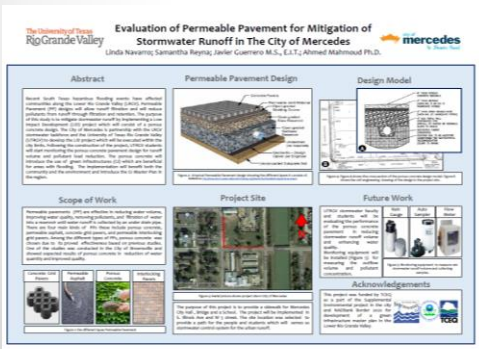


- https://rgvstormwater.org/projects/mitigating-localized-flooding-development-of-a-green-infrastructure-master-plan-in-the-lower-rio-grande-valley/

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.

Thanks

http://www.southwesturbanhydrology.com/solutions/bio-retention-basins/

Questions?

Bioretention basin at Water Street in Plymouth Center, Massachusetts. https://capecodgreenguide.wordpress.com/bio-retention/

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LID Workshop

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Wed 1/29/2020 3:47 PM

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Cc: jfigueroa@cityofmercedes.com <jfigueroa@cityofmercedes.com>; dlevrier@ratesresearch.org <dlevrier@ratesresearch.org>; Ahmed Mahmoud <ahmed.mahmoud@utrgv.edu>

Aaron/Alex:

We are presenting a brief lecture on LID and GI to the City of Mercedes tomorrow at 3 pm. The presentation is funded by a Border 2020 grant that required us to develop a conceptual GI/LID Master Plan for the City. We are inviting you to attend.

RESEARCH, APPLIED TECHNOLOGY,
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http://rgvstormwater.org
http://rgvlidprogram.com/
http://www.rgvscec.com/
http://www.lagunamadreestuary.com/
http://www.rates.org

Green Infrastructure

Peter Hermida <phermida@weslacotx.gov>

Thu 1/30/2020 4:49 PM

To: Ahmed Mahmoud <ahmed.mahmoud@utrgv.edu>
Cc: Rolando Garza <rogarza@weslacotx.gov>; Alberto J. Aldana <aaldana@weslacotx.gov>

Dr. Mahmoud

Thank you for inviting us to your meeting. It definitely sparked an idea in me as we are working on another project in our city and I wanted to show some of our staff in hopes of creating potential interest in incorporating some green infrastructure in our new pond.

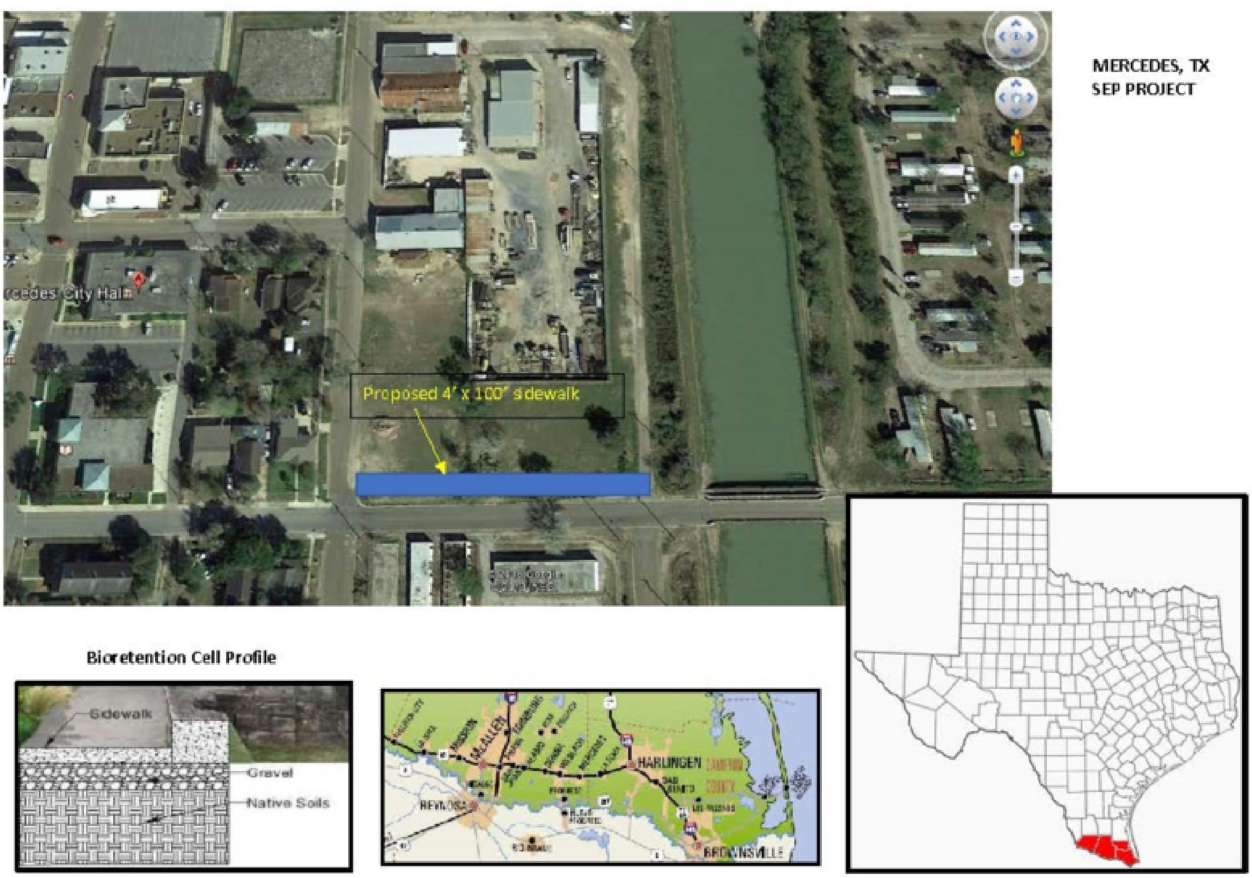
Best Regards,

Peter Hermida E.I.T.
Engineering Technician
Ph. (956) 973-4002 ext. 1401

City of Weslaco
255 S. Kansas Avenue
Weslaco TX, 78596

"Never give up on a dream just because of the time it will take to accomplish it"

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



(https://rgvstormwater.org/wp-content/uploads/2019/07/Website-1-e1563334212336.png)

The GI Master Plan will provide a unique innovative strategy that will be used as a demonstration tool that can be duplicated throughout the region. 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. Through the GI Master Plan, the City intends to establish the general and specific guidelines for the management and treatment of rainwater to diminish its impact and to apply the strategies that allow for the construction of "green" structures. Of the twenty-one (21) LRGV Stormwater Task Force members, solely the City of Weslaco has GI language in its drainage policy, primarily stating that GI strategies can be used in managing stormwater runoff. Through this project, the City of Mercedes and other participating local governments will assess GI facilities, and will consider providing language that encourages GI in their policies. The GI Master Plan is an approach for land development that works with nature to manage rainwater and it's based in the preservation and recreation of natural landscape characteristics, minimizing impervious surfaces to create a functional drainage. The idea is that rainwater can be integrated as a natural attraction of urbanism instead of being considered a discarded product, therefore avoiding the creation of ponds and future contamination.

The GI Master Plan will benefit the public and the environment by providing innovative and emerging information to the region in order to meet the challenging requirements of water quality, flooding and public safety. Improving water quality, reducing localized flooding, and identifying sustainable, economical and innovative stormwater management strategies is a key benefit that will result from the development of the GI Master Plan. Although this project will be implemented in the City of Mercedes, UTRGV is partnering with the LRGV TPDES Stormwater Task Force (STF) and the Coastal Cities Task Force (CTF) in the promotion of the GI Master Plan to the region. The coalitions are comprised of 33 local governments, a population of over 750,000. The institutionalization of GI infrastructure strategies, the introduction of low impact development programs, and the implementation of innovative planning, management and engineering approaches to water programs will not only benefit communities, but the environment. The successful institutionalization of innovative stormwater management programs will reduce NPS pollutants, mitigate localized flooding in urban, colonia, and rural settings, and improve water quality BMPs utilized by residential, commercial and industrial stakeholders. The improvement of water quality within the surface waters of the region is a significant benefit to the environment.

The City will contract with UTRGV in developing this project and assuring a regional buy in from local communities and stakeholders. UTRGV will provide facilitation, and project reporting directly with the border 2020 project manager.

Objectives

The proposed GI Master Plan project meets the requirements of Goal 2 under the Objective 2, Type 2 project classification. Goal 2 is fulfilled by the project content which will include educational and research topics associated with stormwater management. Goal 2 is further fulfilled by the educational outreach activities that will be required by the project in order to promote the GI stormwater runoff management strategies to local school districts officials, colonias, institutes of higher education, city and county officials, water professionals, professional organizations and water-related organizations. The goals of the GI Master Plan are as follows:

- Provide an understanding of drainage concepts and patterns in the community;
- Describe properties and tendencies of the major watersheds in the region;
- Explain precipitation patterns and the concept of percentiles, zero runoff approaches, and the importance of water quality;
- Explain detention and promote alternatives to conventional design;
- Engage residential, commercial and educational stakeholders;
- Promote topics that will educate residential, commercial and educational stakeholders;
- Change the mind set of water professionals by promoting a new engineering paradigm

Contact Info

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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 Activities

Event	Date	Presentation
Lower Rio Grande Valley 21st Annual Water Quality Management and Planning Conference	May 19-25, 2019	Poster Presentation (file:///C:/Users/Robert%20Martinez/Downloads/SPI%20Poster%20Conference%20FINAL.pdf)
2019 EPA Region 6 Stormwater Conference	July 28-August 1, 2019	Powerpoint Presentation (file:///C:/Users/Robert%20Martinez/Downloads/2019%20EPA%20conference%20Ahmed%20Mahmoud.pdf) Agenda

Resources

Priority locations in the City of Mercedes (file:///C:/Users/Robert%20Martinez/Downloads/Green%20Infrastructure%20&%20Areas.pdf)

Final Report

Funding

This funding technical assistance agreement TAA18-007 is provided by the Northern American Development Bank and the Border Environmental Cooperation Commission.

Contact Us

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News (https://rgvstormwater.org/22nd-annual-water-quality-and-management-conference/)

19th Annual RGV Quality Management and Planning Conference (https://rgvstormwater.org/news/19th-annual-rgv-quality-management-and-planning-conference/)
June 5th, 2017

19th Annual RGV Quality Management and Planning Conference

Read more → (https://rgvstormwater.org/news/19th-annual-rgv-quality-management-and-planning-conference/)

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