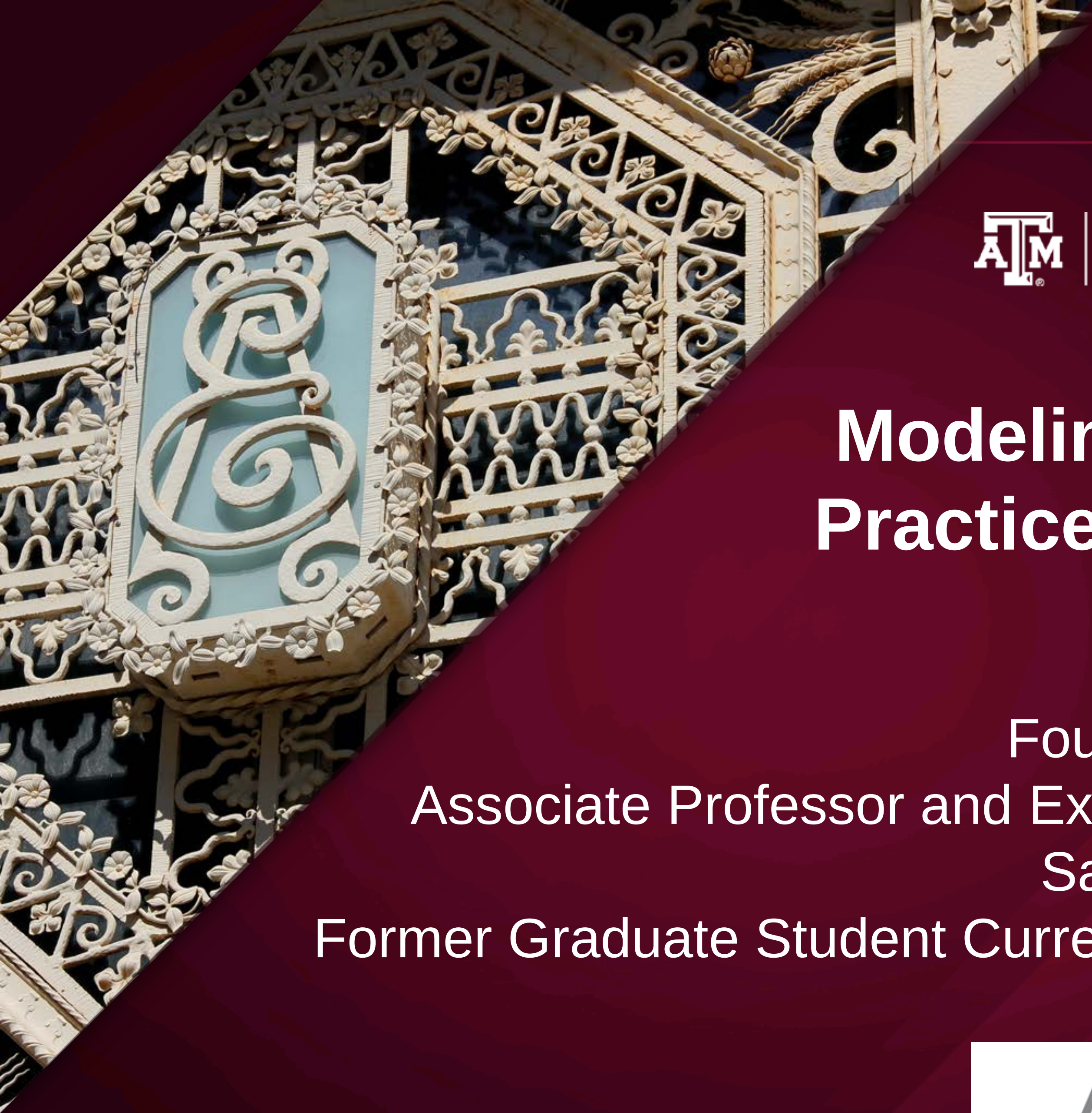


BIOLOGICAL & AGRICULTURAL ENGINEERING
TEXAS A&M UNIVERSITY

Modeling LID Effect Practices on Stream Health

Fouad H. Jaber, PhD
Associate Professor and Extension Specialist
Sa’d Shannak, PhD
Former Graduate Student Currently at KASPARC

TEXAS A&M AGRILIFE
RESEARCH | EXTENSION

URBANIZATION AND STREAMS

- Increased volume
- Increased peak flow
- Increased peak flow duration
- Increased stream temperature
- Decreased base flow
- Changes in sediment loadings
- Habitat loss(e.g., inadequate substrate, loss of riparian areas, etc.)
- Erosion, Channel widening, and Streambed alteration

Nueces River, TX
Source: By Billy Hathorn (Own work) [CC-BY-SA-3.0 (http://creativecommons.org/ licenses/by-sa/3.0) or GFDL (http://www.gnu.org/copyleft/fdl.html)], via Wikimedia Commons

Non-alluvial stream, Gilleland Creek, TX
Source: By Lynn75 (Own work) [CC-BY-SA-3.0 (http://creativecommons.org/licenses/ by-sa/3.0)], via Wikimedia Commons

Low Impact Development (LID)

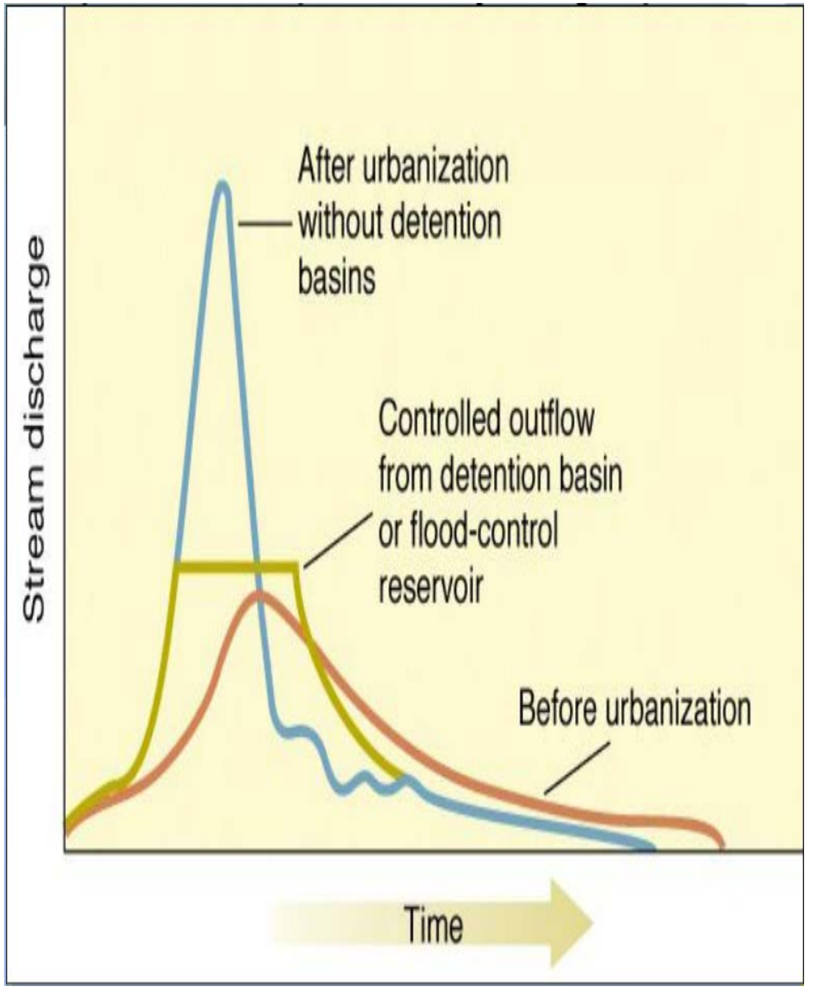
1) Reduce the water quality impacts caused by land development and construction

2) Reduce peak flows

3) Reduce total volumes of runoff

4) Delay the time to peak flows

5) LID can be aesthetically woven into roads, rights-of-way and open space



LID PRACTICES

LID practices can be integrated on both scales; household and neighborhood scale

Urban Street Retrofit (Seattle, WA)

HYPOTHESIS

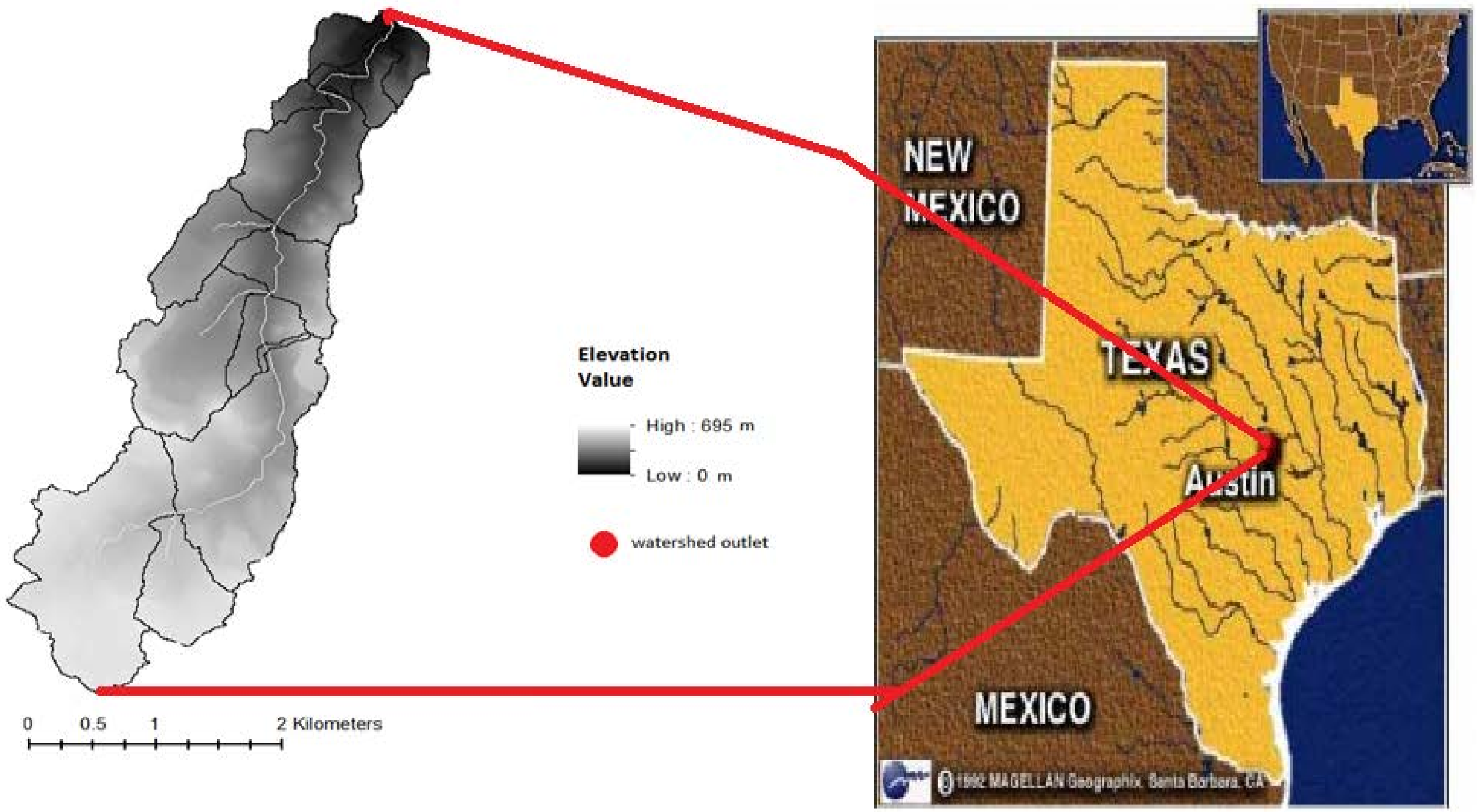
- The integration of LID practices at watershed scale improves stream health and conditions. Specifically:

1) LID practices reduce potential stream bed erosion in urban areas
2) LID practices provide healthy environment for aquatic life habitat
3) LID practices reduce potential flooding in urban streams

Goal and Objectives

- Evaluate the effectiveness of LID practices at watershed scale.
- Specific objectives: Model and evaluate the effectiveness of LID practices:
  a) in reducing potential erosion
  b) in reducing flooding due to urbanization
  c) in providing healthy environment for aquatic life

BLUNN CREEK WATERSHED- AN OVERVIEW



BLUNN CREEK WATERSHED

- Blunn creek is located in Austin-Texas, it flows through the center of Big Stacy Park and Little Stacy Park before emptying into Lady Bird Lake

- 54% impervious cover in 2003 and the catchment total area is 1 square mile

- The creek has a length of three miles, census estimated total population living in the watershed area by 6,000 and the projection of 2030 might reach 6,810

SWAT MODEL; Simulation period : 24 year (1987 to 2012)

Model Setup

1) Weather data (precip. and temp.
2) Landuse and land cover data
3) Soil data
4) Topography (geospatial database)

Calibration

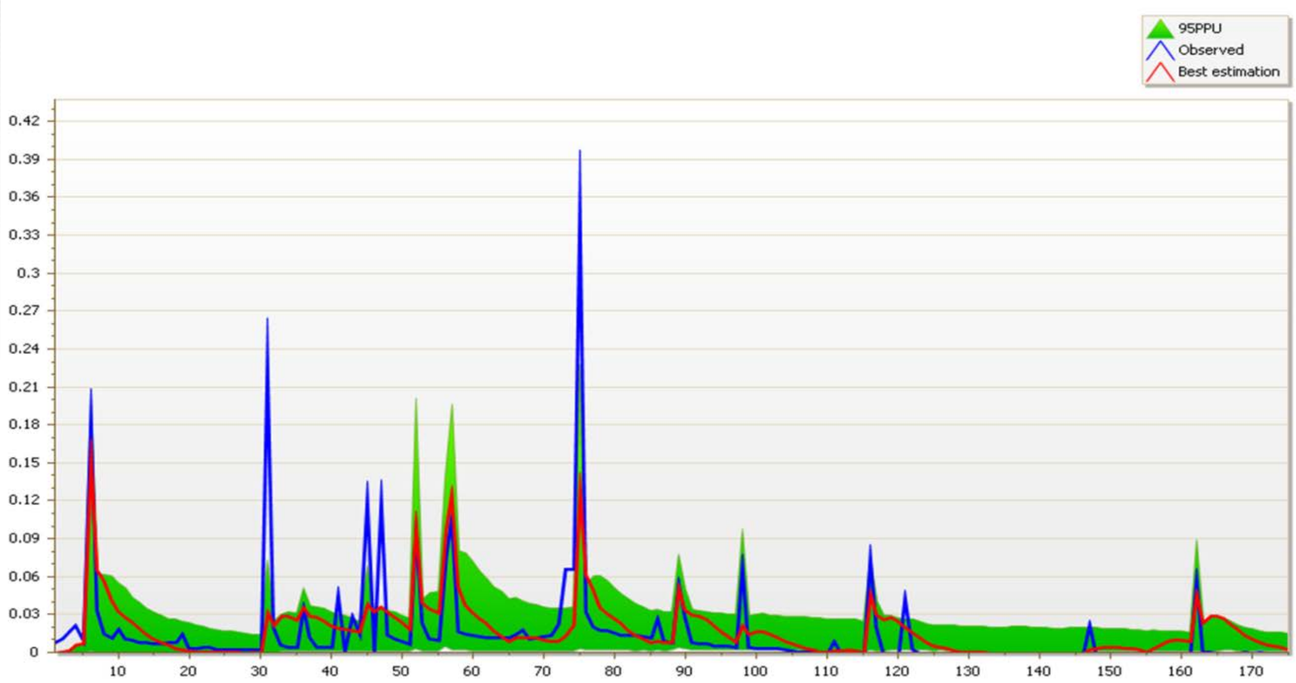
1) Model Calibration (1998-1999) and validation (2001 - 2002)
2) SWAT-CUP using SUFI-2 procedures

1) Evaluation of the model results:
(NSE) & (R2)
2) Uncertainty analysis
p-factor (the percentage of the observed data)
r-factor

Sensitivity Analysis

a) The absolute sensitivity analysis in which the value of one parameter is vary while the other parameters remain constant
b) Relative sensitivity in which all parameters vary simultaneously

Calibration



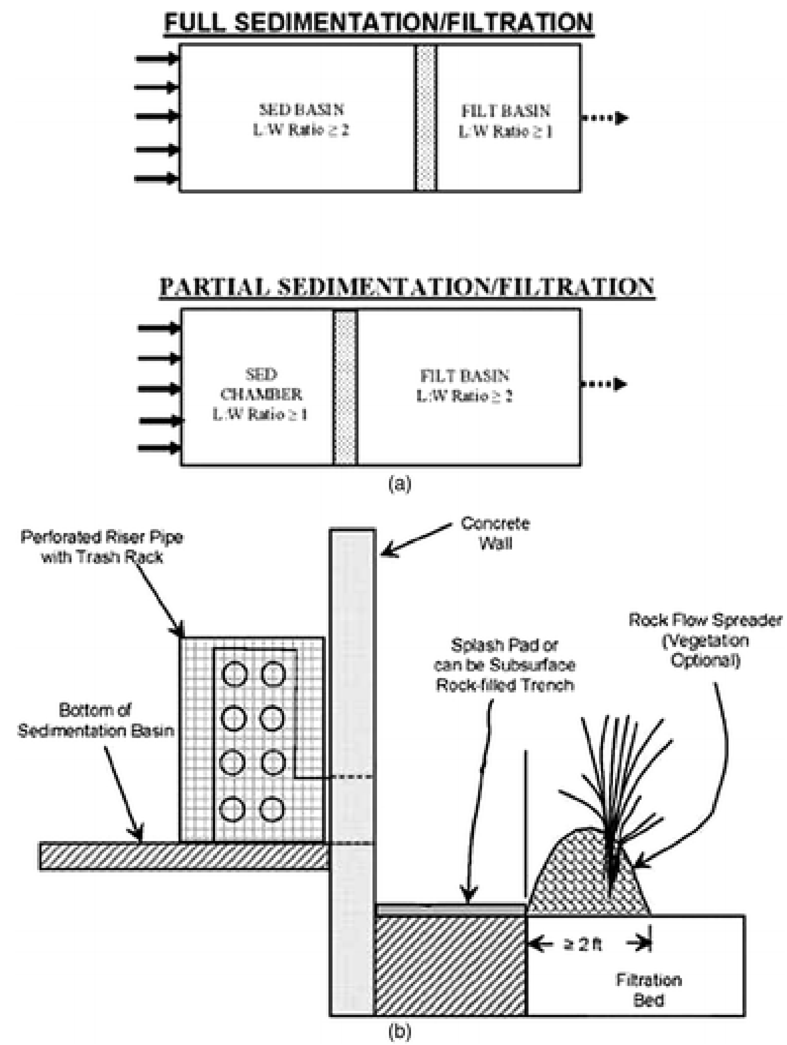
Variable	Value
p-factor	56%
r-factor	0.54
R2	0.78
NS	0.78
br2	0.6423
MSE	0.0035
SSQR	0.0005

BMPs IN SWAT 2012

- **Urban BMPs in SWAT 2012 :**
  - Detention pond
  - Wet pond
  - Retention Irrigation
  - Sedimentation Filtration basins
- **Bioretention and Permeable Pavement are not included.**
- **Modified SEDFIL to represent PP in Bioretention**

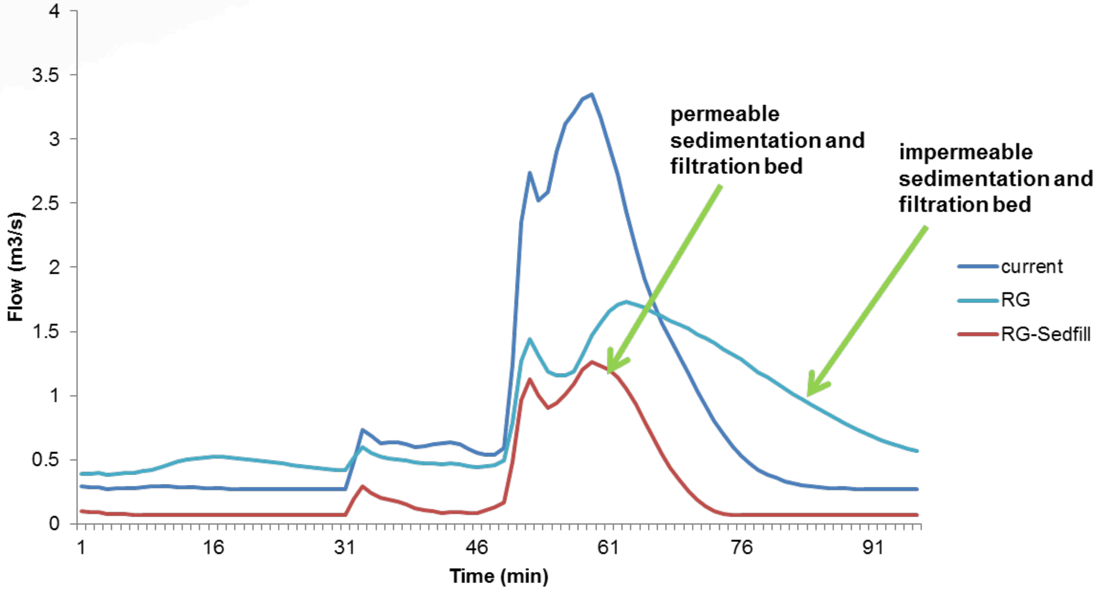
SEDFIL MODIFICATIONS

- Two parameters were considered in adjusting the Sedfil design; water ponding depth and filtration media depth.
- Sedimentation area to represent a forebay and filtration basin to represent a bioretention area or permeable pavement



SEDFIL modification continued

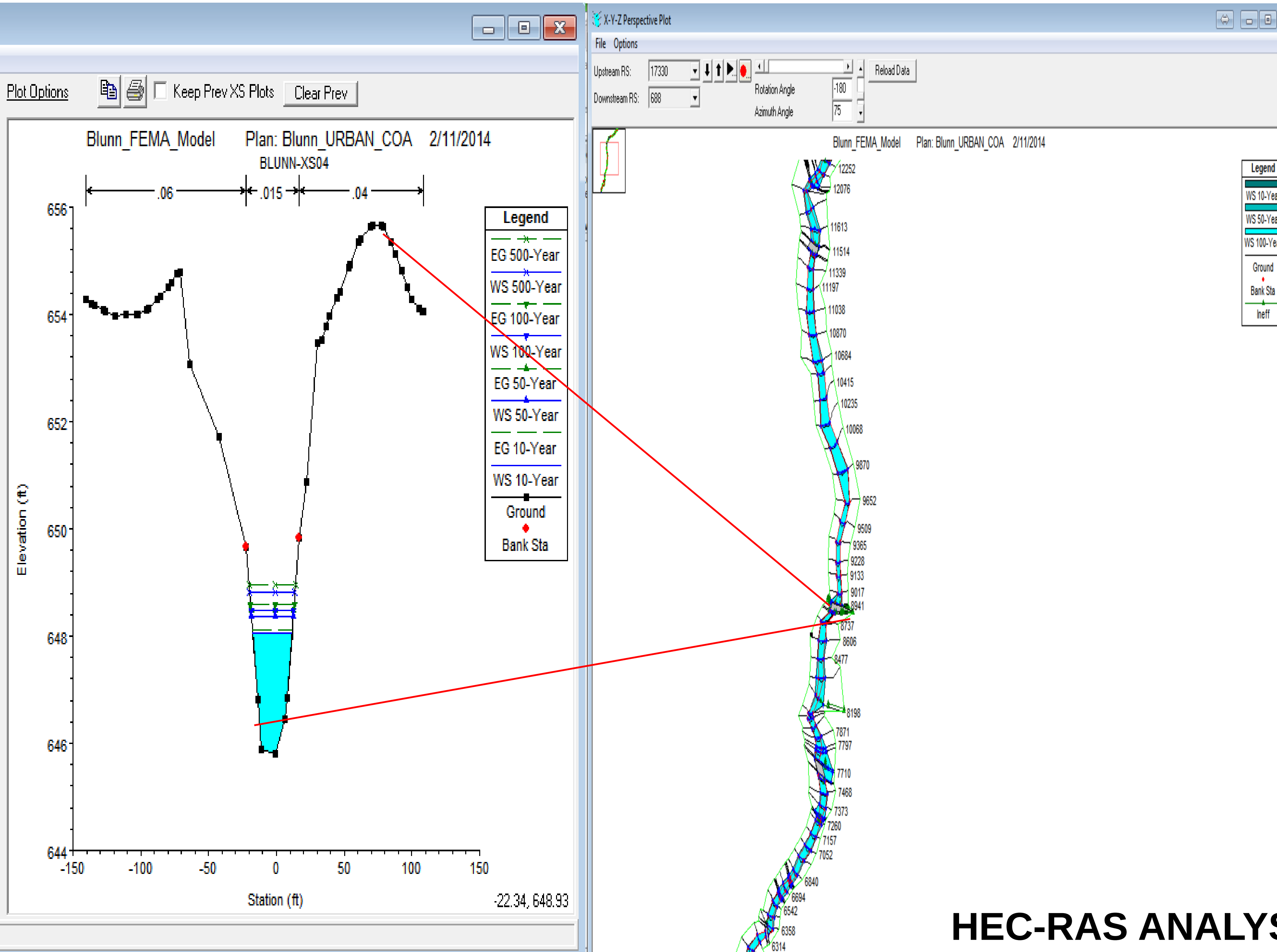
- Reduction in peak flows but not total volumes ?? This is not LID!!



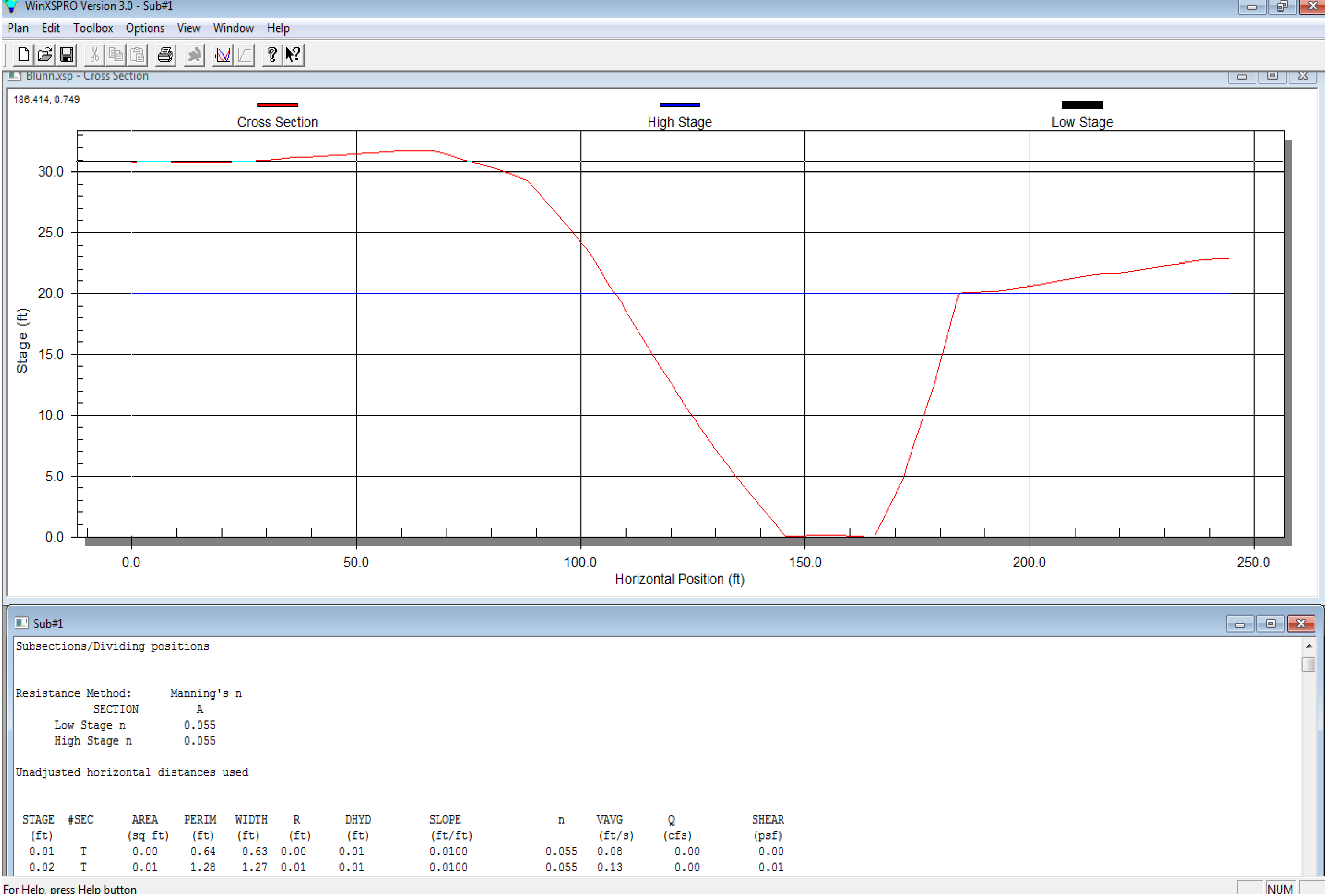
- Beta version of the model was developed so it accounts for a filtration basin to be permeable

EROSION IMPACTS

1. Calculate critical shear stress for each subbasin for different soil diameters
2. Calculate shear stress for modeled flows
3. Calculate percentage of flows that exceeds critical shear stress
4. Evaluate the effectiveness of LID practices on several levels



HEC-RAS ANALYS



WinXSPRO output

SHEAR AND CRITICAL SHEAR STRESSES

$$\tau = \gamma_w \times D_H \times S_W$$

$$\tau_c = \theta_c \times (S_g - 1) \times \gamma_w \times d_{50}$$

where,

τ = shear stress

τ_c = critical shear

γ_w = density of water

D_H = depth of water

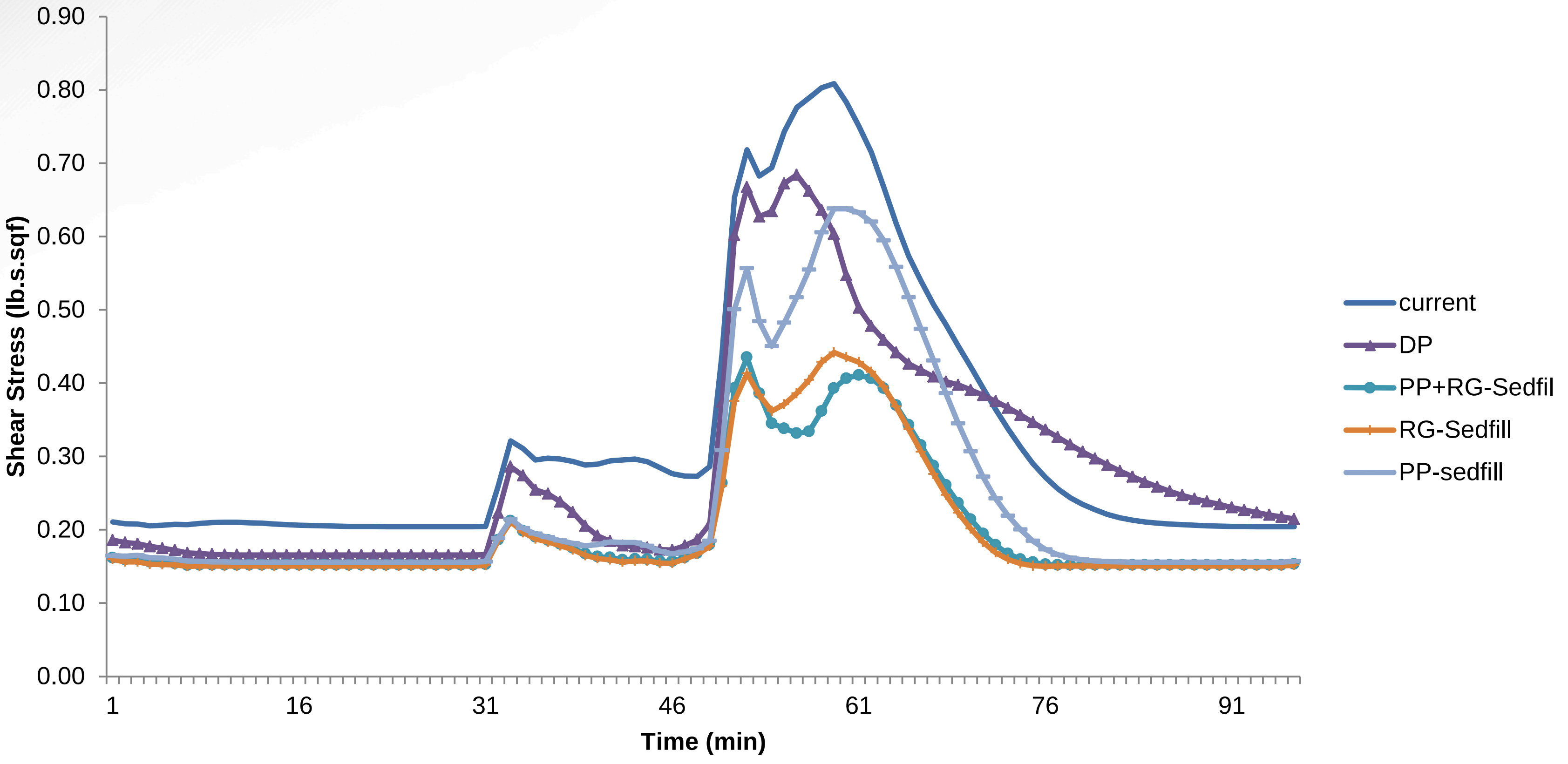
S_w = channel slope

S_g = specific gravity of soil, 2.65

d_{50} = median particle diameter, (mm)

θ_c = critical Shield's parameter

Results of LID on Shear Stress

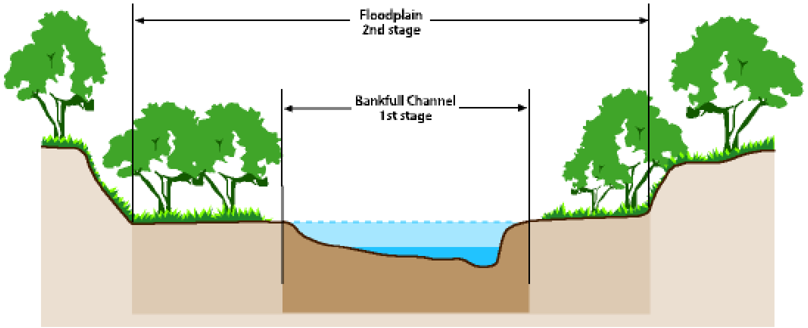


Erosion Reduction

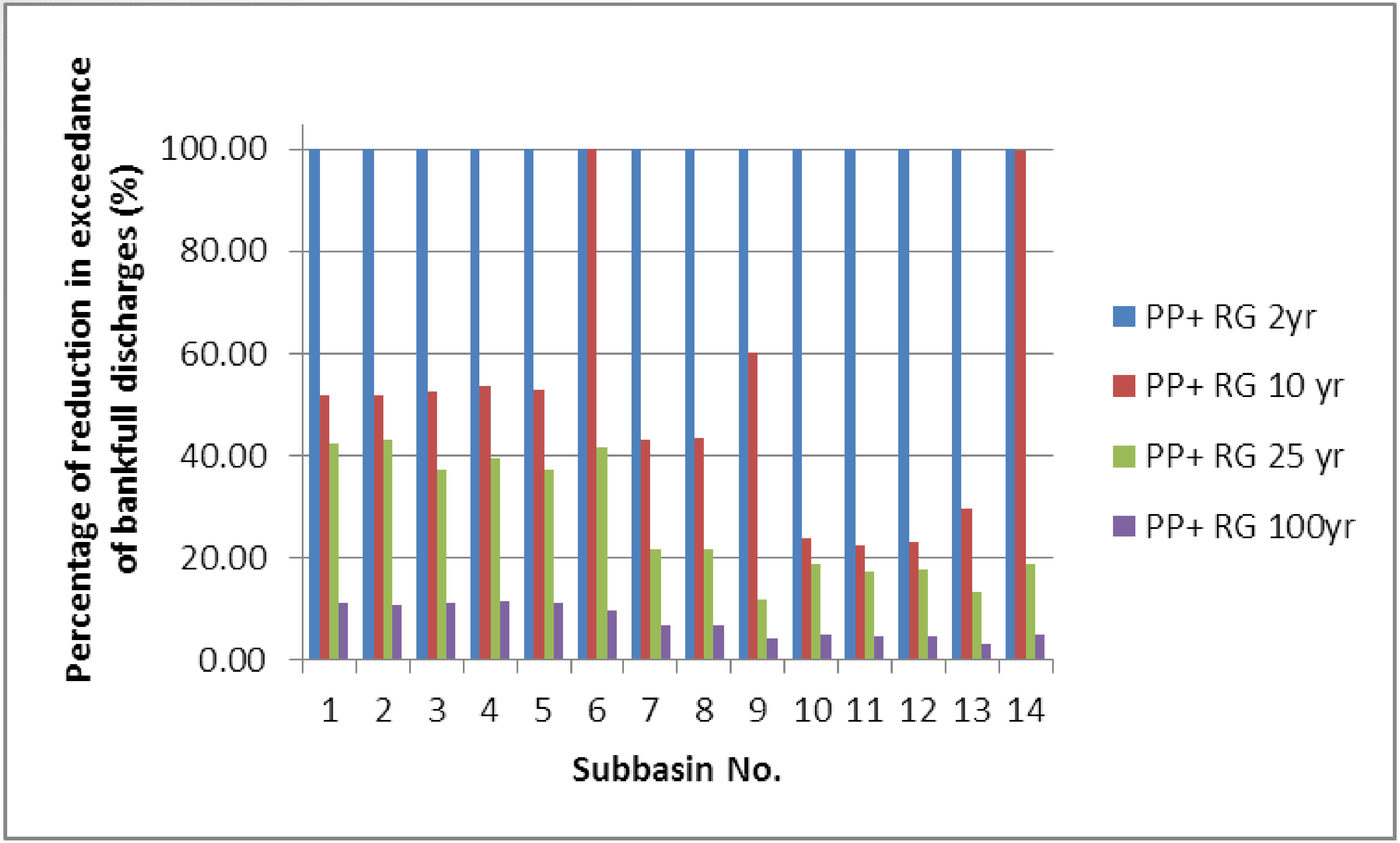
- LID reduced the exceedance of critical shear stress from 40% to 100% depending on sediment size. The best performance was when permeable pavement and bioretention were installed throughout the watershed

FLOOD IMPACTS

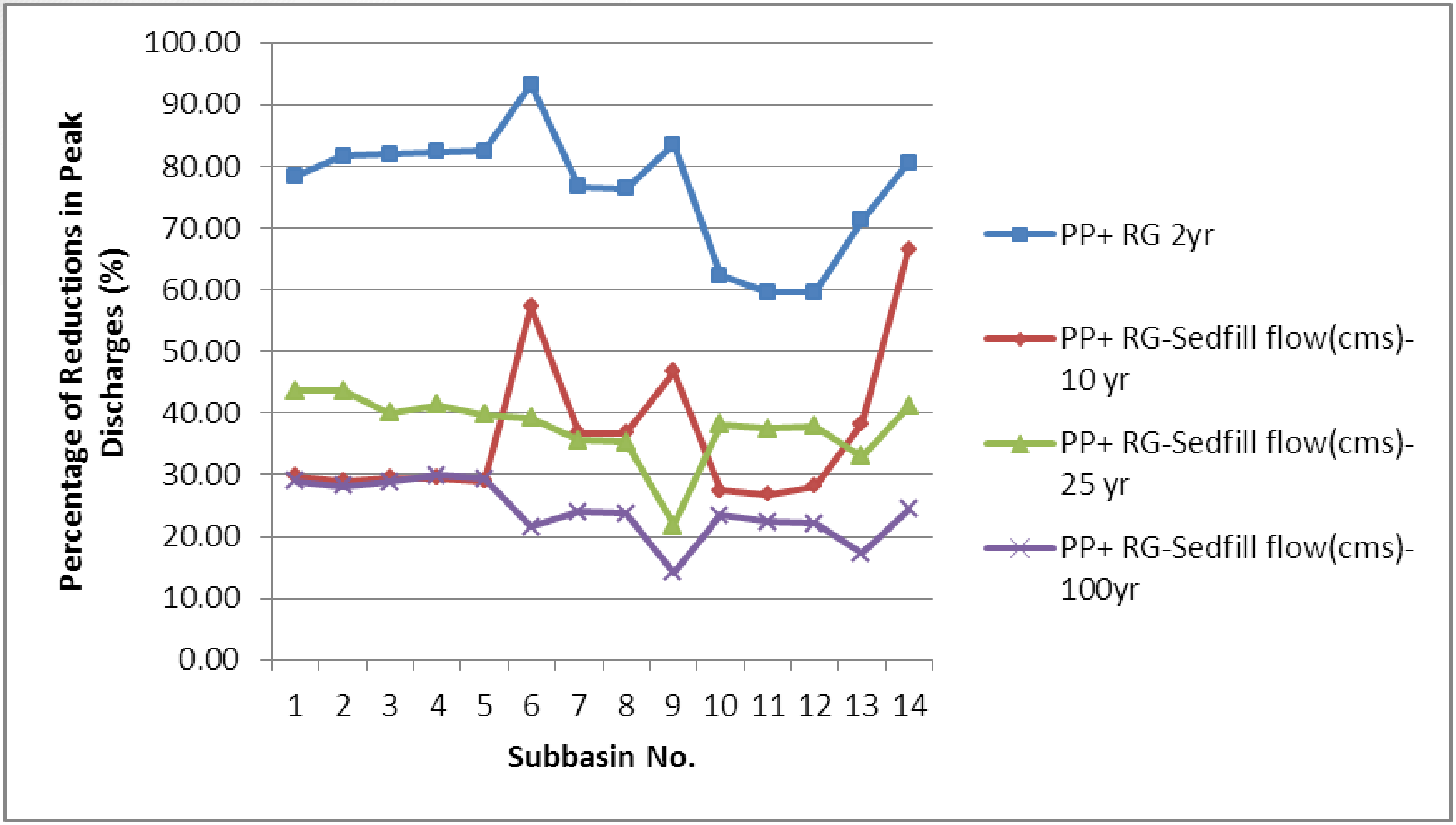
- Evaluated based on the exceedance of the Bankfull stage
- Bankfull discharges for each subbasin was determined
- Design storms for the following recurrence intervals (2-year, 10-year, 25-year, and 100-year) were modeled for the SCS 24 hour rainfall distribution for type III region



Reduction in flooding due to LID



Reduction of Peak Flow

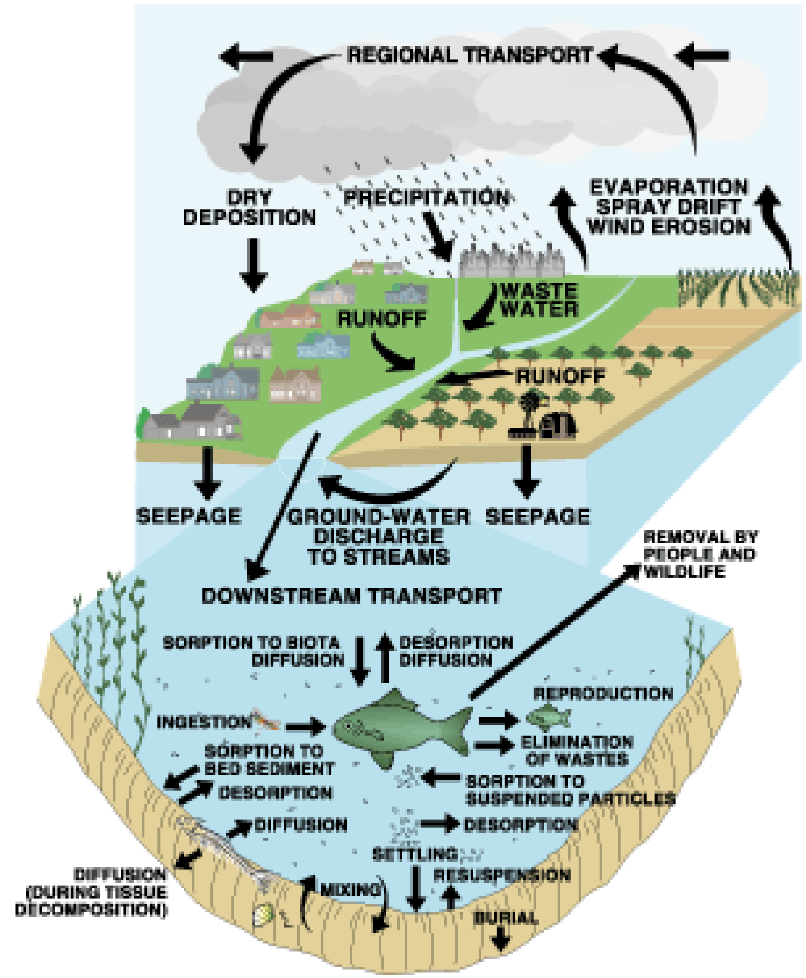


AQUATIC LIFE IMPACTS

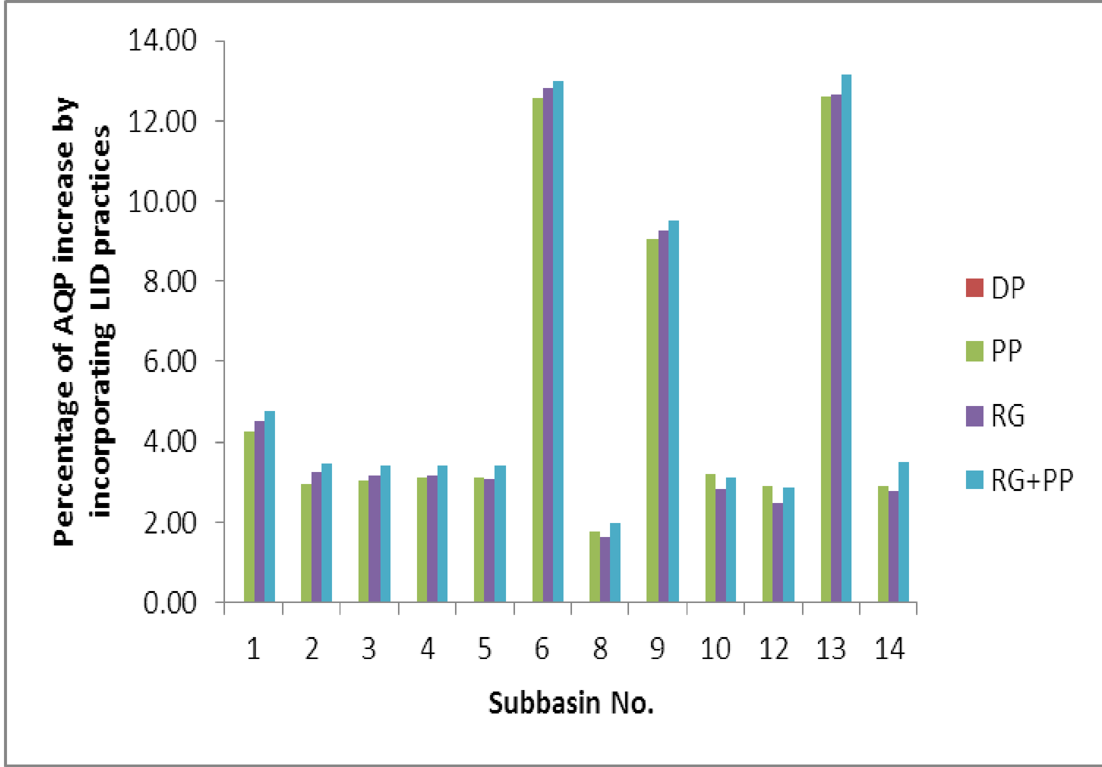
- COA collects water quality and aquatic health data as part of Environmental Integrity Index (EII) based on Hydrological indicators (peak flow, baseflow,..etc.). A statistical model was developed to predict and quantify future aquatic life potential score in urban streams (Glick et al., 2011)

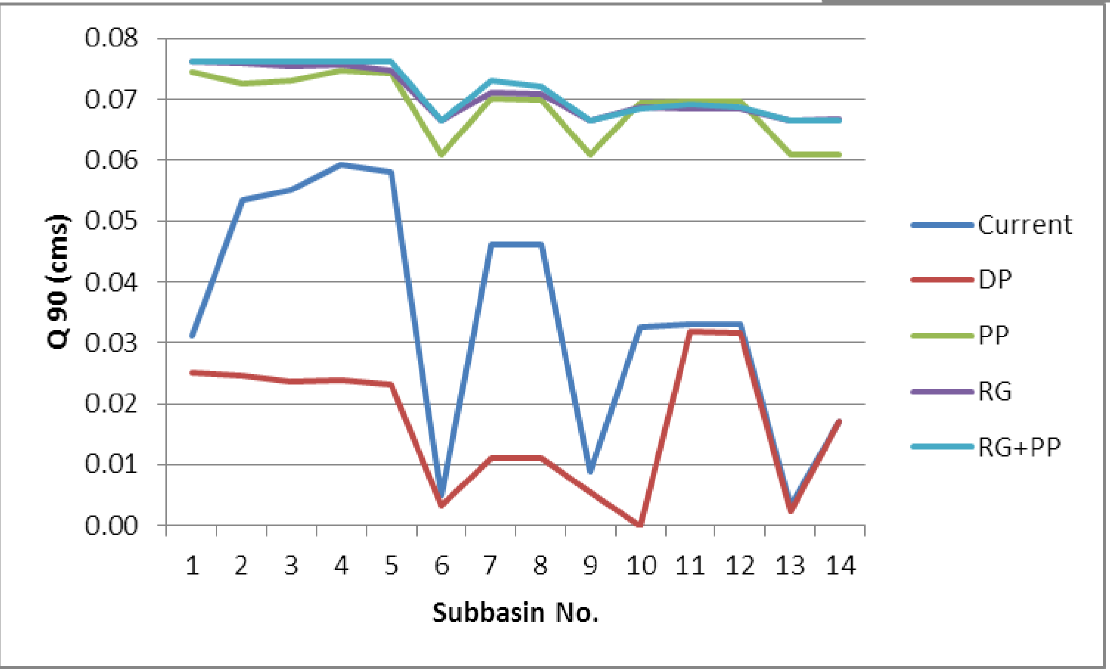
AQP = 87.7539 – 1.5961 x (Qpeak/area) + 4.3842 x Ln (Q90) – 21.2655 x (Avg_Rise)

Where, AQP : Aquatic life potential
Qpeak/area : peak flow rates ($m^3/s/km^2$)
Q90 : 90th percentile flow rate in m^3/s, 90% of the flow is below this this value
Avg_Rise: Median of all positive differences between consecutive rising values (rise rate, m^3/s / sec)



Combining bioretention area with permeable pavement resulted with the greatest percentage of AQP value increase, followed by RG only, PP and DP





Greatest increase in baseflow resulted when combining bioretention area with permeable, followed by RG only, PP and lastly DP

Acknowledgements

- The authors want to thank Dr. Roger Glick from the City of Austin for his assistance with this project. Funding was provided from the Texas Sea grant and NOAA.

Fouad H. Jaber, PhD, PE
Associate Professor and Extension Specialist
Biological and Agricultural Engineering
Texas A&M Agrilife Extension
Dallas Research and Extension Center
f-jaber@tamu.edu
972-952-9672