COUNTY OF SUMMIT 1840

Sustainable Streams LLC
Science · Service · Solutions

Yellow Creek
State of the Watershed

Bob Hawley, Ph.D., P.E.

August 19, 2019

Outline

State of the Watershed

- Welcome and Introductions
- Stream Assessments & Watershed Inventory
- Stormwater Management & Stream Erosion
- Mitigation Strategies & Example Concepts
- Questions

Welcome

State of the Watershed

Summit County Engineer

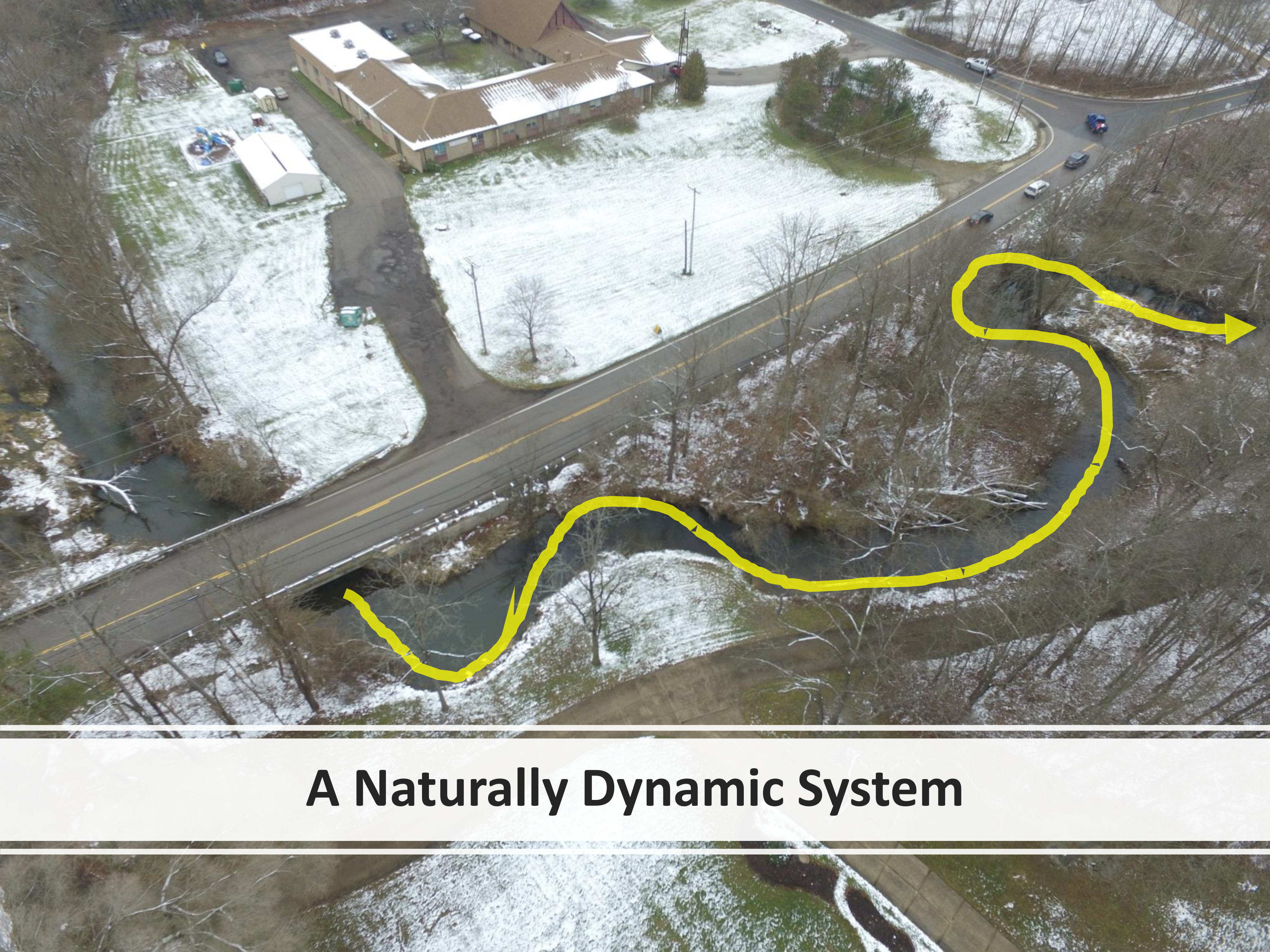
- Alan Brubaker, P.E., P.S.
- Lawrence Fulton, P.E.
- David Koontz, P.E., S.I.

Bath Township Trustees

- Elaina Goodrich
- James Nelson
- Becky Corbett

Friends of Yellow Creek

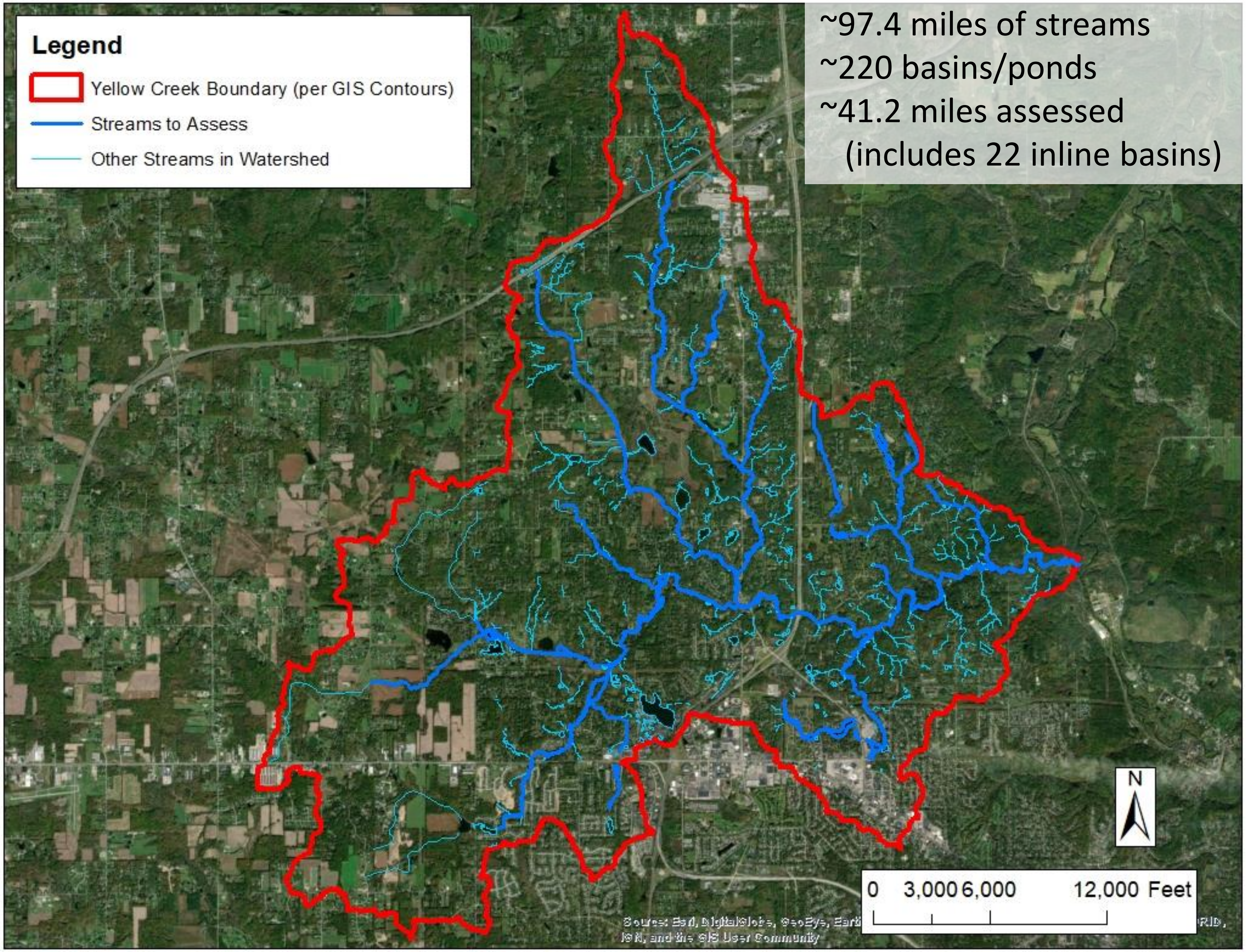
- Tom Doran



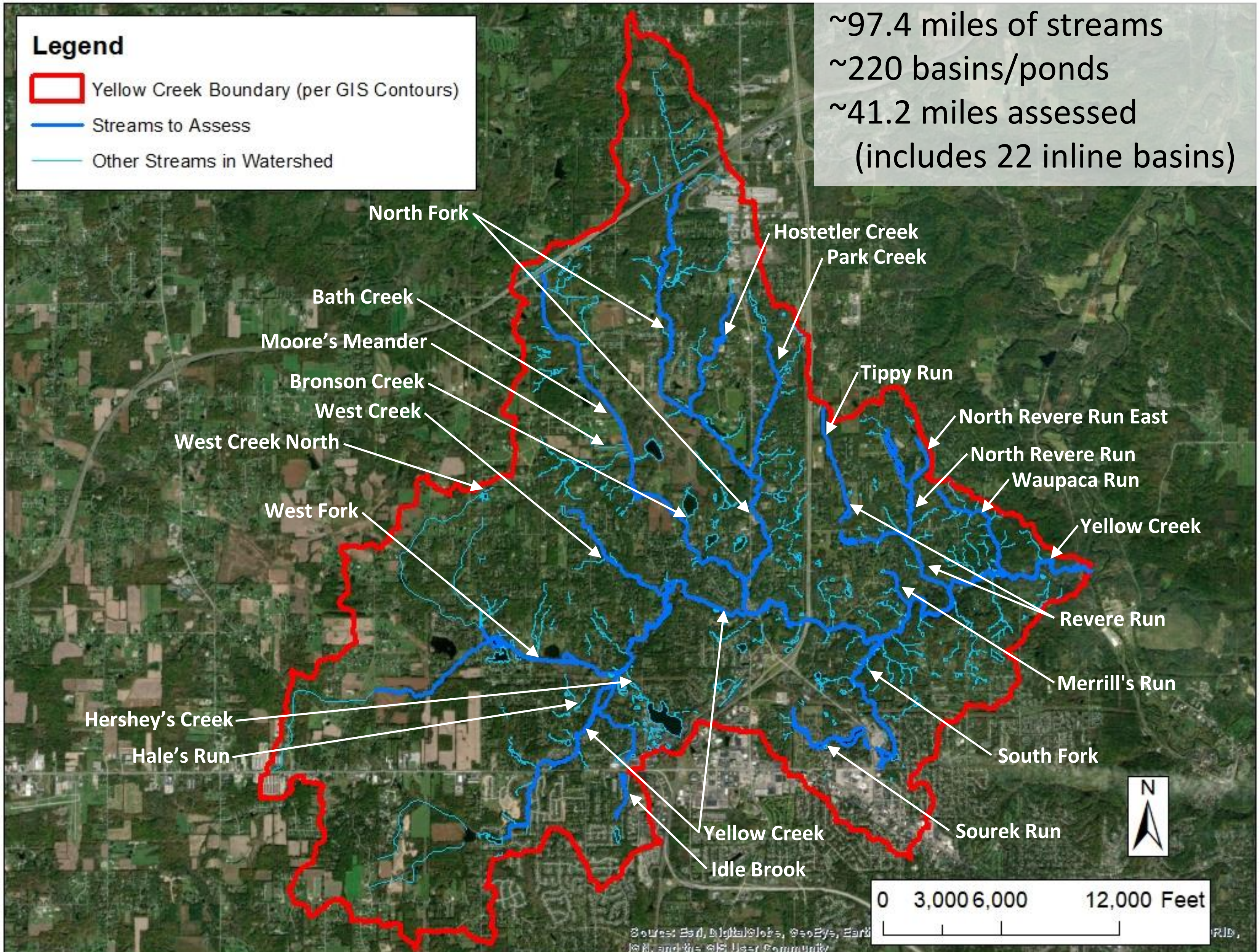
A Naturally Dynamic System

Stream Assessments & Watershed Inventory

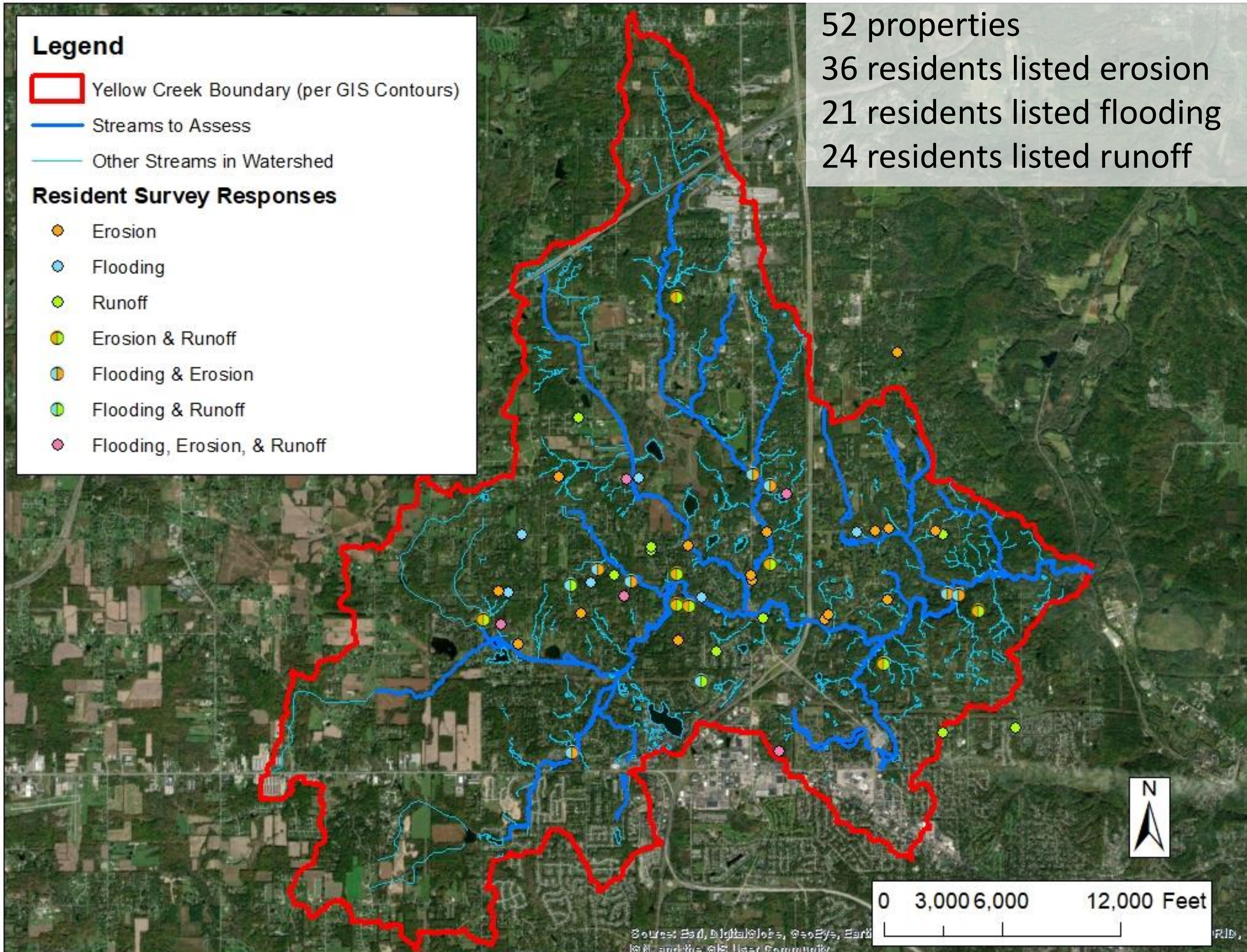
Streams


Legend
Yellow Creek Boundary (per GIS Contours)
Streams to Assess
Other Streams in Watershed
~97.4 miles of streams
~220 basins/ponds
~41.2 miles assessed
(includes 22 inline basins)
N
0 3,000 6,000 12,000 Feet

Streams


Legend
Yellow Creek Boundary (per GIS Contours)
Streams to Assess
Other Streams in Watershed
~97.4 miles of streams
~220 basins/ponds
~41.2 miles assessed
(includes 22 inline basins)
North Fork
Hostetler Creek
Park Creek
Bath Creek
Moore's Meander
Bronson Creek
West Creek
West Creek North
West Fork
Tippy Run
North Revere Run East
North Revere Run
Waupaca Run
Yellow Creek
Revere Run
Merrill's Run
South Fork
Sourek Run
Hershey's Creek
Hale's Run
Yellow Creek
Idle Brook
N
0 3,000 6,000 12,000 Feet

Resident Survey Responses



Resident Survey Responses

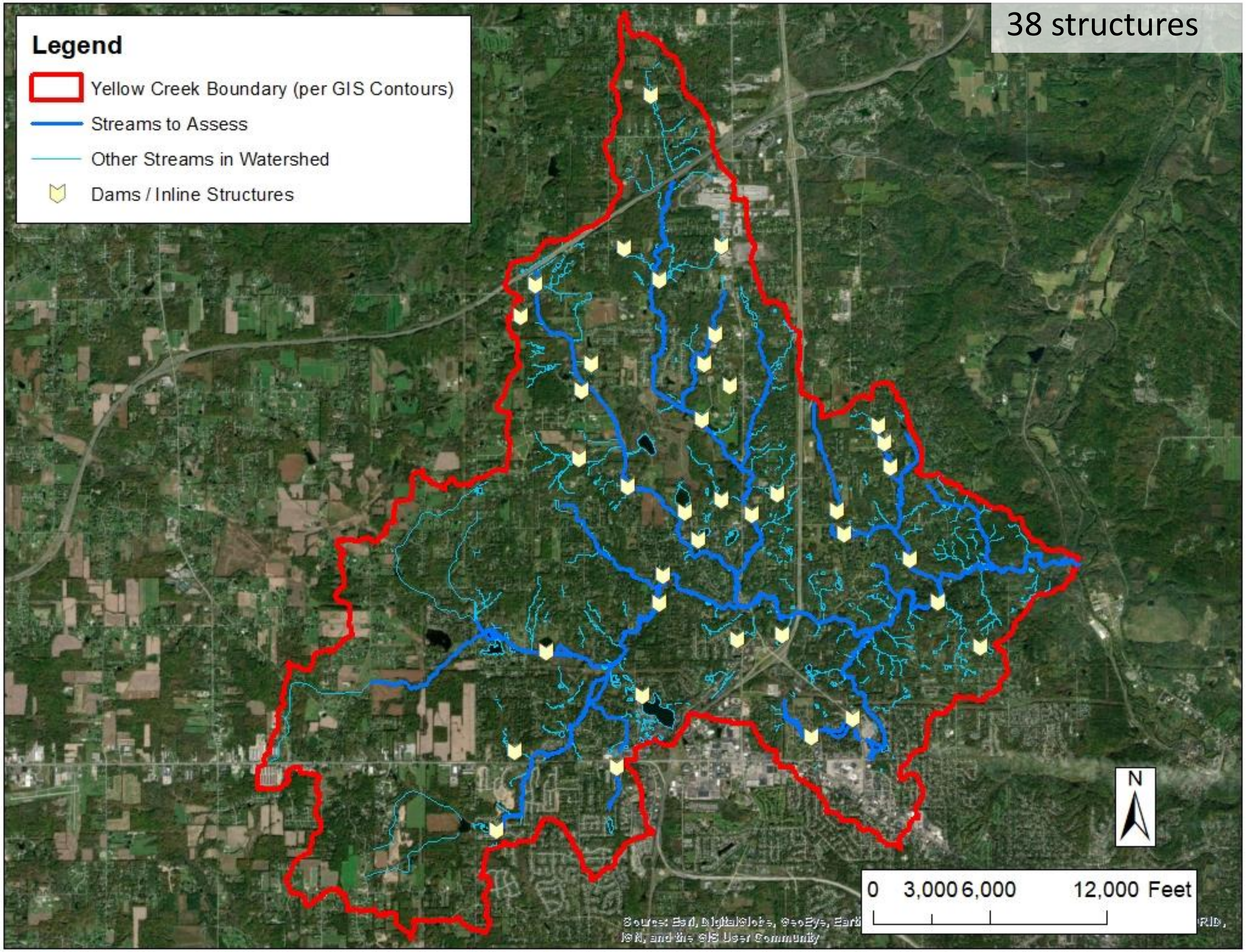
N. Cleveland-Massillon Road

W. Bath Road

W. Bath Road

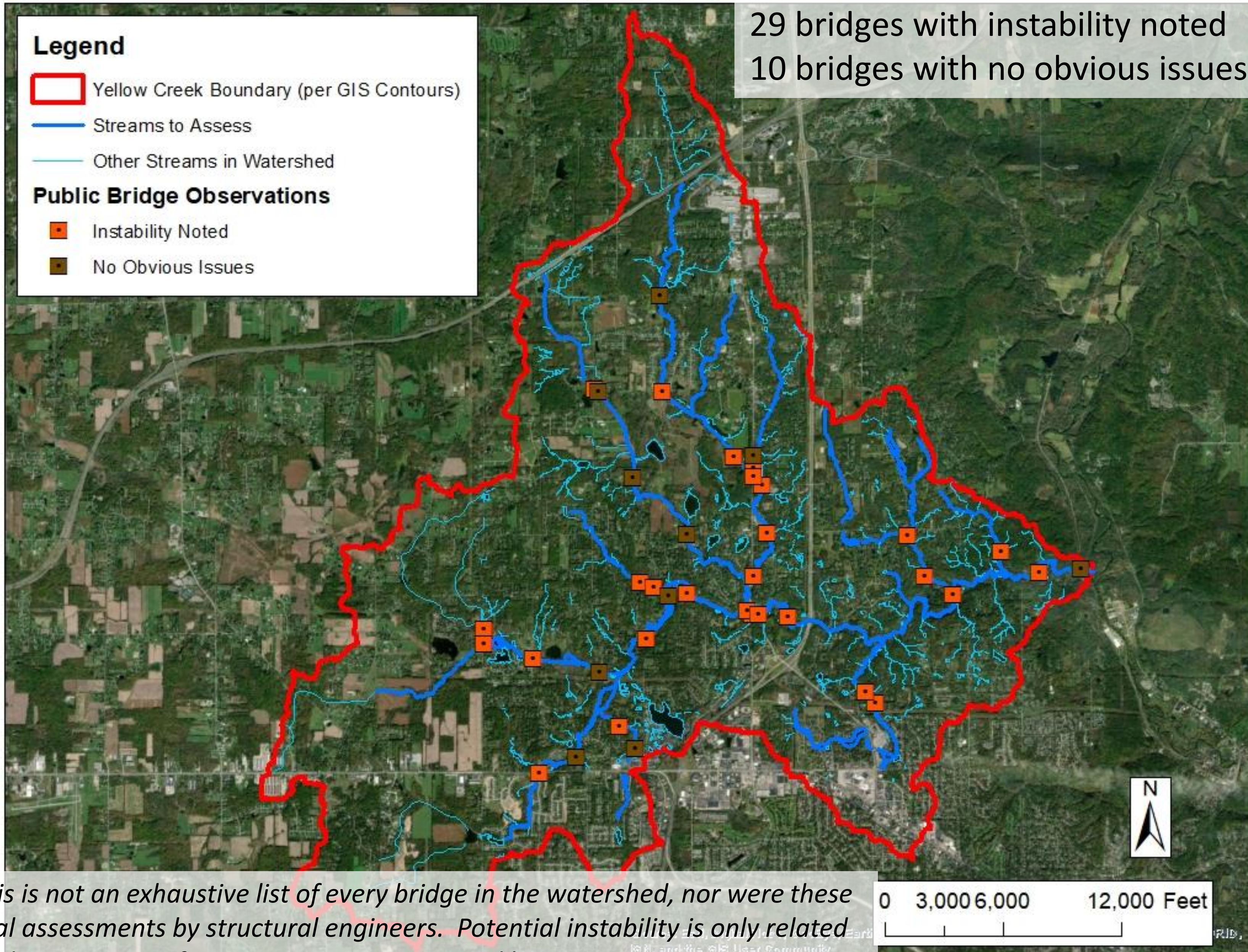
Harmony Road

Dams/Inline Structures



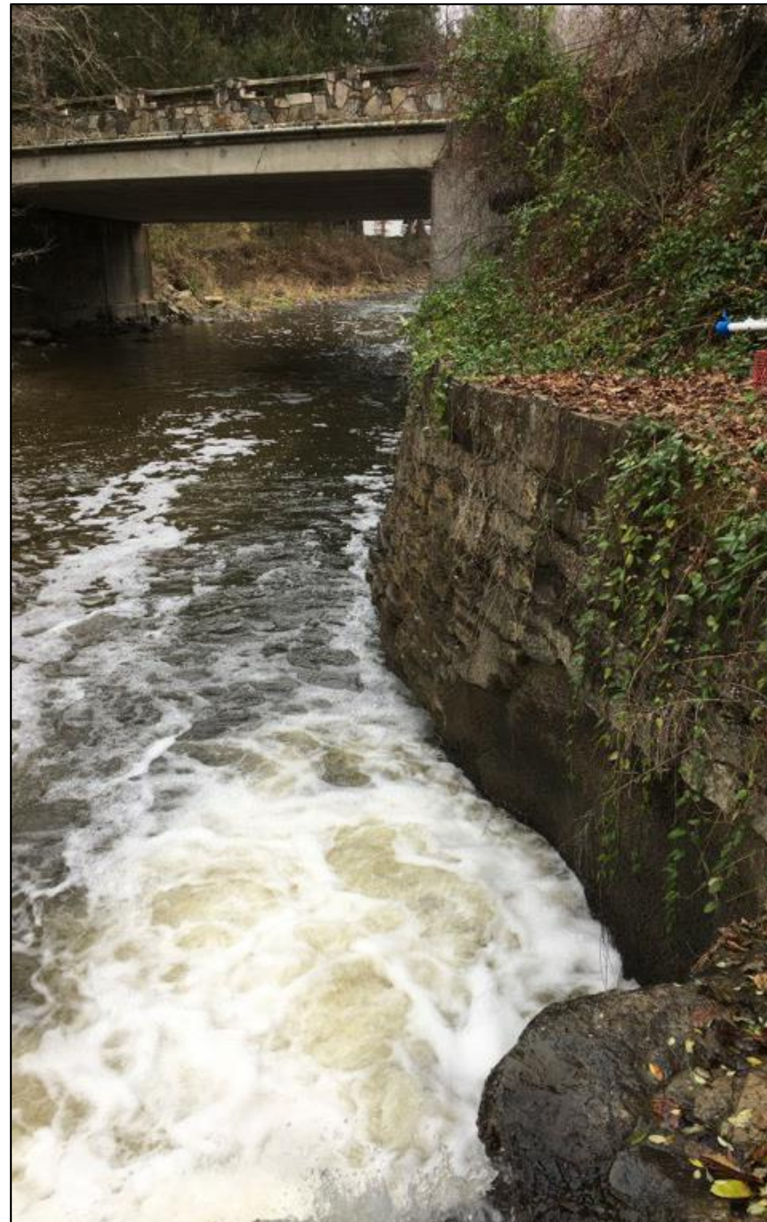
Dams/Inline Structures

Public Bridge Observations

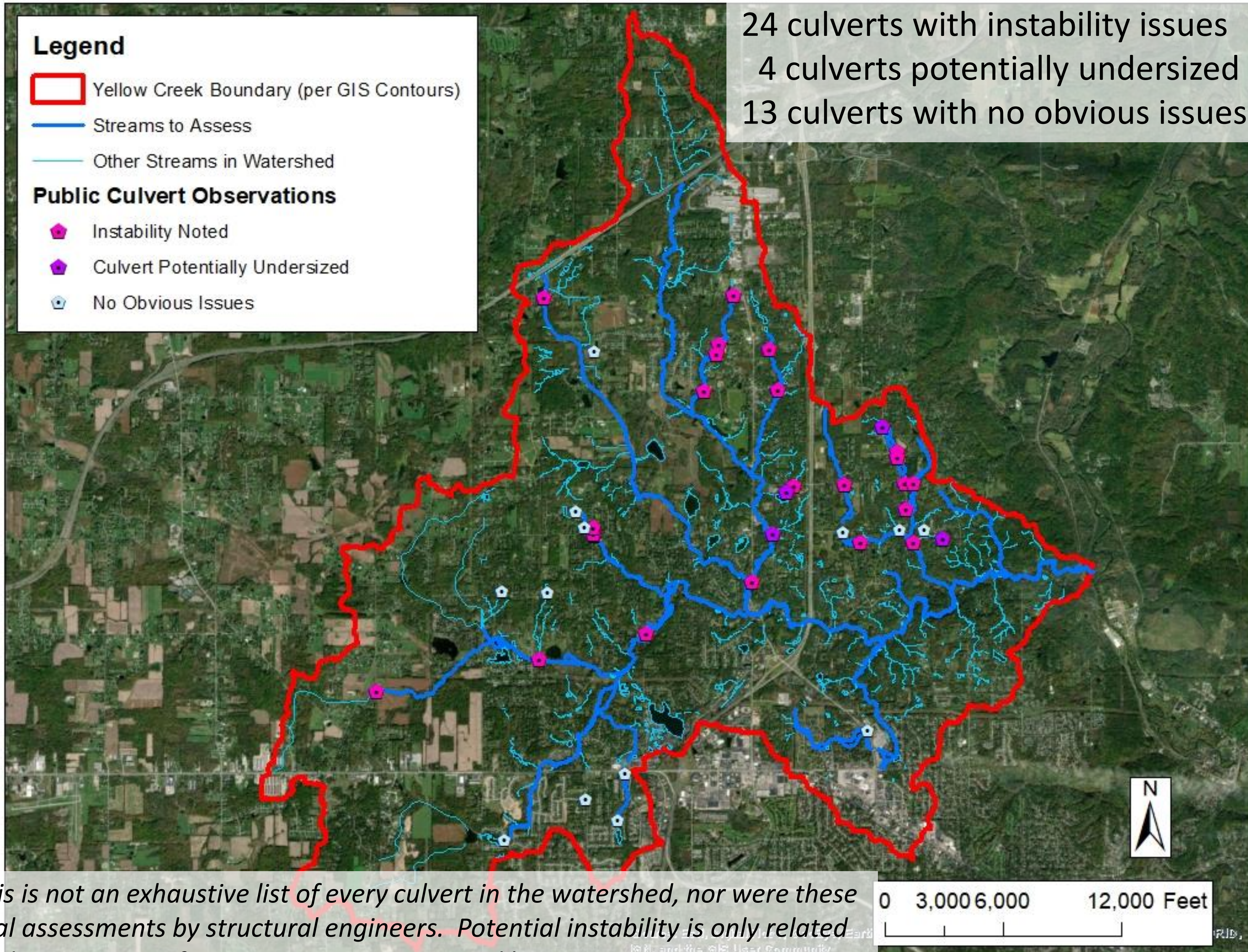


Note: this is not an exhaustive list of every bridge in the watershed, nor were these structural assessments by structural engineers. Potential instability is only related to a rapid assessment of stream erosion as assessed by stream experts.

Public Bridge Observations



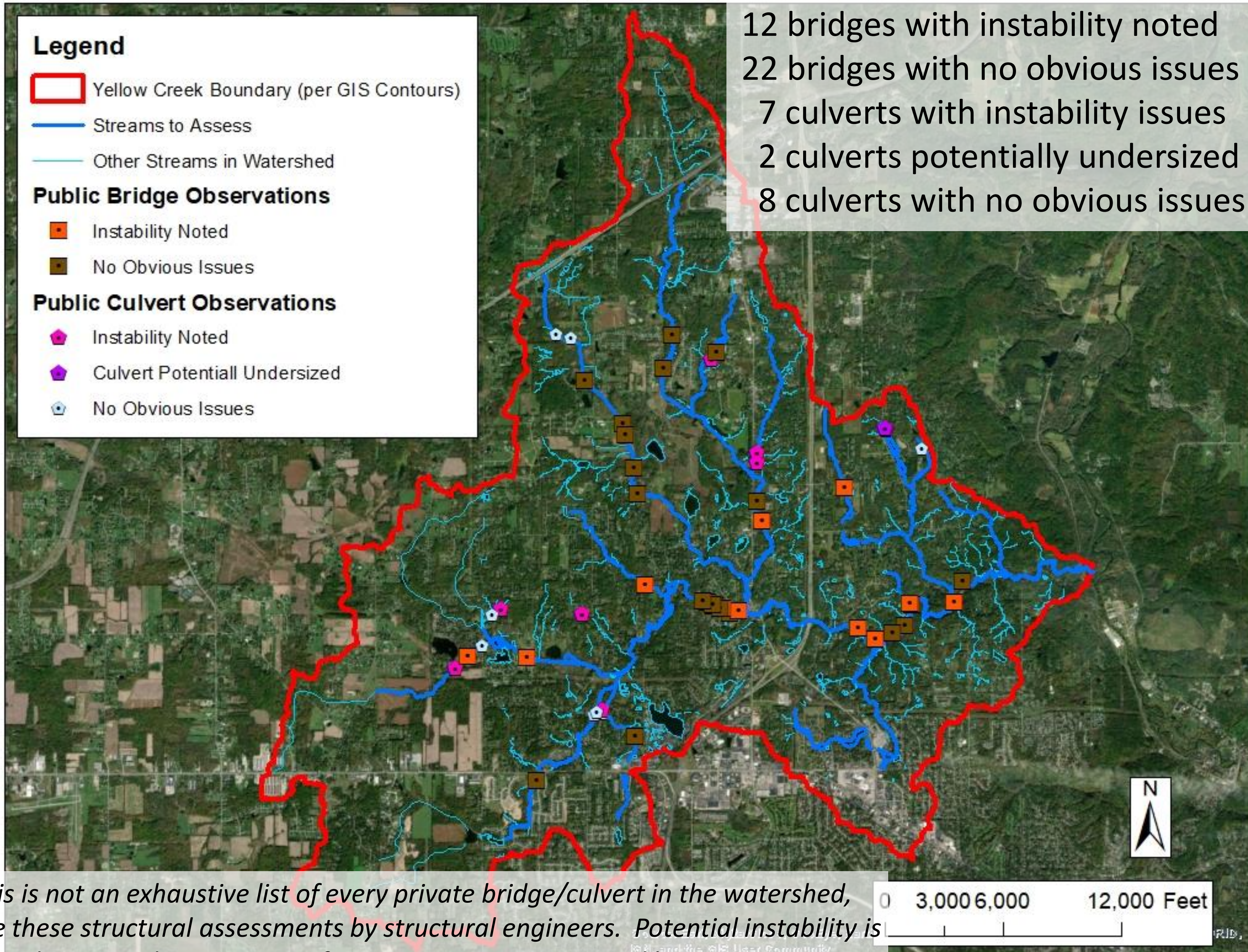
Public Culvert Observations



Note: this is not an exhaustive list of every culvert in the watershed, nor were these structural assessments by structural engineers. Potential instability is only related to a rapid assessment of stream erosion as assessed by stream experts.

Public Culvert Observations

Private Bridge and Culvert Observations

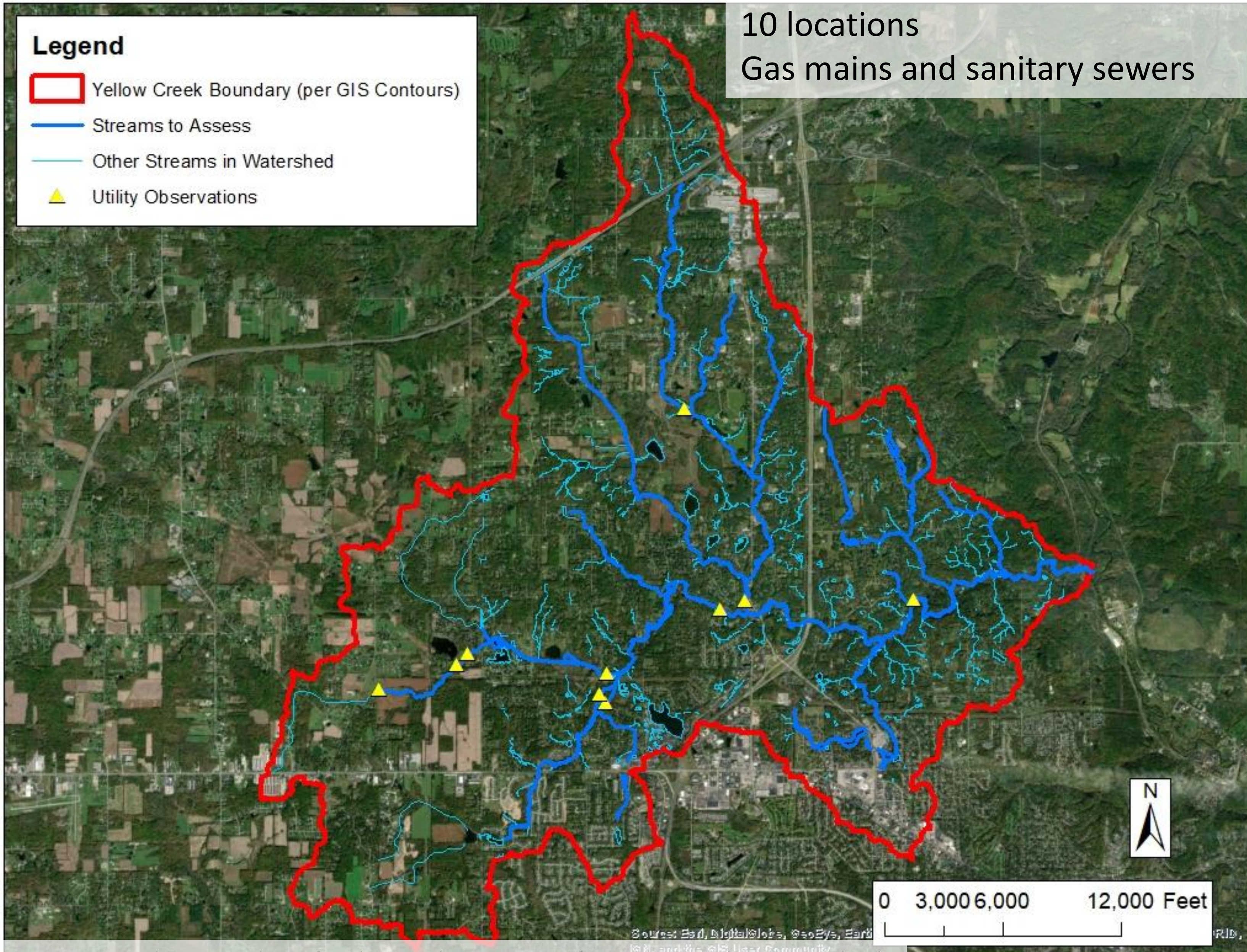


12 bridges with instability noted
22 bridges with no obvious issues
7 culverts with instability issues
2 culverts potentially undersized
8 culverts with no obvious issues

Note: this is not an exhaustive list of every private bridge/culvert in the watershed, nor were these structural assessments by structural engineers. Potential instability is only related to a rapid assessment of stream erosion as assessed by stream experts.

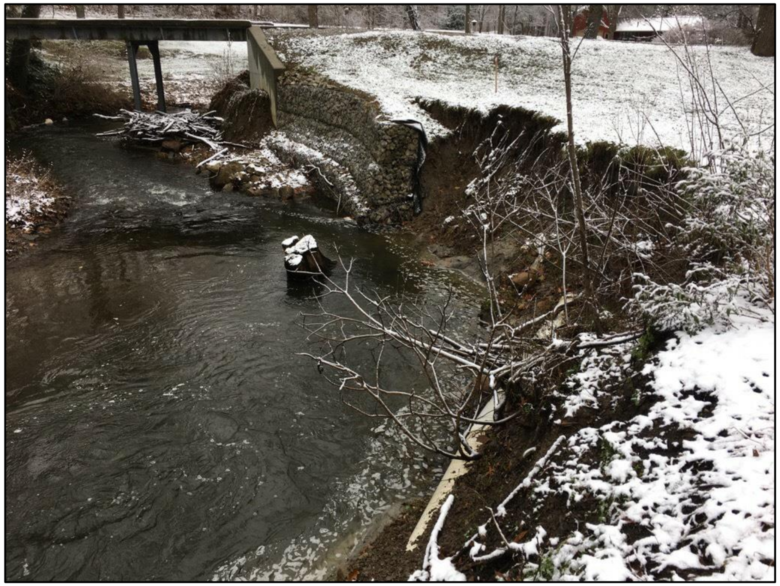
Private Bridge and Culvert Observations

Utility Observations

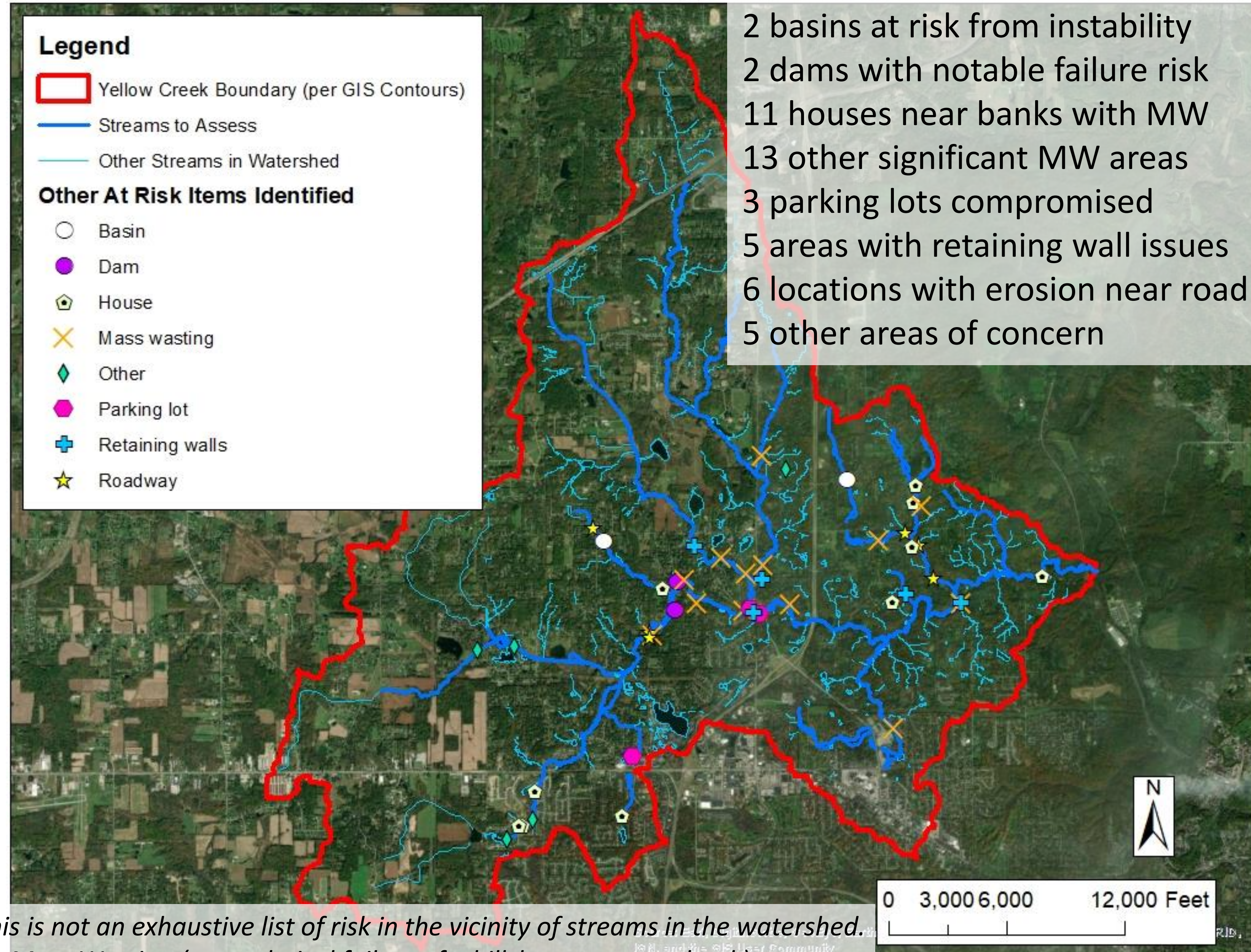


Note: this is not an exhaustive list of utility in the vicinity of streams in the watershed.

Utility Observations



Additional Areas with Potential Risks



2 basins at risk from instability
2 dams with notable failure risk
11 houses near banks with MW
13 other significant MW areas
3 parking lots compromised
5 areas with retaining wall issues
6 locations with erosion near road
5 other areas of concern

Note: this is not an exhaustive list of risk in the vicinity of streams in the watershed.
"MW" = Mass Wasting (geotechnical failure of a hillslope or streambank)

Additional Areas with Potential Risks

Examples of Mass Wasting

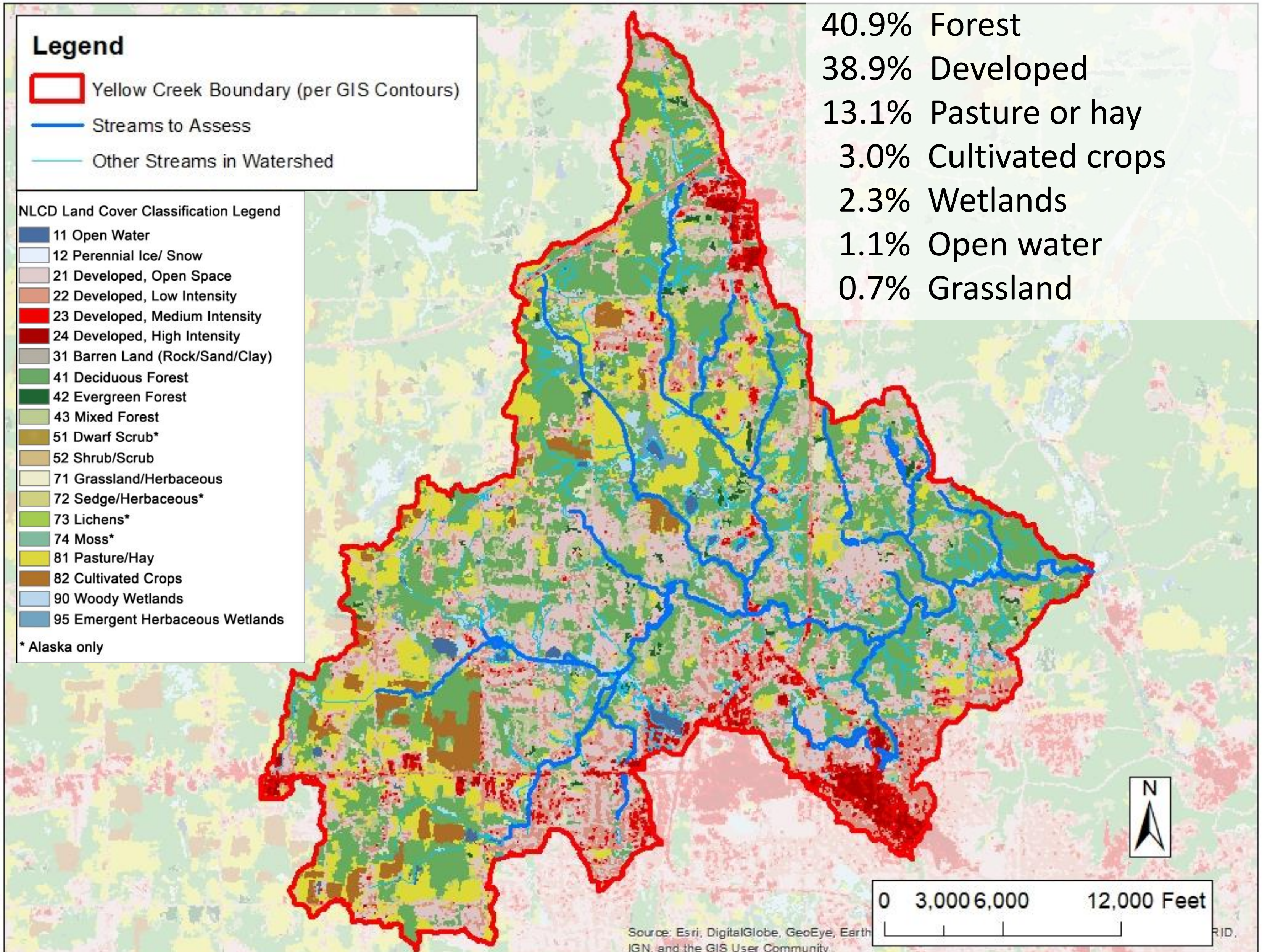
Watershed Inventory

LAND COVER & SOILS

TOPOGRAPHY

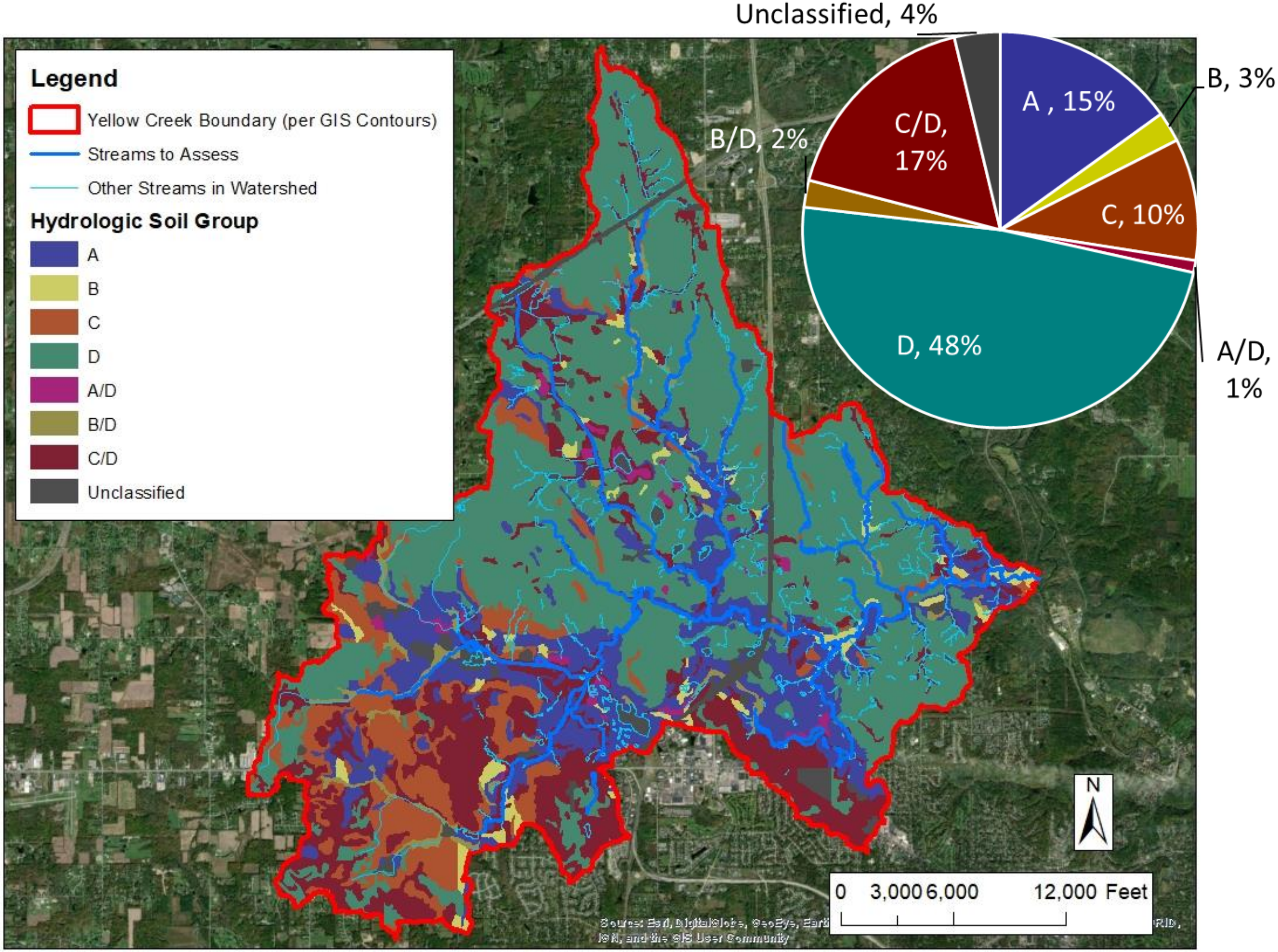
IMPERVIOUS SURFACES

Land Cover

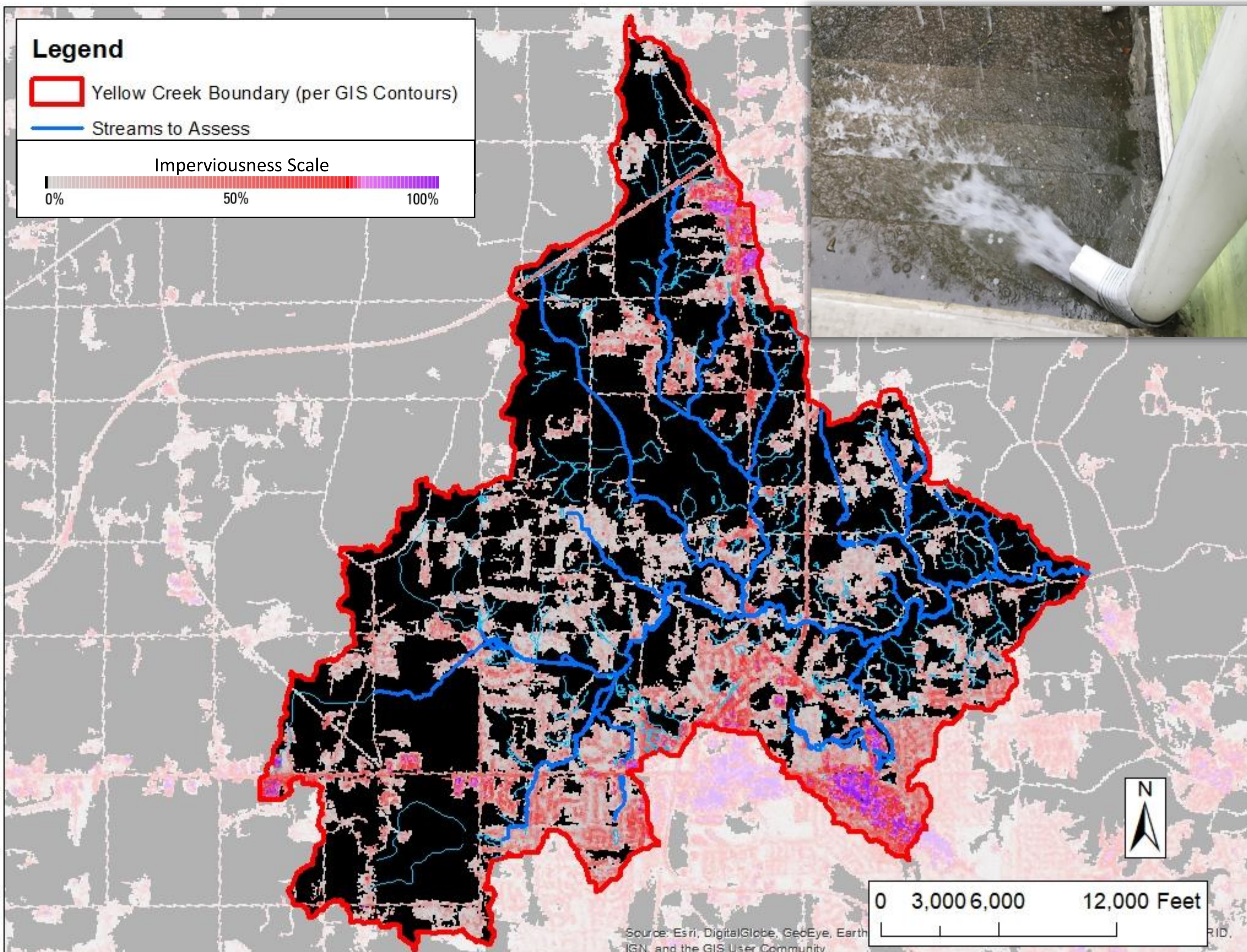


Legend
Yellow Creek Boundary (per GIS Contours)
Streams to Assess
Other Streams in Watershed
NLCD Land Cover Classification Legend
11 Open Water
12 Perennial Ice/ Snow
21 Developed, Open Space
22 Developed, Low Intensity
23 Developed, Medium Intensity
24 Developed, High Intensity
31 Barren Land (Rock/Sand/Clay)
41 Deciduous Forest
42 Evergreen Forest
43 Mixed Forest
51 Dwarf Scrub*
52 Shrub/Scrub
71 Grassland/Herbaceous
72 Sedge/Herbaceous*
73 Lichens*
74 Moss*
81 Pasture/Hay
82 Cultivated Crops
90 Woody Wetlands
95 Emergent Herbaceous Wetlands
* Alaska only
40.9% Forest
38.9% Developed
13.1% Pasture or hay
3.0% Cultivated crops
2.3% Wetlands
1.1% Open water
0.7% Grassland
N
0 3,000 6,000 12,000 Feet
Source: Esri, DigitalGlobe, GeoEye, Earth
IGN, and the GIS User Community

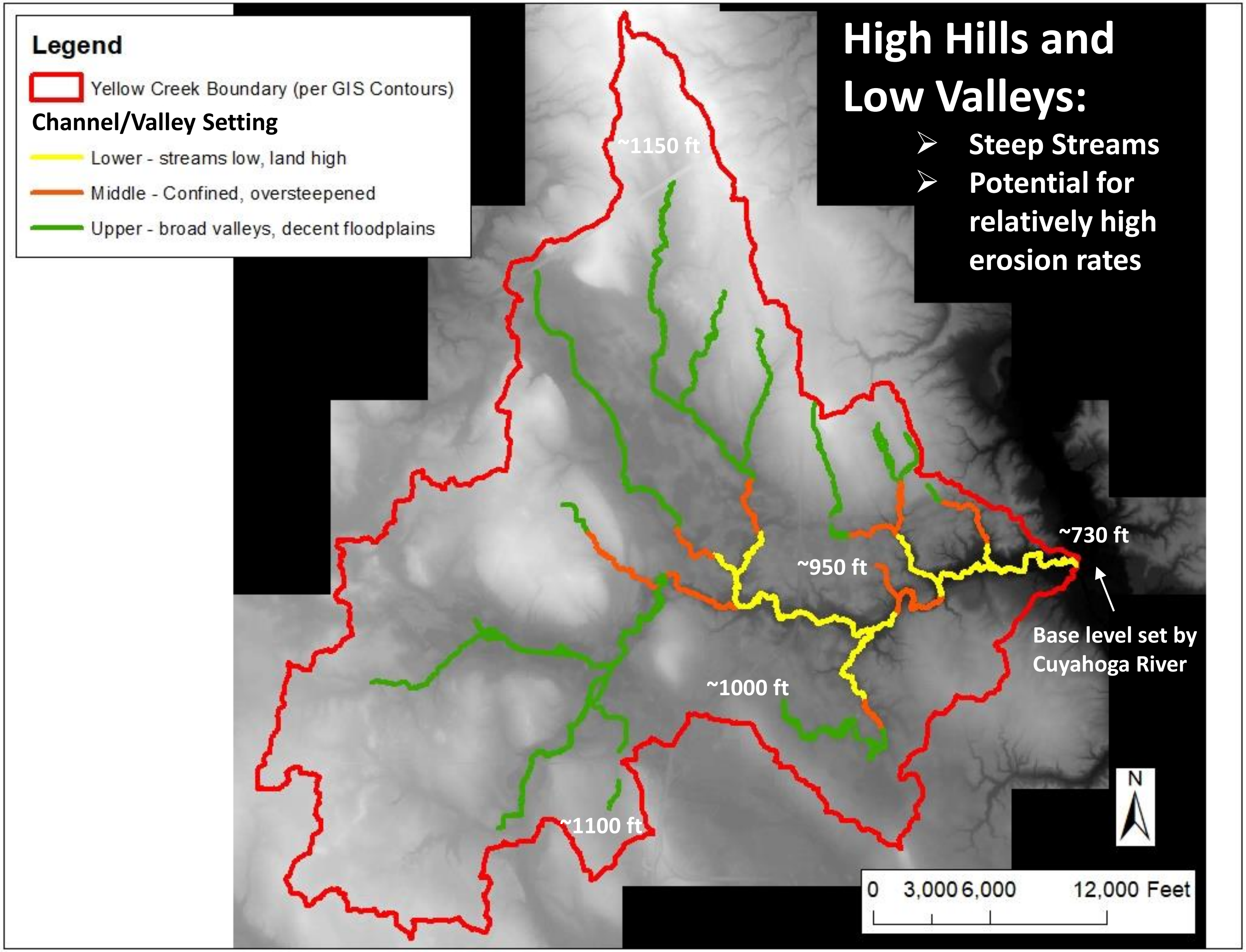
Soils


Legend
Yellow Creek Boundary (per GIS Contours)
Streams to Assess
Other Streams in Watershed
Hydrologic Soil Group
A
B
C
D
A/D
B/D
C/D
Unclassified
Unclassified, 4%
A , 15%
B, 3%
C, 10%
A/D, 1%
D, 48%
B/D, 2%
C/D, 17%
N
0 3,000 6,000 12,000 Feet

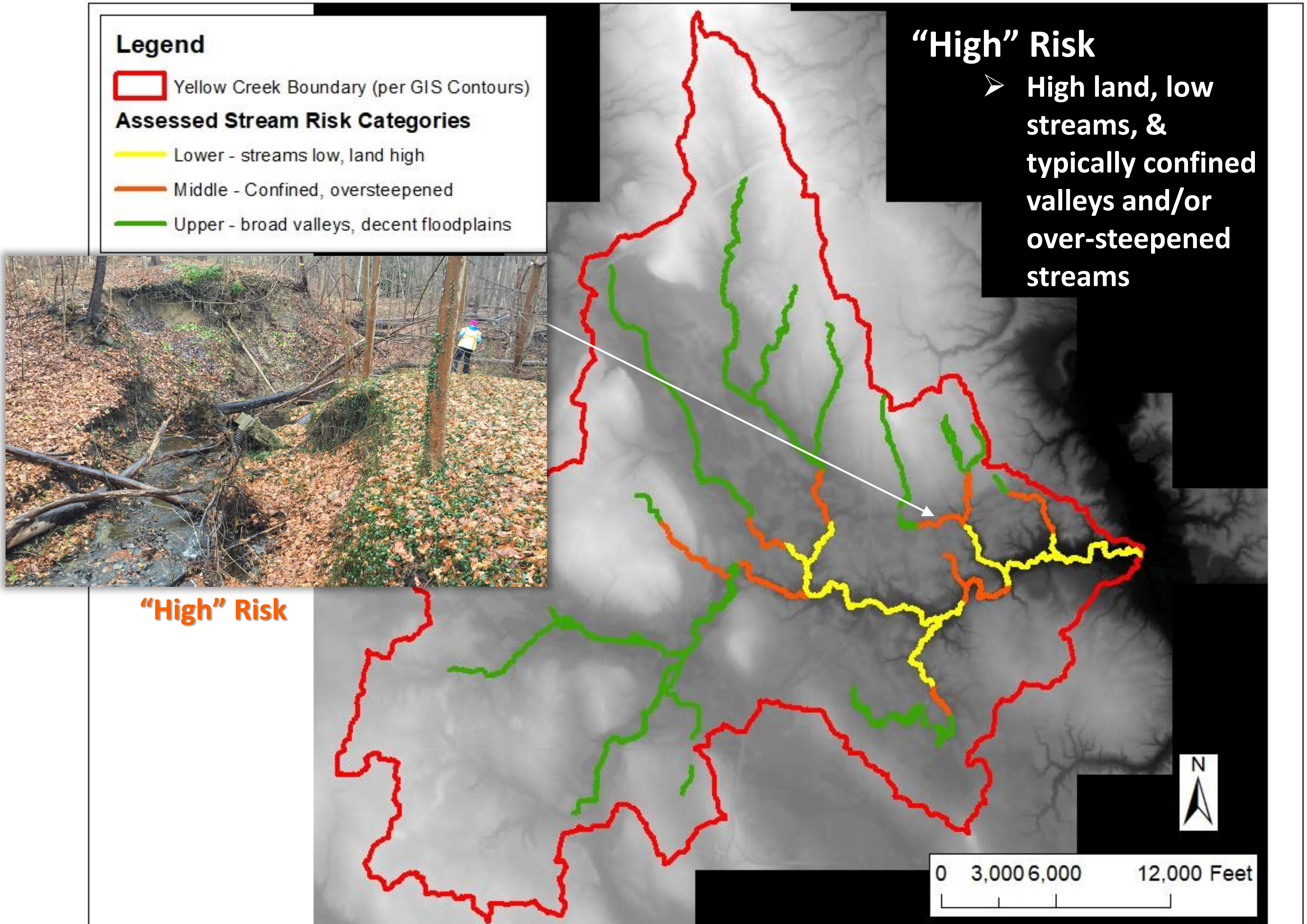
Impervious Cover



Topographic Setting

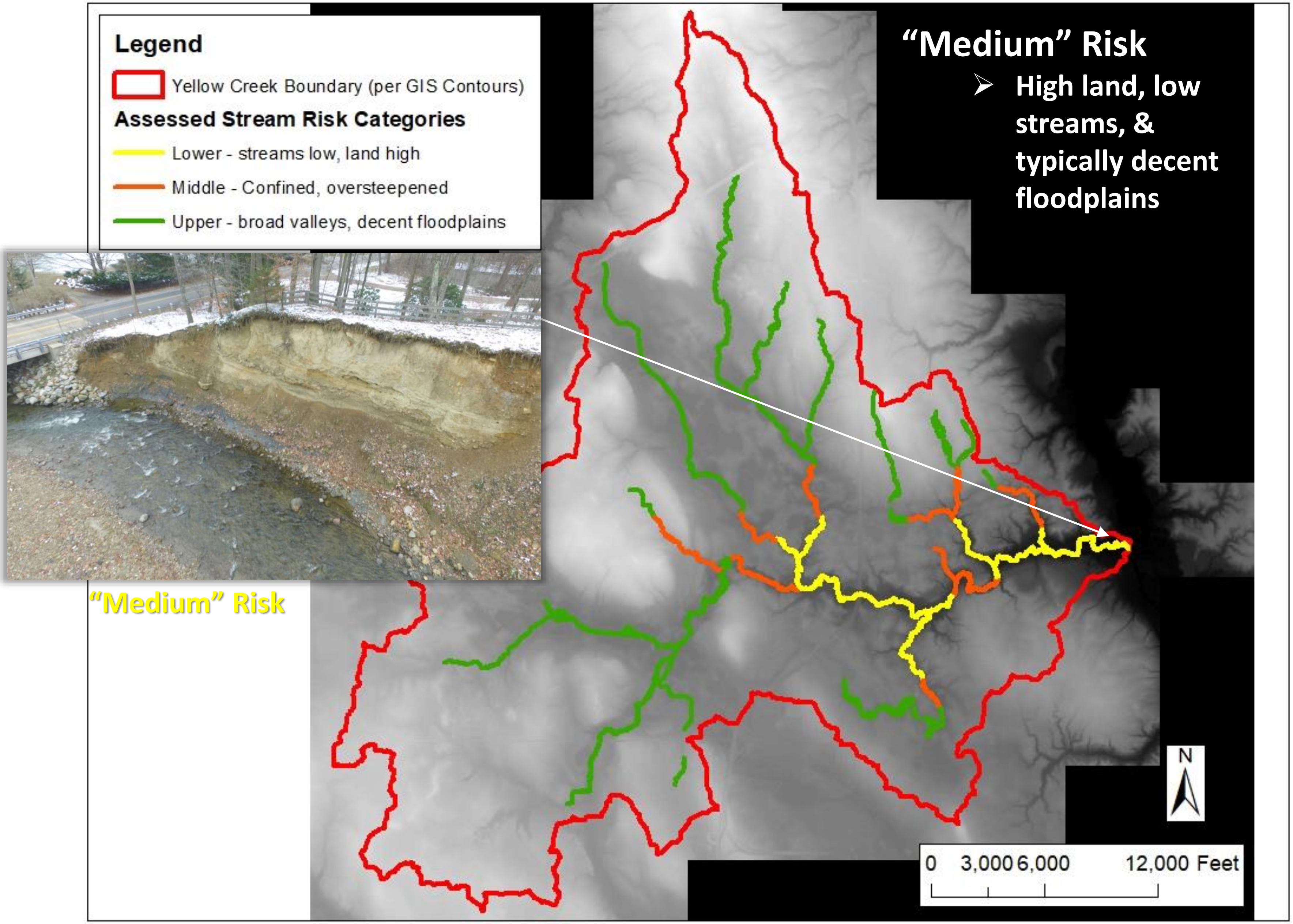


Valley Setting → Relative Risk Categories

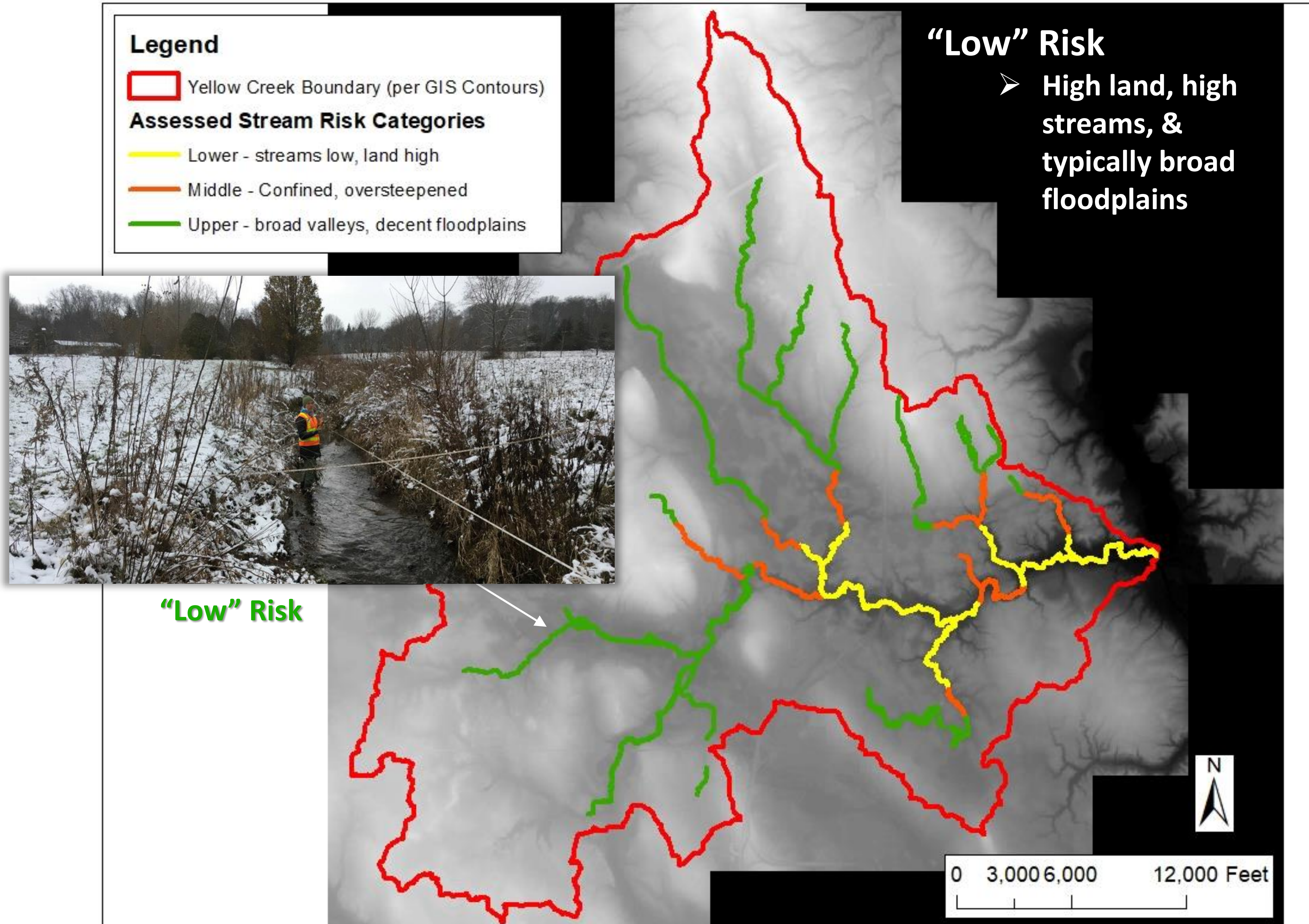


"High" Risk

Valley Setting → <u>Relative</u> Risk Categories



Valley Setting → Relative Risk Categories



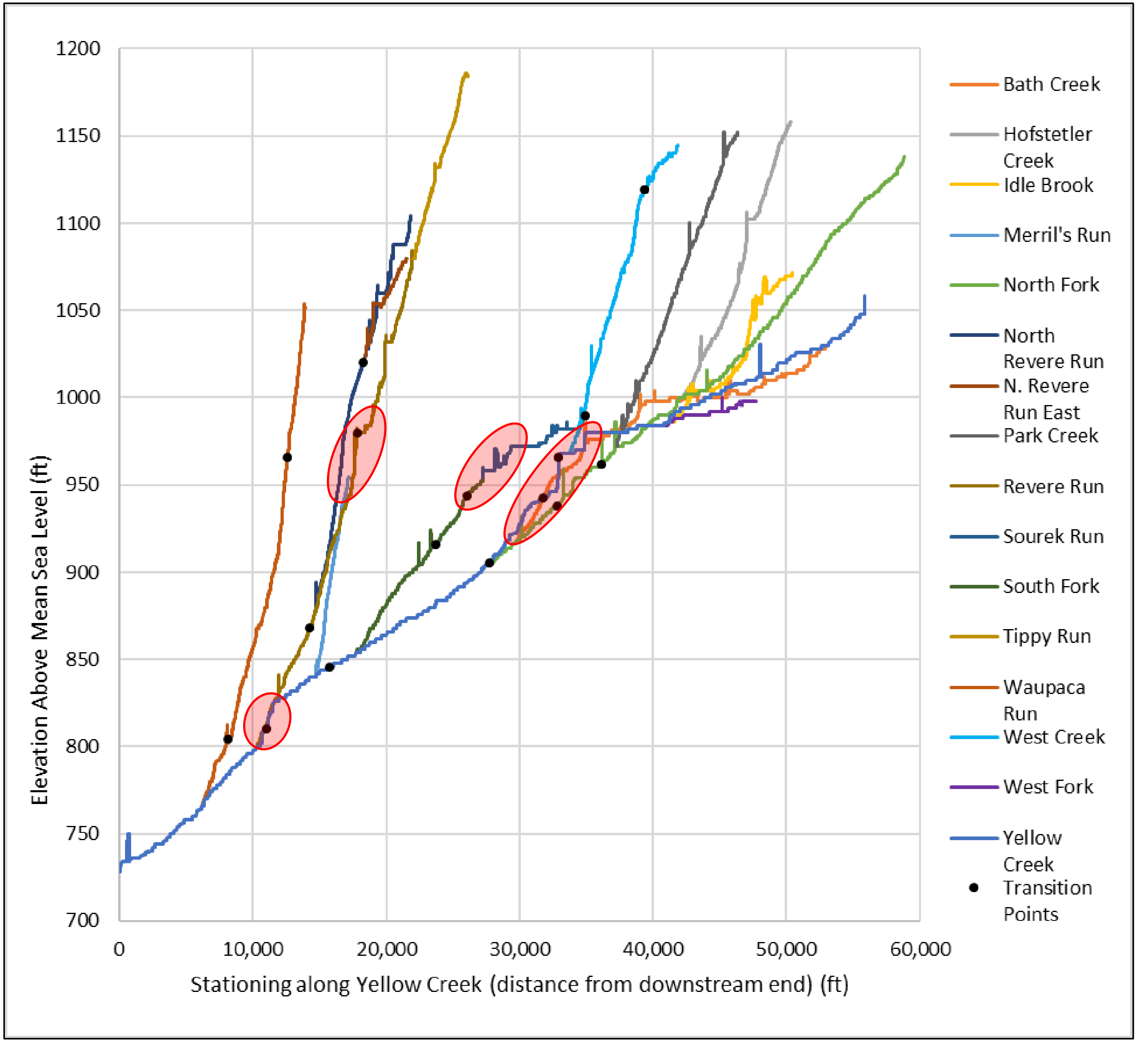
"Low" Risk

- High land, high streams, & typically broad floodplains

"Low" Risk

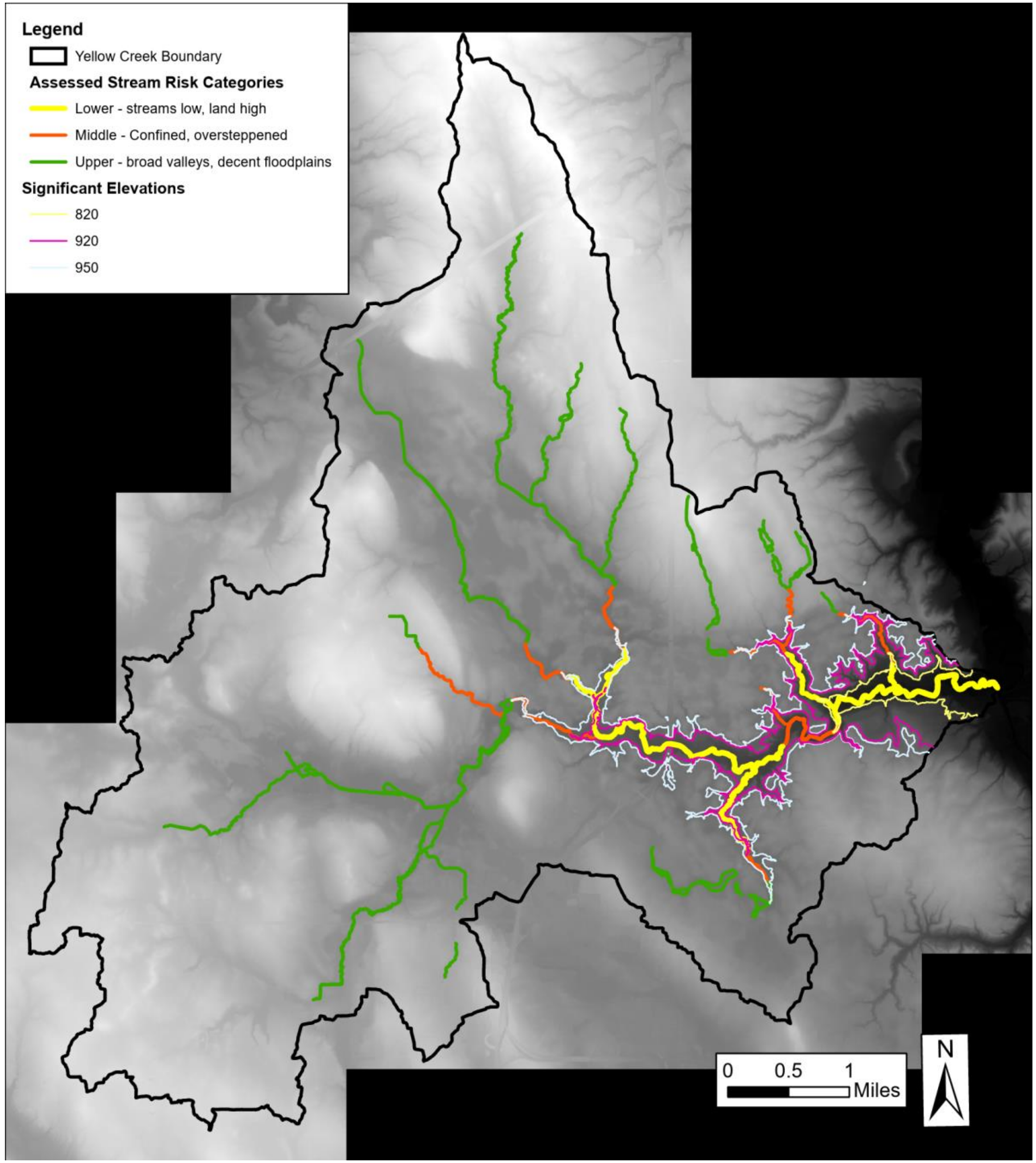

"Low" Risk Does NOT Equal No Risk

Over-steepened Reaches and Knickpoints




Bedrock Weathering at
“Knickpoint”

Knickpoints Correspond to Similar Elevations



Channel Evolution Stages

- Predictable trajectory of channel downcutting, widening, and enlargement in response to channelization and/or watershed urbanization


JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
VOL. 36, NO. 1 AMERICAN WATER RESOURCES ASSOCIATION FEBRUARY 2000

CHANNEL INSTABILITY IN THE LOESS AREA OF THE MIDWESTERN UNITED STATES[1]

Andrew Simon and Massimo Rinaldi[2]

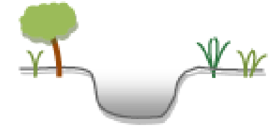
ABSTRACT: The loess area of the midwestern United States contains thousands of miles of unstable stream channels that are undergoing system-wide channel-adjustment processes as a result of (1) modifications to drainage basins dating back to the turn of the 20th century, including land clearing and poor soil-conservation practices, which caused the filling of stream channels, and consequently (2) direct, human modifications to stream channels such as dredging and straightening to improve drainage conditions and reduce the frequency of out-of-bank flows. Today, many of these channels are still highly unstable and threaten bridges, other structures, and land adjacent to the channels. The most severe, widespread instabilities are in western Iowa where a thick cap of loess and the lack of sand- and gravel-sized bed sediments in many channels hinders downstream aggradation, bed-level recovery and the consequent reduction of bank heights, and renewed bank stability. In contrast, streams draining west-central Illinois, east-central Iowa, and other areas, where the loess cap is relatively thin and there are ample supplies of sand- and gravel-sized material, are closer to recovery. Throughout the region, however, channel widening by mass-wasting processes is the dominant adjustment process.
(KEY TERMS: unstable channels; loess channels; degradation; bank instability; shear strength.)

INTRODUCTION

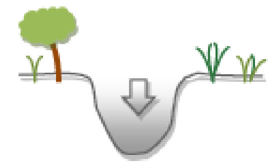
The dynamic nature of alluvial streams signifies the ability to adjust to changes imposed on the fluvial system, be they natural or a result of human activities. Channel adjustments migrate upstream and downstream in an attempt to offset the disturbance by altering aspects of their morphology, sediment load, and hydraulic characteristics. Under "natural" conditions, in geologically stable areas such as the midwestern United States, the processes of erosion and deposition might occur at such low rates and over such extended periods of time, that they can be virtually imperceptible. Human and natural factors or disturbances, however, combine to accelerate and exacerbate these processes, and as a result, rapid and observable morphologic changes occur as the channel attempts to offset the disturbance and return to an equilibrium condition. Adjustments to human disturbances can involve short time scales (days) and limited spatial extents (a stream reach), or longer periods of time (scores to hundreds of years) and entire fluvial systems, depending on the magnitude, extent, and type of disturbance (Williams and Wolman, 1984; Simon, 1994).

In the highly erodible loess area of the midwestern United States (Figure 1), human disturbances to flood plains and upland areas culminating near the turn of the 20th century resulted in channels being choked with sediment and debris. Beginning about 1910, channels were enlarged and straightened throughout the region to alleviate frequent and prolonged flooding of bottomlands (Speer *et al.*, 1965). Over the next 80 years, accelerated channel erosion and the formation of canyon-like stream channels have resulted in severe damage to highway structures, pipelines, fiber-optic lines, and land adjacent to the stream channels. Accelerated stream-channel degradation has resulted in an estimated $1.1 billion in damages to infrastructure and the loss of agricultural lands since the turn of the century in western Iowa (Baumel, 1994). A survey of 15 counties in northwestern Missouri identified 957 highway structures as damaged by channel degradation. Degradation and channel widening in the loess area led to the collapse of several bridges in West Tennessee (Robbins and Simon, 1983), southwest Mississippi (Wilson, 1979), Missouri (Emerson,

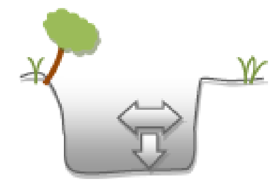
[1]Paper No. 99012 of the *Journal of the American Water Resources Association*. **Discussions are open until October 1, 2000.**
[2]Respectively, USDA-Agricultural Research Service, National Sedimentation Laboratory, 598 McElroy Drive, P.O. Box 1157, Oxford, Mississippi 38655; and Universita degli Studi di Firenze, Florence, Italy (E-Mail/Simon: simon@sedlab.olemiss.edu).



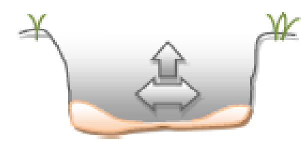
Stage1 – Equilibrium



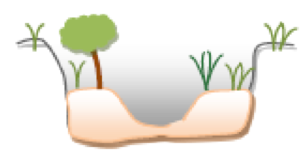
Stage 2– Incision



Stage 3 – Widening



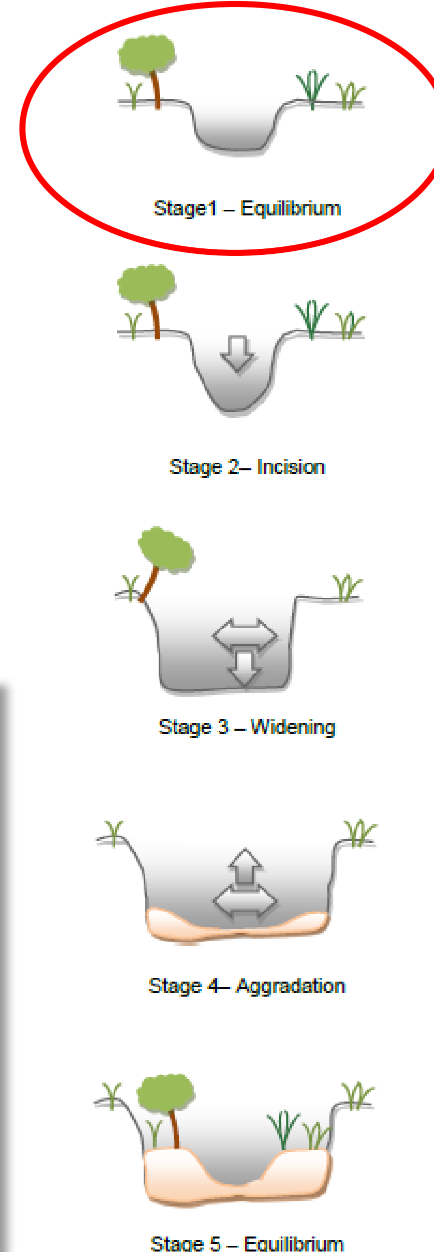
Stage 4– Aggradation



Stage 5 – Equilibrium

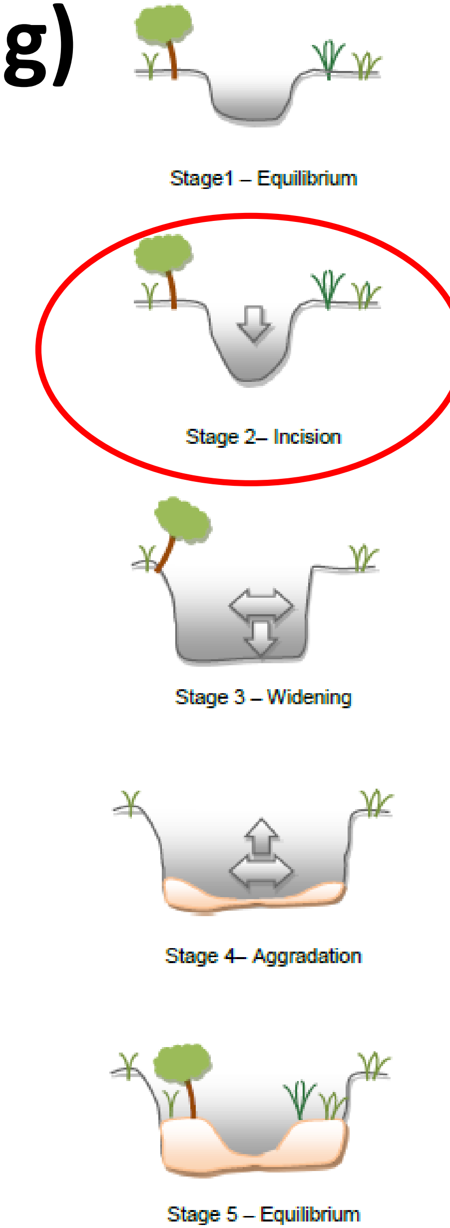
Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

Stage 1 – Equilibrium



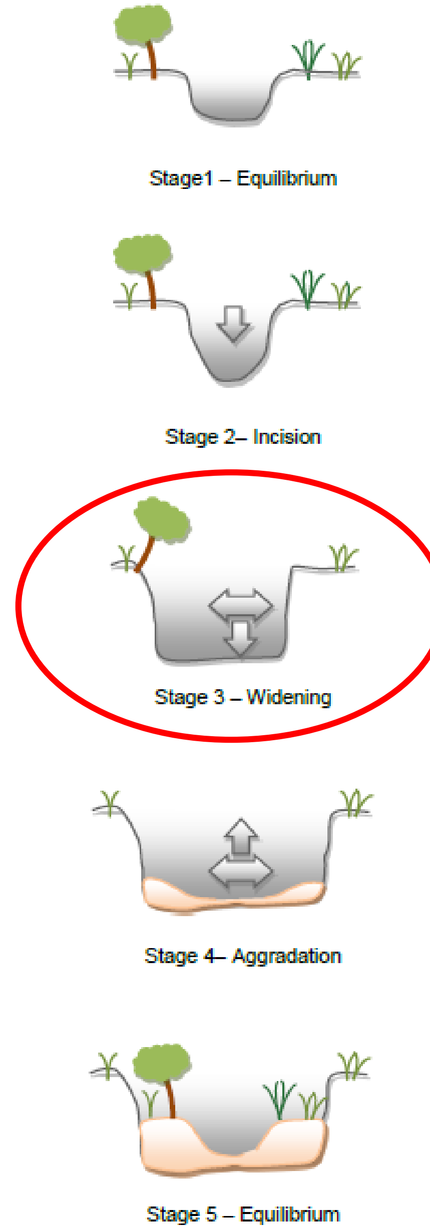
Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

Stage 2 – Incision (Downcutting)



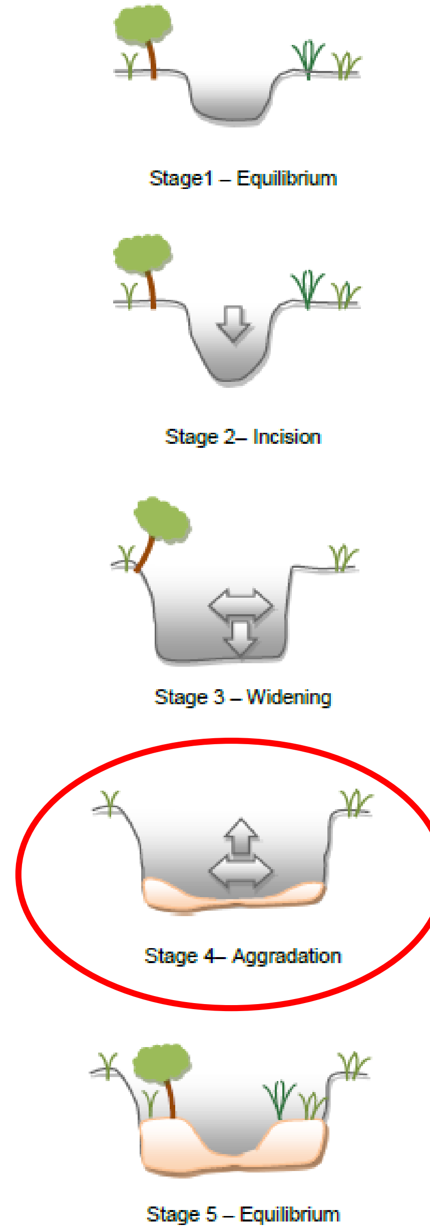
Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

Stage 3 – Widening



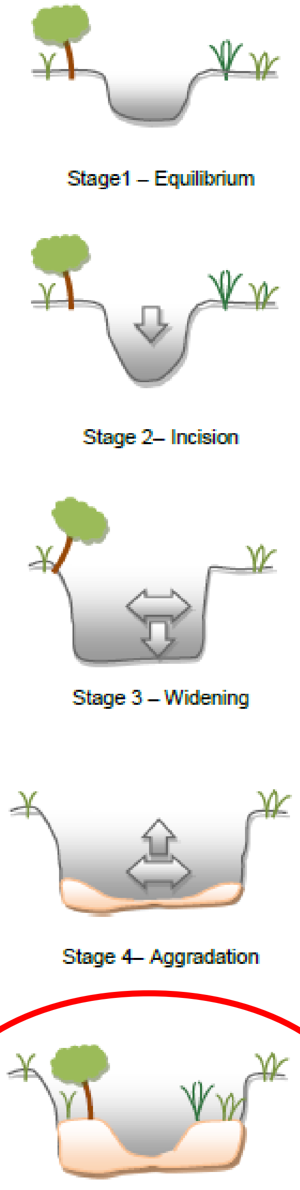
Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

Stage 4 – Aggradation



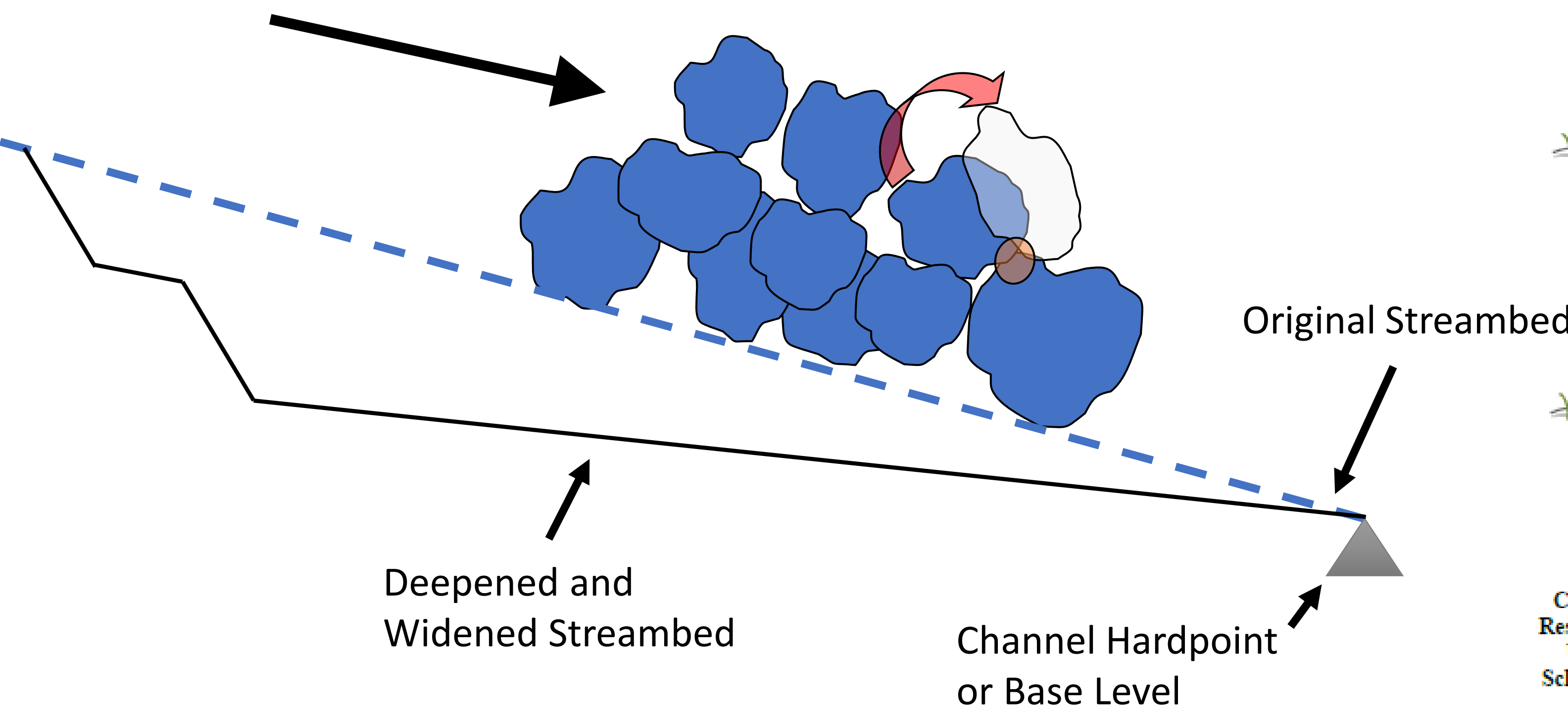
Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

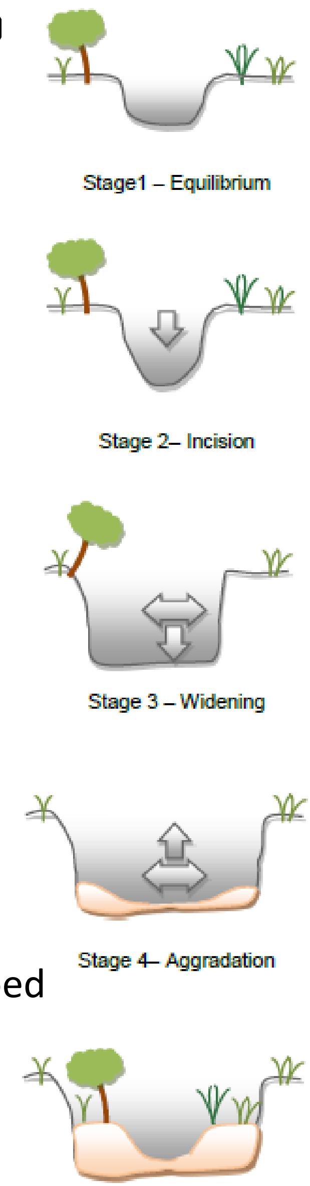
Stage 5 – Equilibrium (Recovered)



Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

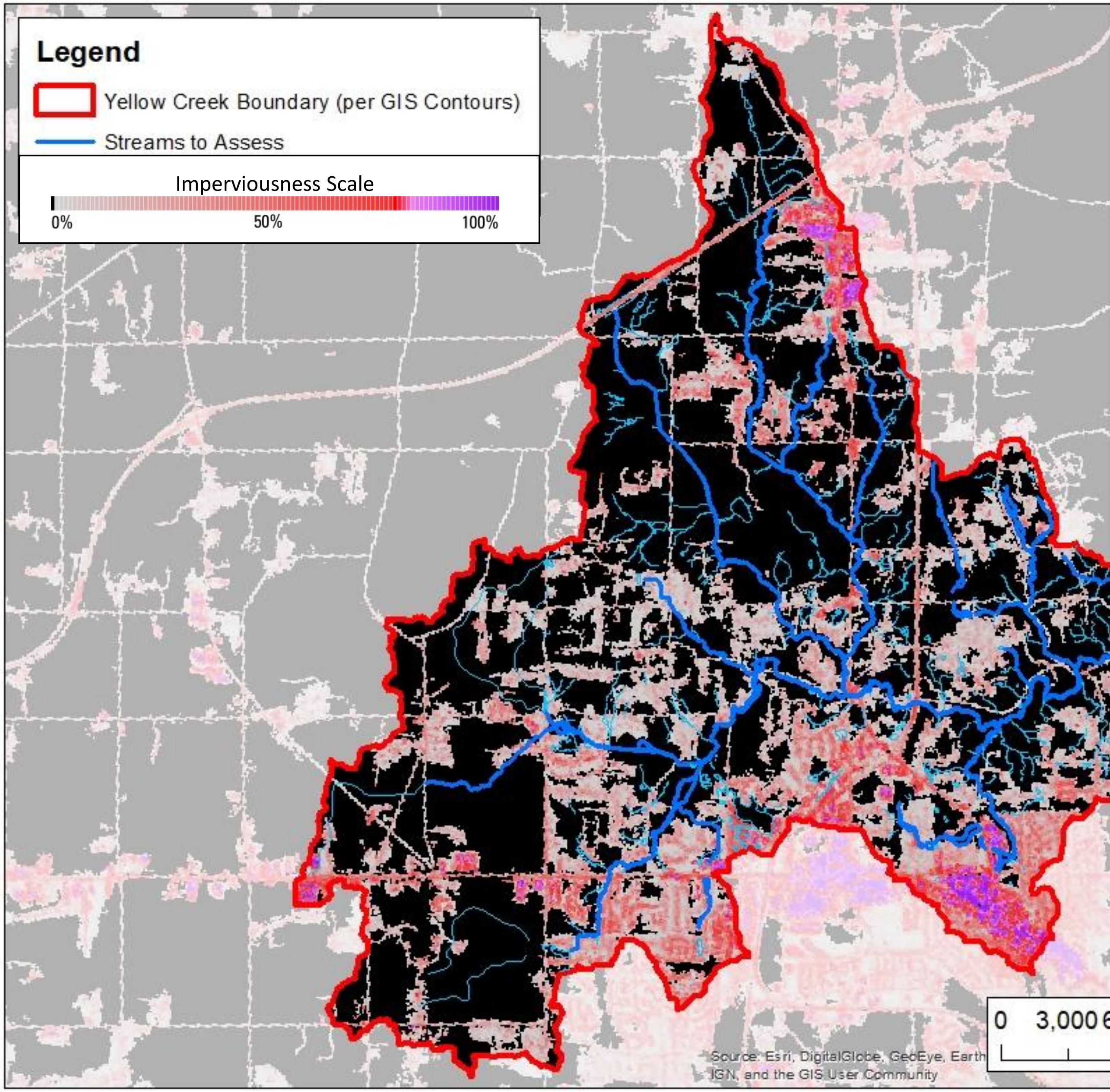
How Does A Stream Get Deeper?

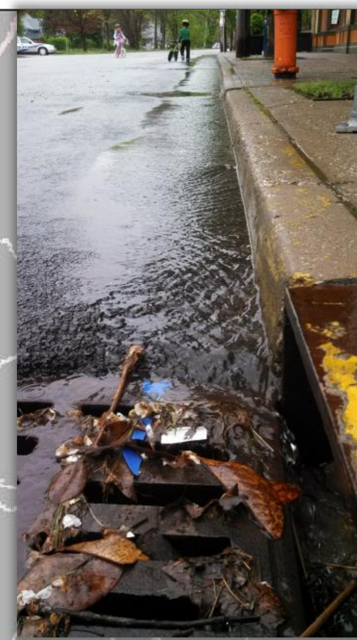




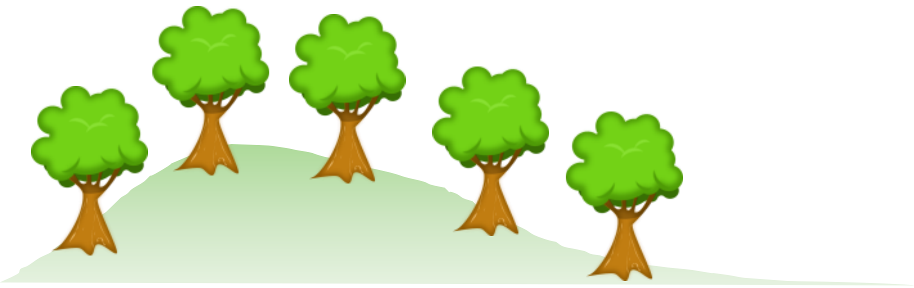
Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

How Can Stormwater Runoff Contribute to Erosion?

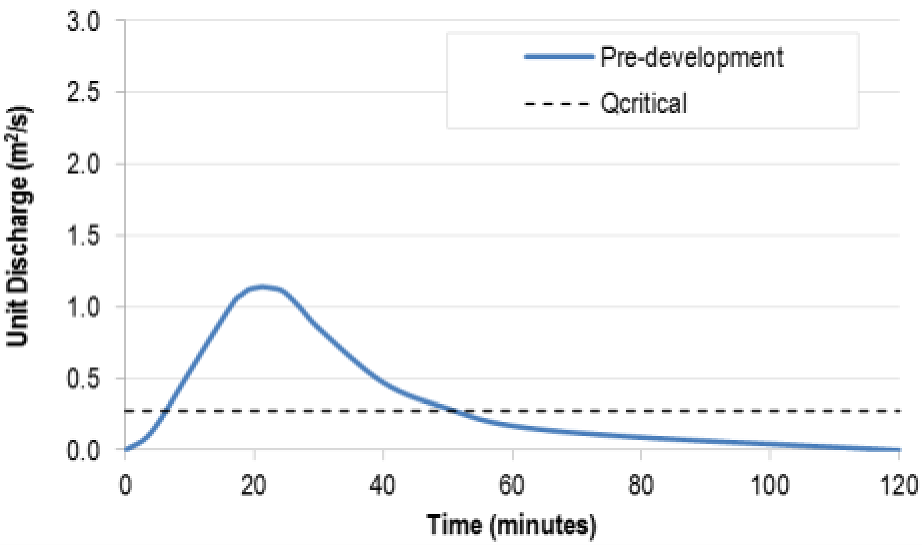




History of Stormwater Management

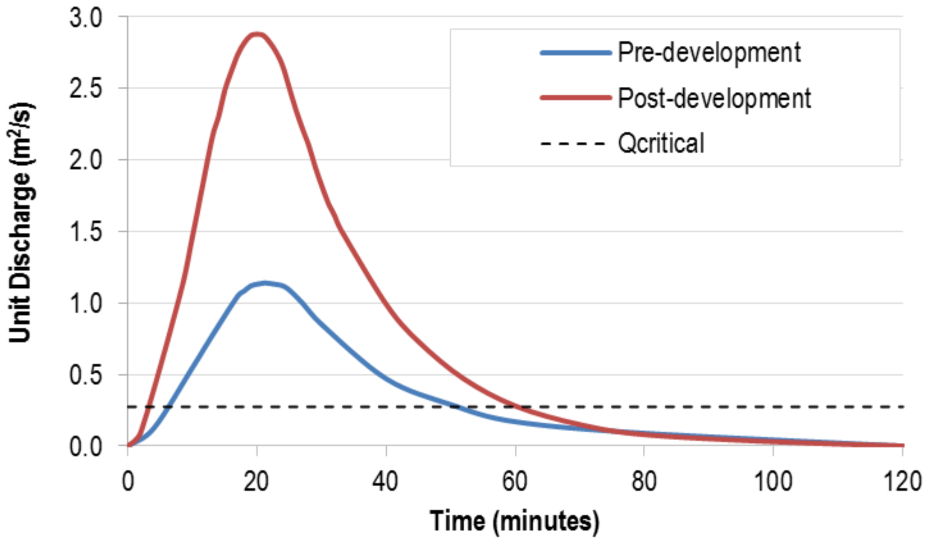


(sensu Roy et al., 2008)



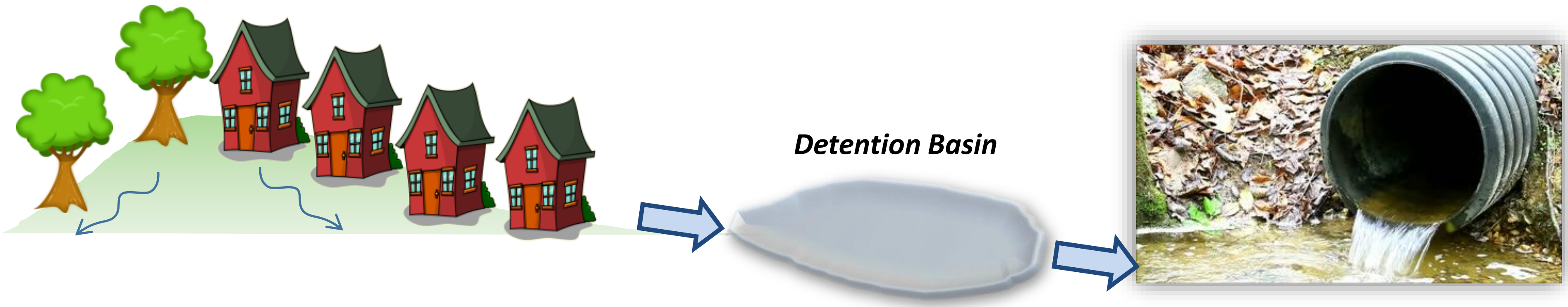
Analysis of the 2-yr, 2-hr storm from Fort Collins, CO by Bledsoe (2002), Journal of Water Resources Planning and Management

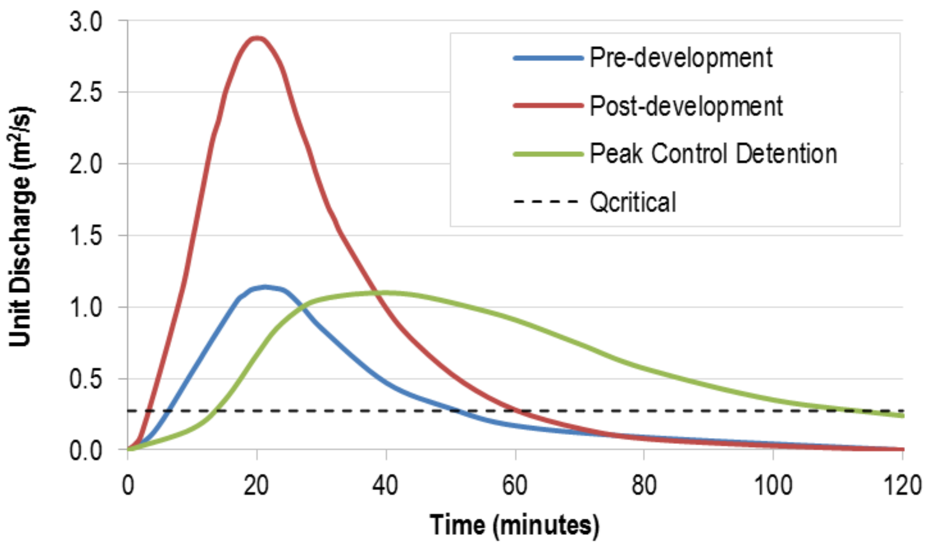
~Pre-1950



Analysis of the 2-yr, 2-hr storm from Fort Collins, CO by Bledsoe (2002), Journal of Water Resources Planning and Management

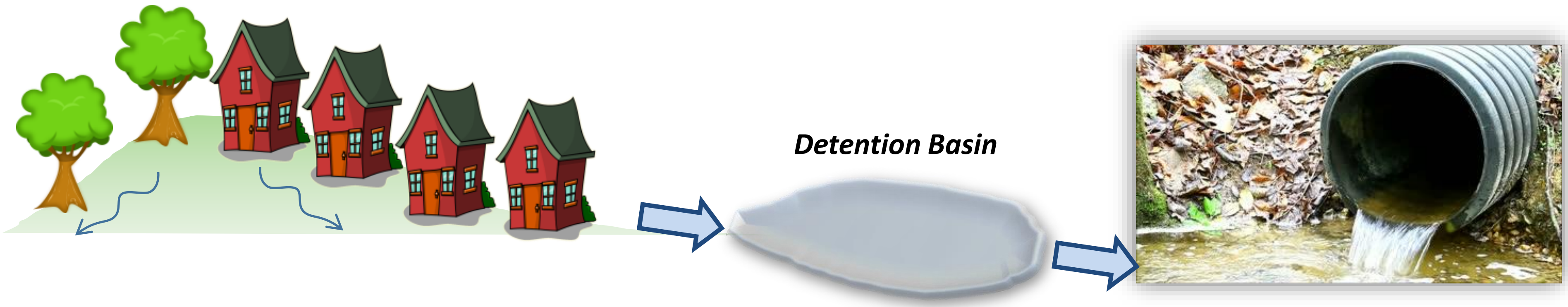
~1980-2000

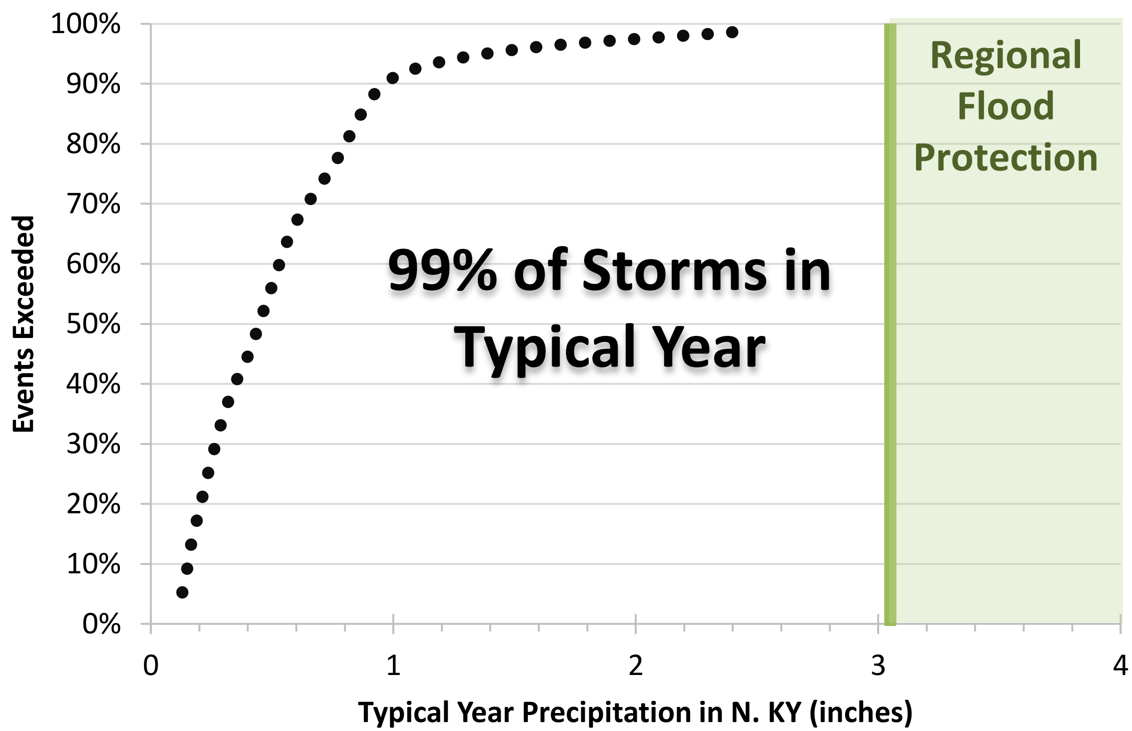




Analysis of the 2-yr, 2-hr storm from Fort Collins, CO by Bledsoe (2002), Journal of Water Resources Planning and Management

~1980-2000





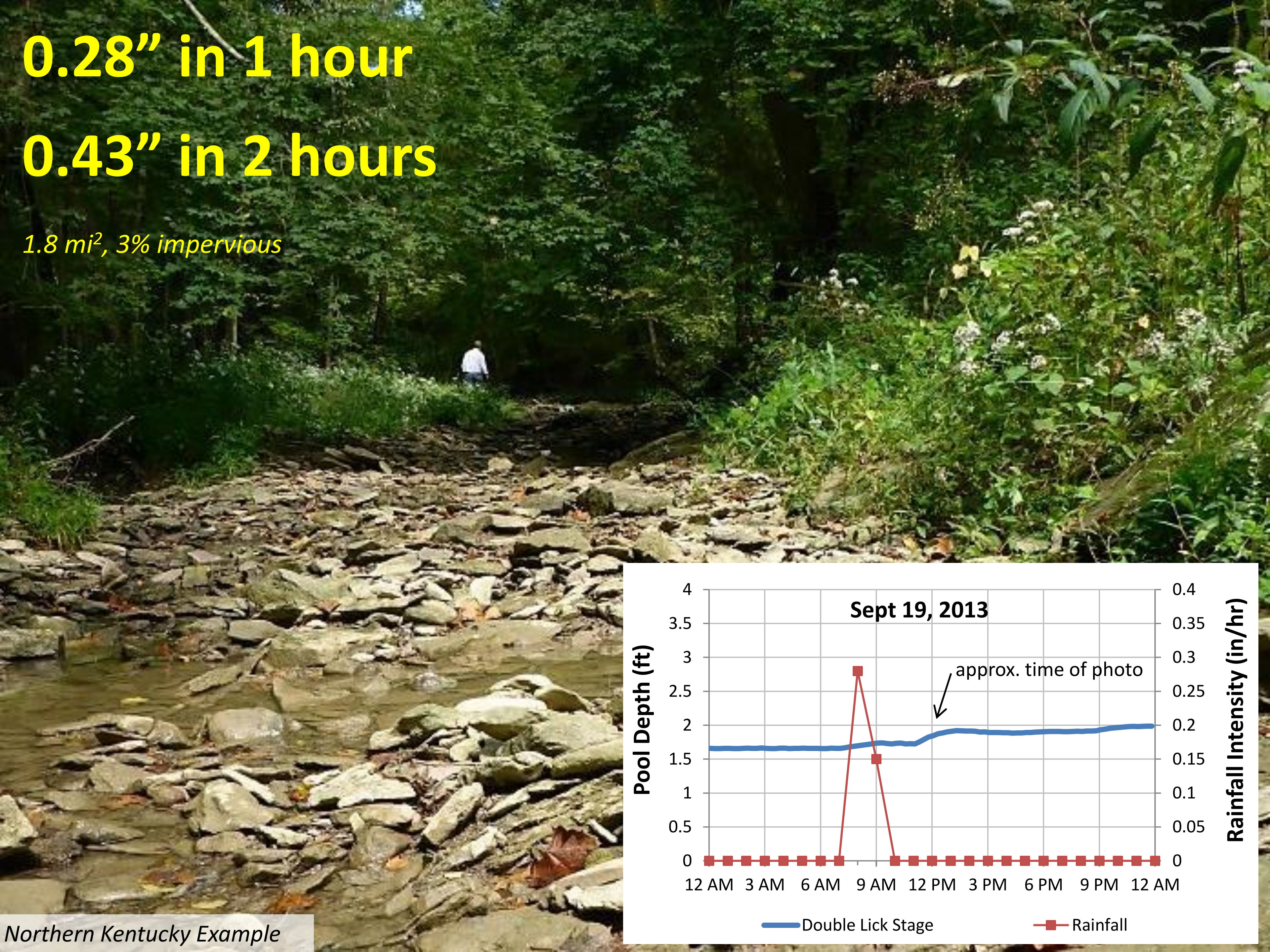
Adapted from Hawley (2012)


0.3” in 1 hour
2.2 mi², 29% impervious
06/10/2009 08:26
Northern Kentucky Example

0.28” in 1 hour

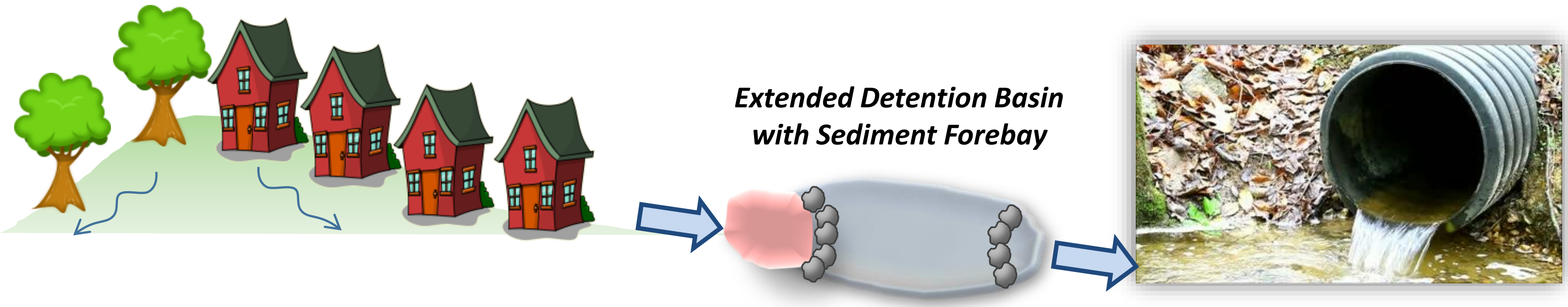
0.43” in 2 hours

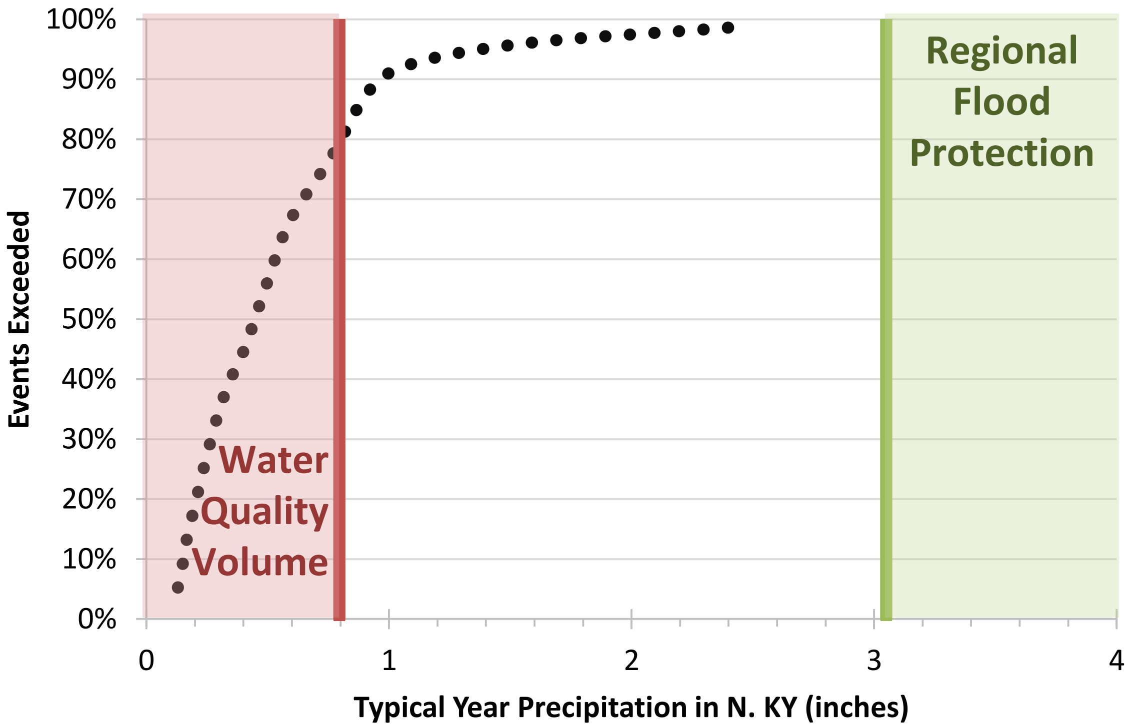
1.8 mi^2, 3% impervious



Northern Kentucky Example

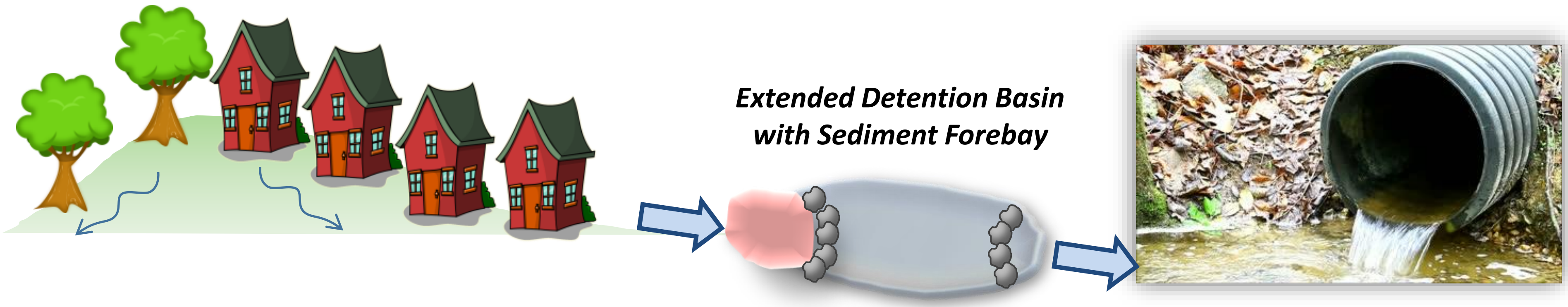
~2000-2015

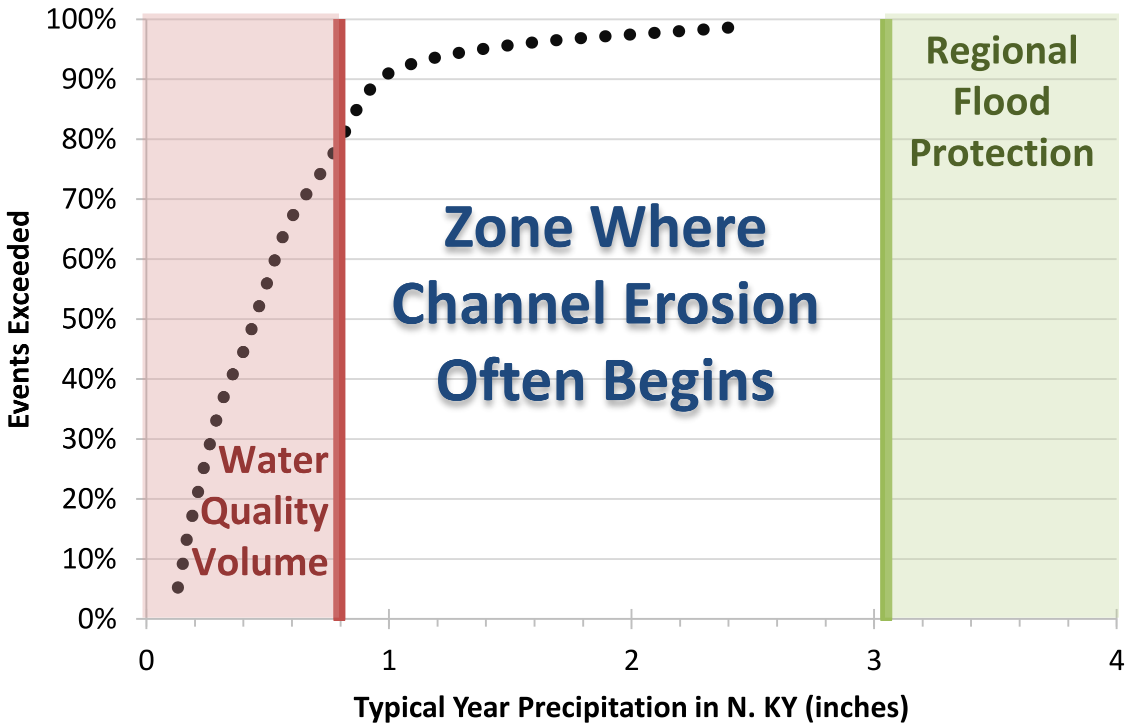




Adapted from Hawley (2012)

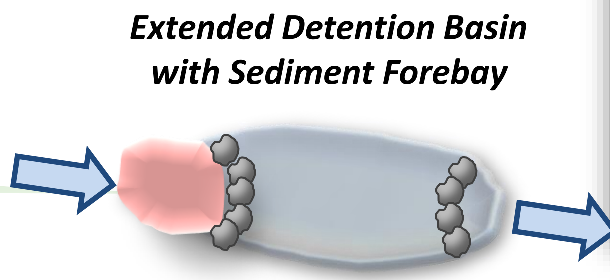
~2000-2015

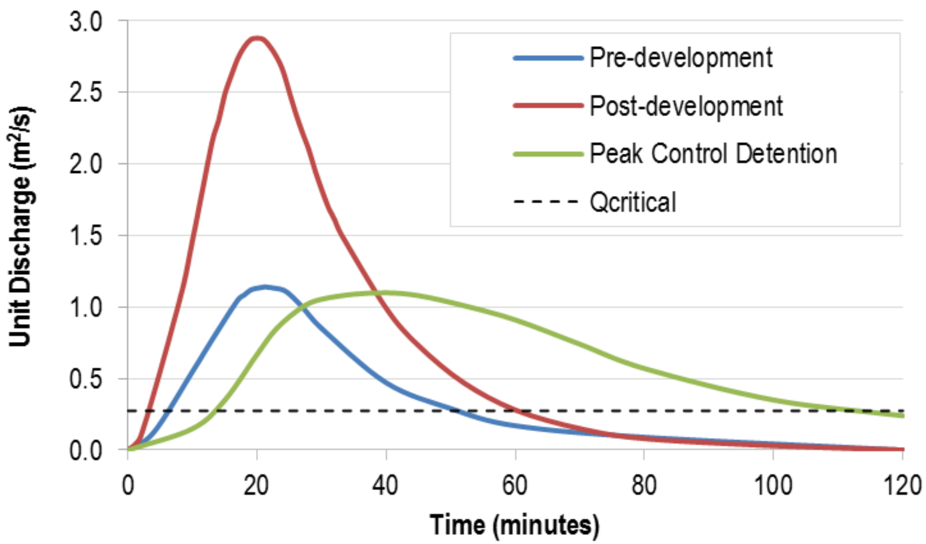




Adapted from Hawley (2012)

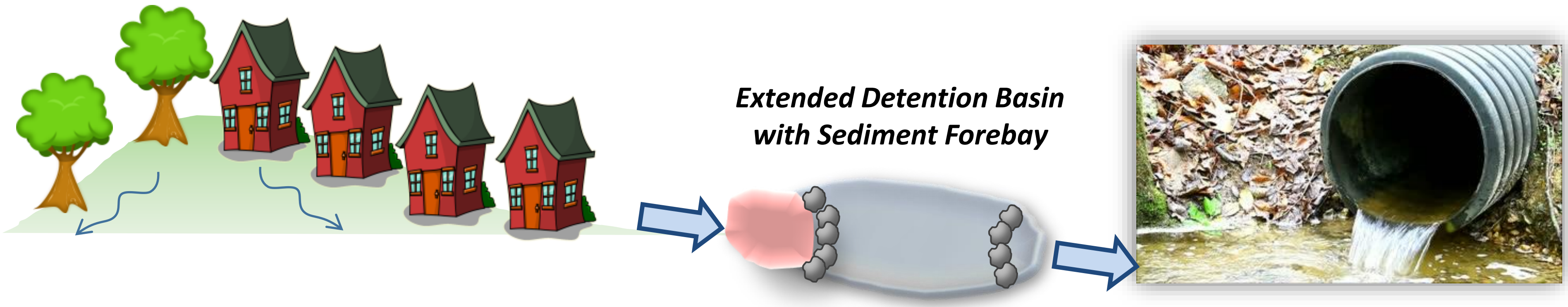
~2000-2015

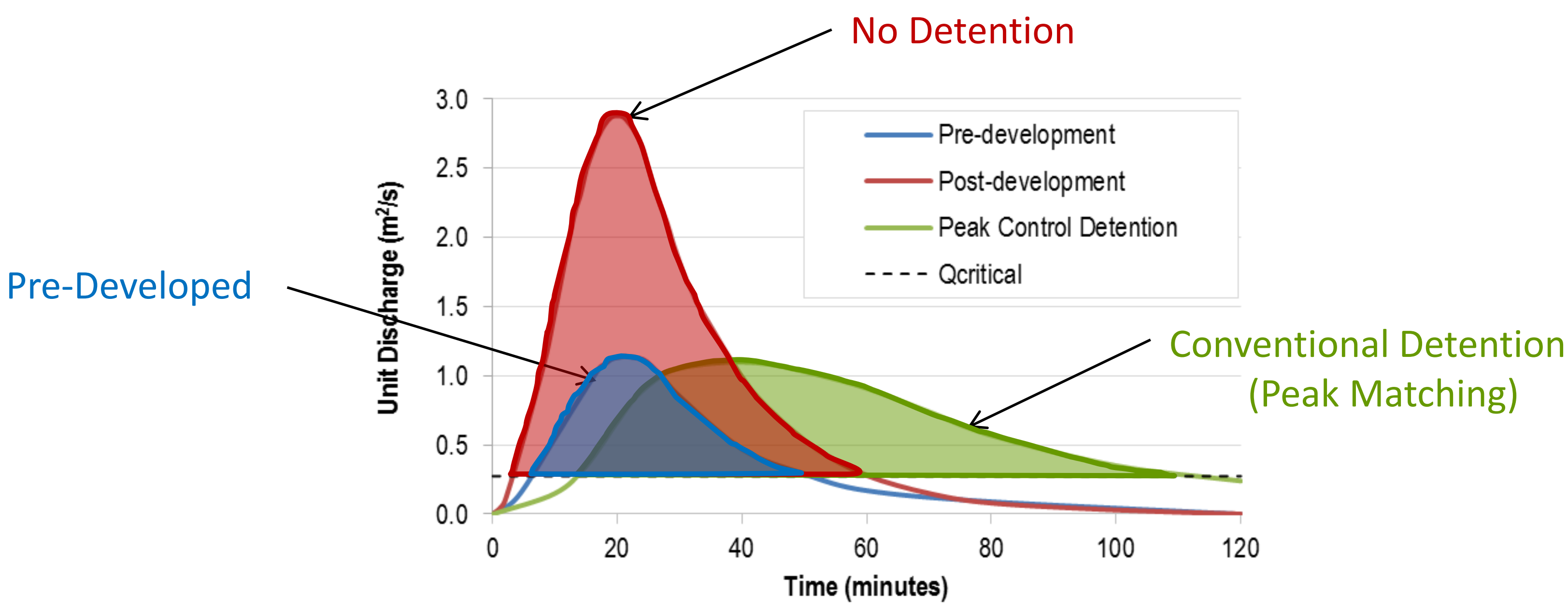




Analysis of the 2-yr, 2-hr storm from Fort Collins, CO by Bledsoe (2002),
Journal of Water Resources Planning and Management

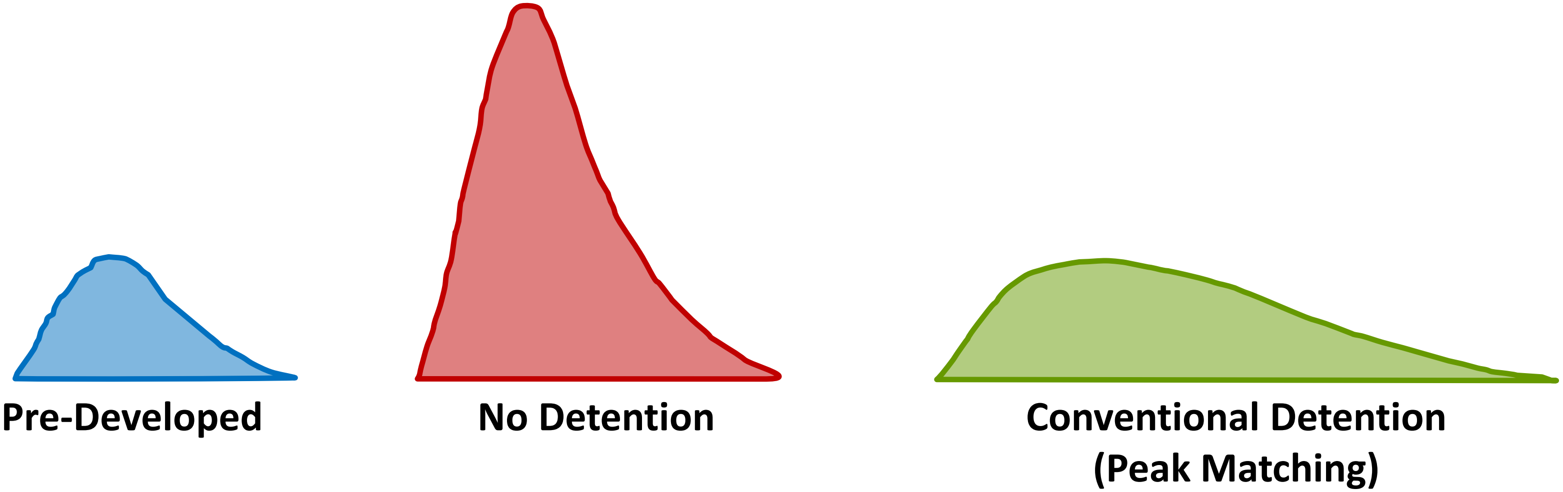
~2000-2015





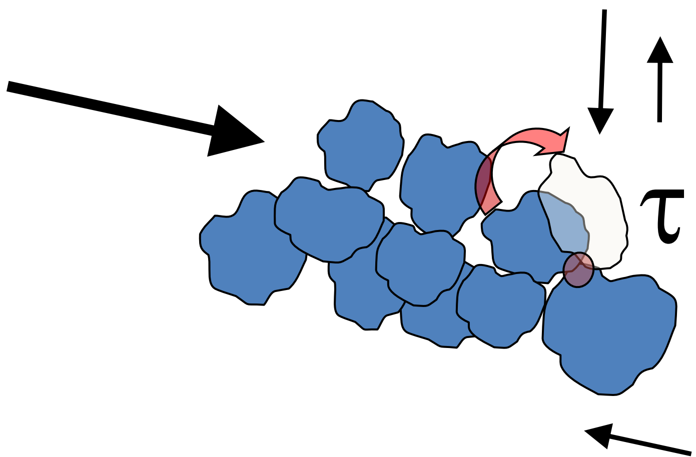
Analysis of the 2-yr, 2-hr storm from Fort Collins, CO by Bledsoe (2002), Journal of Water Resources Planning and Management

Conventional Detention = ***<u>More Erosion</u>*** than Pre-Developed Conditions

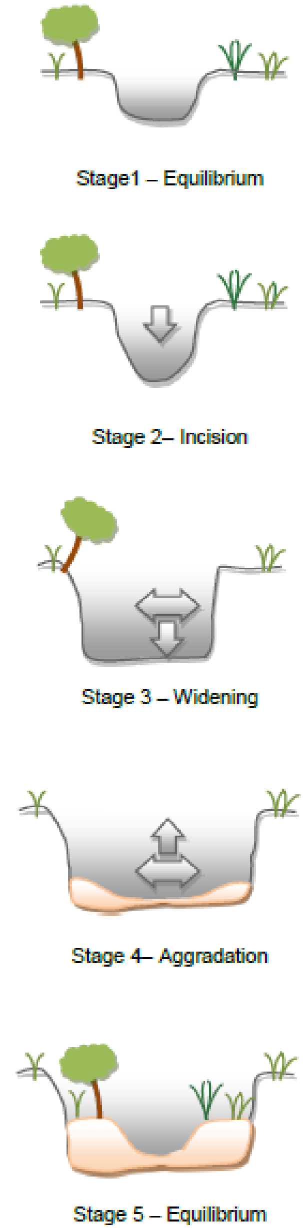


Introduction of $Q_{critical}$

The Critical Flow for Stream Bed Erosion

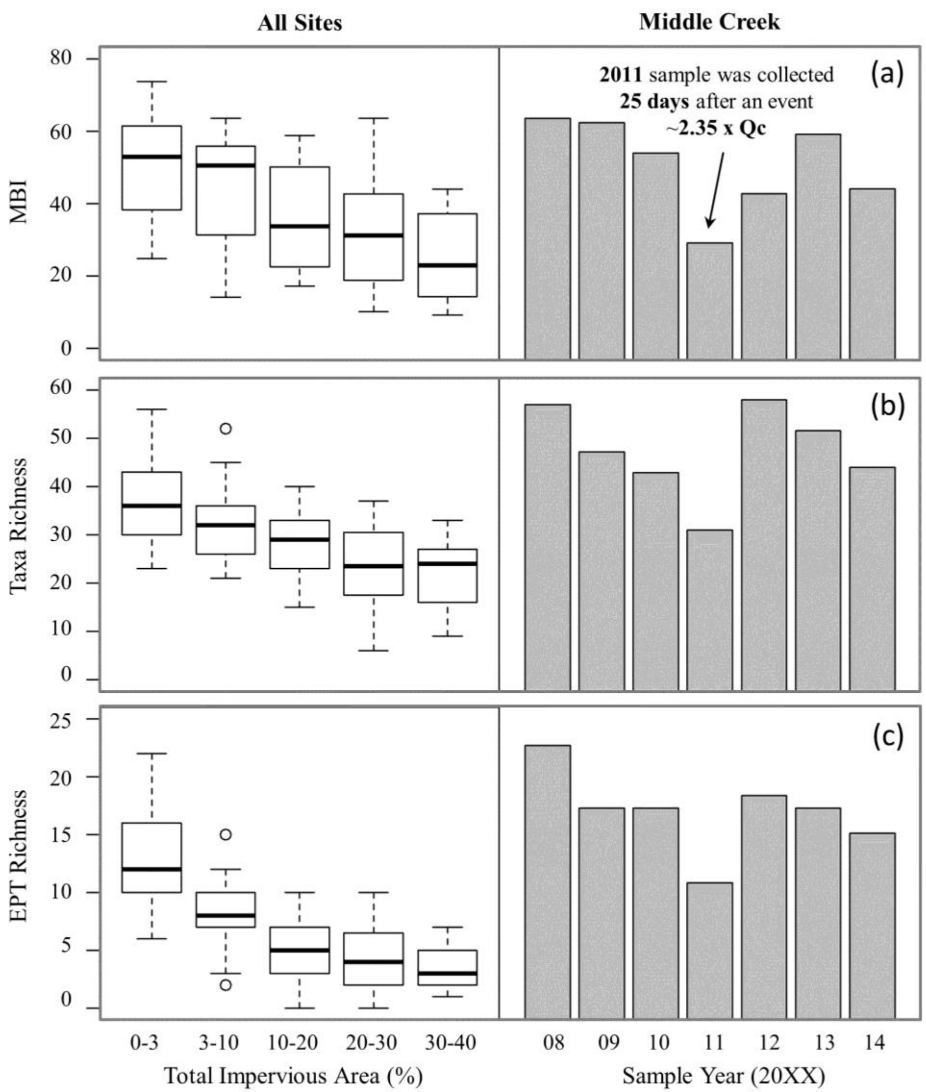


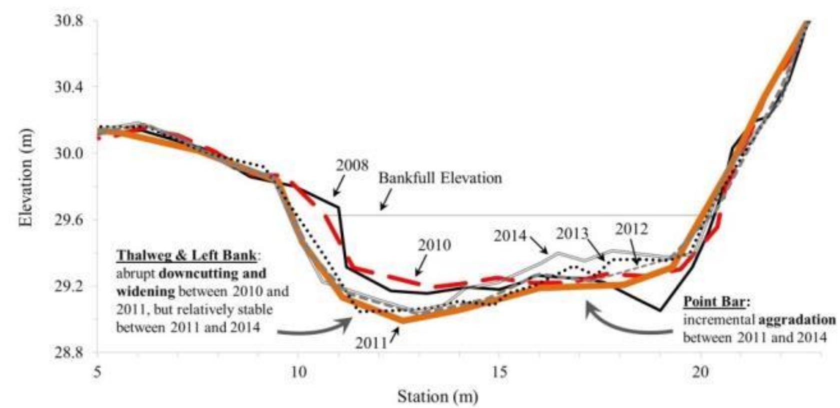
$$\tau > \tau_c$$



Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

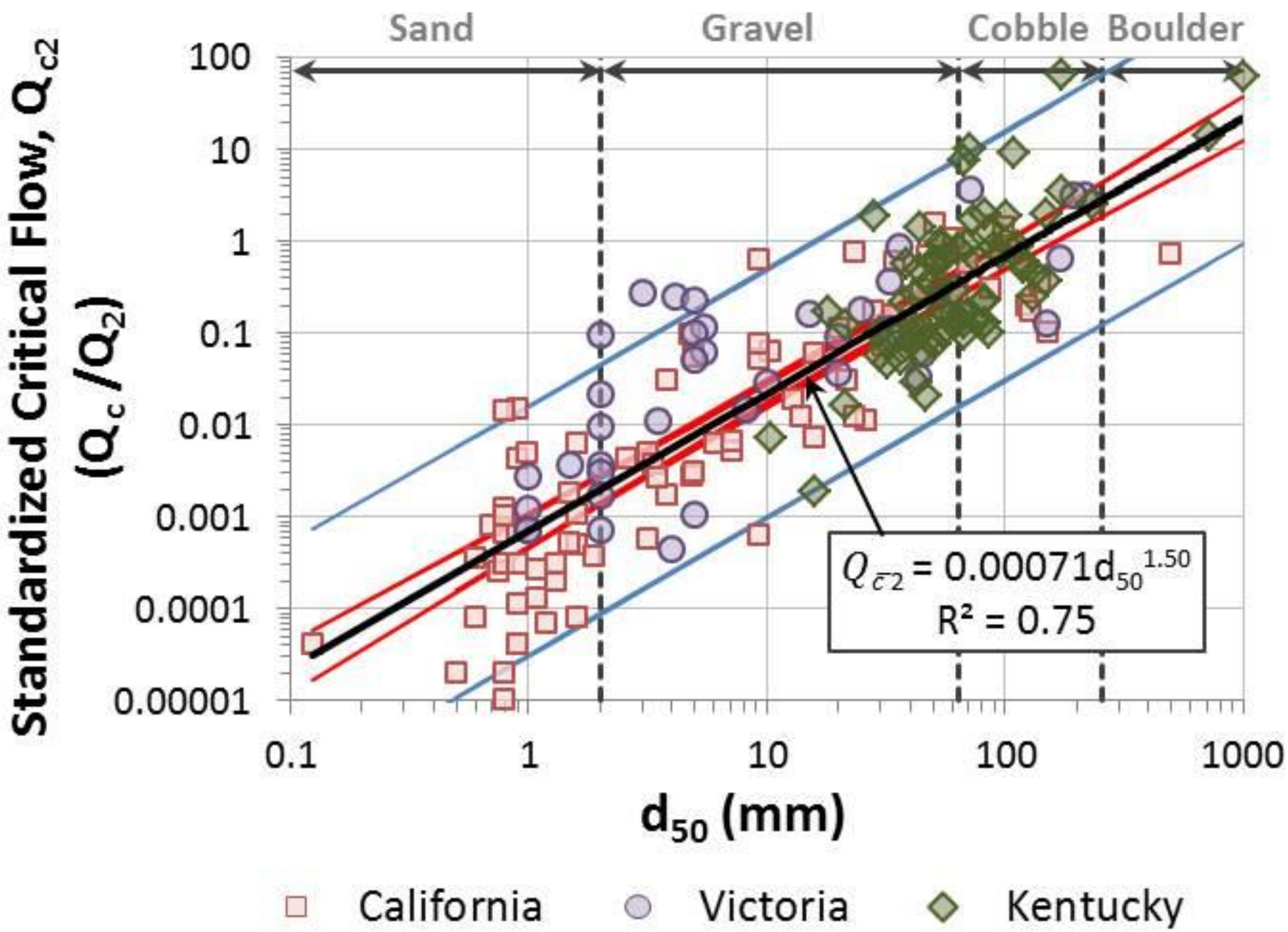
The Importance of $Q_{critical}$ is even Evident at Reference Sites





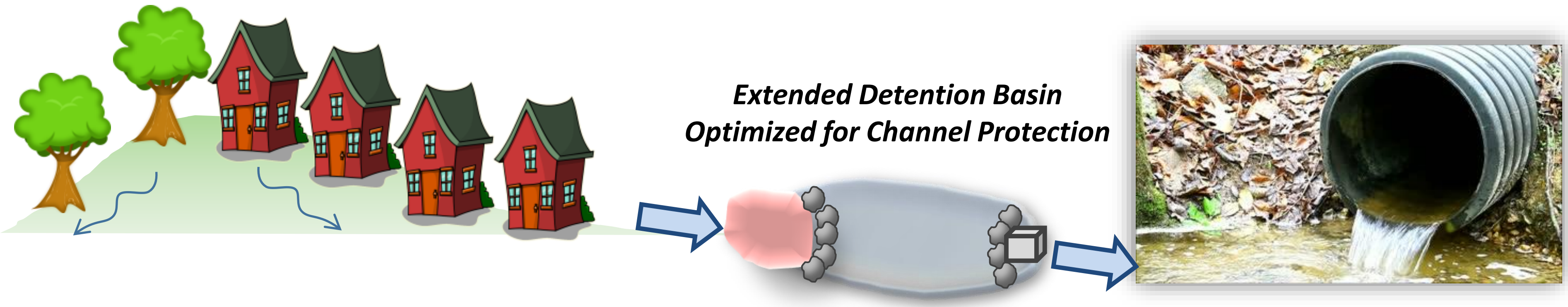
Adapted from Hawley et al. (2016, Freshwater Science)

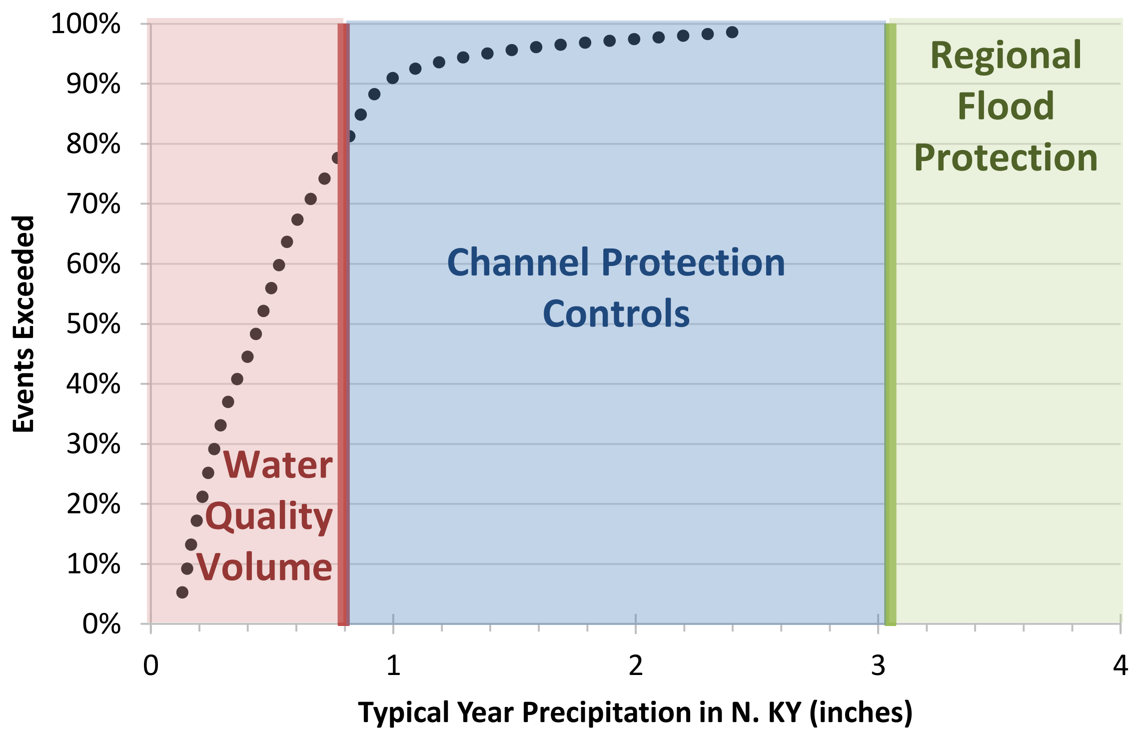
$Q_{critical}$ Needs to Be Calibrated to Stream/Region



Adapted from Hawley and Vietz (2016, Freshwater Science)

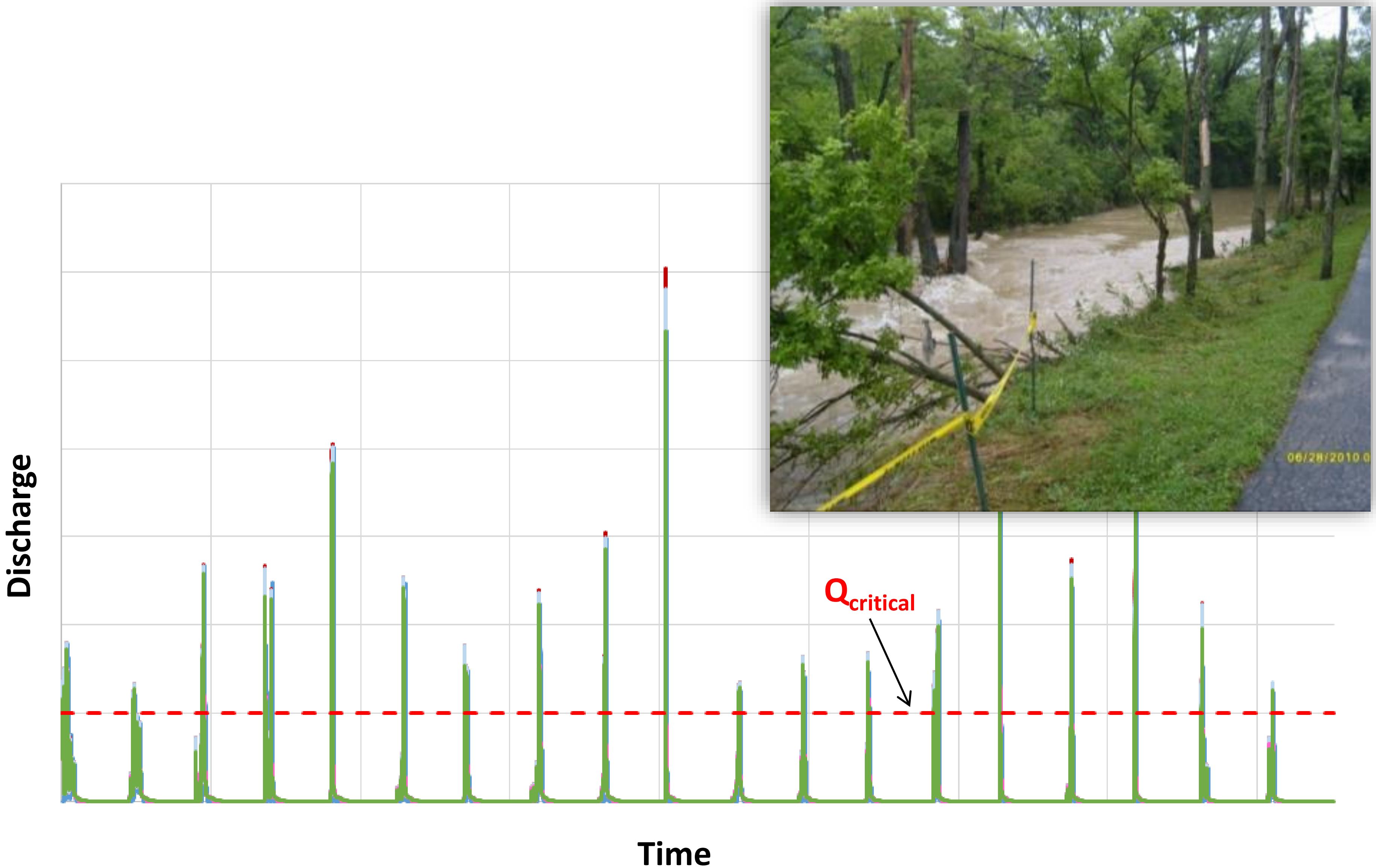
Future of Stormwater Management



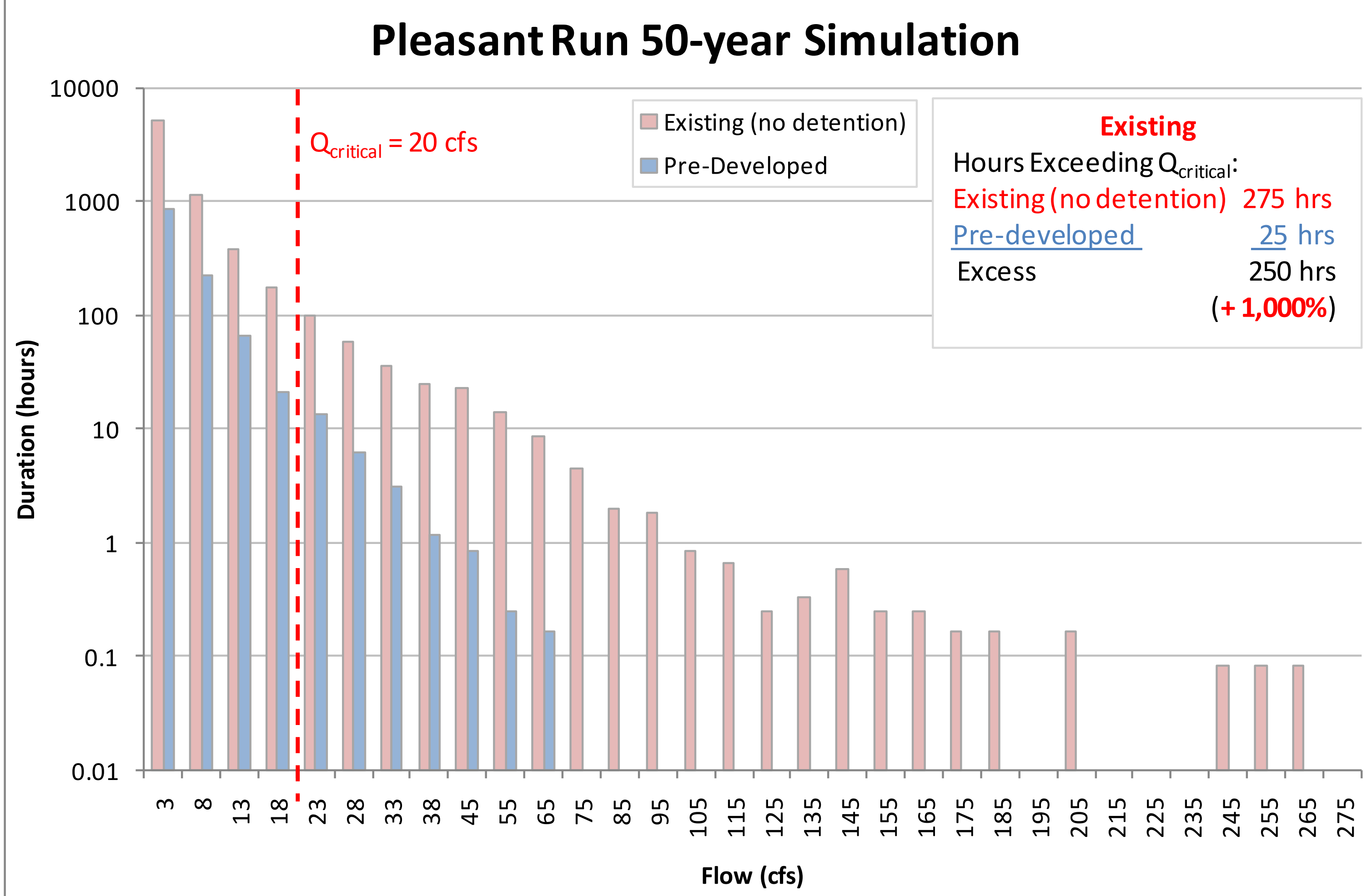


Adapted from Hawley (2012)

Consider All Storms > $Q_{critical}$

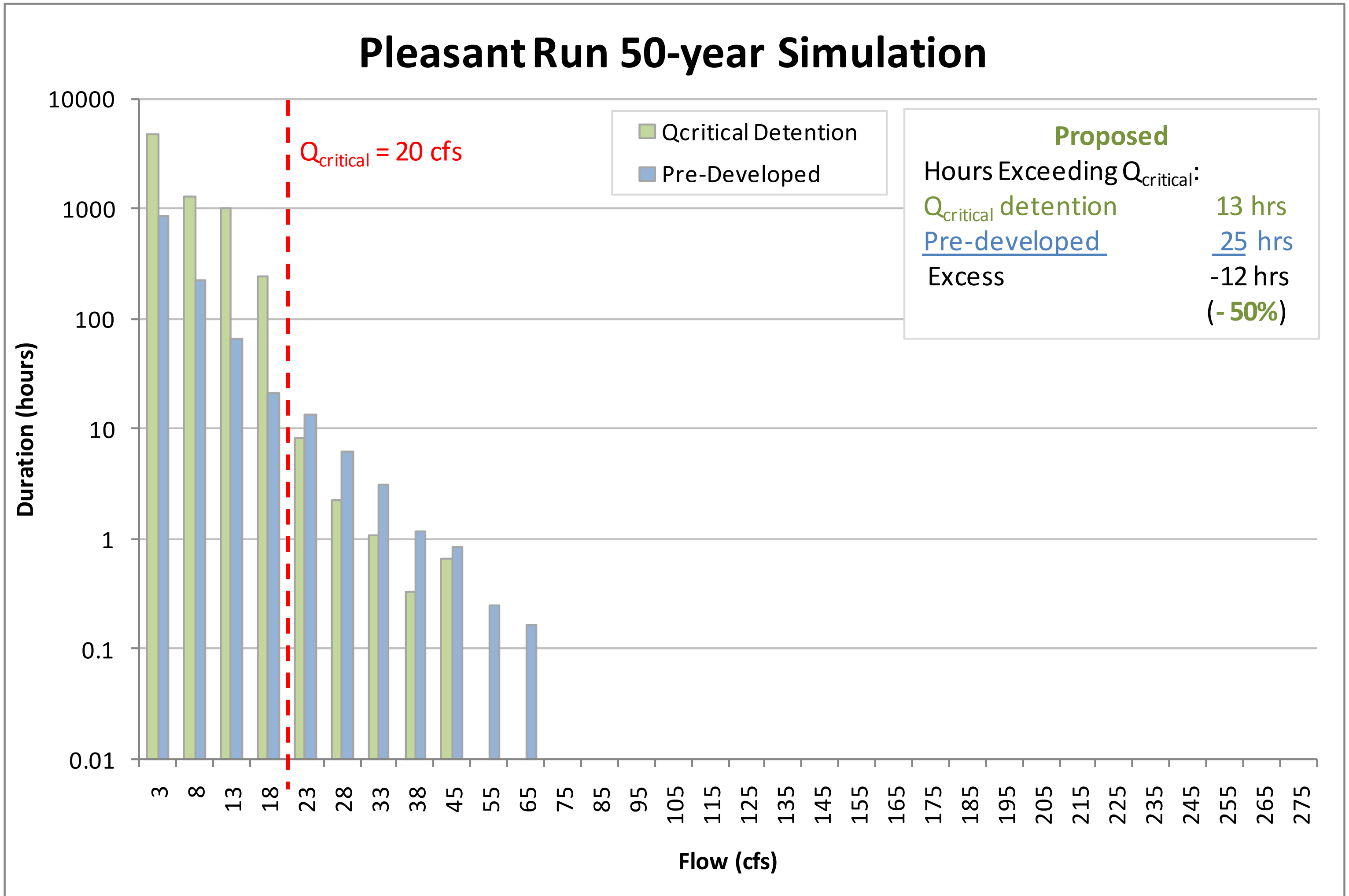


$Q_{critical}$ Design Target = “Safe Release Rate”



Adapted from Hawley et al. (2012)

If Excess Volume Is Released Below $Q_{critical}$ → No Excess Erosive Flows



Adapted from Hawley et al. (2012)

Stormwater-based Management Strategies

Reduce the erosive power of stormwater runoff (potentially in conjunction with stream restoration)

Biological

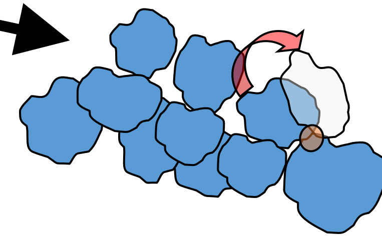
Physicochemical

Geomorphology

Hydraulics

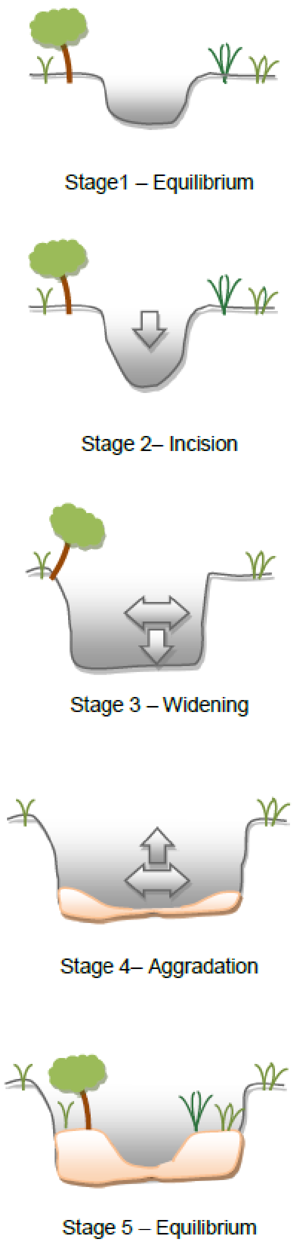
Hydrologic

Stormwater Management



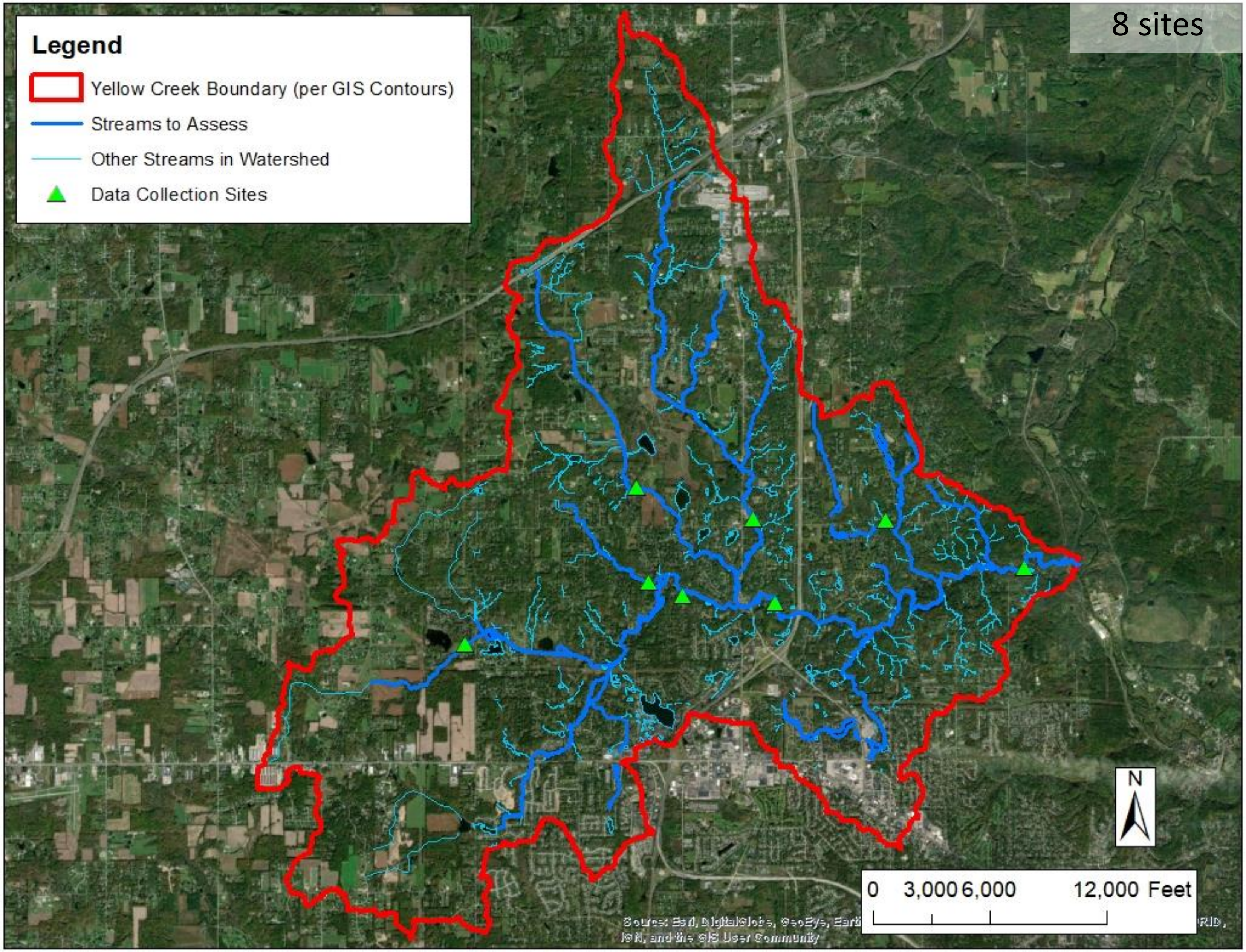
$\boldsymbol{Q_{critical}}$

It all starts here



Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

What is $Q_{critical}$ for Yellow Creek?



Hydrogeomorphic Data Collection

Hydrogeomorphic Data Collection

$Q_{critical}$ ~ 40-50% of Q_2

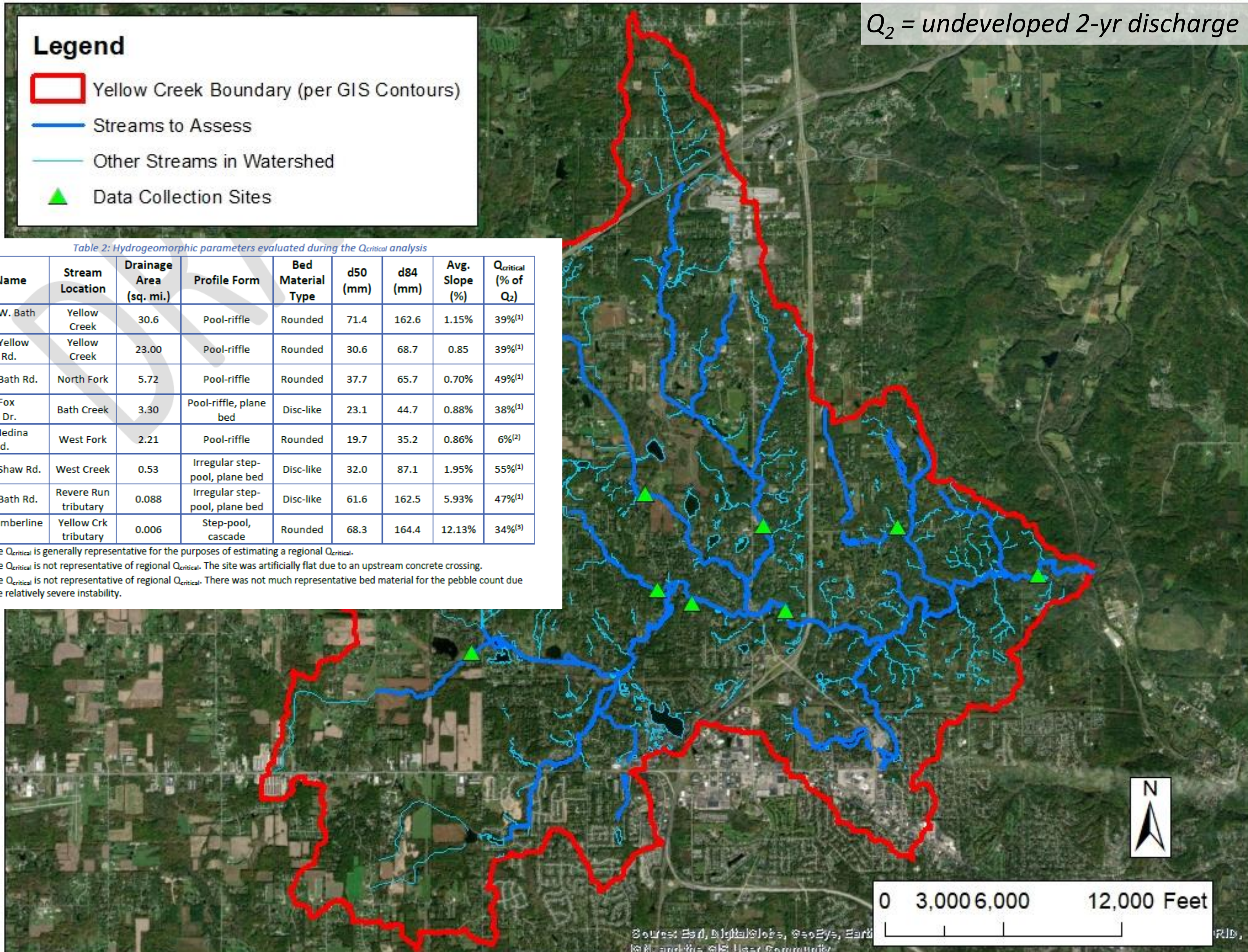


Table 2: Hydrogeomorphic parameters evaluated during the $Q_{critical}$ analysis

Site Name	Stream Location	Drainage Area (sq. mi.)	Profile Form	Bed Material Type	d50 (mm)	d84 (mm)	Avg. Slope (%)	$Q_{critical}$ (% of Q_2)
2226 W. Bath Rd.	Yellow Creek	30.6	Pool-riffle	Rounded	71.4	162.6	1.15%	39%(1)
3495 Yellow Creek Rd.	Yellow Creek	23.00	Pool-riffle	Rounded	30.6	68.7	0.85	39%(1)
3757 Bath Rd.	North Fork	5.72	Pool-riffle	Rounded	37.7	65.7	0.70%	49%(1)
1405 Fox Chase Dr.	Bath Creek	3.30	Pool-riffle, plane bed	Disc-like	23.1	44.7	0.88%	38%(1)
588 Medina Line Rd.	West Fork	2.21	Pool-riffle	Rounded	19.7	35.2	0.86%	6%(2)
4023 Shaw Rd.	West Creek	0.53	Irregular step-pool, plane bed	Disc-like	32.0	87.1	1.95%	55%(1)
3139 Bath Rd.	Revere Run tributary	0.088	Irregular step-pool, plane bed	Disc-like	61.6	162.5	5.93%	47%(1)
901 Timberline Dr.	Yellow Crk tributary	0.006	Step-pool, cascade	Rounded	68.3	164.4	12.13%	34%(3)

(1) Site $Q_{critical}$ is generally representative for the purposes of estimating a regional $Q_{critical}$.
(2) Site $Q_{critical}$ is not representative of regional $Q_{critical}$. The site was artificially flat due to an upstream concrete crossing.
(3) Site $Q_{critical}$ is not representative of regional $Q_{critical}$. There was not much representative bed material for the pebble count due to the relatively severe instability.

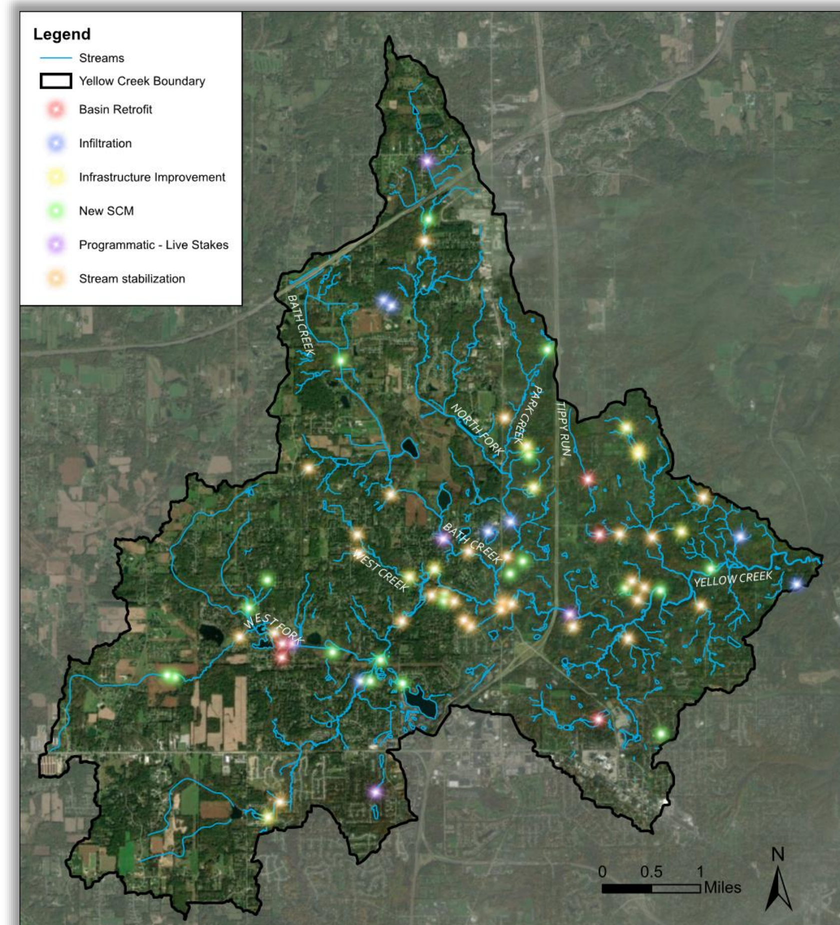
Mitigation Strategies

Stormwater Strategies

In-Stream Restoration

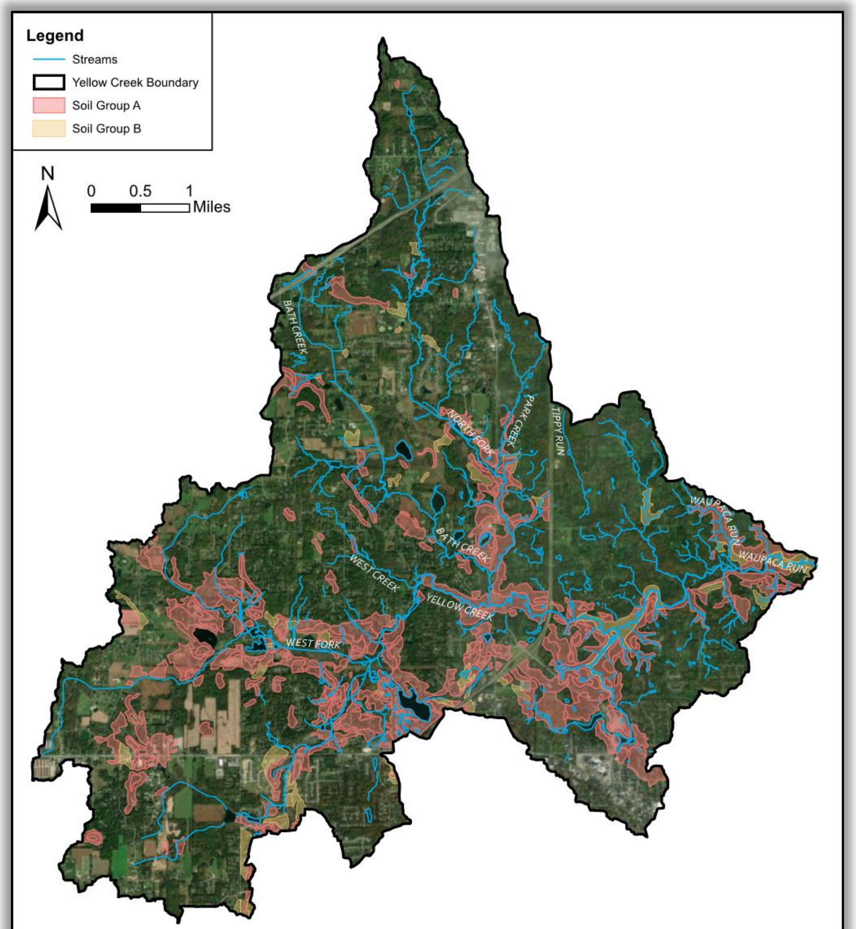
Preliminary Conceptual Opportunities

1. Preserve/enhance high infiltration areas
2. Infrastructure improvements
3. Optimize existing SCMs
4. Install new SCMs
5. Mitigate instability in “seasonal channels”
6. Bank protection projects that could potentially be within the scope of the SWMD
7. Partial bank protection projects that could potentially be within the scope of the SWMD
8. Programmatic/non-structural improvements



“SCM” = Stormwater Control Measure

1. Preserve/Enhance High Infiltration Areas

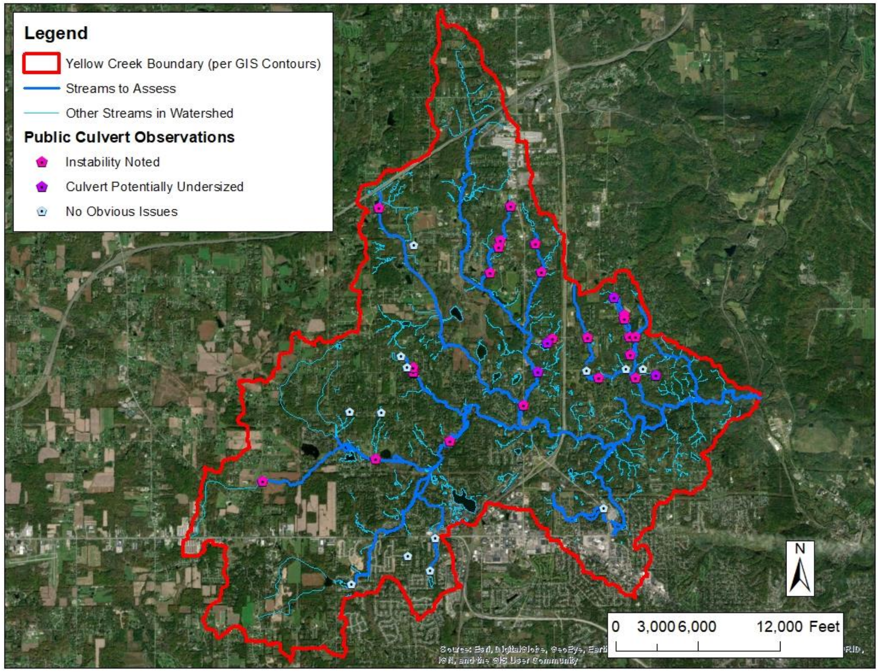


Locations of Type A and Type B soils in Yellow Creek watershed

- Undeveloped Type A or Type B soils
- Public parcel forest preservation and/or SCM infiltration optimization
- Private parcels could also promote preservation and optimize SCMs for high infiltration

Example of a forested area with Type A soil

2. Infrastructure Improvements



- Culvert maintenance
- Stabilization of outfalls
- Storm sewer repairs, etc.

Outlet would benefit from additional armoring and stabilization

→ Notifications to Other Responsible Parties

- Many areas of potential concern do not fall under SWMD jurisdiction

Cracked bridge abutment

Dam is patched with a piece of plywood & chain-link fence

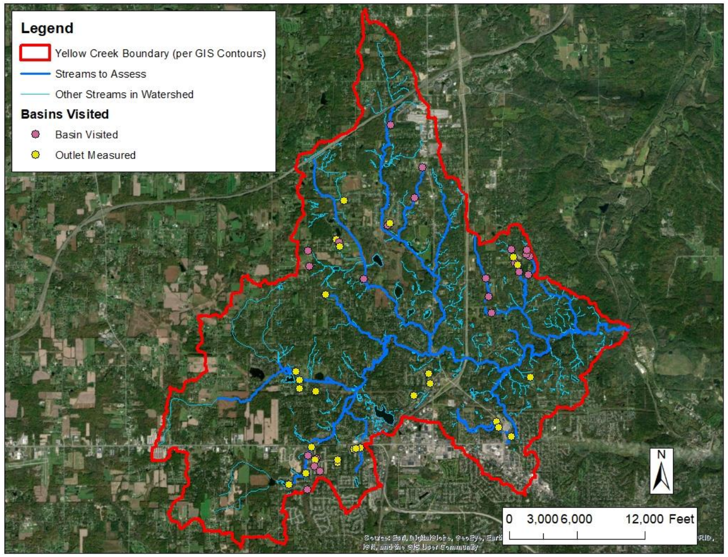
Slumping gabions next to road

3. Optimization of Existing SCMs

Existing outlet structure that could potentially be optimized to reduce downstream erosion.

Example of private pond that could benefit from Stream/Wetland complex construction.

- 50 existing detention basins visited
- Preliminary analysis suggests that cost-effective retrofits could partially mitigate excess erosive power at several basins
- Armoring, potential spillway improvements, etc. could be included

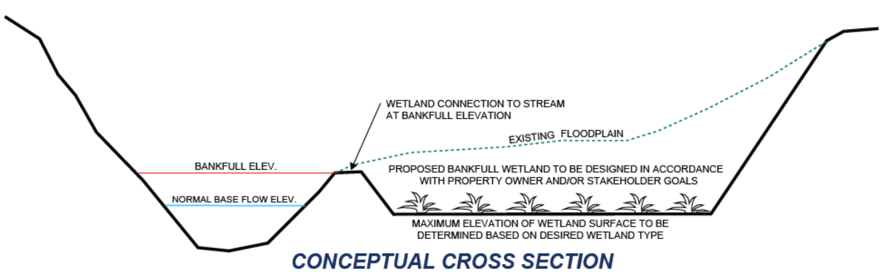


Locations of existing SCMs in Yellow Creek watershed

4. Install New SCMs

Conceptual contours of bankfull wetlands

- Add new storage specifically designed to offload erosive flows
- ~40+ acre-feet of potential new storage could be created in undevelopable floodplain areas
- Could be optimized to reduce the erosive power of the 1-year discharge, particularly during summer storms



Bankfull wetland conceptual cross section

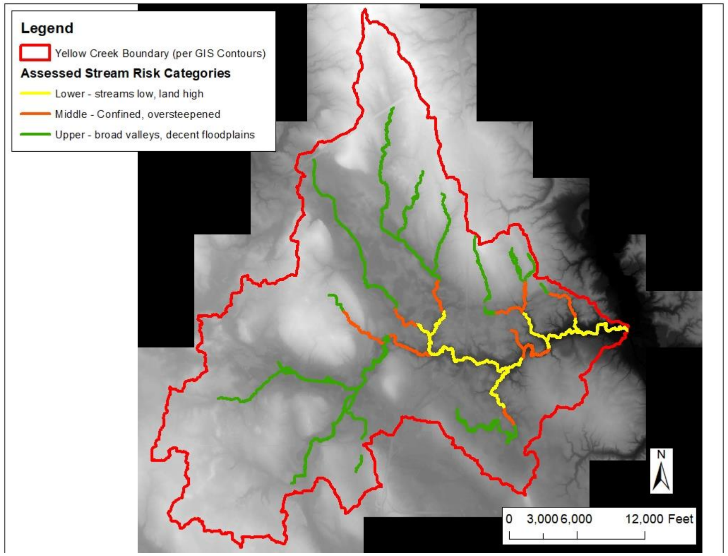
Constructed Bankfull Wetland in Northern KY

5. Rehabilitation in "Seasonal Channels"

- Primarily address localized instability
- Chronic erosion creates relatively high sediment loads to downstream waters
- Conceptual examples include swale and tributary stabilization and headcut repair

Eroded ravine downstream of driveway.

~4-ft headcut in tributary



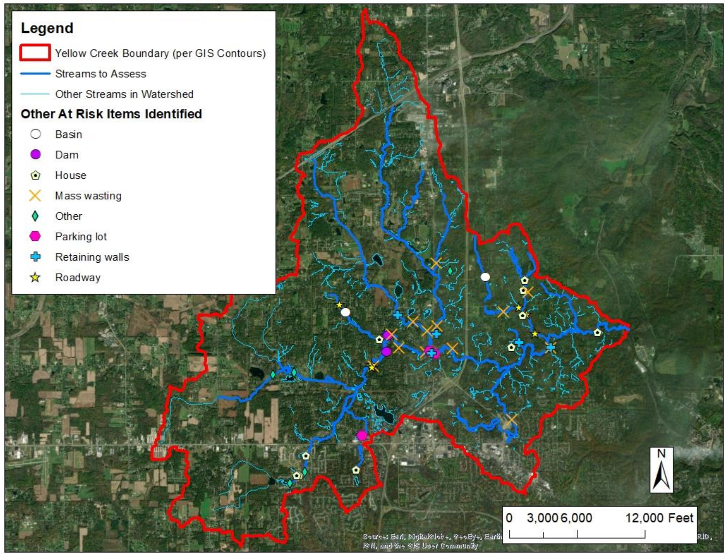
Relative stream instability risk throughout Yellow Creek watershed

6. Bank Protection Potentially within the Scope of the SWMD

Stream erosion undermining parking lot → public safety risk

Exposed pipes in bank show extents of bank erosion near Wastewater Facility

- Stream instability on private parcels that might have risks to public infrastructure
- Streams with relatively short banks
- Not adjacent to excessively large/ steep hillslopes



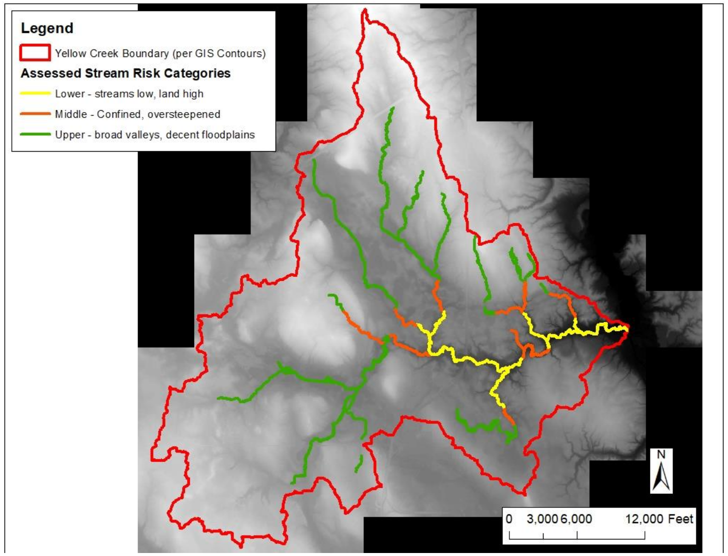
Various at-risk items in Yellow Creek watershed

7. Partial Bank Protection Potentially within the Scope of the SWMD

Mass wasting along ~70-ft tall bank

~40-foot tall, near vertical bank with mass wasting and tree loss

- Adjacent to tall, unstable hillslopes
- Public/private division along toe of slope
- Moving stream off toe of slope would reduce the risk of future undercutting
- Full geotechnical stabilization (e.g. retaining walls, etc.) likely outside the scope of the SWMD



Stream instability risk throughout Yellow Creek watershed

8. Programmatic/Non-Structural Improvements

- Optimization of stormwater design targets for new development
- Staff training/support
- Homeowner outreach/education
- Routine inspections and maintenance

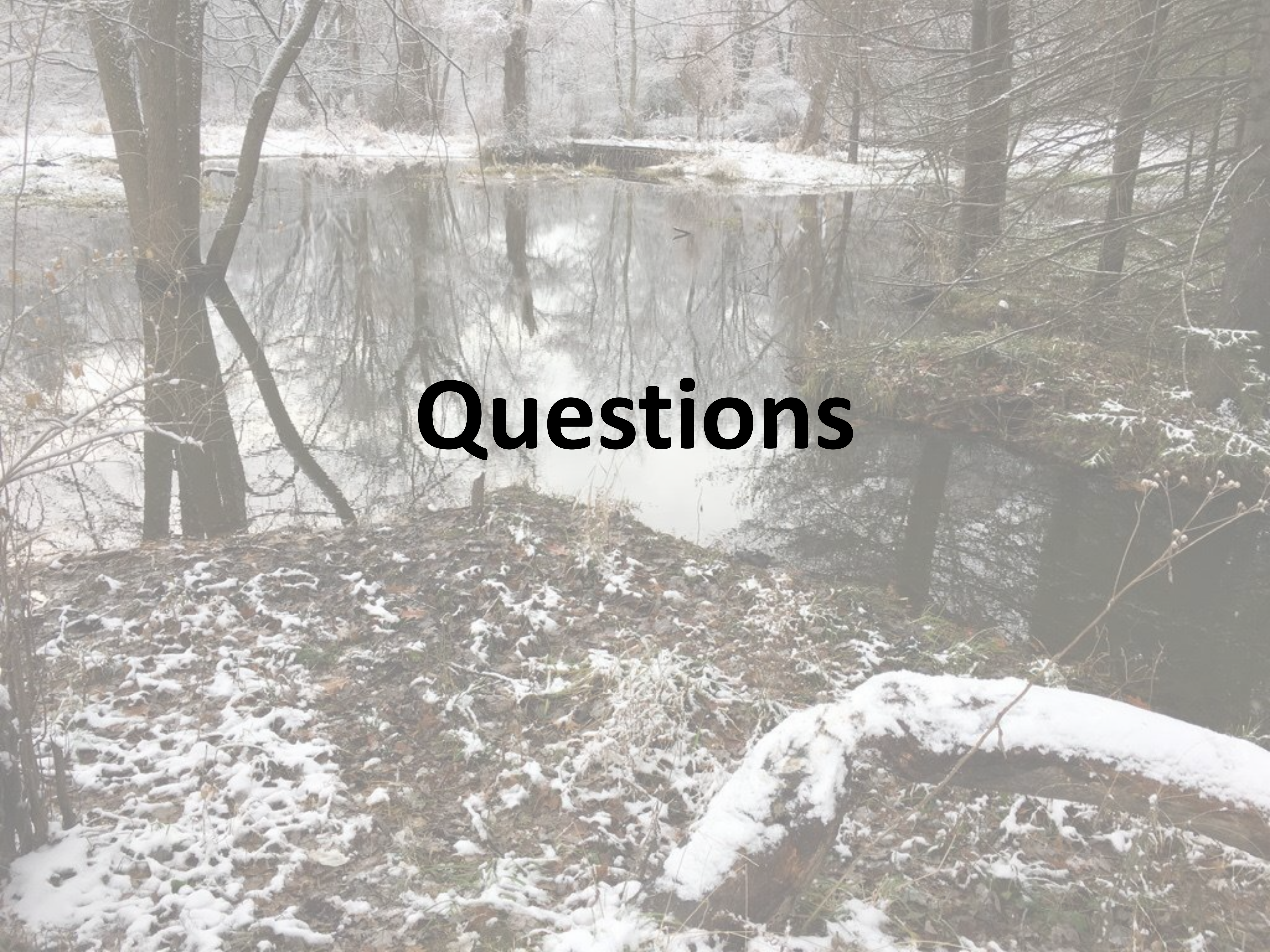
Literature from a workshop that addresses streambank instability

Septic tank maintenance is important to watershed health

Home-Owner Protection Examples from the Yellow Creek Watershed

Conclusion & Next Steps

- FINALIZE REPORT & CONCEPTUAL OPPORTUNITIES
- STAKEHOLDER INPUT
- PUBLIC/PRIVATE COORDINATION
- FINANCING
- IMPLEMENTATION PLAN



Questions