Smart Stormwater Solutions

BURNS McDONNELL

Governor's Conference on the Future of Water in Kansas

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Smart Stormwater Solutions = Sustainable Solutions

- Are we investing our limited stormwater dollars on the right solutions?
- Who benefits when we spend stormwater dollars?
- Are we maximizing our current assets?
- Can we maintain what we have?
  - Can we maintain what we will build?
- Can we afford to meet a standard of practice that is based on one flowrate?
- Is stormwater a resource or a waste?

Stormwater Regulations and Criteria

- FEMA Regulatory Floodplains - Planning Policy
  - > 640 acres, Open conveyance (streams and rivers)
  - Detail varies and accuracy is questionable
- Stream Setback or Buffer Ordinances - Planning Policy
- Corps of Engineers Regulations – Design Policy
  - Levees, Dams, Waters of the United States (WOTUS)
- Transportation – Design Policy
  - Gutter Spread
  - Level of Service Varies by Road Type
- Public Municipal Separate Storm Sewer System (MS4) – Design Policy
  - Enclosed collection system
  - Legacy systems
- Land Development – Planning and Design Policy
  - Required to offset land use changes

Regulations Impact Our Policies

- FEMA Floodplain Regulations
  - Development policy near streams and rivers
  - Design policy for building within floodplains
- EPA Water Quality Policy
  - MS4 Phase I/II Permit
  - Structural and Non-Structural BMPs
  - CSO Policy – Green Infrastructure
- U.S. Army Corps of Engineers
- U.S. Department of Transportation & Federal Highway Administration (FHWA)
  - HEC 22 – Urban Drainage Design Manual

Stormwater Infrastructure Function

Collection | Conveyance | Storage Outlets |

Stormwater BMPs

Stormwater Infrastructure

Lakes | Streams | Wetlands | Rivers

Building Bigger Doesn’t Mean Better

Why do we need to improve?

1) Are our current stormwater solutions sustainable?
2) Do our current stormwater solutions benefit all/most?
3) Do we have the funding to meet our current standards?
4) Do we consider excess rain a resource or waste?

Smart Stormwater Solutions

GUEST EDITORIAL

Dumbing Down Hydrology

BY DOUGLAS BEYERLEIN

Why are we dumbing down hydrology for engineers? When I say "dumbing down," what I mean is that we (the stormwater profession) are telling engineers to use pre-computer, simple methods and techniques to size stormwater facilities. I recently asked a noted, national stormwater expert this question, and his response was (to paraphrase him), "We need to keep things simple because 99% of stormwater design is being done by a general civil engineer using somewhat dated models, or simple automations of older methods, for whom the stormwater design is about 10% of what he does." That may be true, but it is hardly an appropriate excuse. Today in the United States we spend billions of dollars on stormwater management. For that much money, isn't it important that we use the most accurate tools and methods available? So, why in most parts of the country are we still using pre-computer, slide rule hydrology to do our calculations?

Slide Rule Hydrology

What is slide rule hydrology? Slide rule hydrology is a set of simplified engineering methods to compute runoff from rainfall. This includes methods such as the Rational Method (Q = CIA) and SCS curve numbers. These methods were developed when the only computational tool we had to use

are built into single-event hydrologic modeling. These assumptions are bundled into the standard runoff coefficients for the Rational Method and standardized curve numbers for SCS-based methods.

These single-event methods, by their very nature, have no mechanism to simulate back-to-back storms, variable soil moisture conditions, or the effects of long-term infiltration and evapotranspiration. In the real world, a two-year precipitation event does not always produce a two-year runoff event. Real storms do not have a standard shape, volume, or length. And the soil moisture varies from one event to the next and even during a single event, depending on the climate, season, storm, and soil type.

Today no one uses a slide rule. So why are we still using hydrologic modeling methods designed for the slide rule?

What is the alternative?

Continuous Simulation Hydrology

Continuous simulation models the entire hydrologic cycle. All of the water in the hydrologic cycle is tracked everywhere all of the time. This type of hydrologic modeling can't be done with a slide rule. A computer is required for the needed calculations.

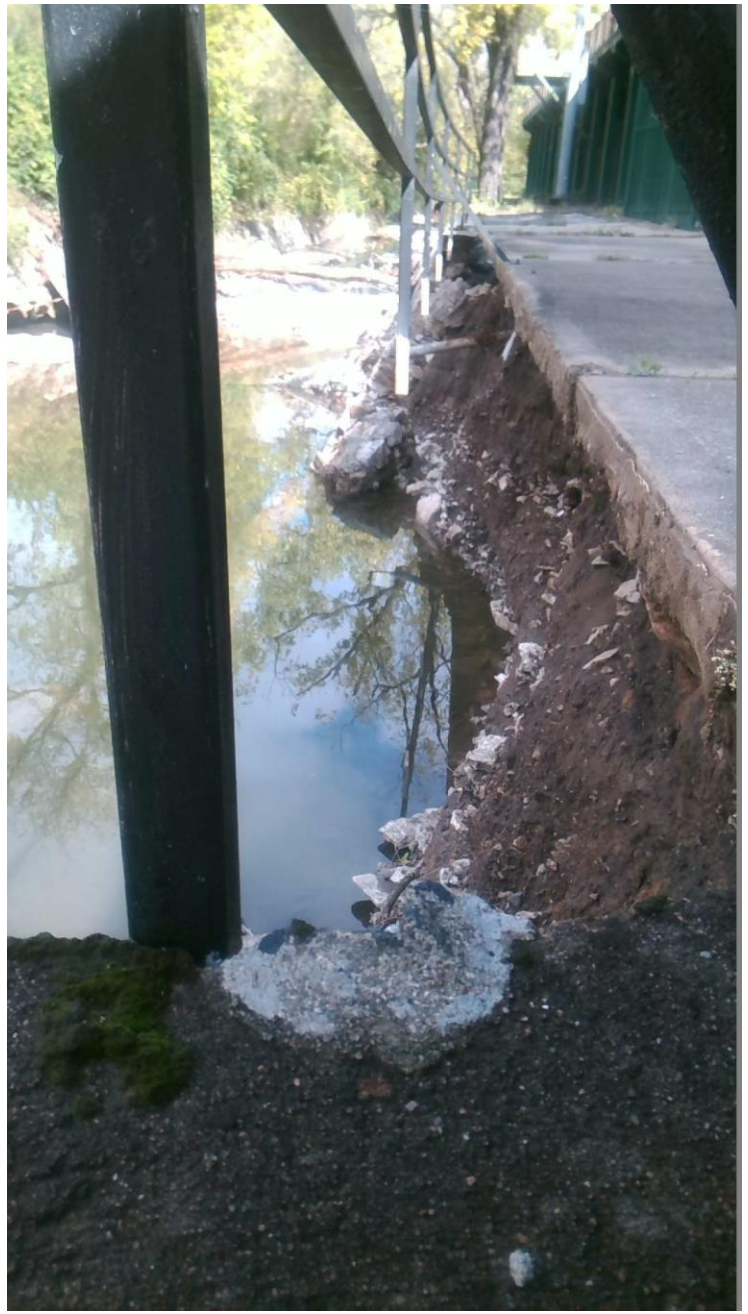
With the use of a computer the continuous simulation model represents all of the processes observed in the hydrologic cycle with appropriate algorithms. The model routes

It’s the Rain Fault!

Does increase rain mean we need bigger pipes?

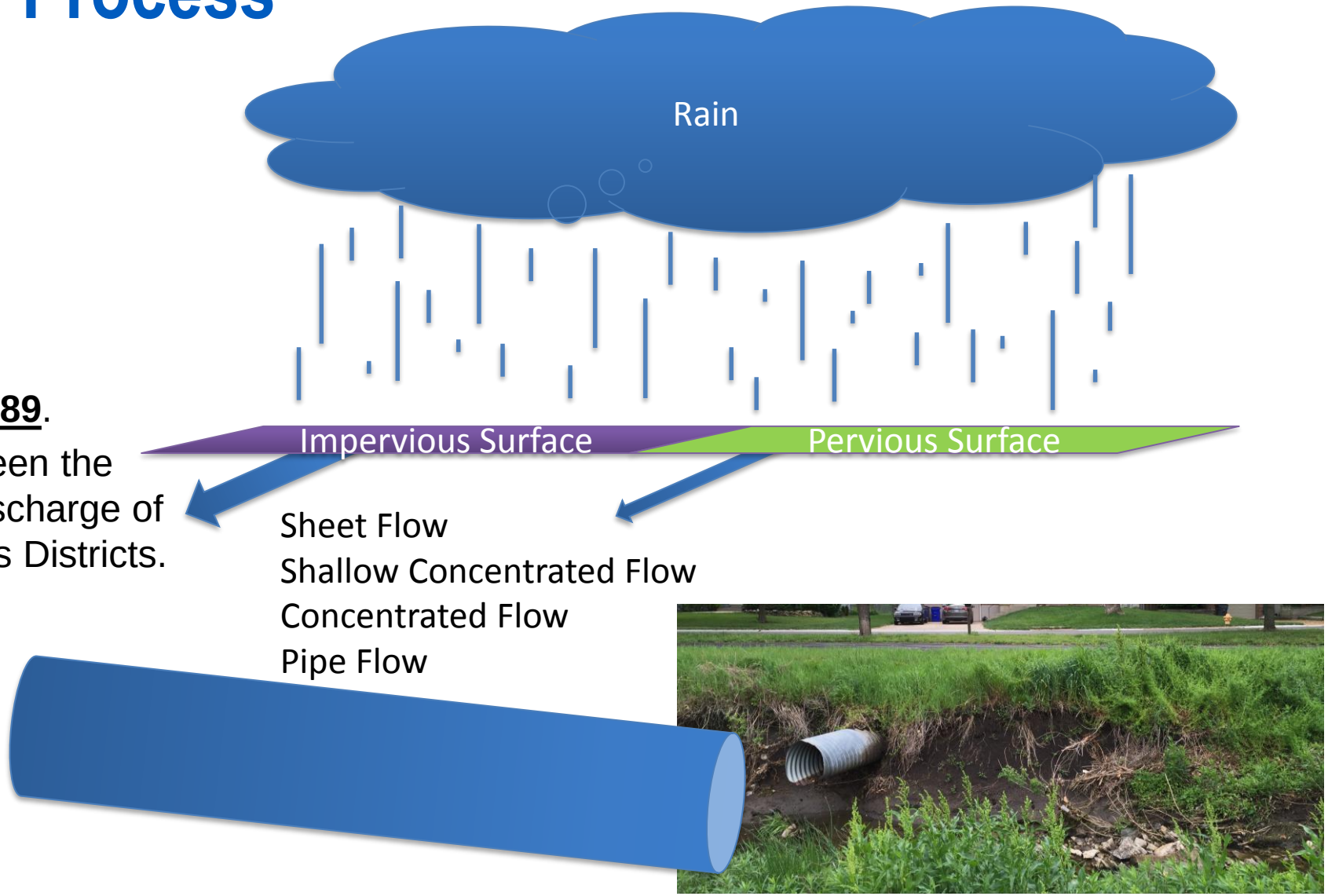
Well it depends

- Need to ask some fundamental questions:
  - What amount of excess rain can we afford to convey in an enclosed system?
  - For rainfall events greater than our enclosed system is there a path for water to reach rivers and streams?
  - What is our design expectation for stormwater systems?
  - Do we understand all of the risks?



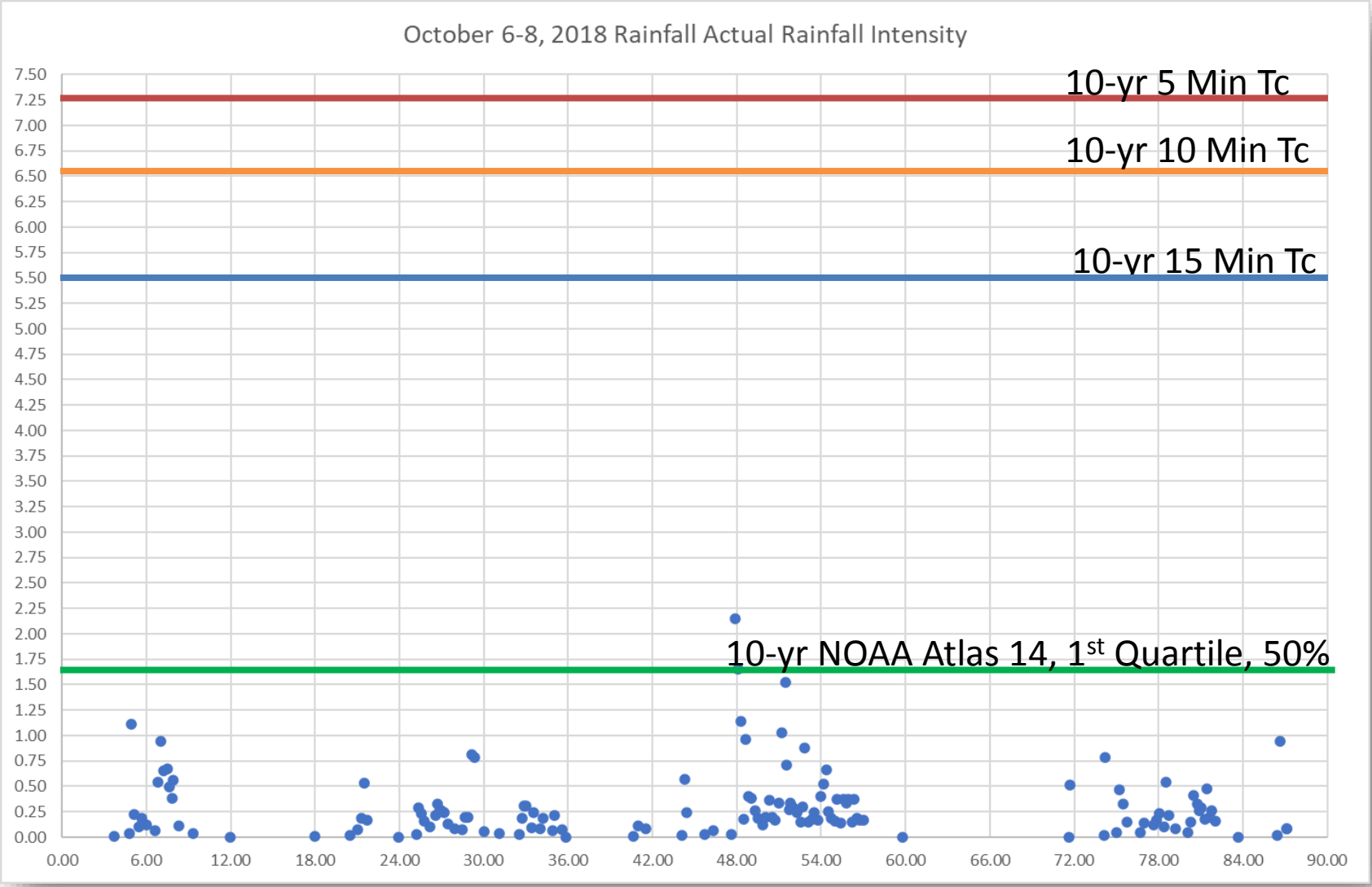
Current Design Process

- Design Storms
  - 24 hr SCS Type2
- Rainfall Intensity
  - Rational
  - Q = C*I*A
  - ASCE, **January 1889**.
  - The Relation Between the Rainfall and the Discharge of Sewers in Populous Districts. Emil Kuichling
- Rational C
- Impervious Area



Question Our Initial Assumptions

- Should we allow short time of concentrations to drive our pipe sizing?



Current Storm Sewer Pipe Design

- Design Example
  - 1.83-acre site
  - 10-Year Level of Service
    - Enclosed System
    - Slope = 1%
    - RCP

Calculations

Rational Method

Area = 1.83 ac

Rational C = 0.87

Rainfall Intensity

- 10-yr, 10min = 5.61 in/hr

Q=1.83*0.87*5.61 = 8.93 cfs

Pipe Design

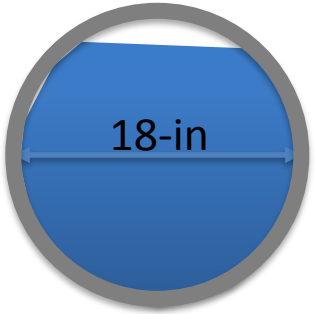
18-inch diameter

RCP

1% Slope

11.3 cfs

6.57 ft/s



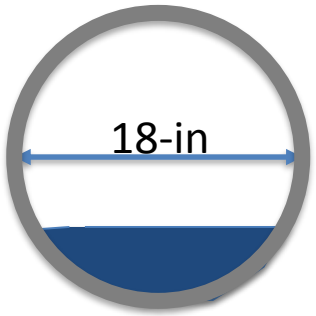
Are you getting what you paid for?

0.5-inch rain @ 1 in/hr

Runoff Vol. = 23,350 Gallons

Runoff Rate = 1.6 cfs

Max Depth in pipe= 4.3 inch (26%)
Velocity = 4.2 ft/s



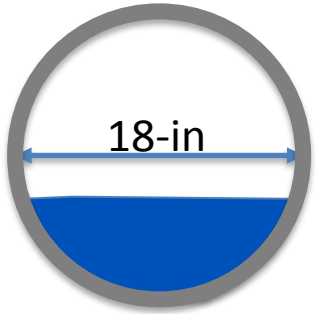
52 min

1-inch rain @2 in/hr

Runoff Vol. = 46,700 Gallons

Runoff Rate = 3.2 cfs

Max Depth in pipe= 6 inches (38%)
Velocity = 5.2 ft/s



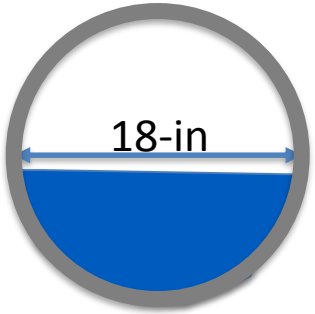
54 min

2-inch rain @ 3 in/hr

Runoff Vol. = 93,420 Gallons

Runoff Rate = 5.3 cfs

Max Depth in pipe= 7.5 inches (50%)
Velocity = 5.9 ft/s



66 min

Smart Sewer Pipe Design

- Design Example
  - 1.83-acre site
  - 10-Year Level of Service
    - Enclosed System
    - Slope = 1%
    - RCP

Calculations

Rational Method

Area = 1.83 ac

Rational C = 0.87

Rainfall Intensity

- NOAA Atlas 14, Q1 6 hr
- 1.6 in/hr

Q=1.83*0.87*1.6 = 2.5 cfs

Pipe Design

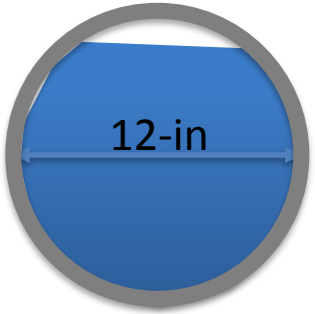
12-inch diameter

RCP

1% Slope

3.8 cfs

5 ft/s



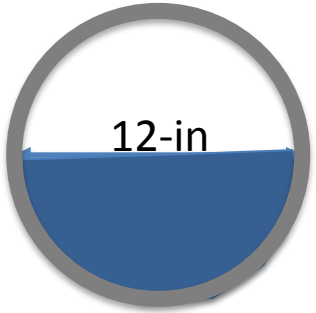
Smart Sewer Pipe Design Provide More Value

0.5-inch rain @ 1 in/hr

Runoff Vol. = 23,350 Gallons

Runoff Rate = 1.6 cfs

Max Depth in pipe= 5.5 inch (48%)
Velocity = 4.5 ft/s



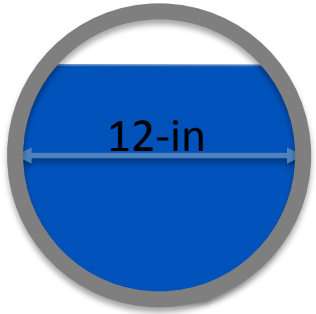
52 min

1-inch rain @2 in/hr

Runoff Vol. = 46,700 Gallons

Runoff Rate = 3.2 cfs

Max Depth in pipe= 9 inches (75%)
Velocity = 5.1 ft/s



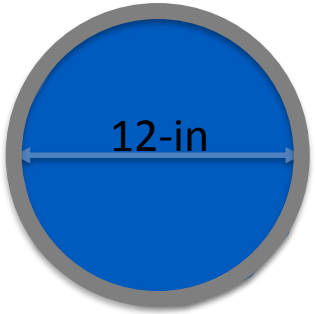
54 min

2-inch rain @ 3 in/hr

Runoff Vol. = 93,420 Gallons

Runoff Rate = 5.3 cfs

Max Depth in pipe= 12 inches (100%)
Velocity = 4.5 ft/s



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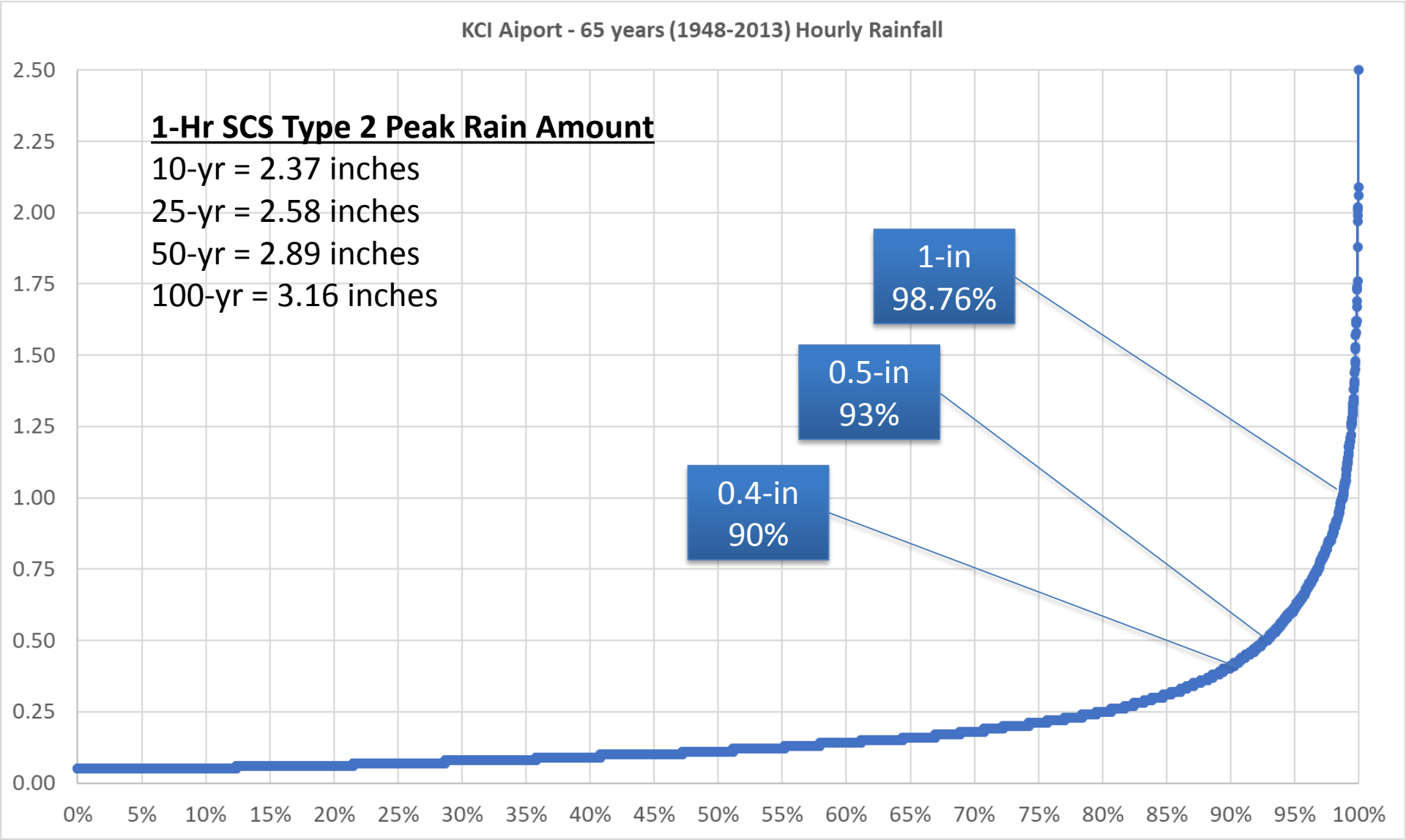
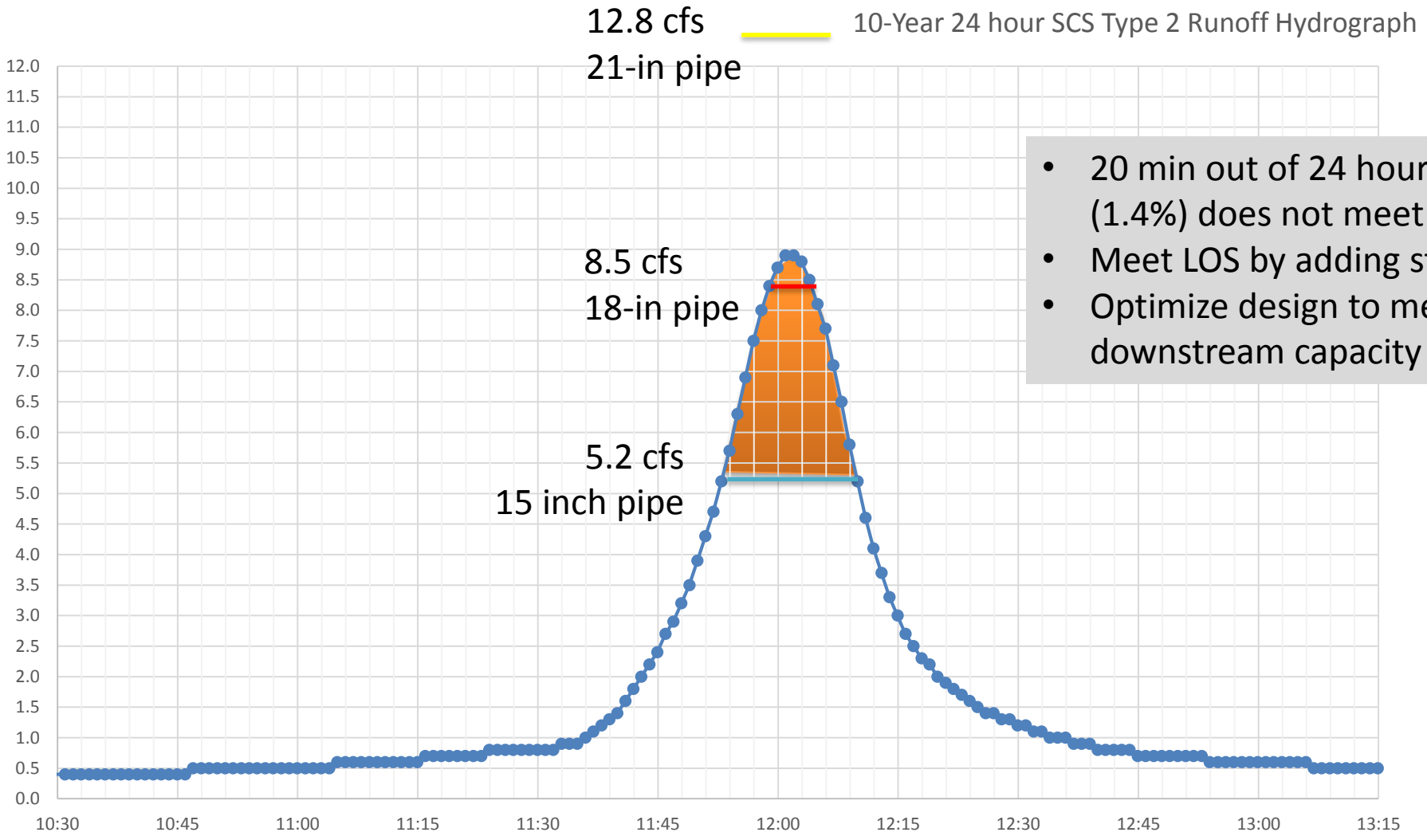
Historical Rainfall Data



Stormwater as a Resource

Capture 1st 0.5 inches of Runoff

Thinking of Stormwater Design Differently

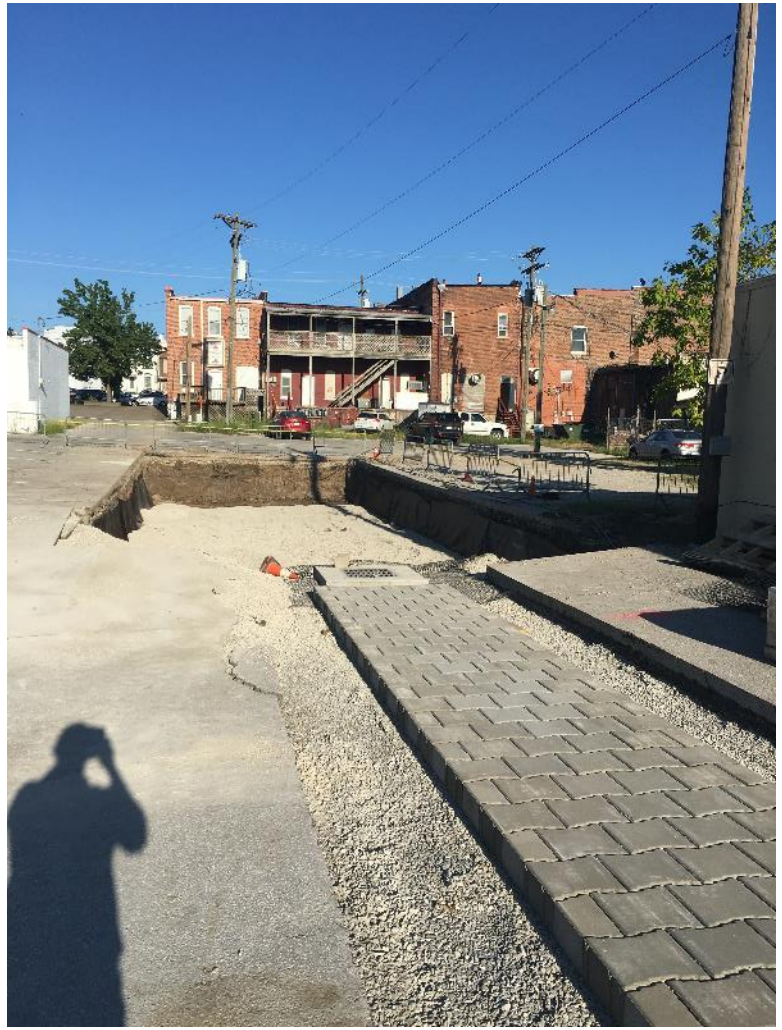


- 20 min out of 24 hour (1.4%) does not meet LOS
- Meet LOS by adding storage
- Optimize design to meet downstream capacity

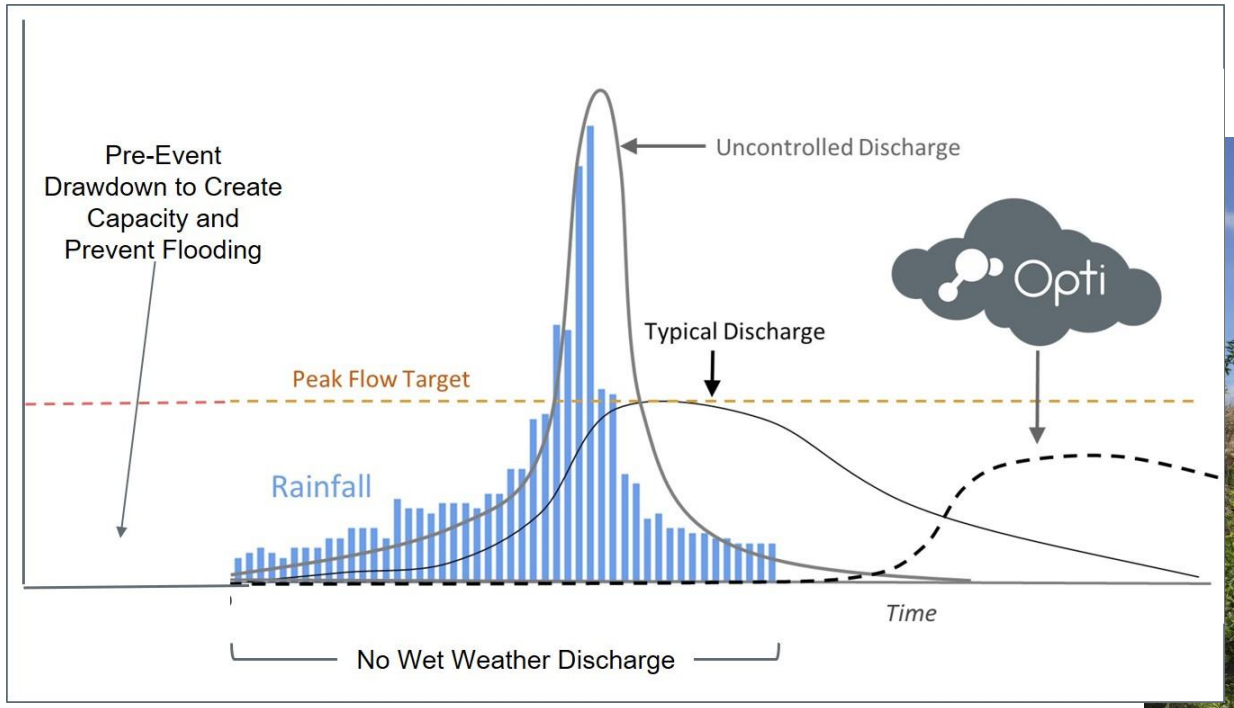
Pervious Pavement with Underground Storage & Conveyance

- 10-year Standard of Care
- Provides 2,300 cf underground storage
- Cost = $35-$45K
- Limits discharge to match existing system

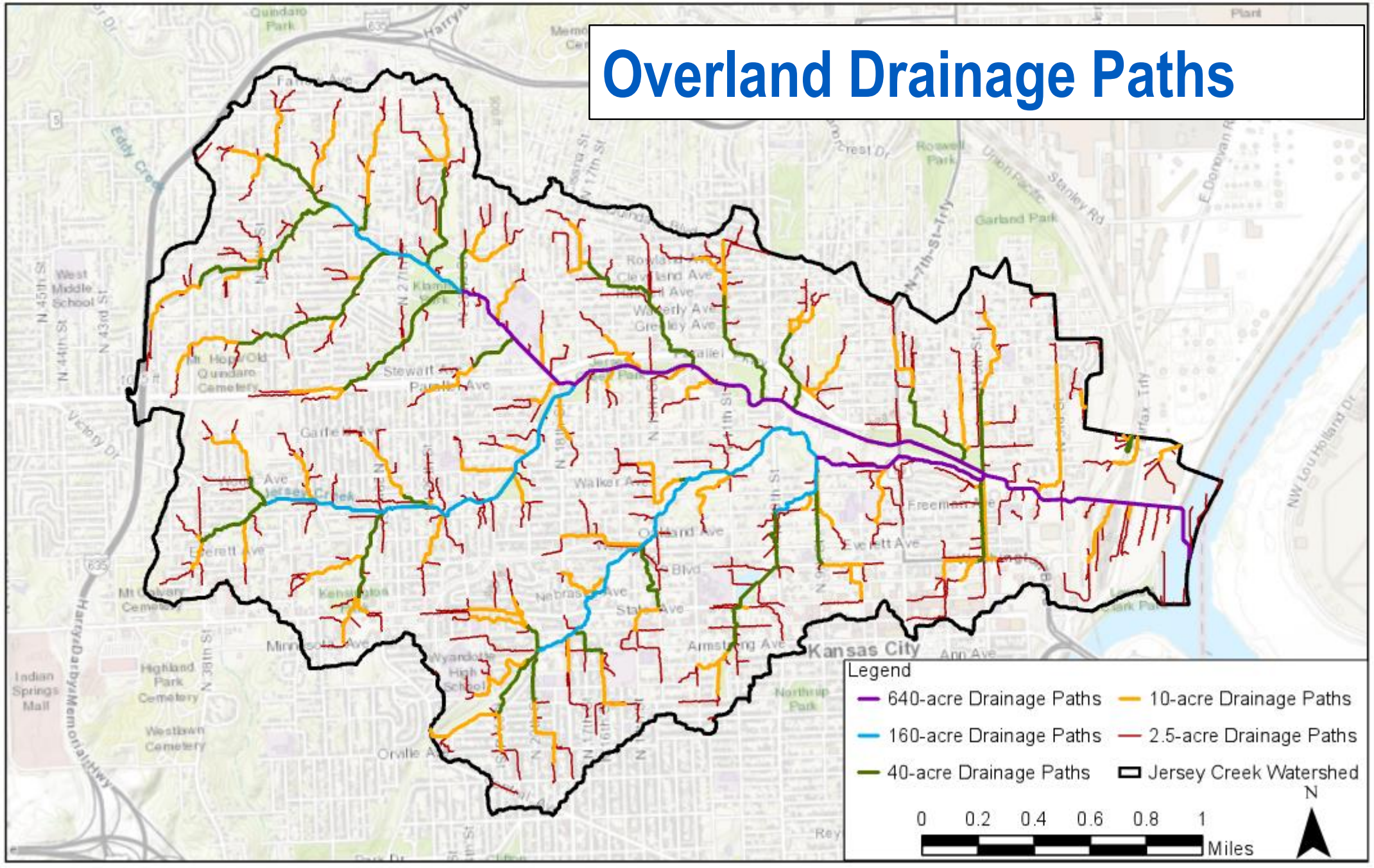
Fulton's Smart Stormwater Solution



Continuous Monitoring and Adaptive Controls (CMAC)

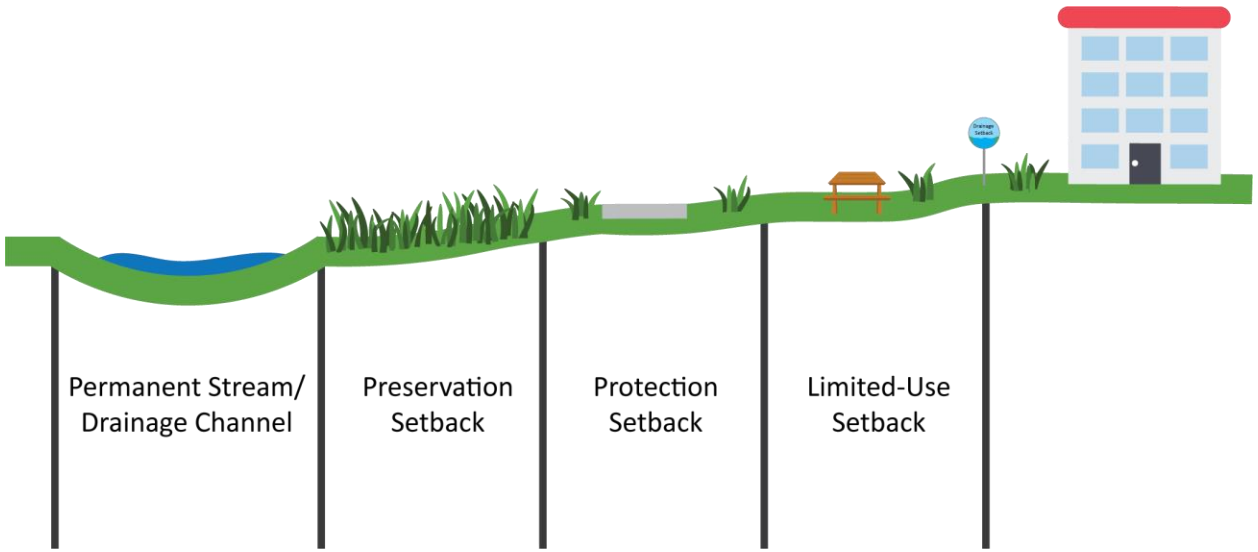


Overland Drainage Paths



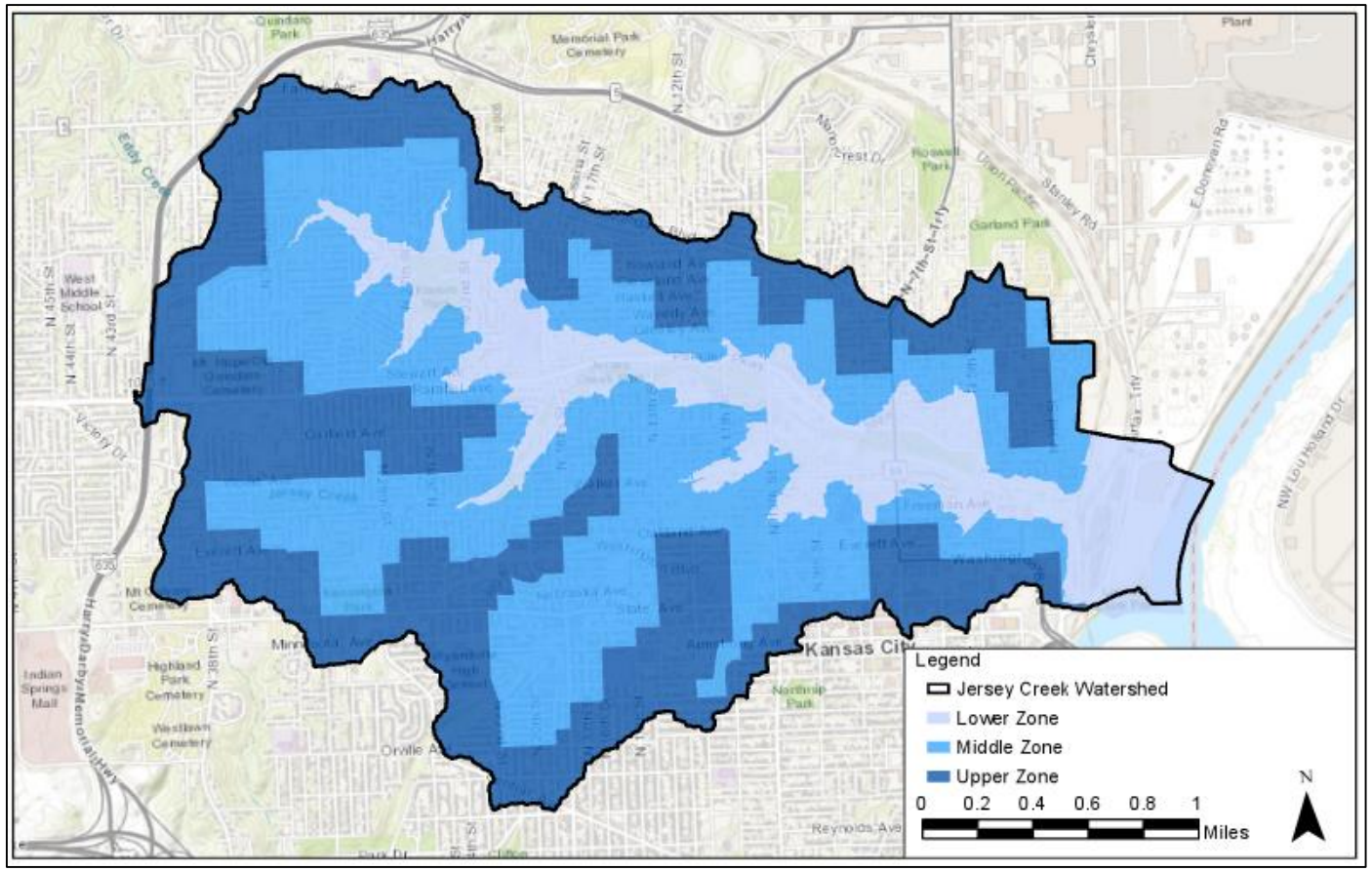
Drainage Setback Policy (Example)

- Drainage Setbacks and Easement
- Setback Distance Based on Drainage Area
- Setback Distance Based on Model Results
- Develop Different Zones for Flexibility



Watershed Approach

- Upper Zone
  - Capture and control before conveyance
  - Retention of most frequent events
  - Green Infrastructure/BMPs
- Middle Zone
  - “Right Size” Conveyance System
  - Cost-benefit analysis
  - Dynamic model of system
- Lower Zone
  - Preserve existing stream and rivers
  - Map flood risk zones
  - Maintain a connected greenway
  - FEMA floodplains & Building Setbacks



Smart Stormwater Solutions Should:

Take Homes for Smart Stormwater Solutions

- Define a standard of care that is affordable while providing an increased benefit
- Evaluate the receiving system (What is downstream)
  - Not just for one design event but for a range of events
- Balance flood risk reduction with water resource risk
- Optimize solutions for increased function
  - Functional performance for more events not one event
- Ability to adapt to future changes

Smart Stormwater Solutions

1. Provide a greater benefit **for all**
2. Create more resilient solutions
3. **Do it at an affordable price**

CREATE AMAZING.

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