Design Thinking Resiliency and Risk

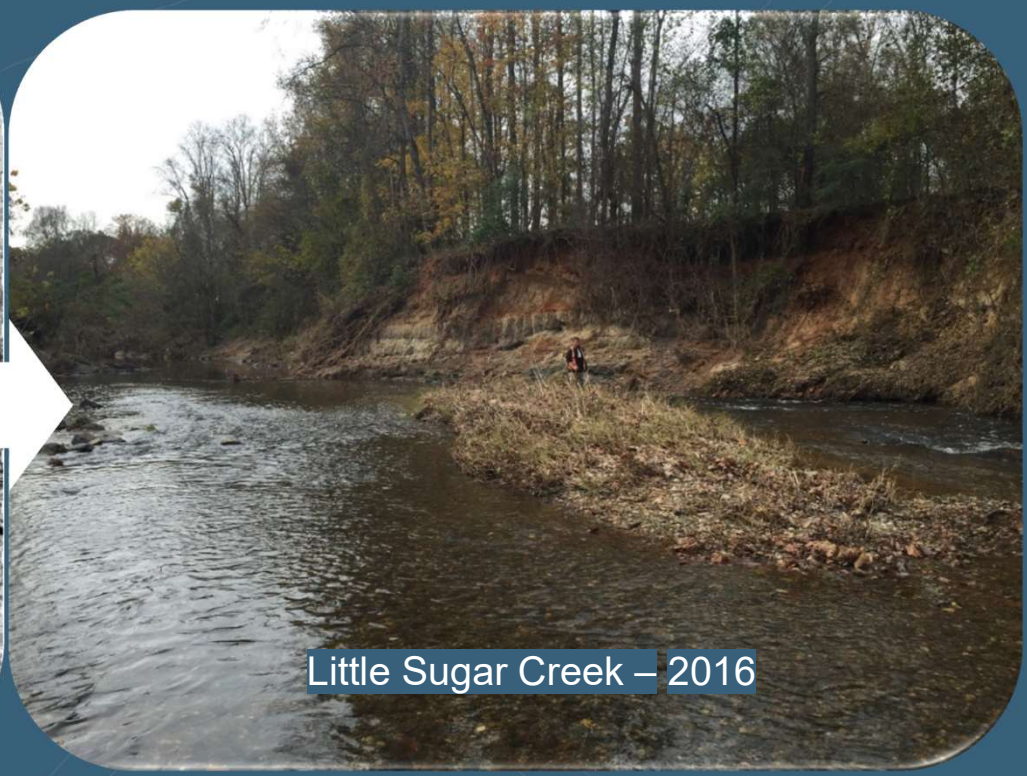
Designing for Urbanization and Climate Changes

Presented by:
Will Wilhelm, P.E., CFM, CPESC

Kimley»Horn

Fishing poles, clothes and streams have changed

Little Sugar Creek –1894



Little Sugar Creek – 2016

Courtesy of Rusty Rozzelle

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Watershed functions for stream resiliency

- Intermittent and ephemeral streams
- Active floodplains
- Riparian areas
  - Wetlands
- Groundwater recharge
  - Uplands and floodplain
- Stream network and landscape connectivity
- Point and non-point discharges

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Hydraulic and geomorphic functions for stream resiliency

- Proper low flow
  - Narrowing low flow can reduce water temperatures
- Inner berms and bank-full benches
  - Sediment capacity and competence
- Pool/riffle frequency and depth(s)
  - Store more water
  - Hyporheic zone
- Proper sinuosity or step-pool sequence(s)
- “Active” floodplains
- Riparian plantings

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Increasing stream resilience to disturbance

Disturbance	Strategy	Restoration Action
Drought	Keep water in headwaters longer; recharge groundwater, increase refuge habitat; stable low flows stream geometries	1) Restore headwater systems 2) Restore/create “active” floodplains 3) Promote floodplain storage and infiltration 4) Increase frequency and size of pools 5) Upland green infrastructure and LID
Floods	Increase capacity of floodplains to absorb and dissipate increased flows; Understand velocity and momentum relative to critical or recommended stress for the boundary. Understand risk and account for uncertainty.	1) Reconnect and restore floodplains 2) Improve culverts/bridges 3) Proper hydraulic geometry 4) Define and communicate risk and uncertainty 5) Add grade control NCD structure(s) based on risk tolerance and floodplain limitations 6) Riparian plantings

Adapted from TU.org

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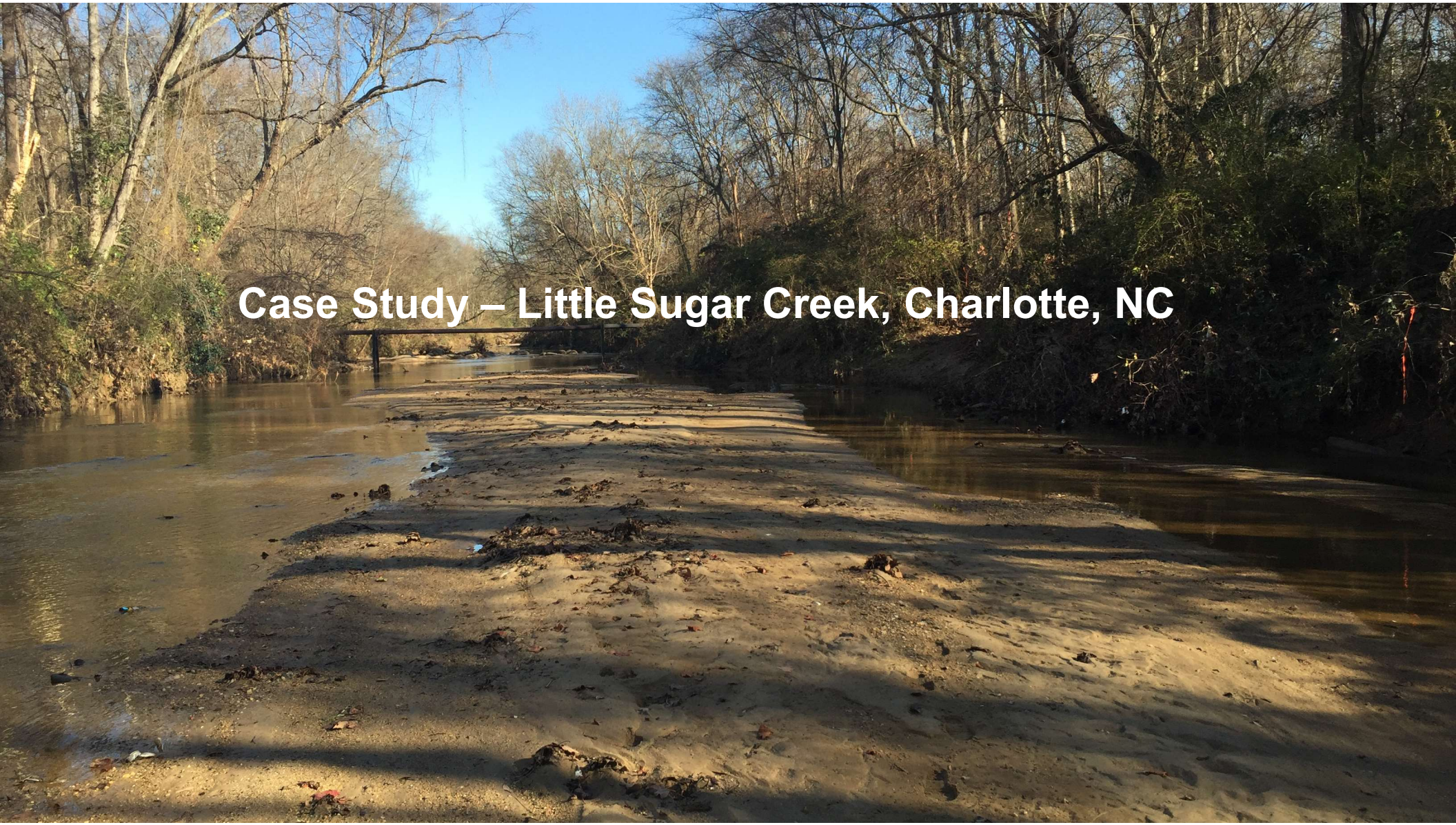
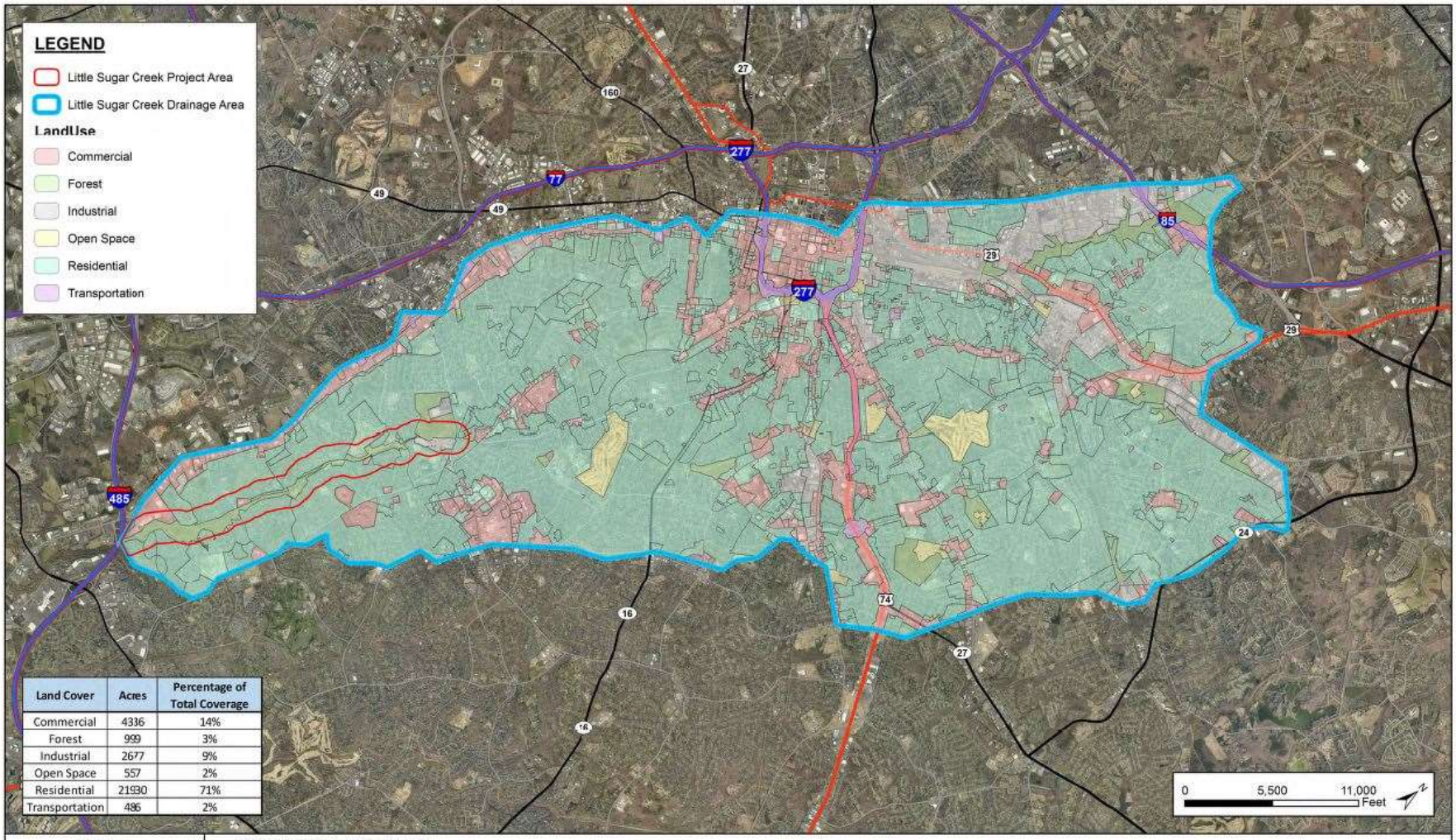

Case Study – Little Sugar Creek, Charlotte, NC



Land Cover	Acres	Percentage of Total Coverage
Commercial	4336	14%
Forest	999	3%
Industrial	2677	9%
Open Space	557	2%
Residential	21930	71%
Transportation	486	2%

Title Project Site Land Cover

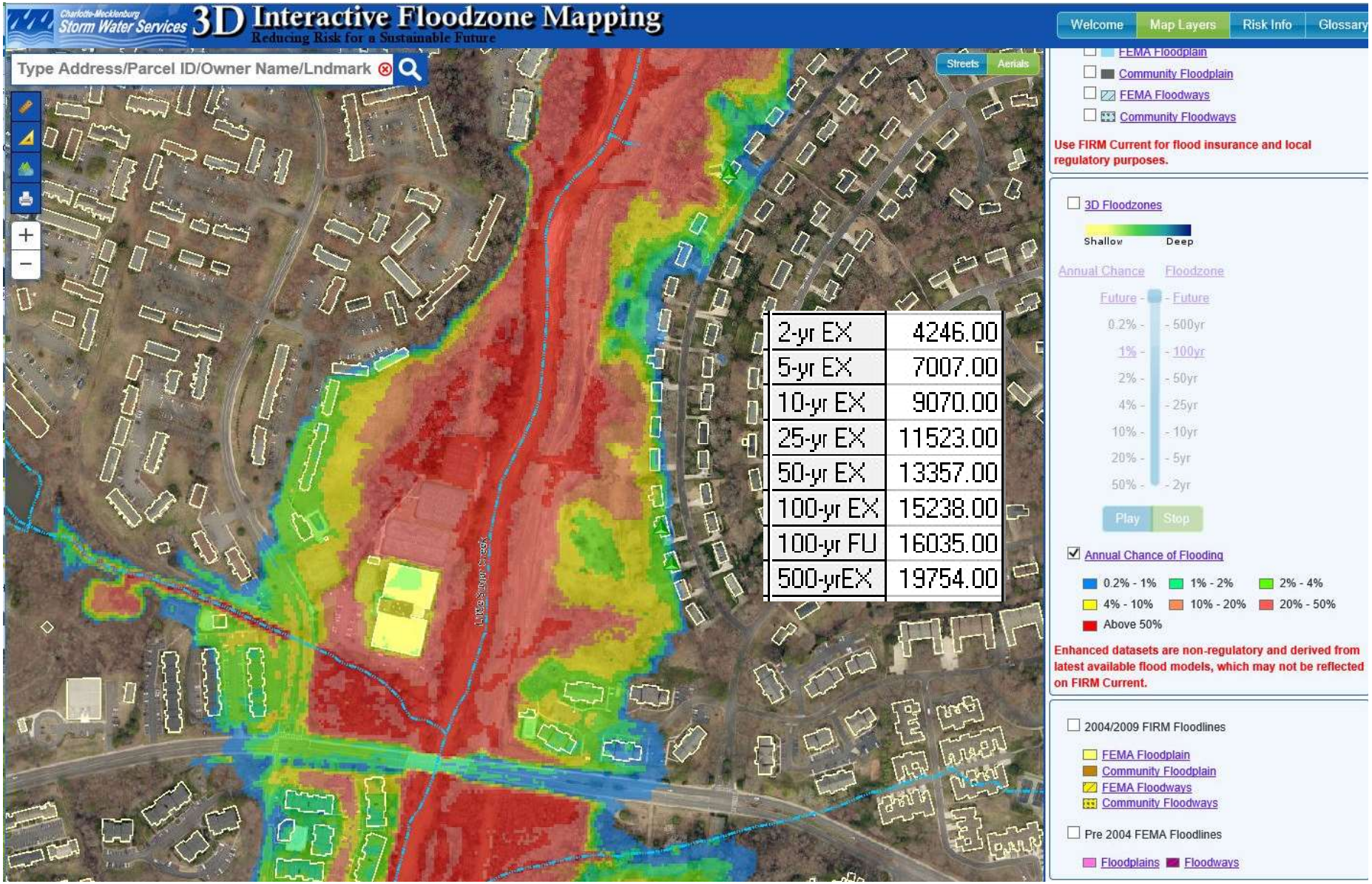
Prepared For: Charlotte-Mecklenburg Storm Water Services

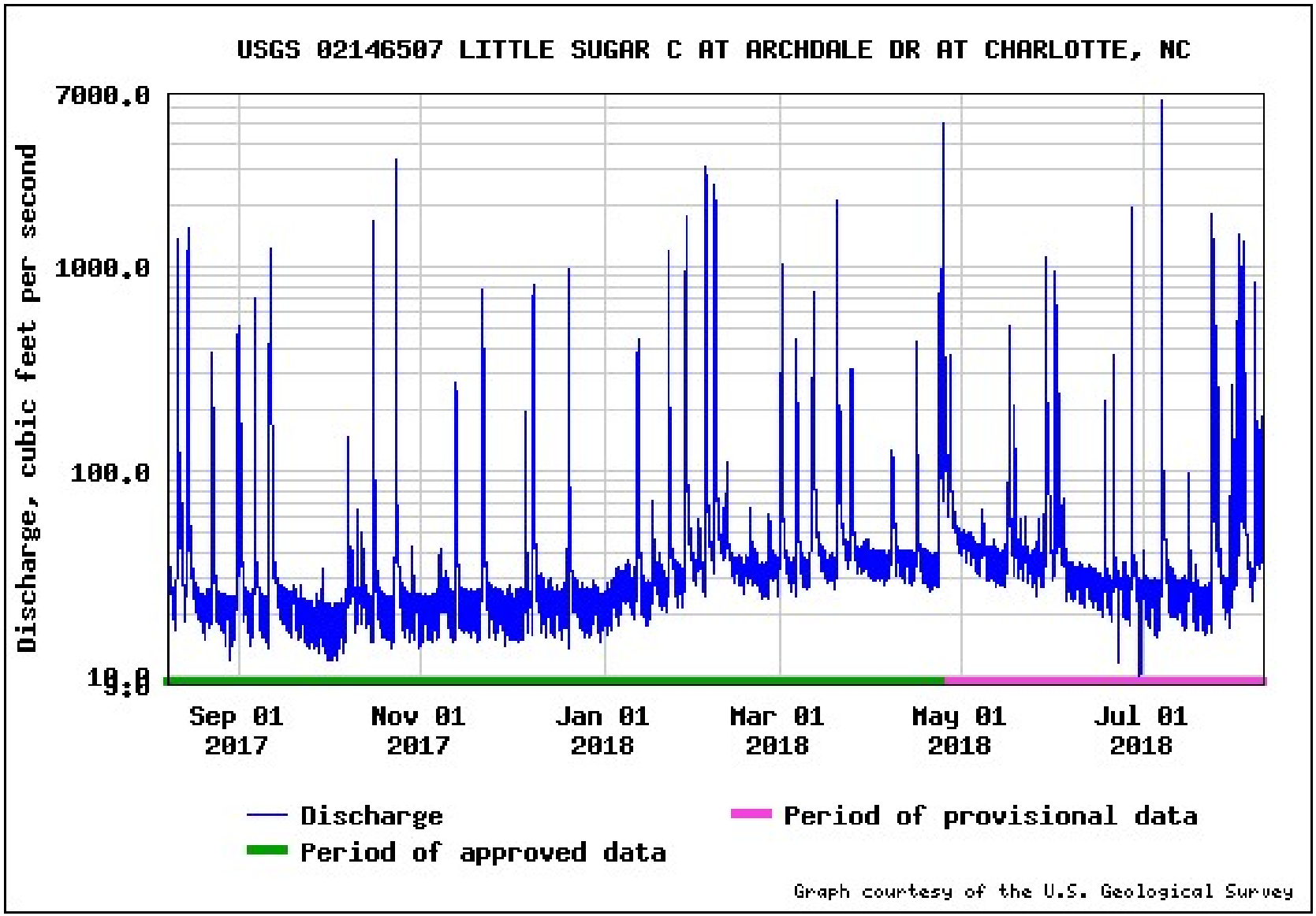
Project Little Sugar Creek (Tyvola Rd. to -485) Stream Restoration
Mecklenburg County, North Carolina

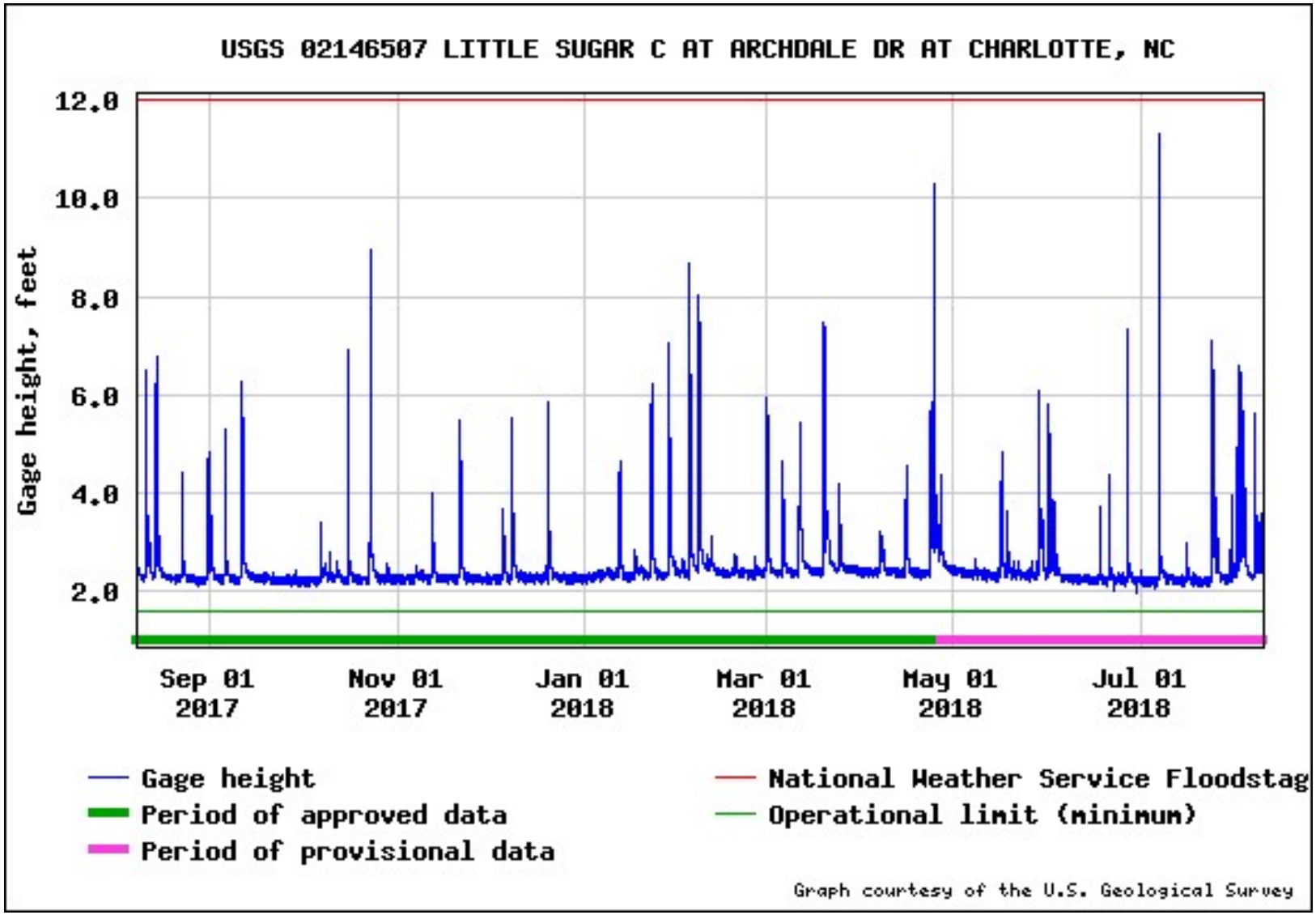
Date 8/5/2015

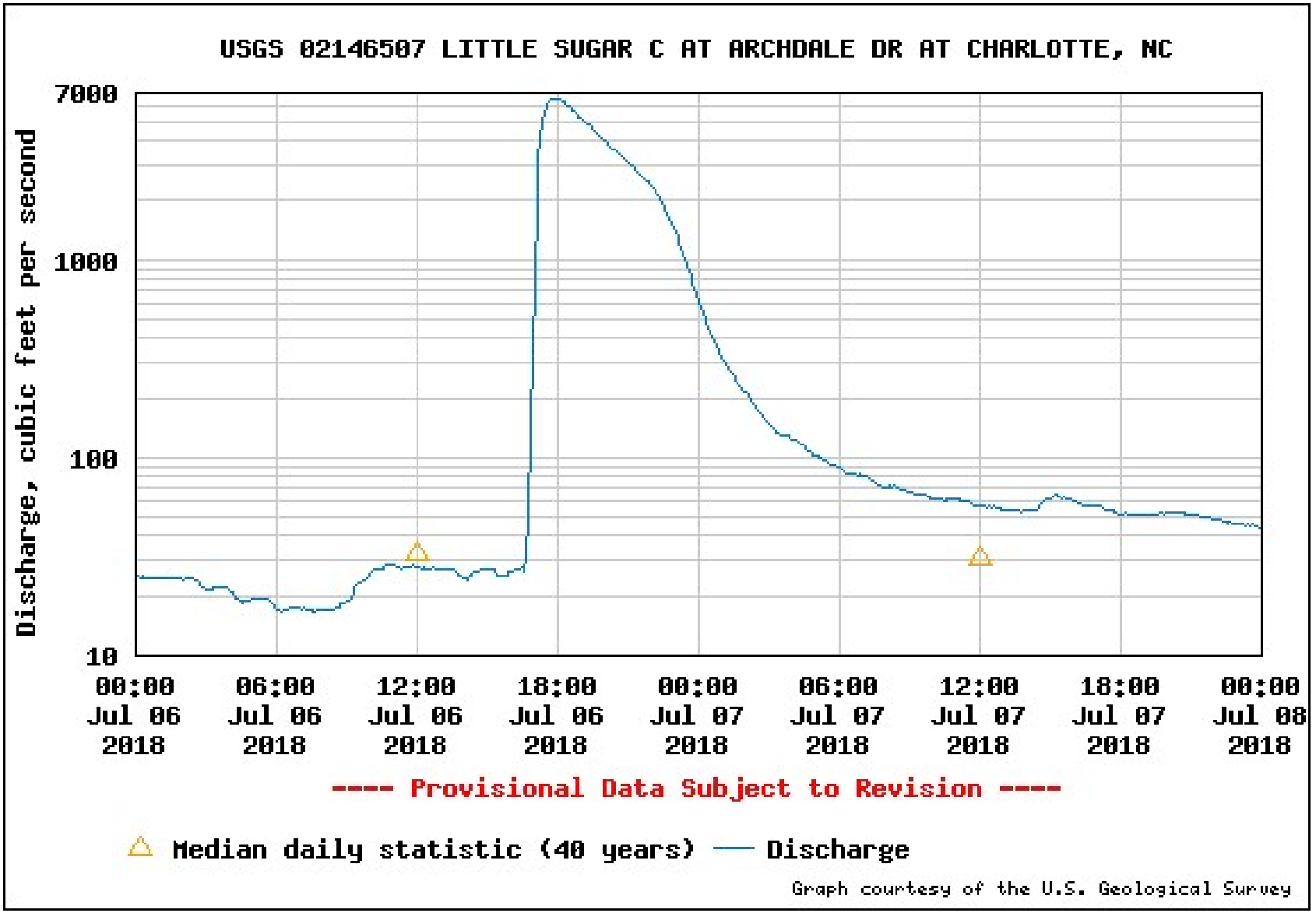
Figure 3

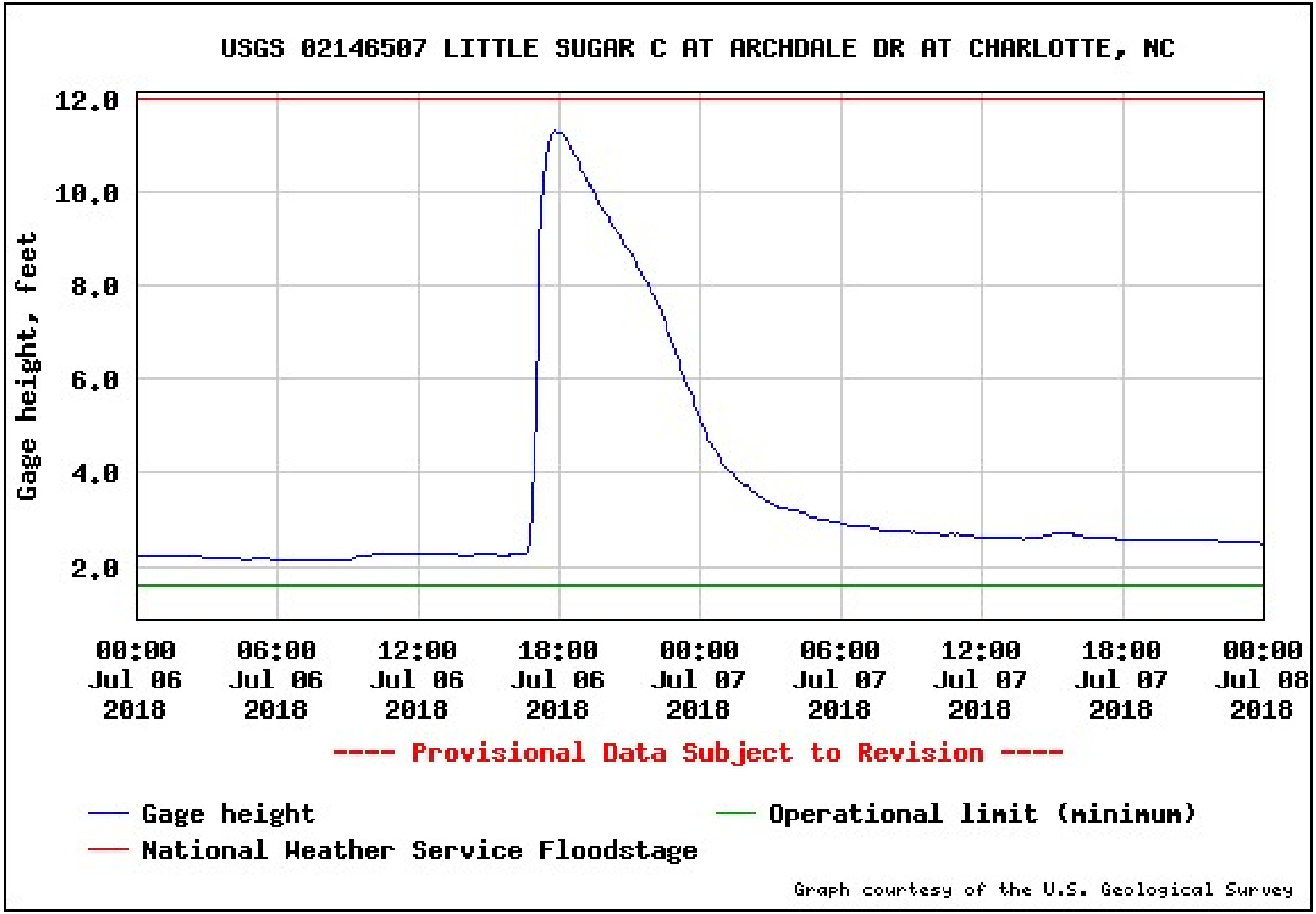
Prepared By: Kimley»Horn

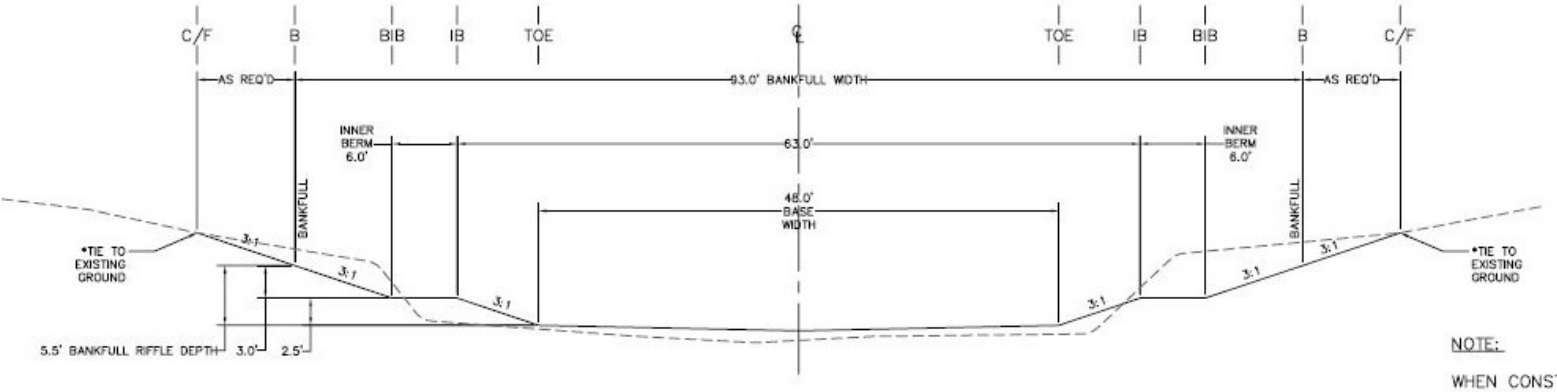

Charlotte-Mecklenburg Storm Water Services
3D Interactive Floodzone Mapping
Reducing Risk for a Sustainable Future
Welcome
Map Layers
Risk Info
Glossary
Type Address/Parcel ID/Owner Name/Lndmark
Streets
Aerials
FEMA Floodplain
Community Floodplain
FEMA Floodways
Community Floodways
Use FIRM Current for flood insurance and local regulatory purposes.
3D Floodzones
Shallow
Deep
Annual Chance
Floodzone
Future - Future
0.2% - 500yr
1% - 100yr
2% - 50yr
4% - 25yr
10% - 10yr
20% - 5yr
50% - 2yr
Play
Stop
Annual Chance of Flooding
0.2% - 1%
1% - 2%
2% - 4%
4% - 10%
10% - 20%
20% - 50%
Above 50%
Enhanced datasets are non-regulatory and derived from latest available flood models, which may not be reflected on FIRM Current.
2004/2009 FIRM Floodlines
FEMA Floodplain
Community Floodplain
FEMA Floodways
Community Floodways
Pre 2004 FEMA Floodlines
Floodplains
Floodways
2-yr EX 4246.00
5-yr EX 7007.00
10-yr EX 9070.00
25-yr EX 11523.00
50-yr EX 13357.00
100-yr EX 15238.00
100-yr FU 16035.00
500-yrEX 19754.00


USGS 02146507 LITTLE SUGAR C AT ARCHDALE DR AT CHARLOTTE, NC
Discharge, cubic feet per second
7000.0
1000.0
100.0
10.0
Sep 01
2017
Nov 01
2017
Jan 01
2018
Mar 01
2018
May 01
2018
Jul 01
2018
Discharge
Period of approved data
Period of provisional data
Graph courtesy of the U.S. Geological Survey


USGS 02146507 LITTLE SUGAR C AT ARCHDALE DR AT CHARLOTTE, NC
Gage height, feet
12.0
10.0
8.0
6.0
4.0
2.0
Sep 01
2017
Nov 01
2017
Jan 01
2018
Mar 01
2018
May 01
2018
Jul 01
2018
Gage height
Period of approved data
Period of provisional data
National Weather Service Floodstag
Operational limit (minimum)
Graph courtesy of the U.S. Geological Survey


USGS 02146507 LITTLE SUGAR C AT ARCHDALE DR AT CHARLOTTE, NC
Discharge, cubic feet per second
7000
1000
100
10
00:00 Jul 06 2018
06:00 Jul 06 2018
12:00 Jul 06 2018
18:00 Jul 06 2018
00:00 Jul 07 2018
06:00 Jul 07 2018
12:00 Jul 07 2018
18:00 Jul 07 2018
00:00 Jul 08 2018
---- Provisional Data Subject to Revision ----
Median daily statistic (40 years)
Discharge
Graph courtesy of the U.S. Geological Survey


USGS 02146507 LITTLE SUGAR C AT ARCHDALE DR AT CHARLOTTE, NC
Gage height, feet
12.0
10.0
8.0
6.0
4.0
2.0
00:00 Jul 06 2018
06:00 Jul 06 2018
12:00 Jul 06 2018
18:00 Jul 06 2018
00:00 Jul 07 2018
06:00 Jul 07 2018
12:00 Jul 07 2018
18:00 Jul 07 2018
00:00 Jul 08 2018
---- Provisional Data Subject to Revision ----
Gage height
Operational limit (minimum)
National Weather Service Floodstage
Graph courtesy of the U.S. Geological Survey



LITTLE SUGAR CREEK

RIFFLE TYPICAL

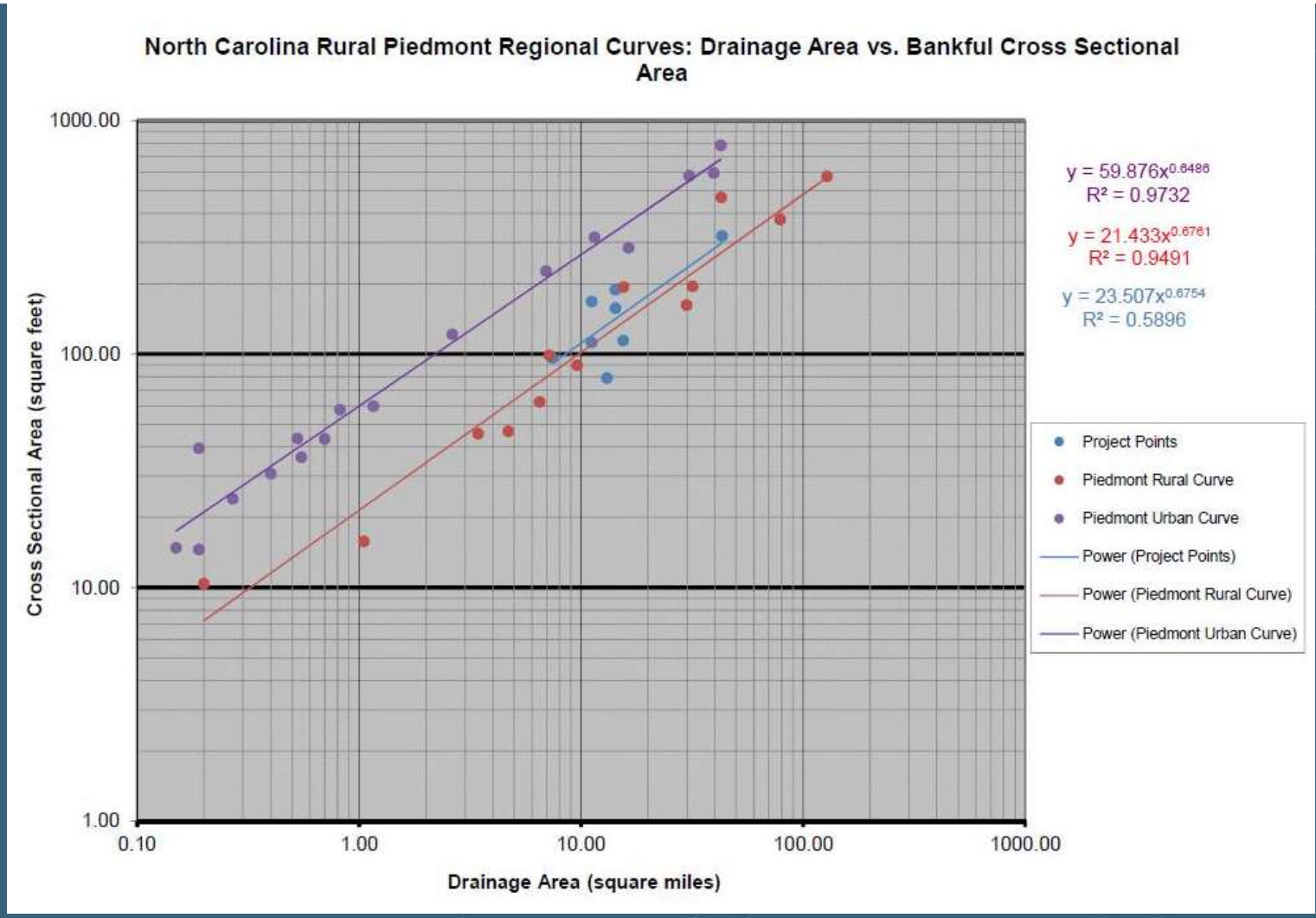
LAY BACK BANK AND BUILD OUT TOES

SEE PLAN VIEW

NOT TO SCALE

NOTE:

WHEN CONSTRUCTING CHANNEL TOES OUT OF FILL THEY SHOULD BE BROUGHT TO GRADE IN 8" LIFTS AND MECHANICALLY COMPACTED. ADD 5" OF TOPSOIL AND COIR MATTING TO BRING TO FINAL GRADE.


North Carolina Rural Piedmont Regional Curves: Drainage Area vs. Bankful Cross Sectional Area
Cross Sectional Area (square feet)
1000.00
100.00
10.00
1.00
0.10
1.00
10.00
100.00
1000.00
Drainage Area (square miles)
y = 59.876x^0.6486
R² = 0.9732
y = 21.433x^0.6761
R² = 0.9491
y = 23.507x^0.6754
R² = 0.5896
Project Points
Piedmont Rural Curve
Piedmont Urban Curve
Power (Project Points)
Power (Piedmont Rural Curve)
Power (Piedmont Urban Curve)

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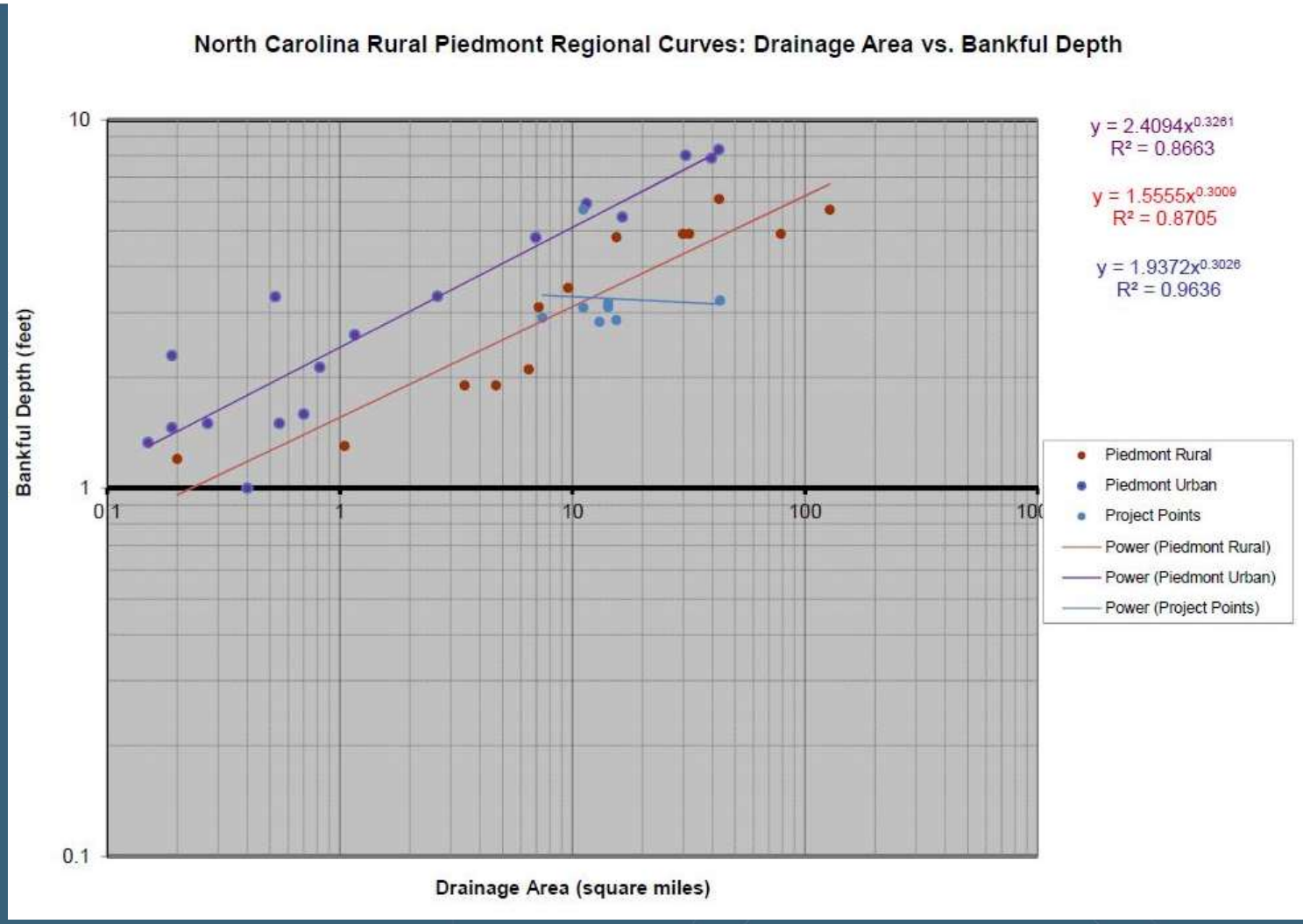
North Carolina Rural Piedmont Regional Curves: Drainage Area vs. Bankful Depth
Bankful Depth (feet)
10
1
0.1
0.1
1
10
100
Drainage Area (square miles)
y = 2.4094x^0.3261
R² = 0.8663
y = 1.5555x^0.3009
R² = 0.8705
y = 1.9372x^0.3026
R² = 0.9636
Piedmont Rural
Piedmont Urban
Project Points
Power (Piedmont Rural)
Power (Piedmont Urban)
Power (Project Points)

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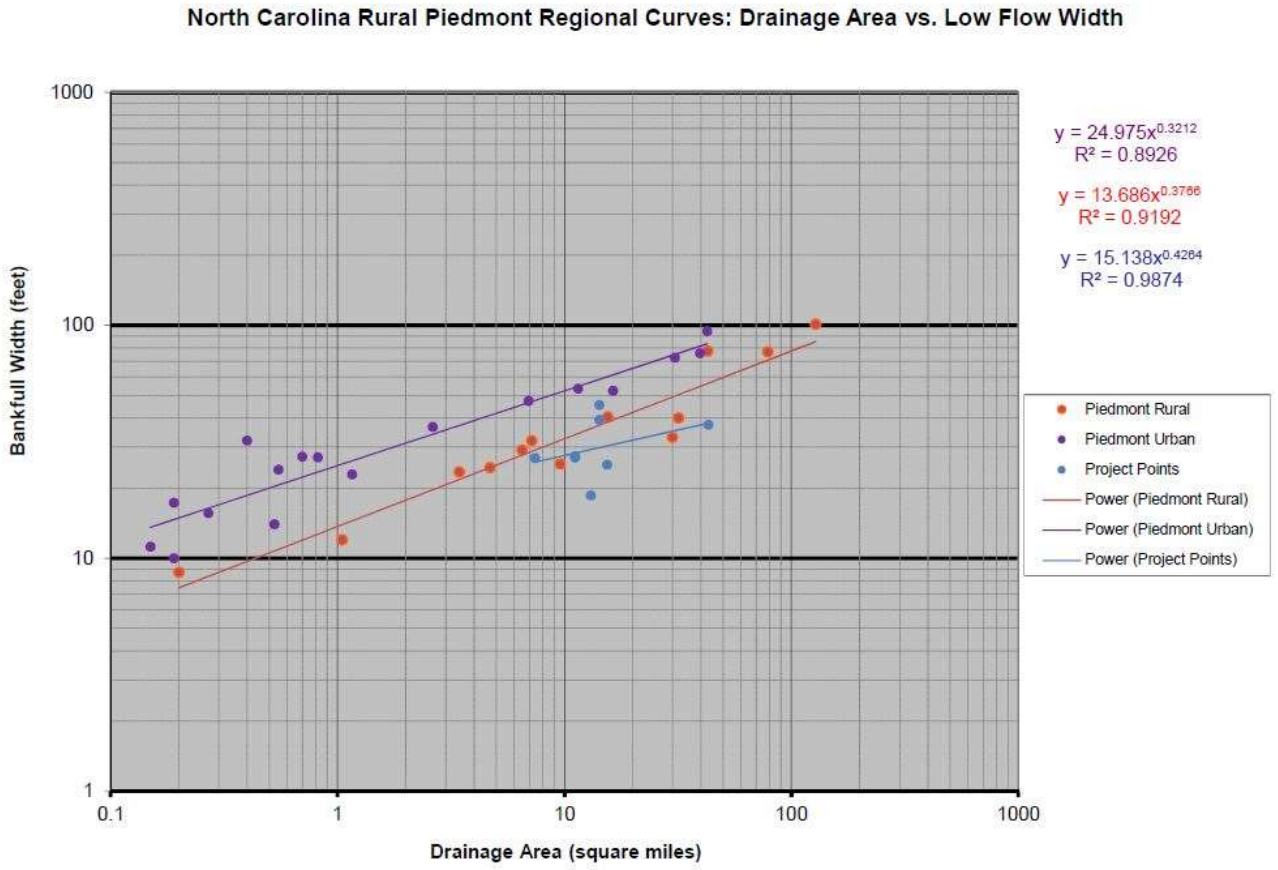
North Carolina Rural Piedmont Regional Curves: Drainage Area vs. Low Flow Width
Bankfull Width (feet)
1000
100
10
1
0.1
1
10
100
1000
Drainage Area (square miles)
y = 24.975x^0.3212
R² = 0.8926
y = 13.686x^0.3766
R² = 0.9192
y = 15.138x^0.4264
R² = 0.9874
Piedmont Rural
Piedmont Urban
Project Points
Power (Piedmont Rural)
Power (Piedmont Urban)
Power (Project Points)

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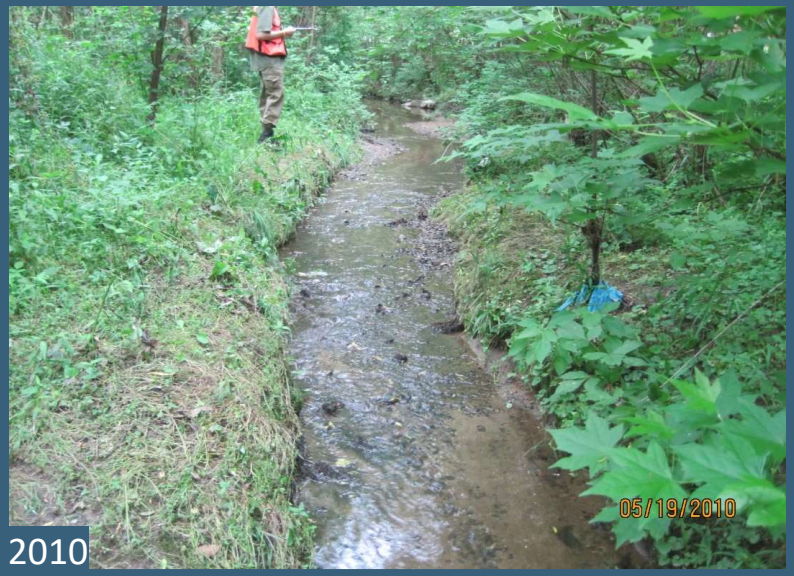
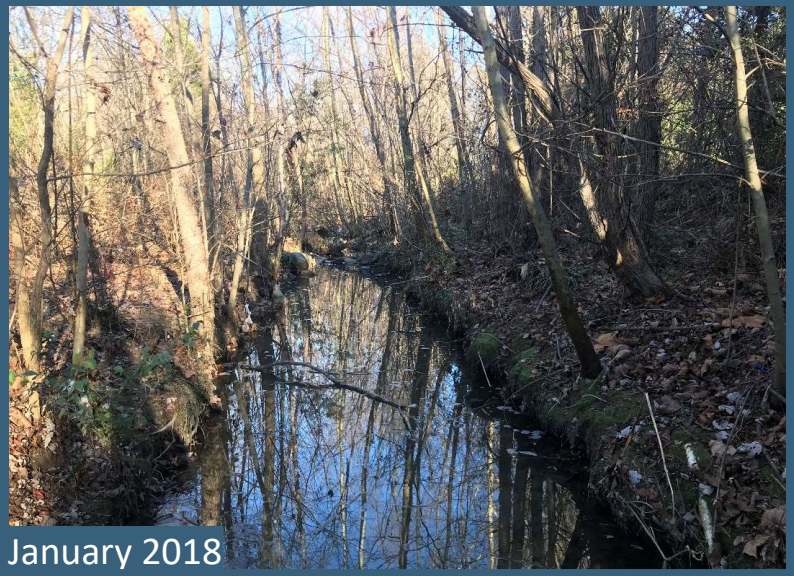
Before Construction 2000

Construction 2004



2010



January 2018

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