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

Introduction

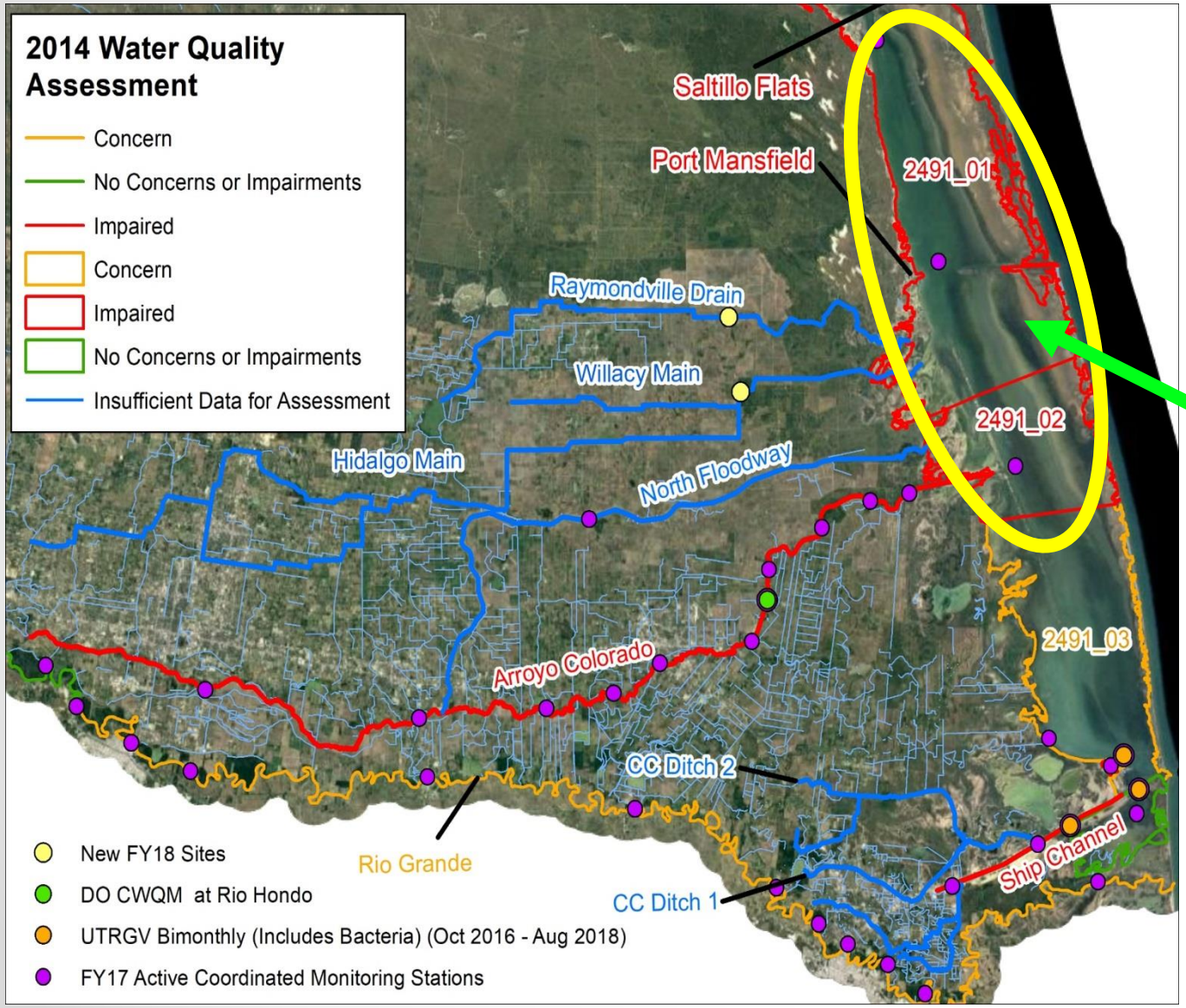
- LRGV was severely impacted by storm events causing flooding within the cities in the region
- UTRGV is working with one of local cities to solve the problem through incorporation of Green Infrastructure Plan within the city limits

- 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

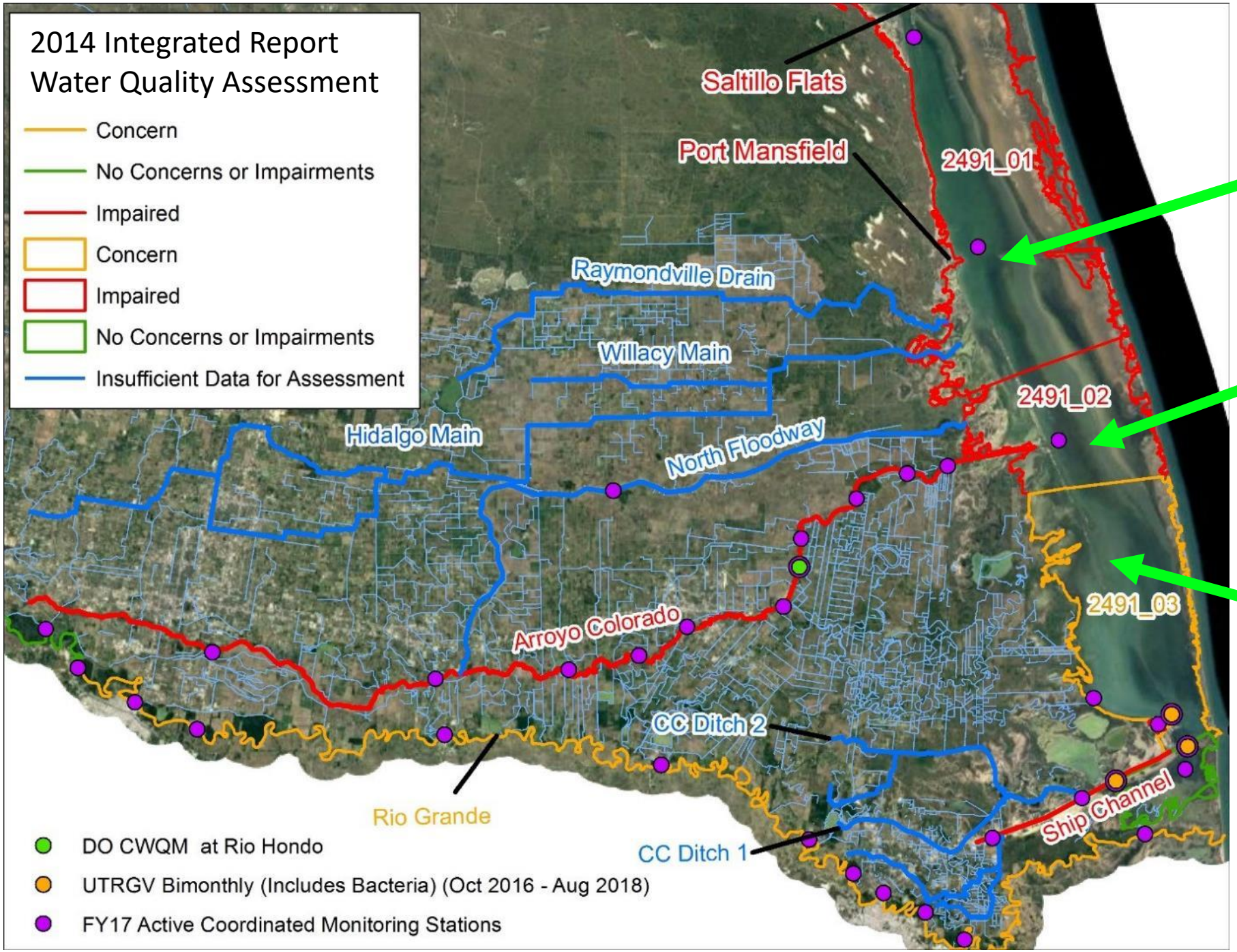
Lower Rio Grande Valley

- 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

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



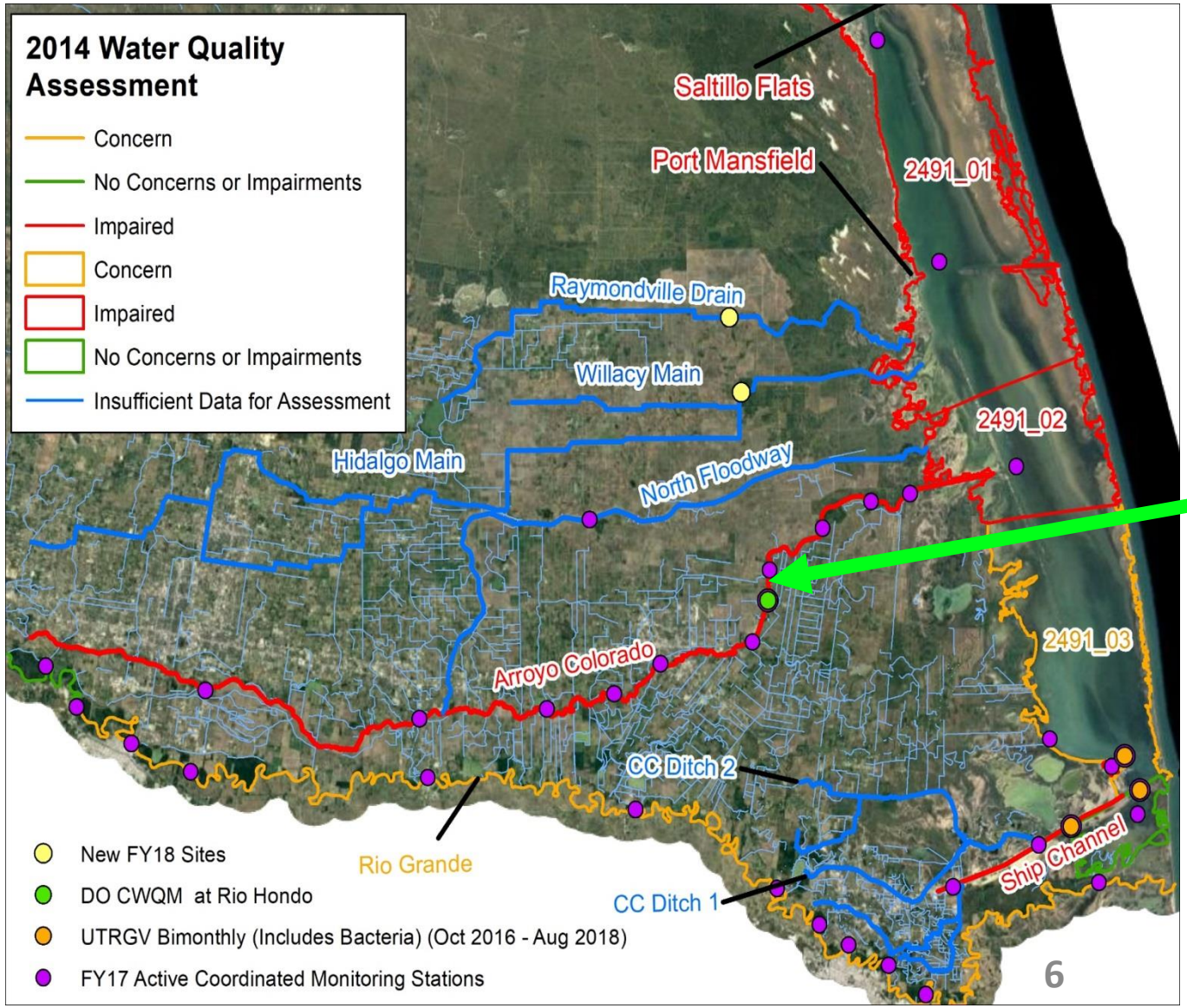
Laguna Madre (2491)

Low Dissolved Oxygen
Chlorophyll-a

Low Dissolved Oxygen
Bacteria
Ammonia
Nitrate
Chlorophyll-a

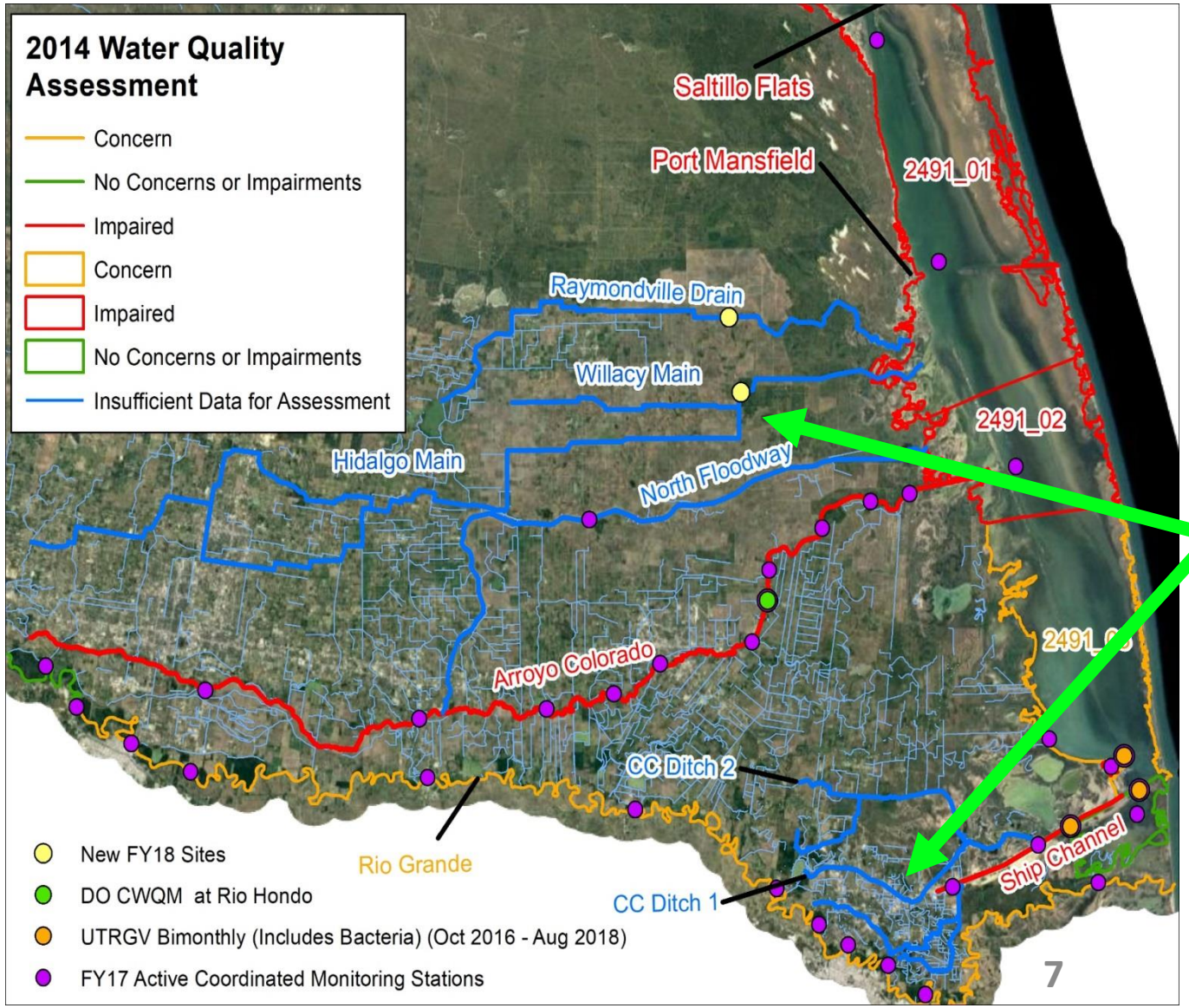
Low Dissolved Oxygen

Arroyo Colorado Watershed



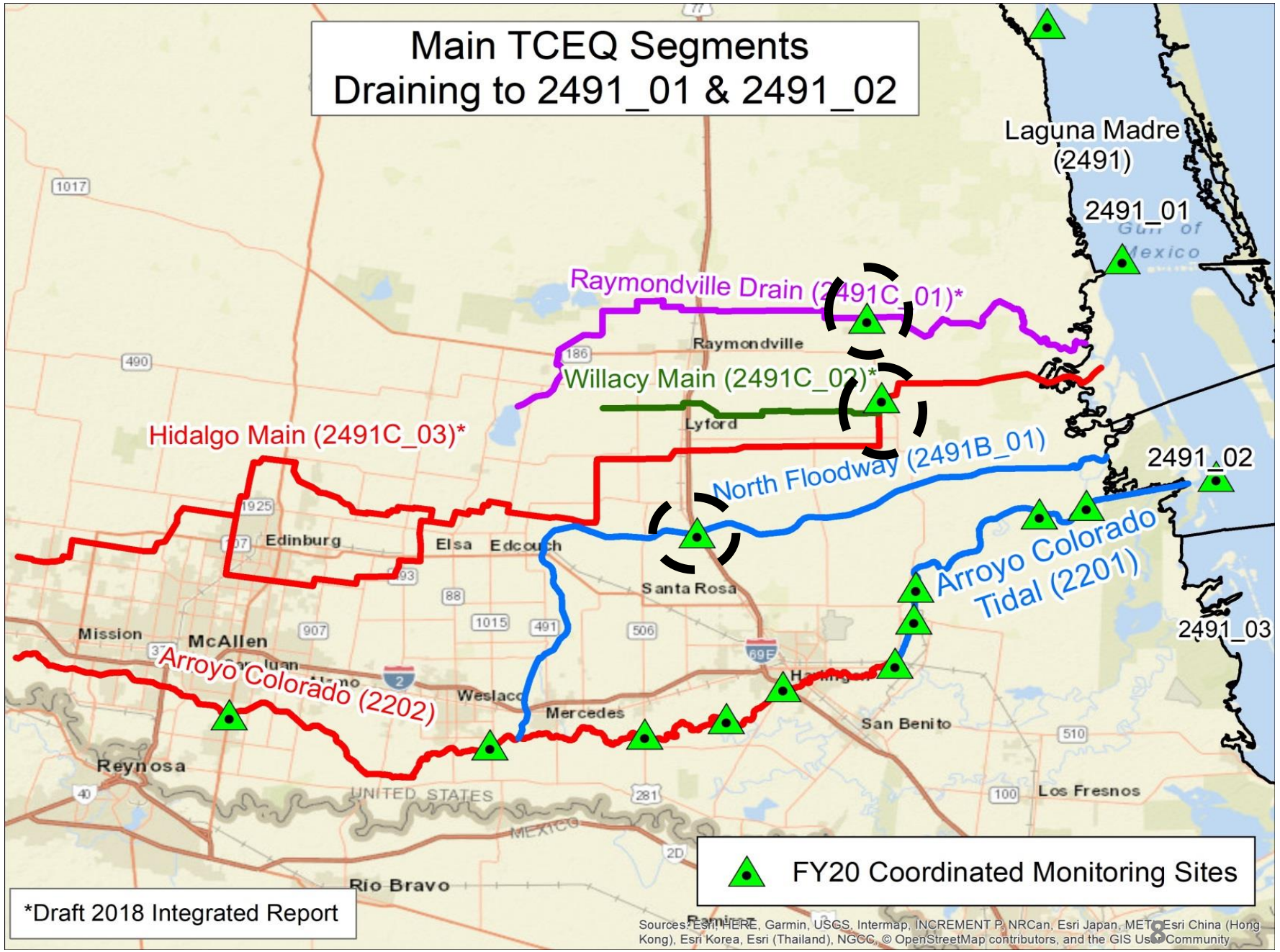
- The stream flow is primarily sustained by wastewater discharges, agricultural irrigation return flows and urban runoff.
- Impaired waterway Does not meet the State's ambient water quality standards
- Elevated levels of fecal coliform bacteria and low dissolved oxygen
- TCEQ, From 1990 to 2004, an estimated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

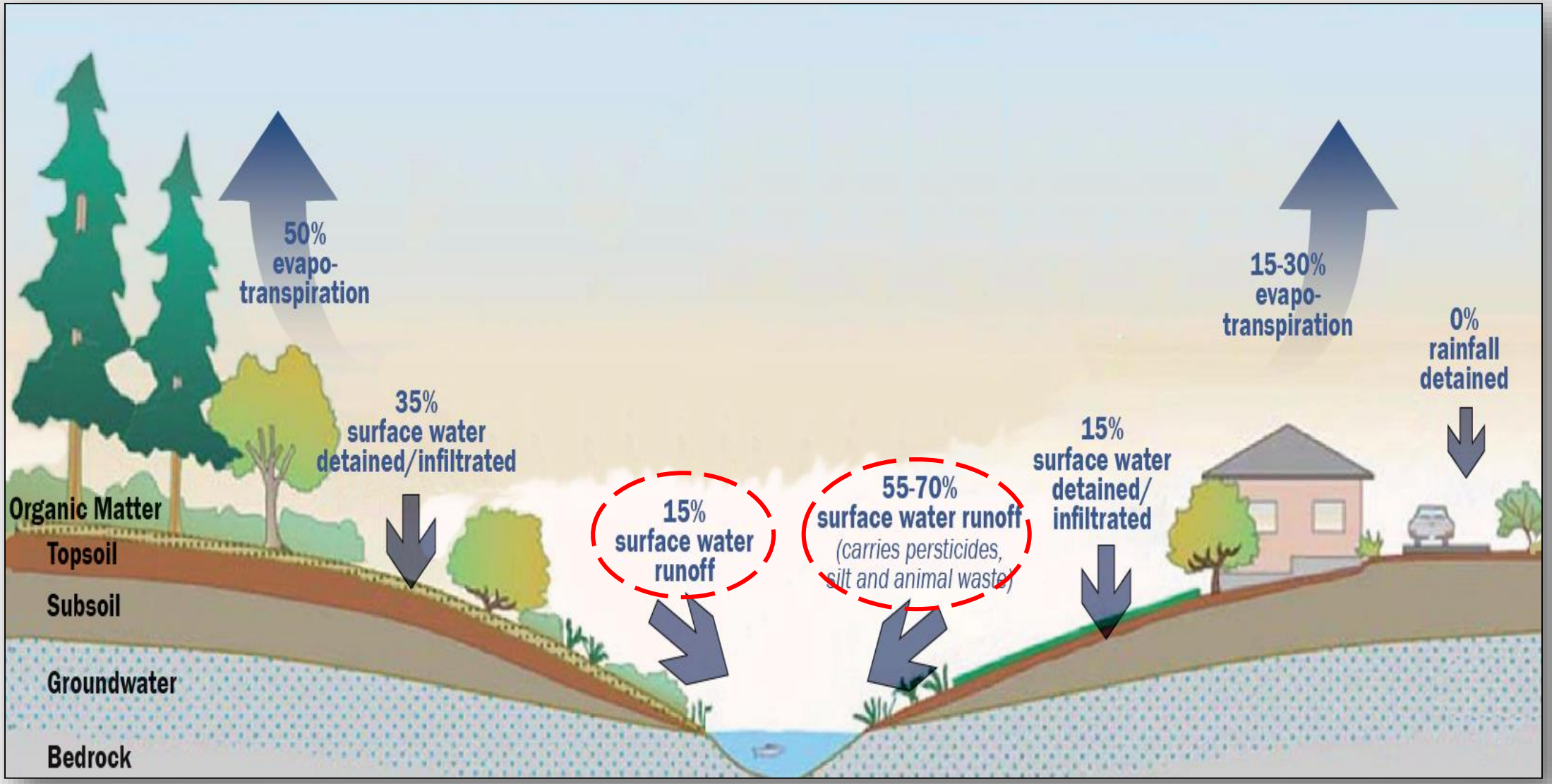
Gray Infrastructure

- **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.

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

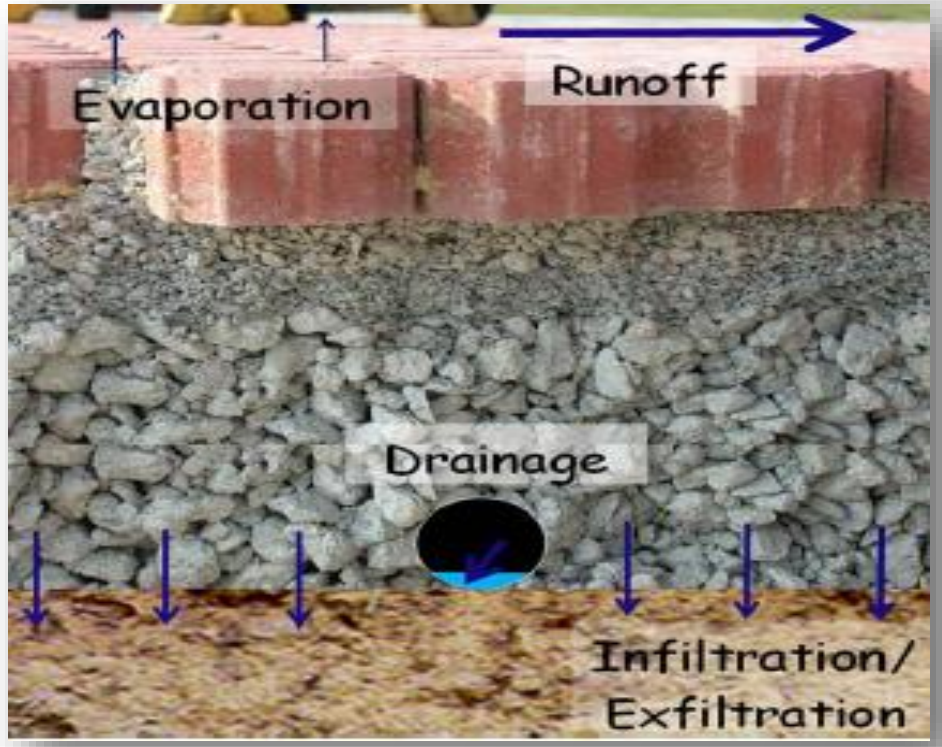
- Permeable pavement systems were developed for infiltration of surface runoff by passing through porous surface, allowing capturing and recycling of storm water on site.
- Effective reducing runoff besides removing various nutrients and pollutants loads associated to the streams in compared to impervious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

  Total Kjeldhal Nitrogen (TKN),

  Total suspended solids,

  Total phosphorus,

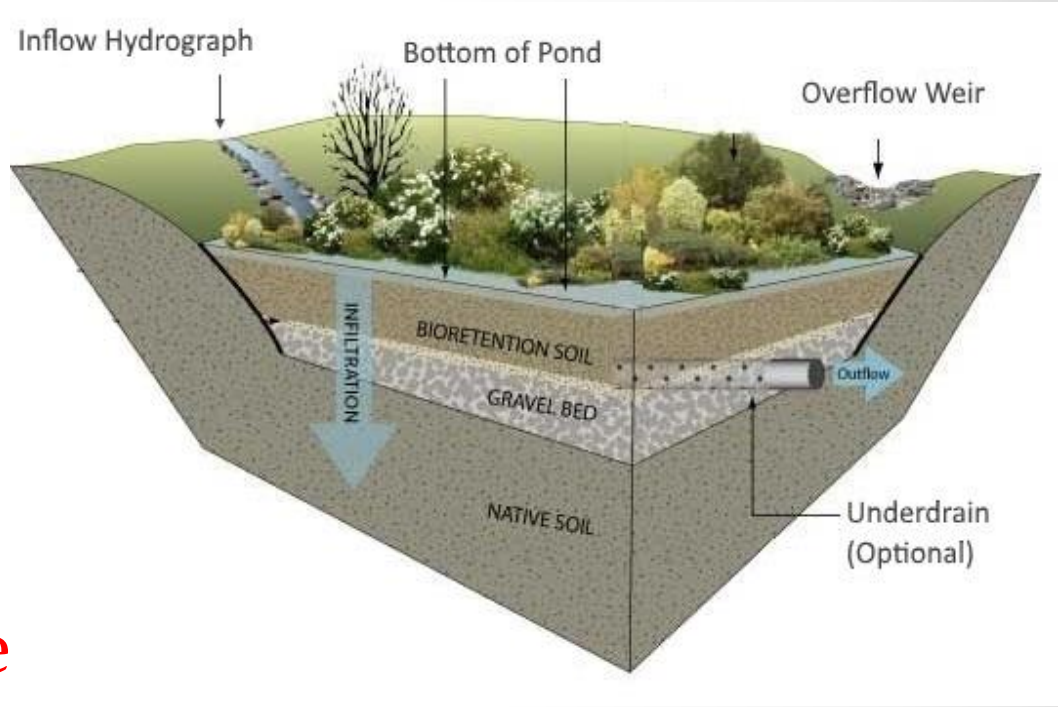
  Heavy metals.



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

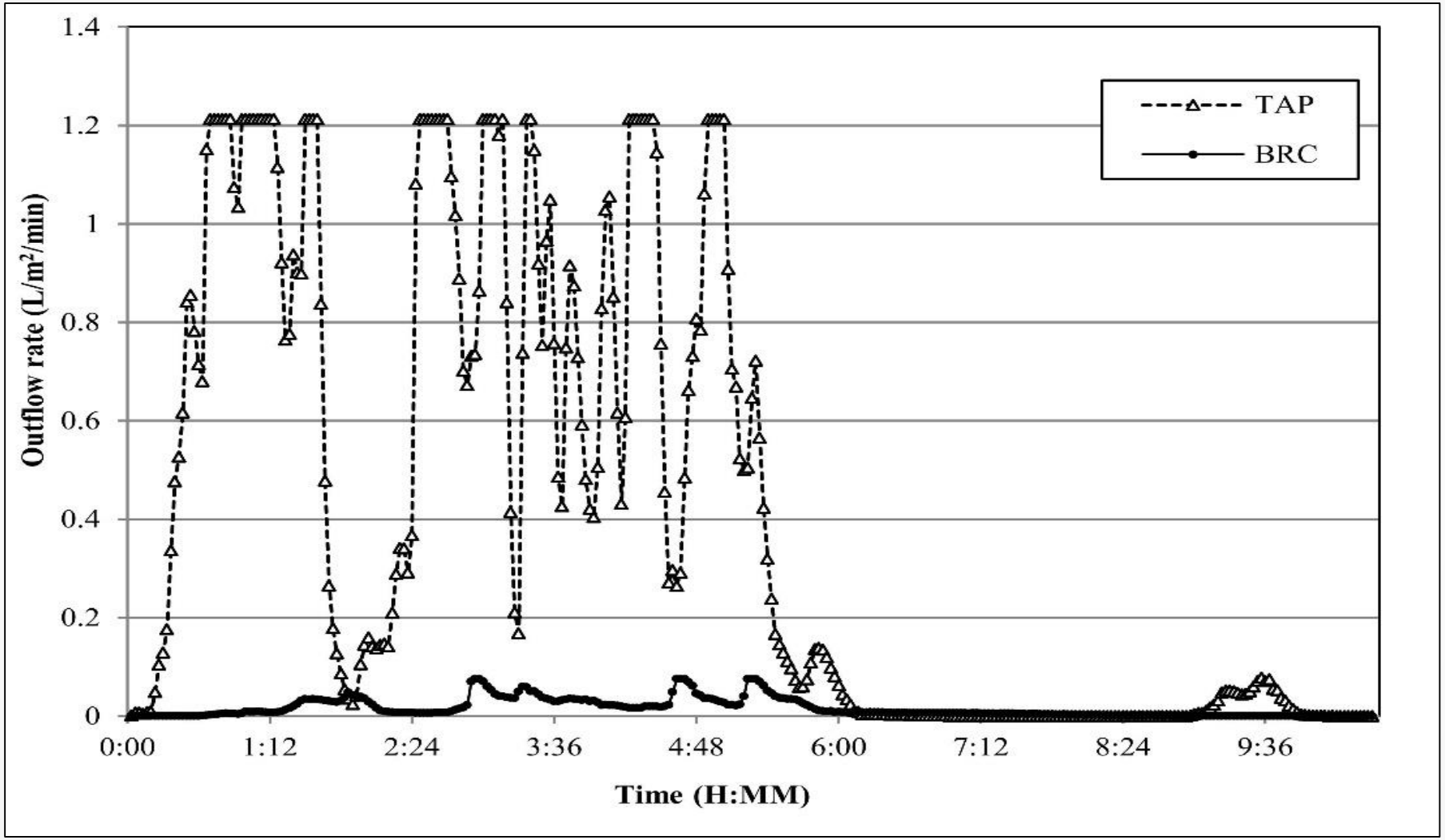
Bioretention

- 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.



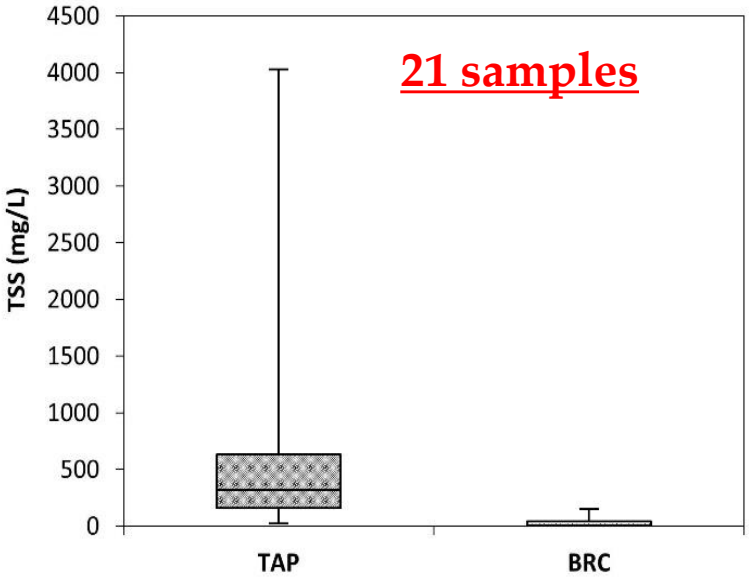
https://www.hydrologystudio.com/help/bioretention-ponds.htm

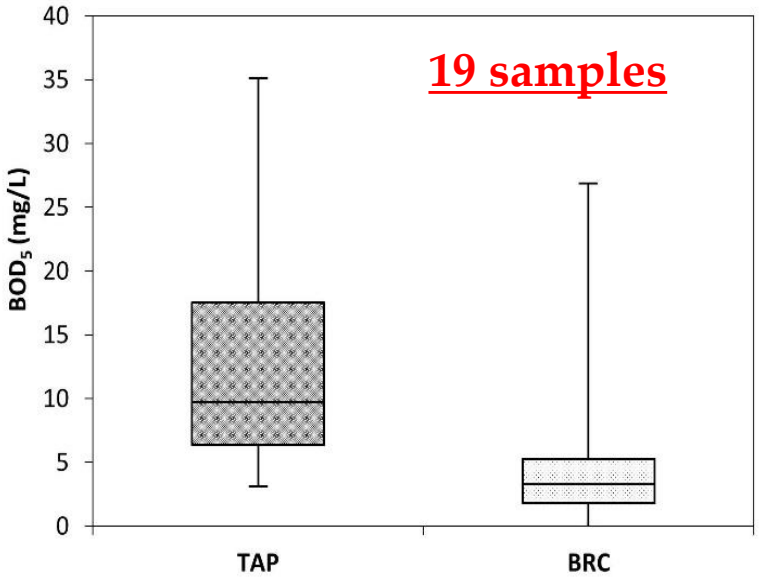
STC Bioretention (McAllen)

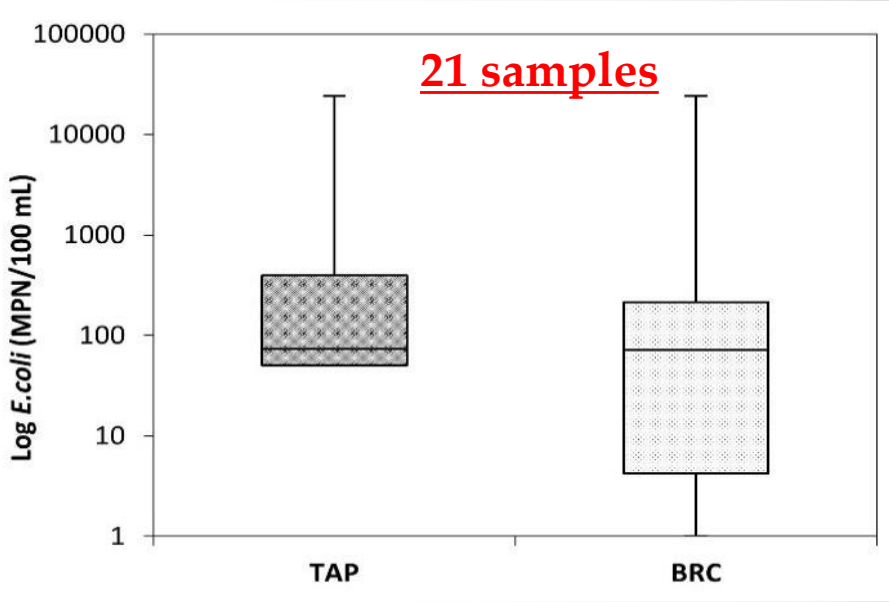


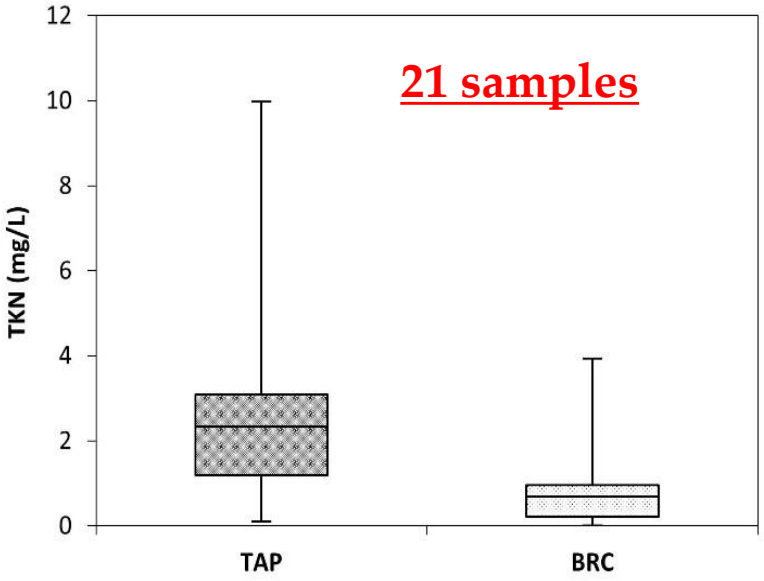
Runoff hydrographs for 10 hours March 3, 2017, rain event totaling 38.3 mm (1.51 inches)

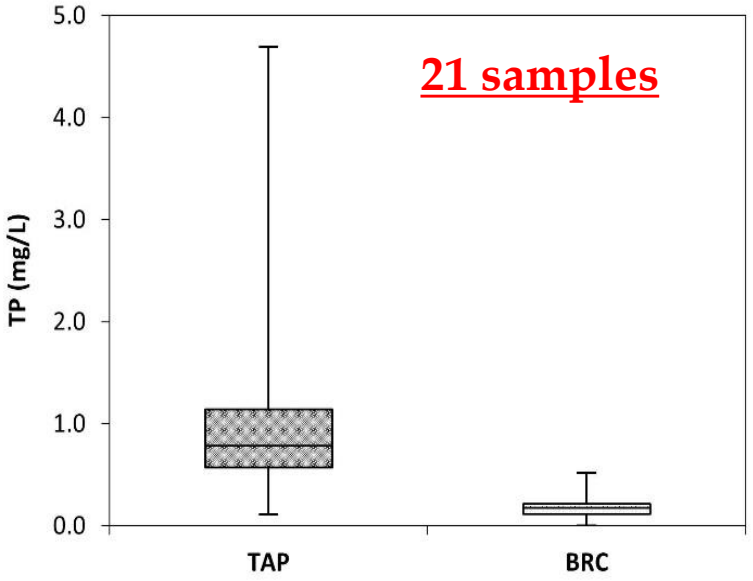
STC Bioretention (McAllen)

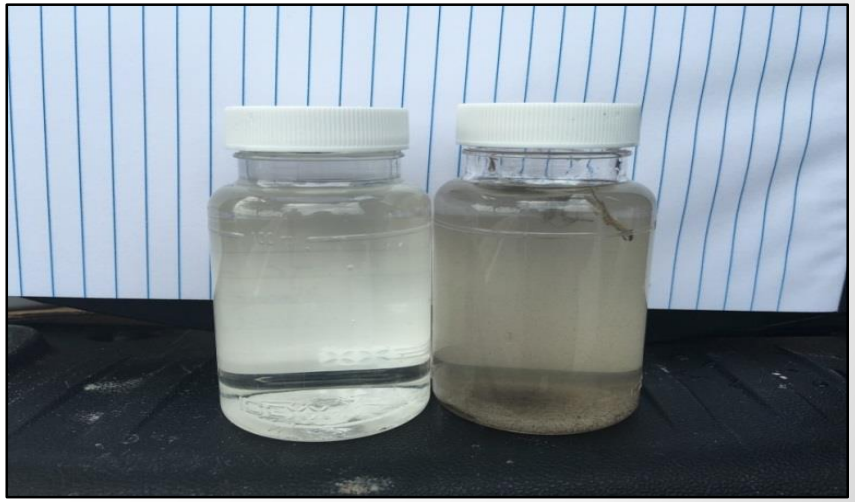












STC Bioretention (McAllen)

Ecological Engineering: X 1 (2019) 100007

Contents lists available at ScienceDirect

Ecological Engineering: X

journal homepage: www.journals.elsevier.com/ecological-engineering-x

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

Ahmed Mahmoud[a,*], Taufiqul Alam[b], Md Yeasir A. Rahman[c], Augusto Sanchez[a], Javier Guerrero[a], Kim D. Jones[b]

[a] Department of Civil Engineering, University of Texas Rio Grande Valley, Edinburg, TX 78539, USA
[b] Department of Environmental Engineering, Texas A&M University-Kingsville, TX 78363-0570, USA
[c] Department of Civil and Environmental Engineering, University of South Florida, Tampa, FL 33620-5350, USA

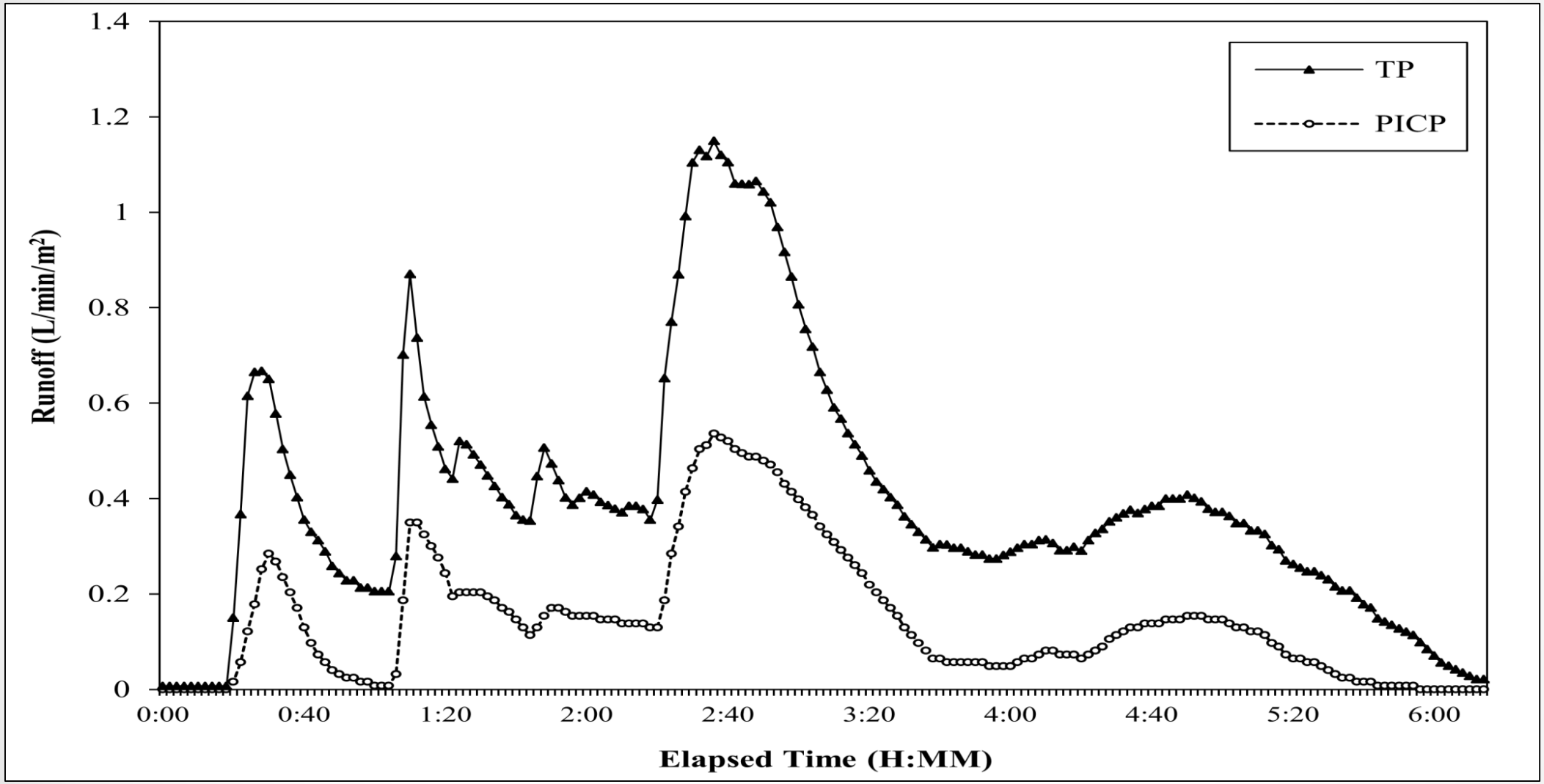
ARTICLE INFO

Keywords:
Bioretention
Runoff
Water quality
Stormwater management
Semi-arid climate
Indicator bacteria

ABSTRACT

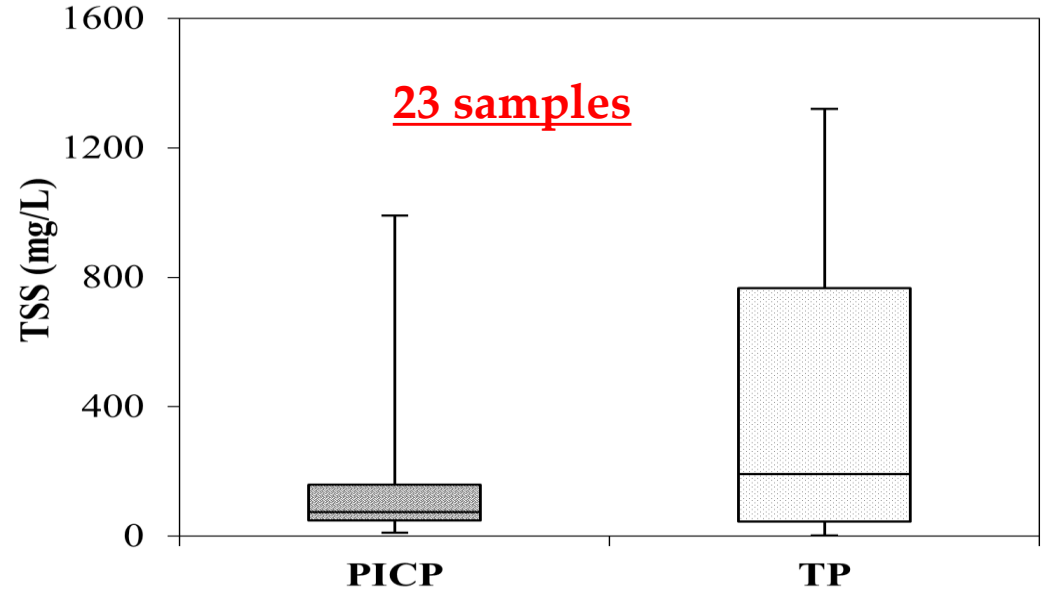
Bioretention has become an effective option for the treatment of stormwater in urbanized watersheds. This field-scale study evaluated a bioretention system designed to reduce runoff volume and pollutant loading and compared its performance over a 13-month period with that of traditional asphalt pavement 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.

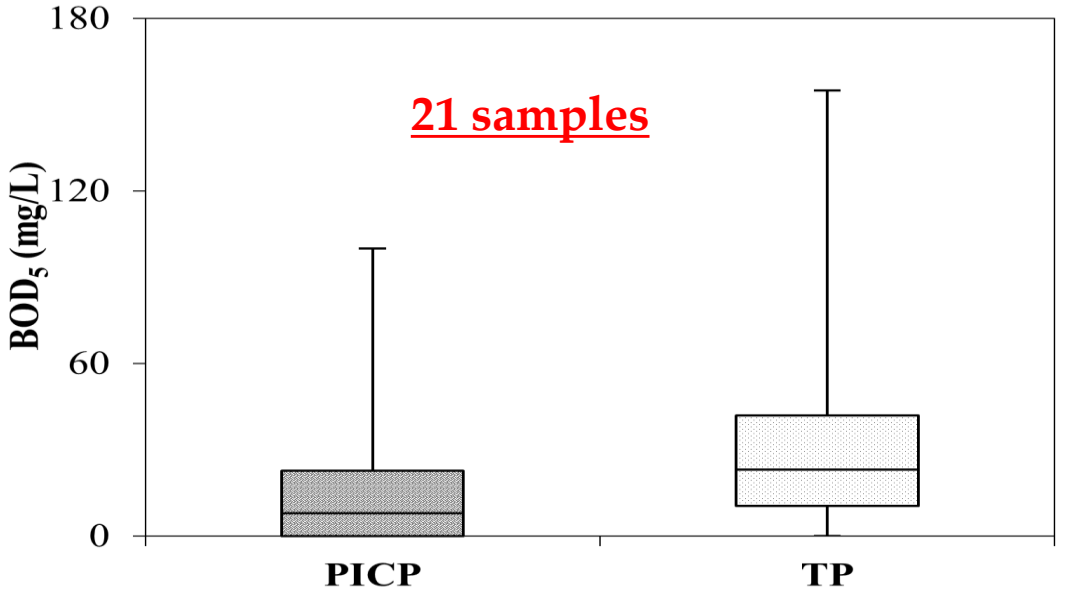
La Feria Permeable Pavement

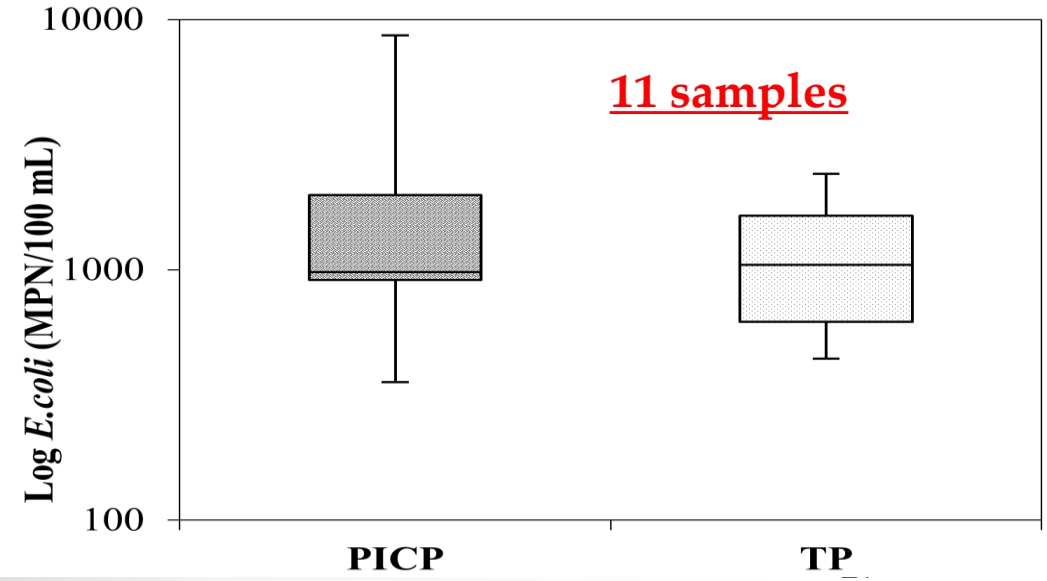


Runoff hydrographs for 6 hours September 13, 2014, rain event totaling 22.6 mm (0.89 inches)

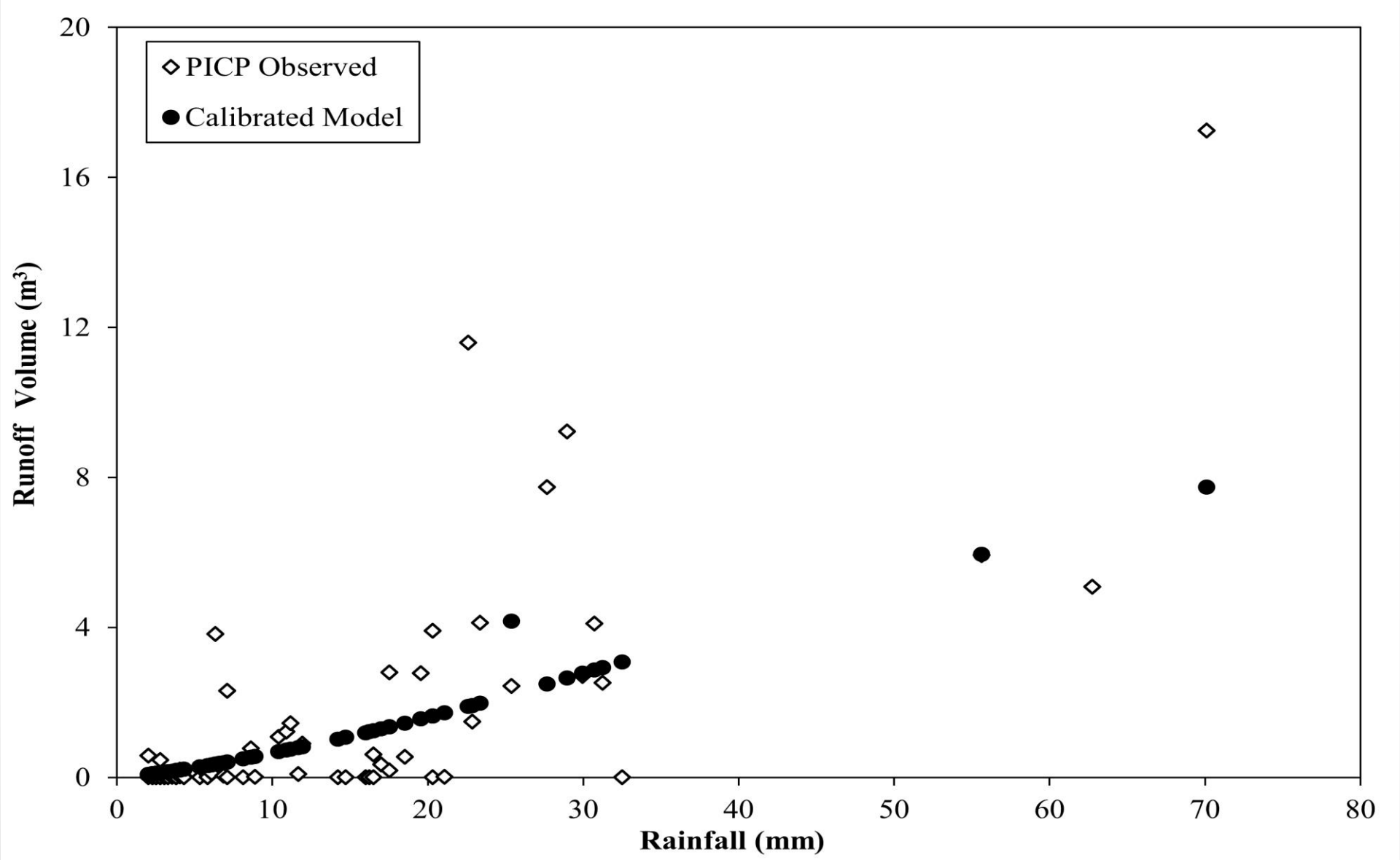
La Feria Permeable Pavement







La Feria Permeable Pavement WinSLAMM Modeling



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

PROJECT

Project will map the following:

- Inventory (7 city Parks)

PROJECT

Project will map the following:

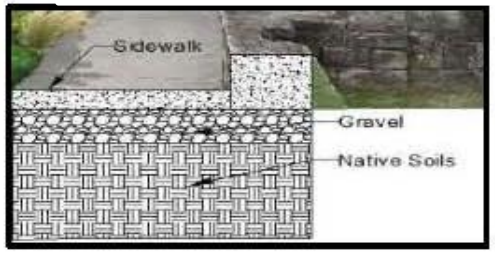
- Priority Areas (17 locations)

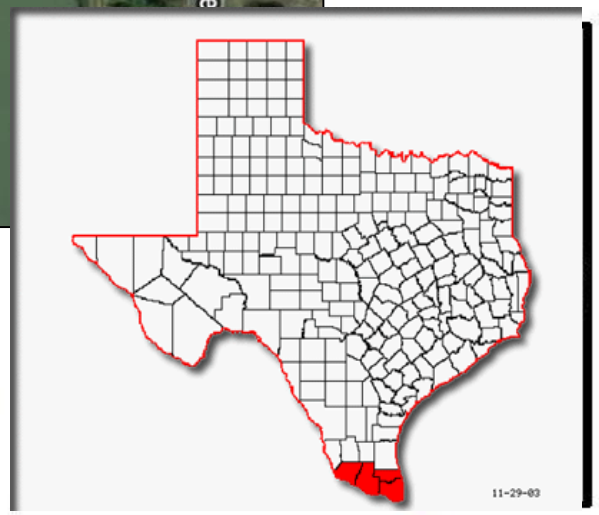
GI Master Plan

GI Master Plan

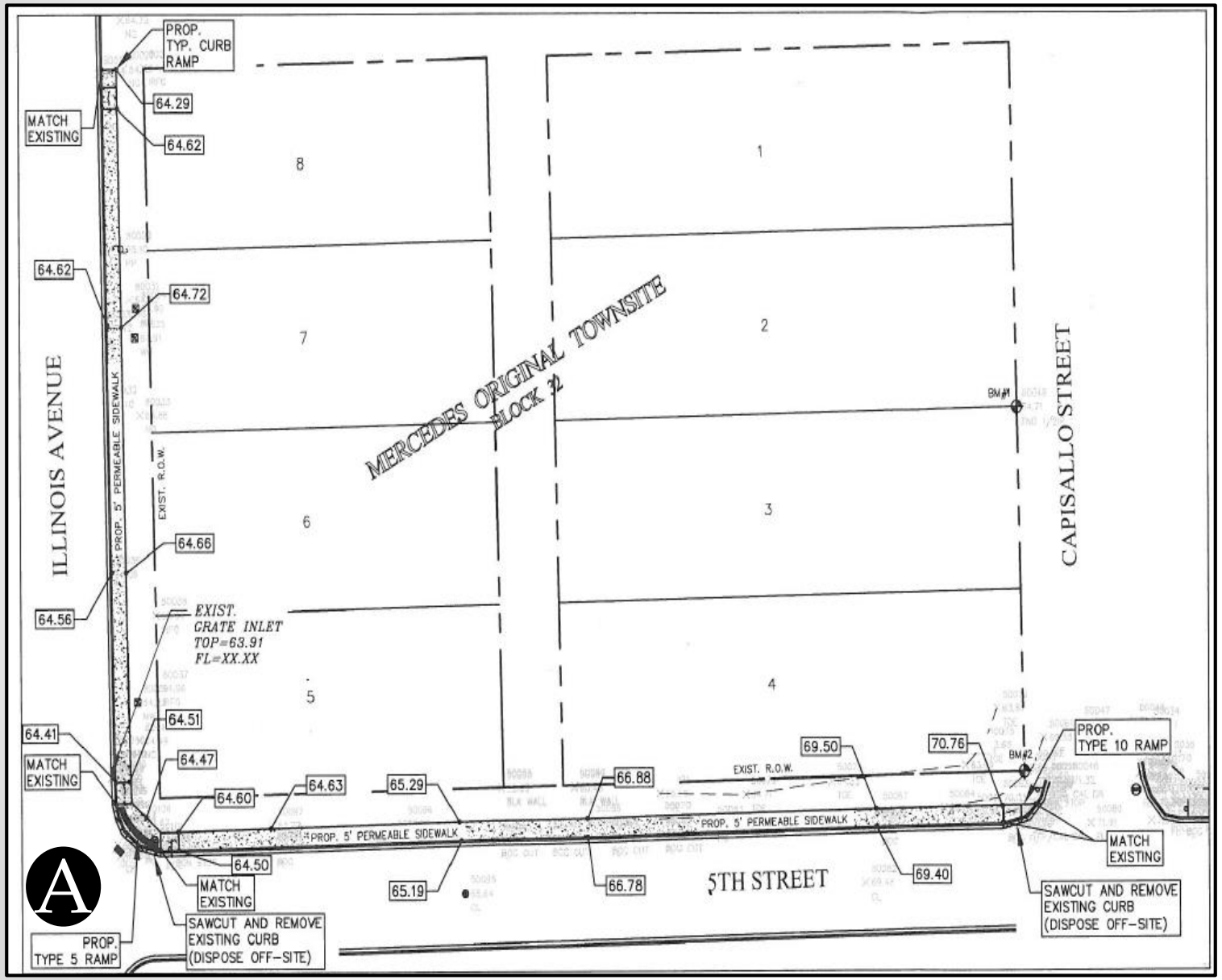
MERCEDES, TX
SEP PROJECT

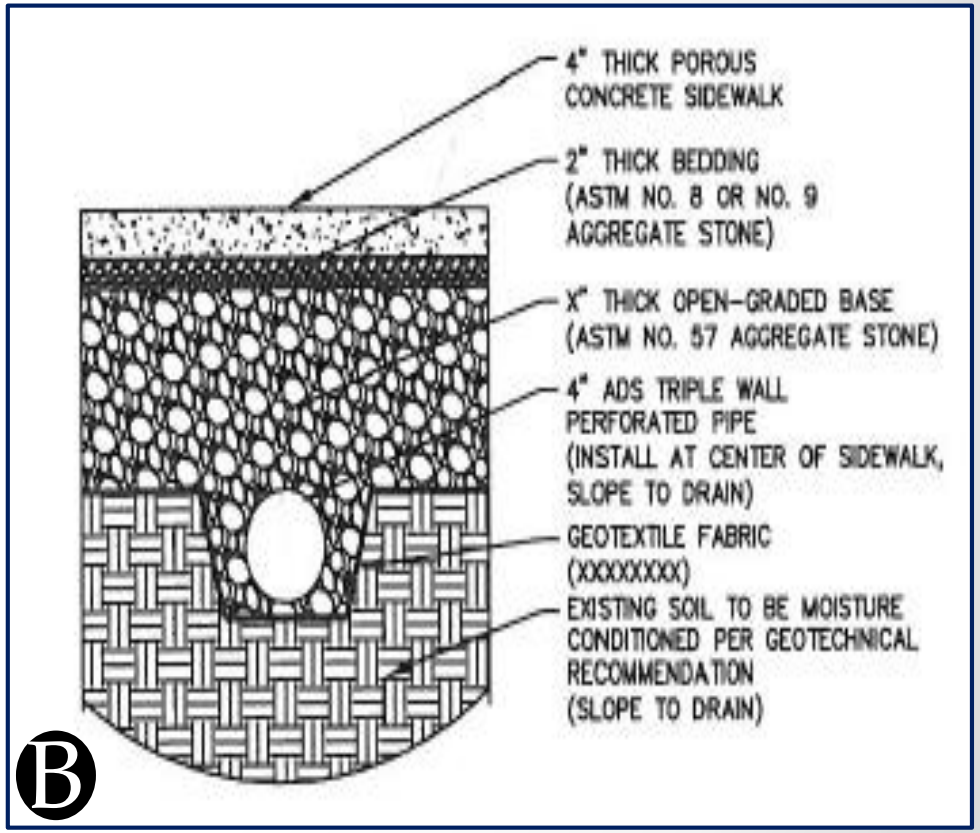
- Sidewalk under design



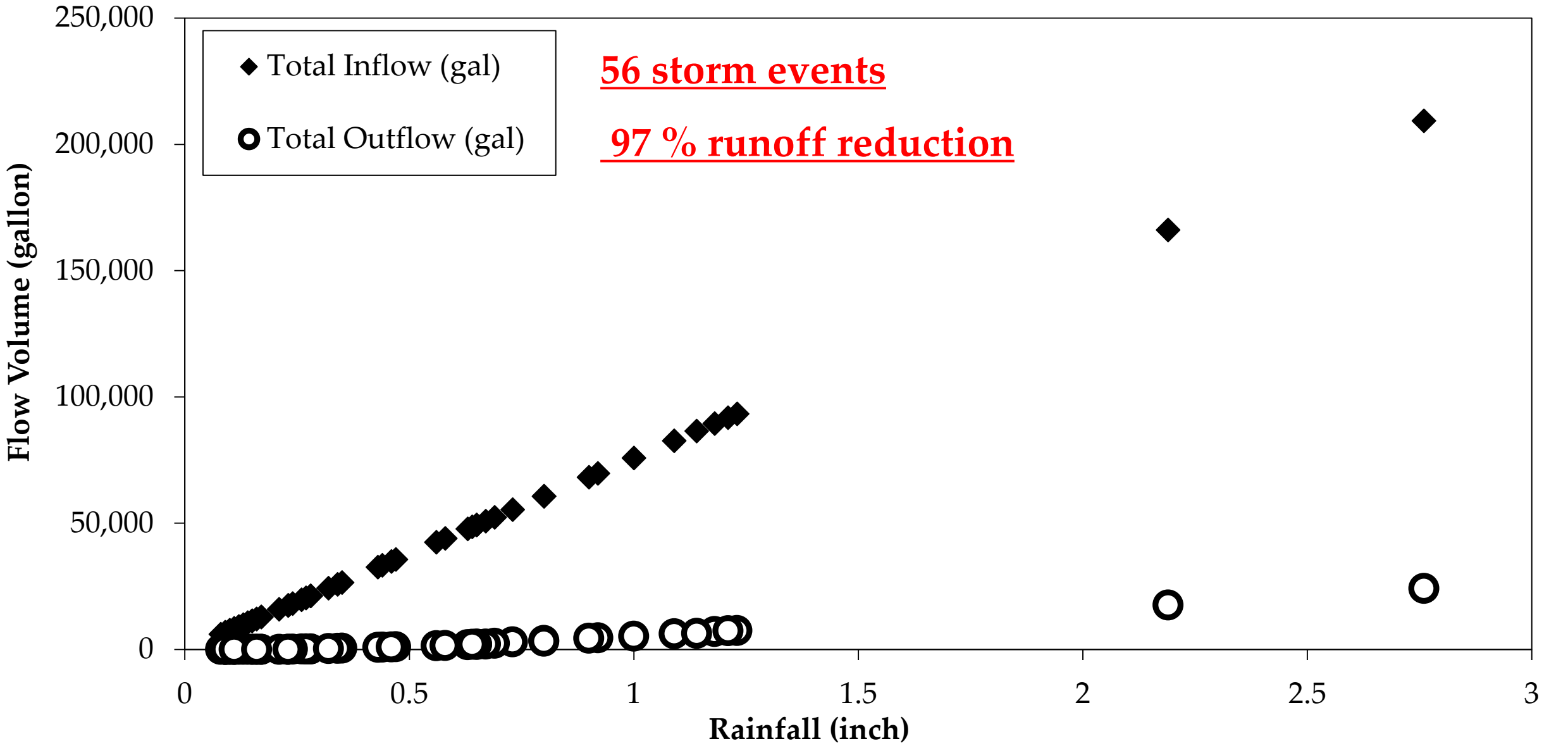


GI Master Plan





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/

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.