Legacy Sediment

What is it, Where is it,
How did it Get There, and
Why does it Matter?

Dr. Dorothy Merritts, Franklin and Marshall College
Dr. Robert Walter, Franklin and Marshall College

LEGACY SEDIMENT

Sediment that was eroded from upland areas …. that deposited in valley bottoms along stream corridors, **burying pre-settlement wetlands, streams, floodplains, and valley bottoms** ….

Legacy sediment often accumulated behind **ubiquitous low-head mill dams** and in their slackwater environments, resulting **in thick accumulations of fine-grained sediment** …..

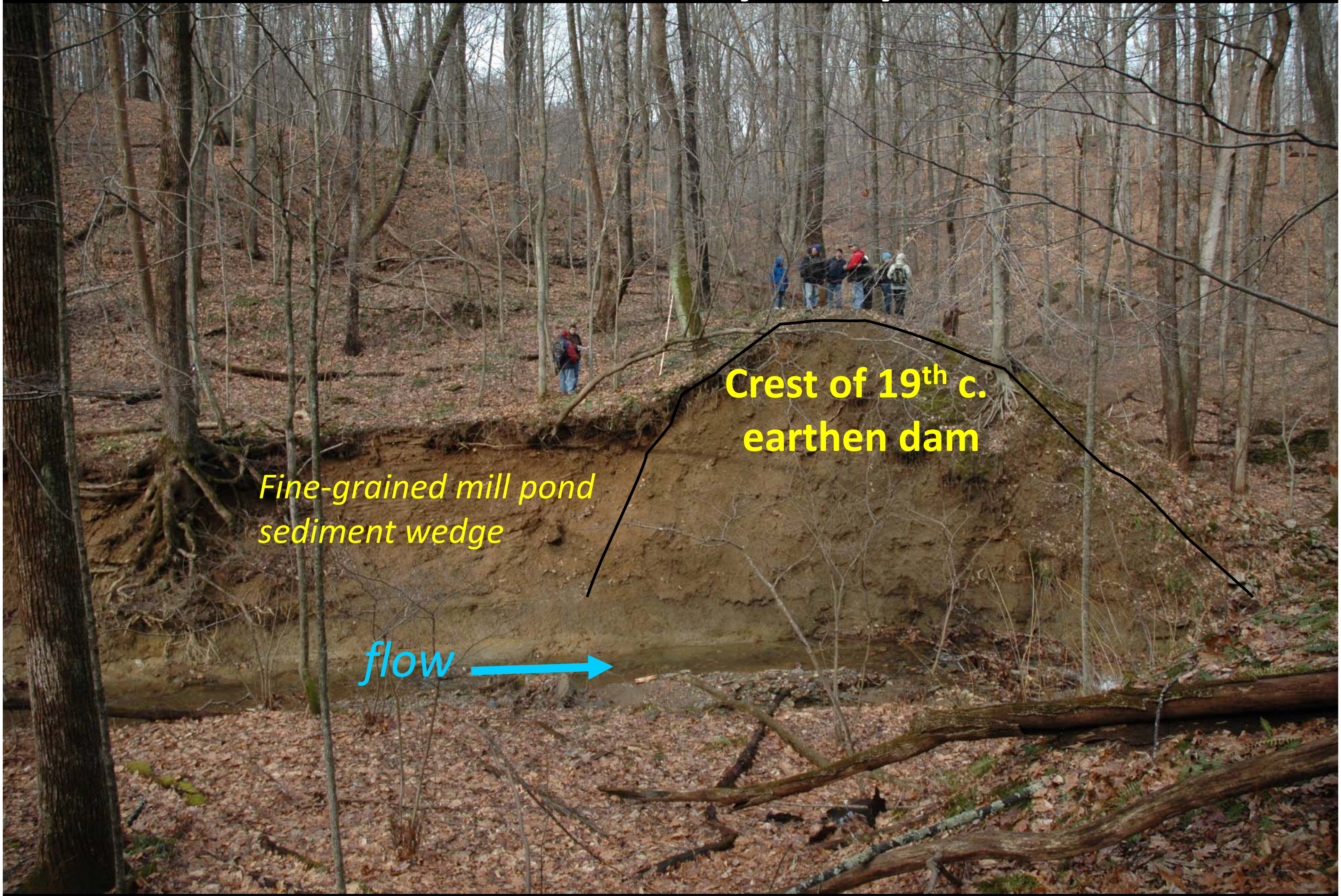
LEGACY SEDIMENT

Sediment that was eroded from upland areas after the arrival of early Pennsylvania settlers and during centuries of intensive land uses; that deposited in valley bottoms along stream corridors, burying pre-settlement wetlands, streams, floodplains, and valley bottoms; and that altered and continues to impair the hydrologic, biologic, aquatic, riparian, and water quality functions of pre-settlement and modern environments. Legacy sediment often accumulated behind ubiquitous low-head mill dams and in their slackwater environments, resulting in thick accumulations of fine-grained sediment that contain significant amounts of nutrients.

[Note: Thin soils and young or no trees on legacy sediment.]

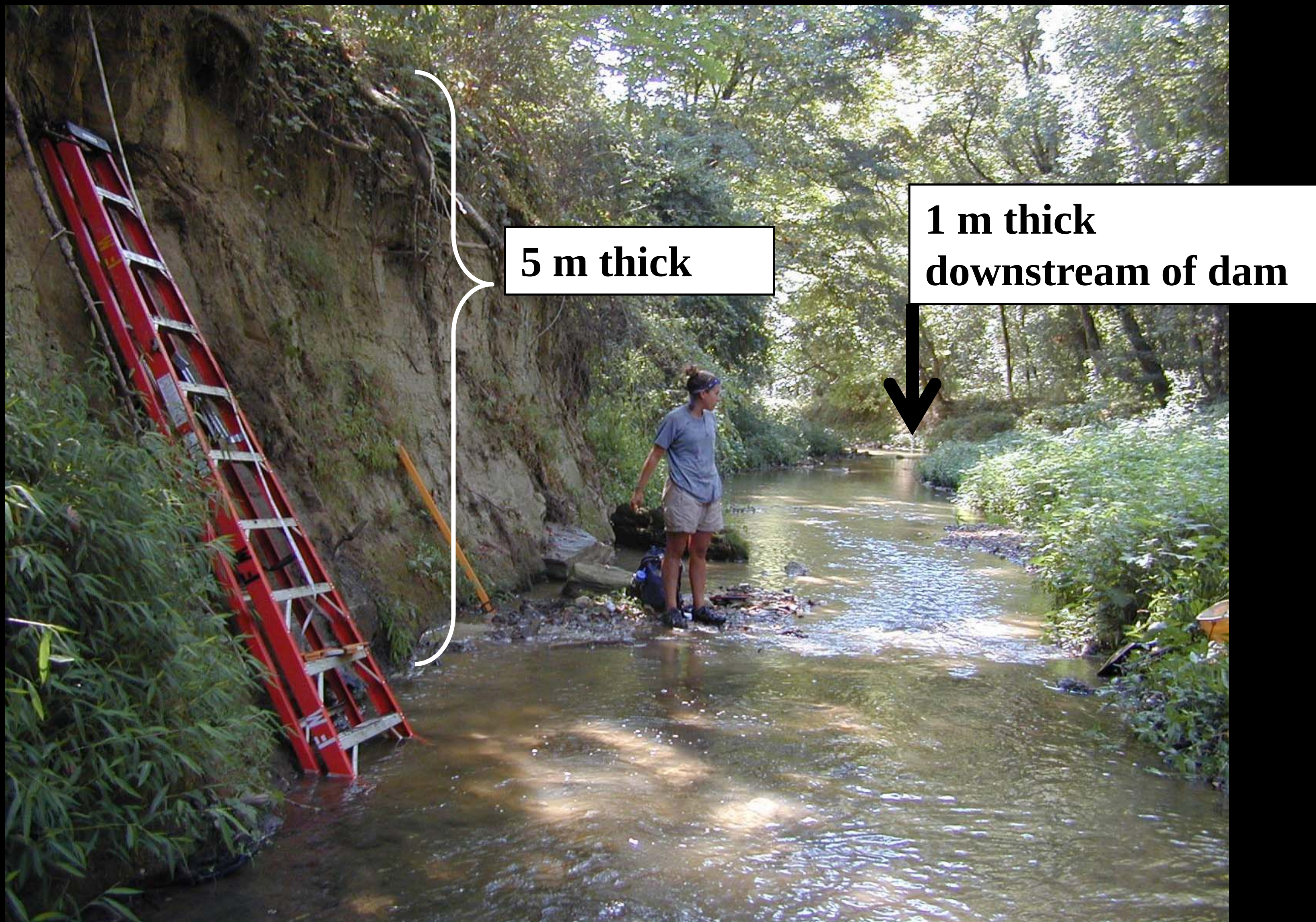
PA DEP http://www.depweb.state.pa.us/chesapeake/lib/chesapeake/pdfs/legacy_sediment_definitions.pdf

Mill Dam Reservoirs Bury Valley Bottoms



Sediment to level of Spillway, Panther Branch Tributary to **Gunpowder Falls, MD**, 2008

Mill Pond Reservoir Sediment Stacks form Wedges



Denlinger's Mill, W. Br. Little Conestoga, PA

Mill Pond Reservoir Sediment Wedge Upstream of Dam

Denlinger's Mill, W. Br. Little Conestoga, PA

Legacy Sediment Buries Stable, Resilient Wetlands

Pond deposits draped on former organic-rich valley bottom (wetland, hydric soil)

Western Run, Maryland

Historic reservoir sediment burying pre-Colonial marsh, Watkins Mill, Seneca Creek, MD

Historic reservoir sediment onlap with Pleistocene (?) colluvium, overlain by recent colluvium

Holocene peat core, wetland seeds

Alder sp. (OBL) [Alder]

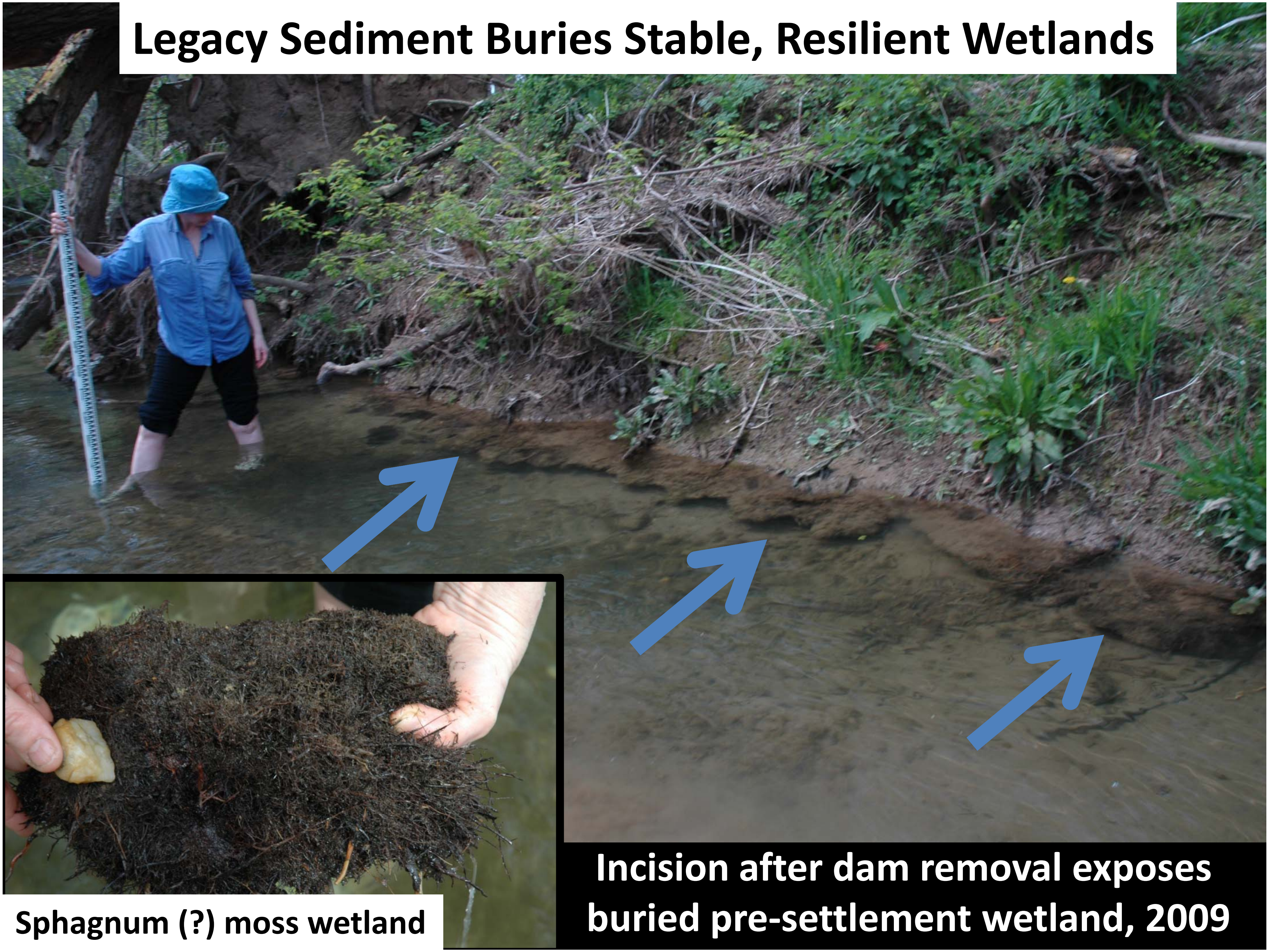
mm scale

Carex sp (OBL) [sedge]

Legacy Sediment Buries Stable, Resilient Wetlands

Incision after dam removal exposes buried pre-settlement wetland, 2009

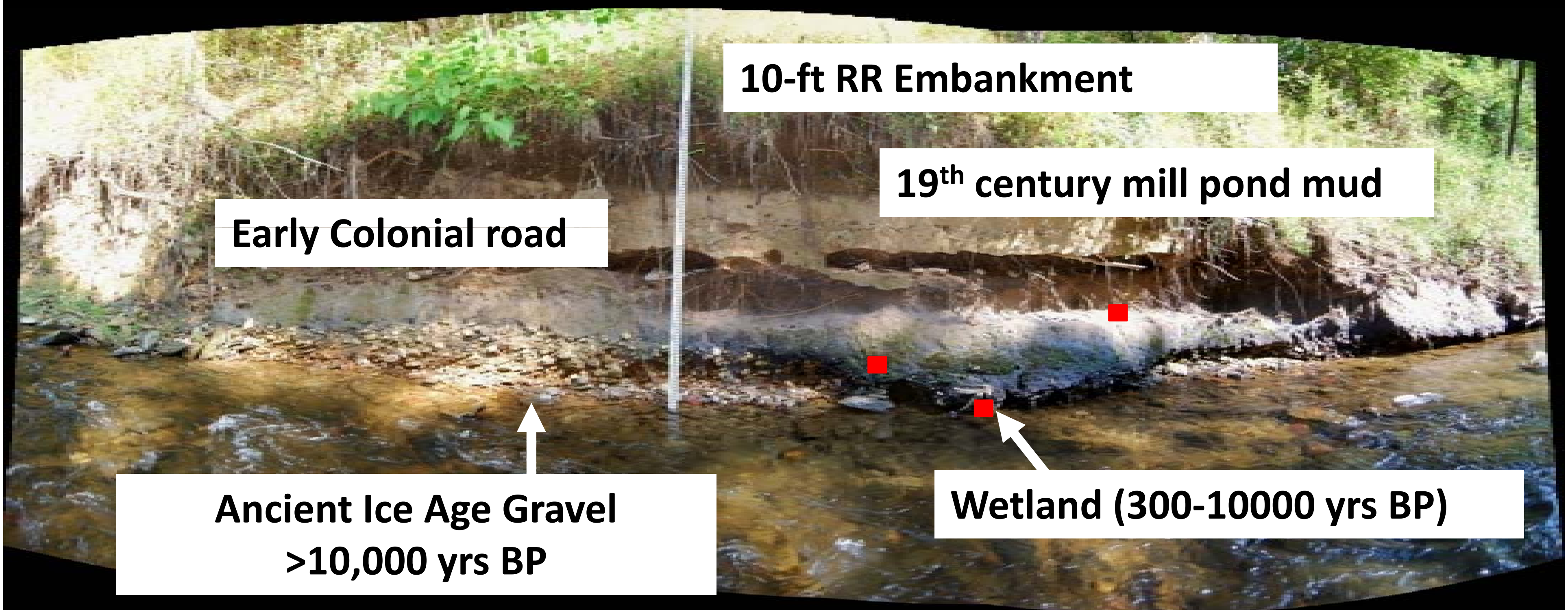
Legacy Sediment Buries Stable, Resilient Wetlands



Sphagnum (?) moss wetland

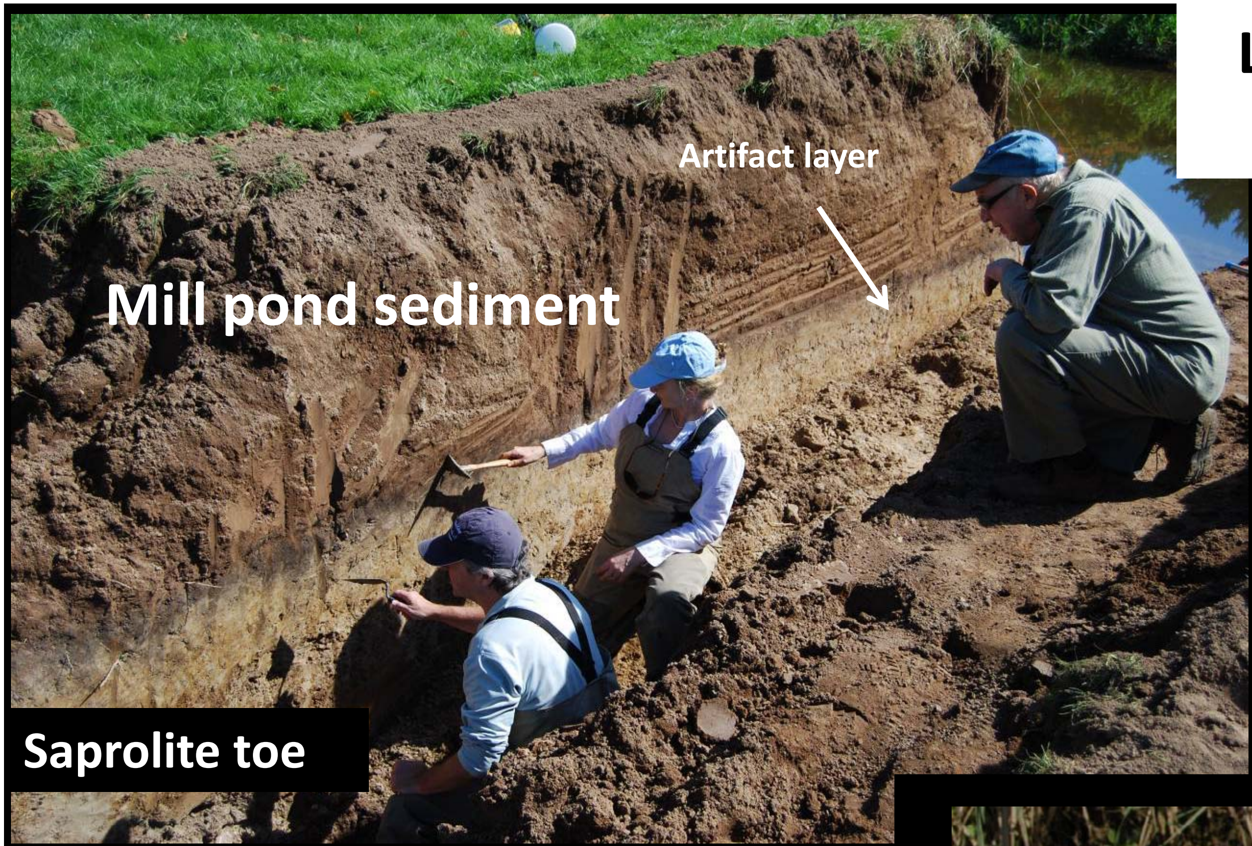
Incision after dam removal exposes buried pre-settlement wetland, 2009

Stable Wetlands and Early Colonial Roads Buried by Millpond Mud, Little Falls, MD



E. Cranmer, F&M thesis, 2008-09

Legacy Sediment Buries the Toes of Hillslopes



Millpond mud burying c. 1730 AD toe of hillslope with Holocene soil

Conoy Creek, Elizabethtown

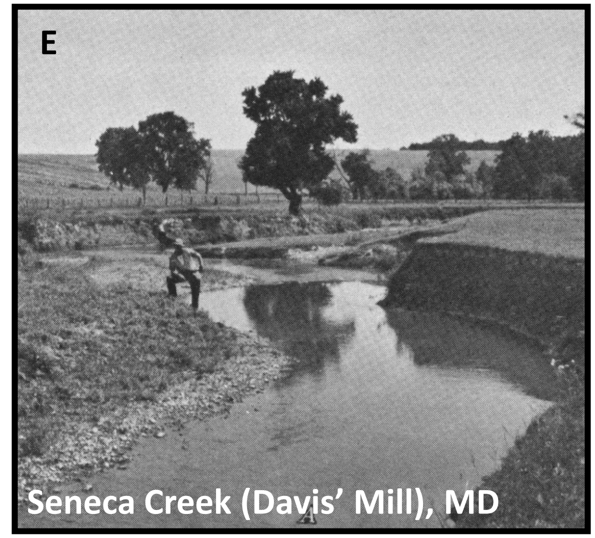
Susquehanna broadspear beneath mill pond sediment

~4000 yrs old

A

B

E



From Wolman and Leopold, 1957, *On the Origin of Floodplains*

C

D

F

Streams in various stages of post-dam breach conditions

CLINTON, NEW JERSEY—THE RED MILL

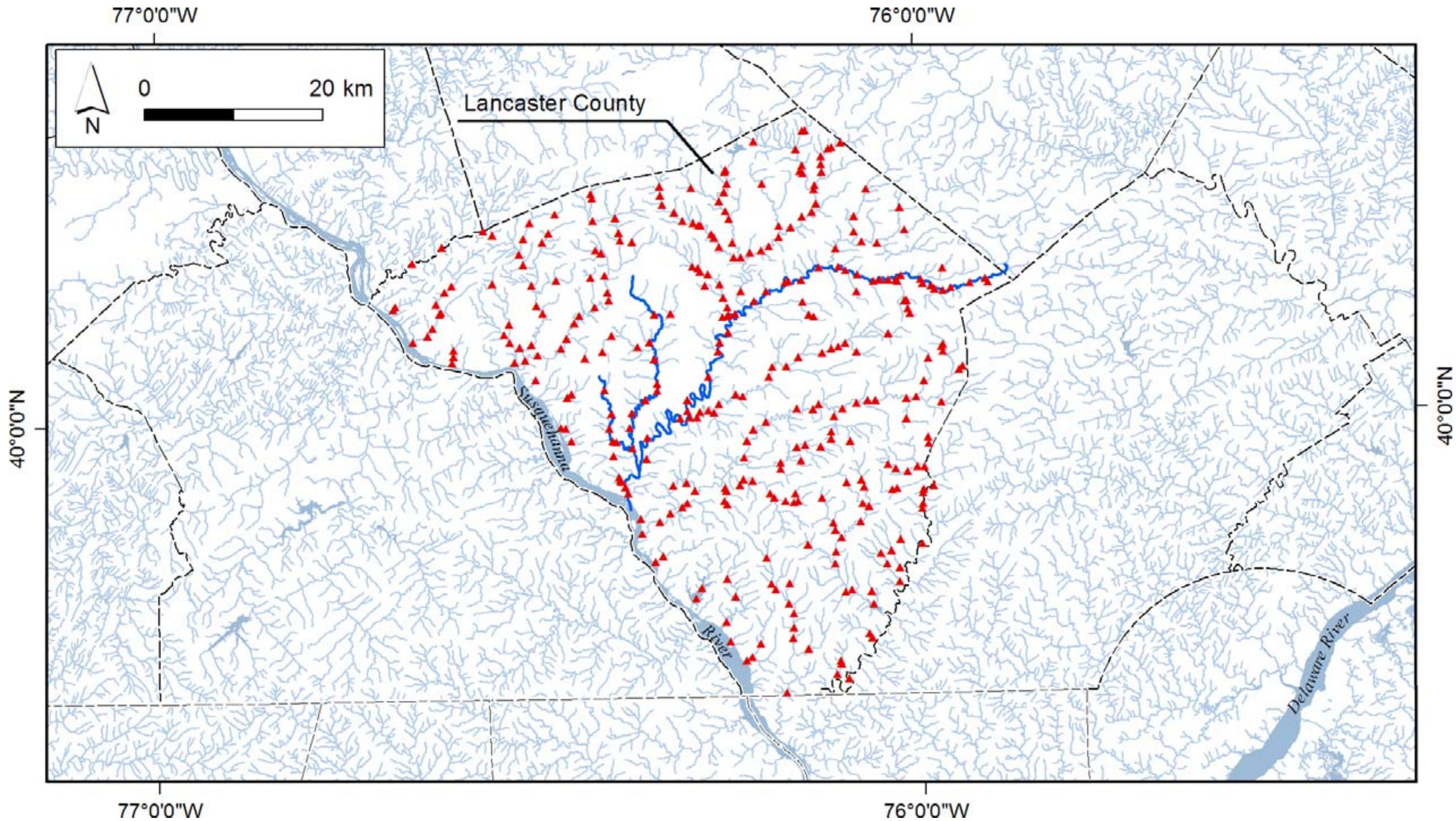
The historic 1810 Red Mill is known across the country as a photogenic symbol of early America's rural industry….. originally built as a woolen mill. …. used at different times to process grains, plaster, talc and graphite, to generate electricity and pump water for the town.

Historic Map Wissahickon Creek, PA, 1868

> A dozen dams and ponds

Historic Evidence of Anthropogenic Impacts:

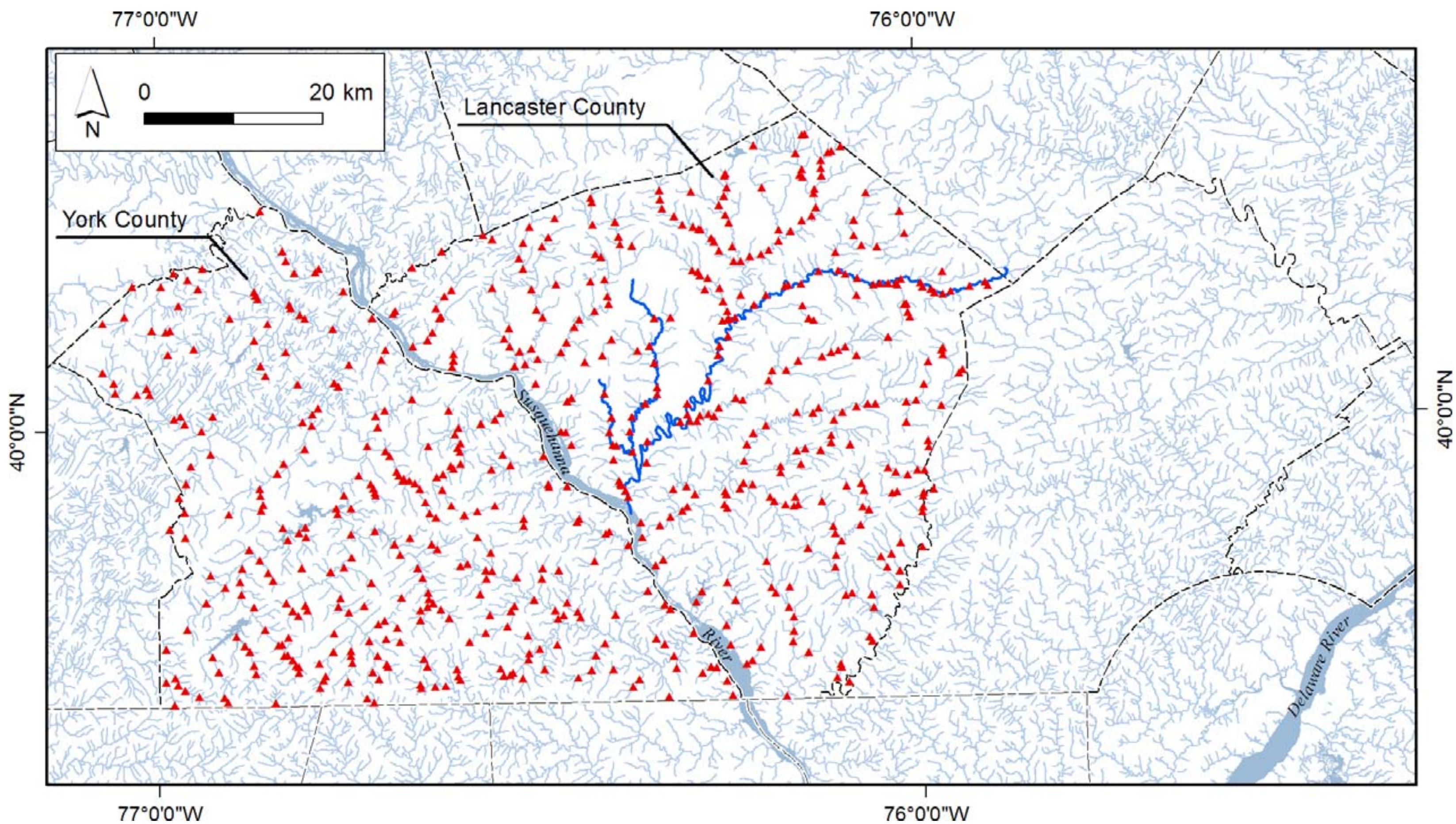
Many Early American Dams (i.e., Sediment Sinks)



~400 mill dams in 19th C. Atlases of Lancaster County, Pennsylvania

▲ Location of mill dams

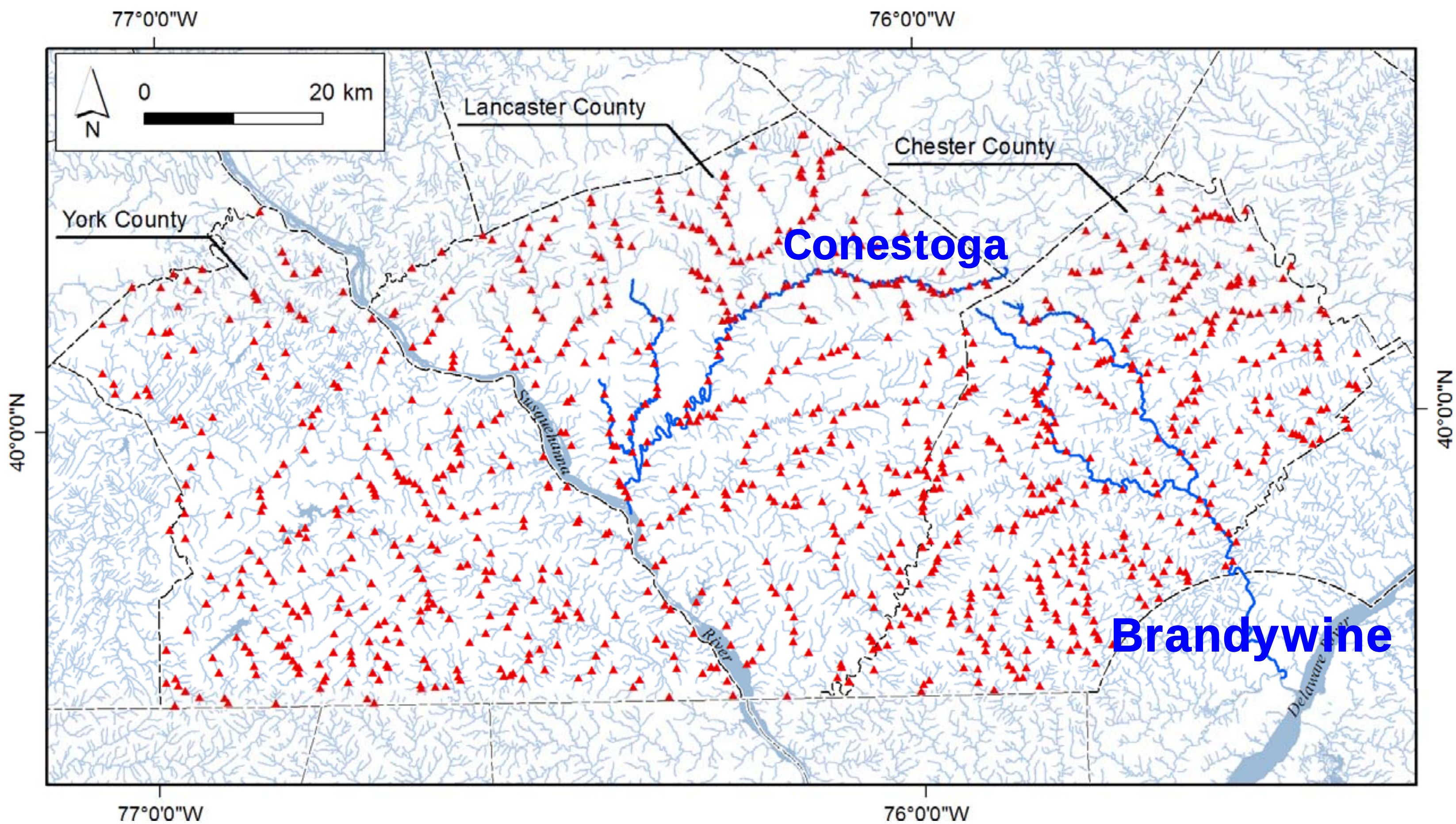
Many More Early American Dams



~800 mill dams in 19th C. Atlases of York and Lancaster Counties

▲ Location of mill dams

>1000 Early American Dams in 3 Pennsylvania Counties
About 1 dam every 2 to 3 km



Over 1,000 mill dams in 19th C. Atlases of York, Lancaster & Chester Counties

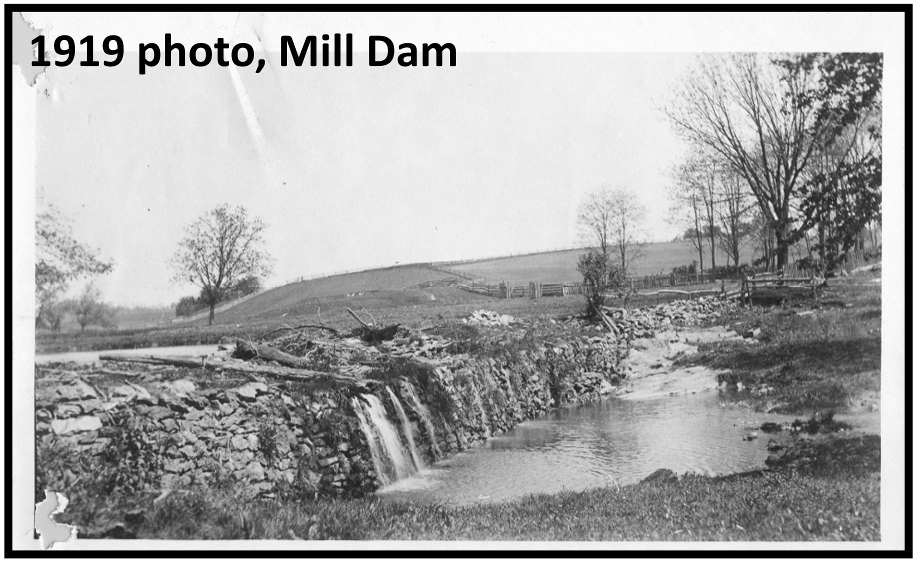
▲ Location of mill dams

Go to the following website to see examples of interactive maps of mill dams for Lancaster, York, Chester, Centre, and Huntingdon Counties in Pennsylvania, and for Baltimore and Montgomery Counties in MD

[note: be sure to click on different maps using the "filter by citation" option in upper right of web page for county mill dam maps]

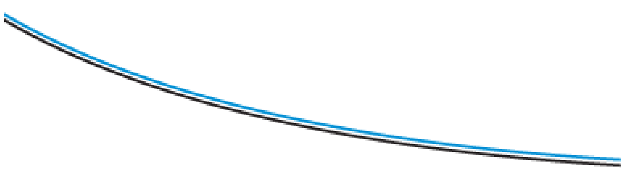
http://www.fandm.edu/x17479

Base-Level Rise and Fall: Dam Building and Dam Breaching

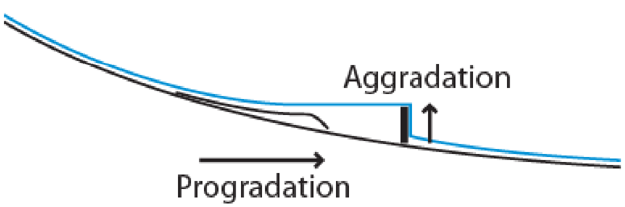


Flume experiments Dr. Allesandro Cantelli, Univ of Minnesota

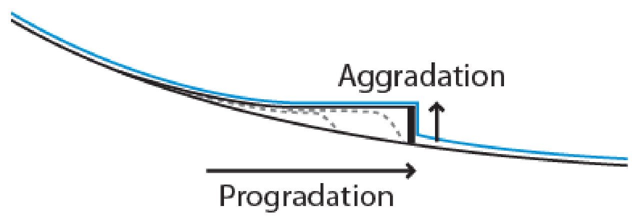
1. Graded stream profile



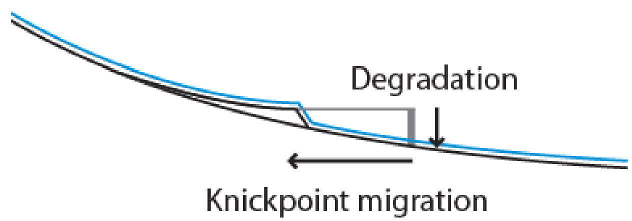
2. Base level rise / Dam building



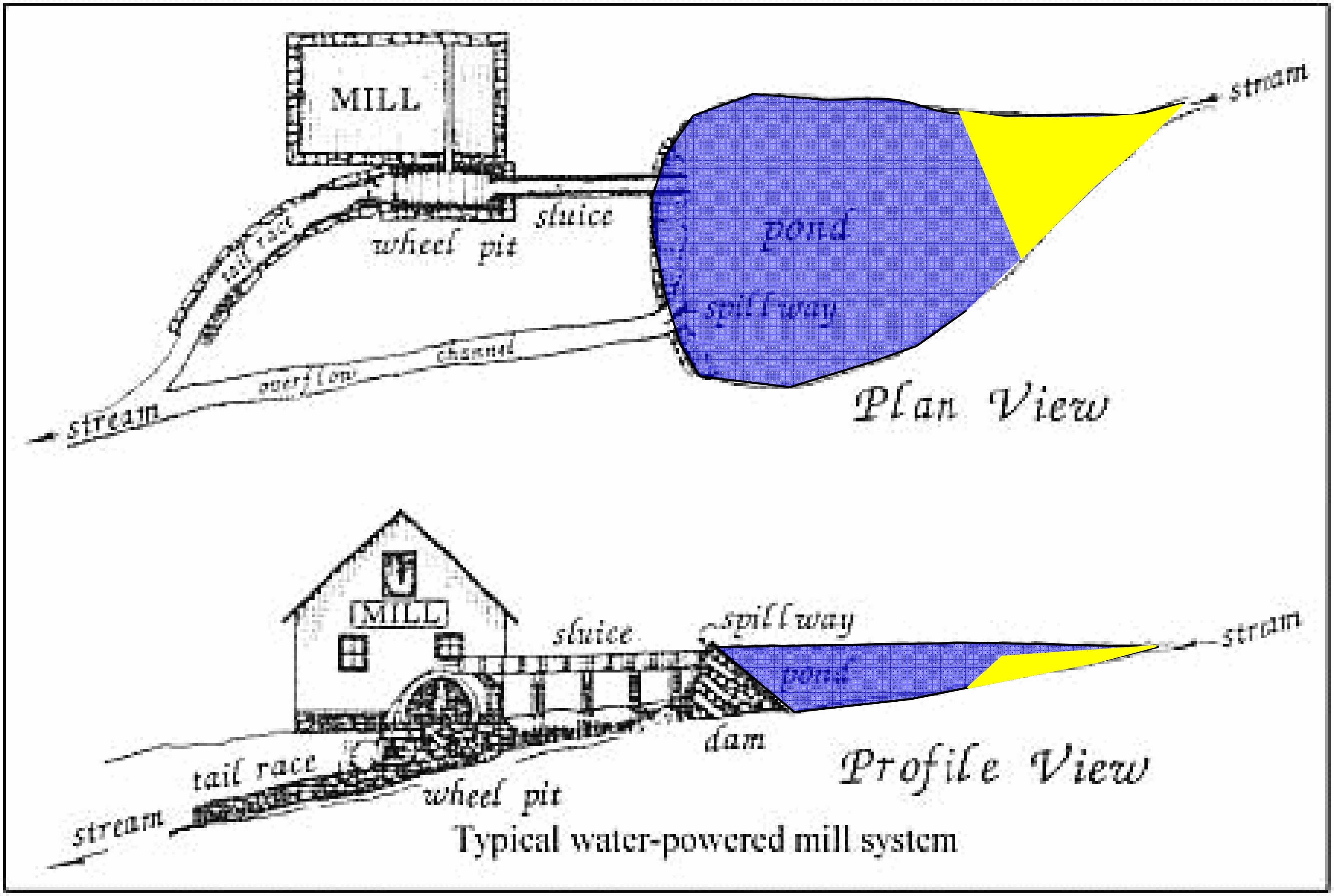
3. Reservoir filling



4. Base level fall / Dam breaching



IMPACT OF MILL DAMS
ON SEDIMENT STORAGE IN VALLEYS



From: Mills on the Tsatsawassa: Techniques for Documenting Early 19th Century Water-Power Industry in Rural New York, by Philip L. Lord

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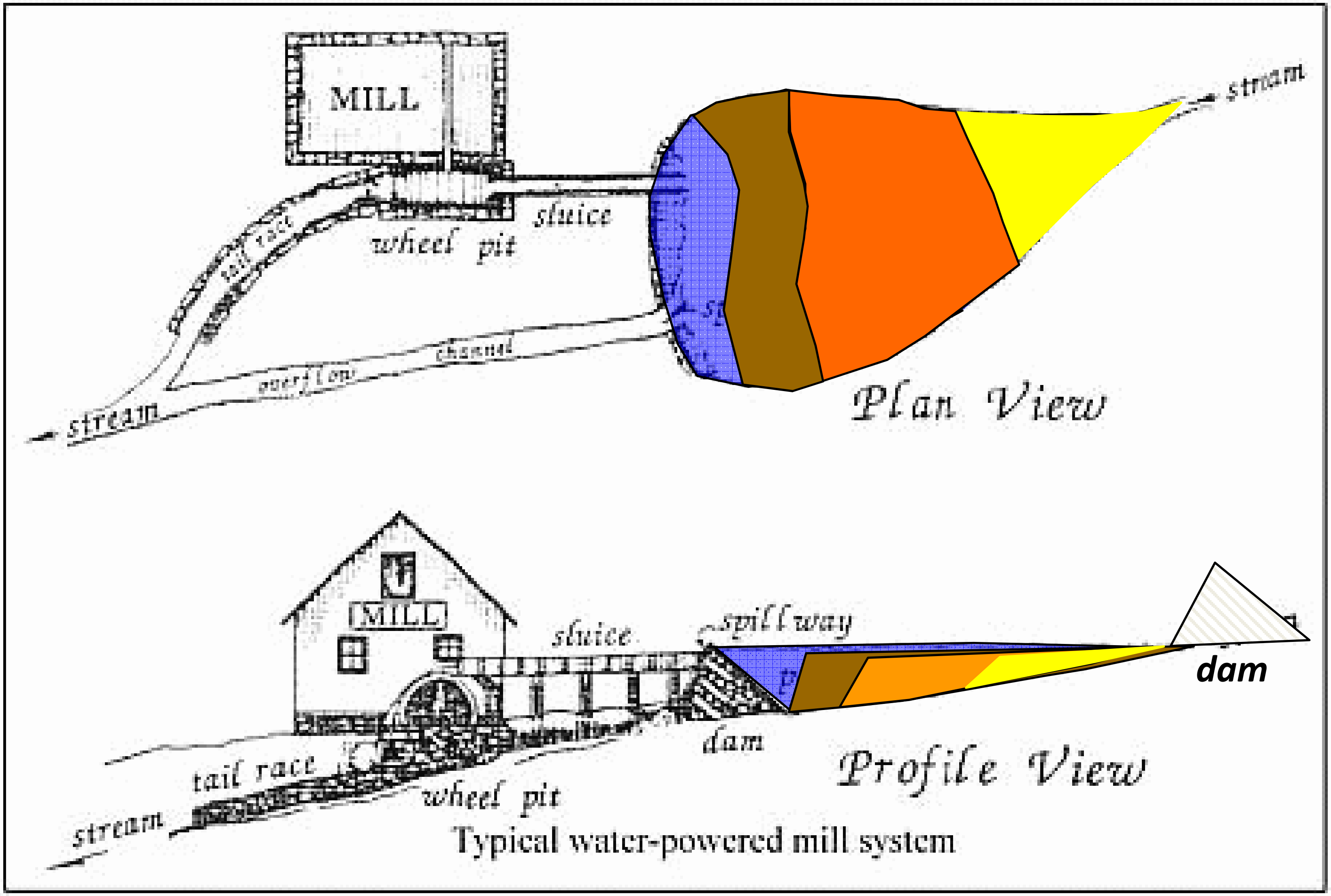
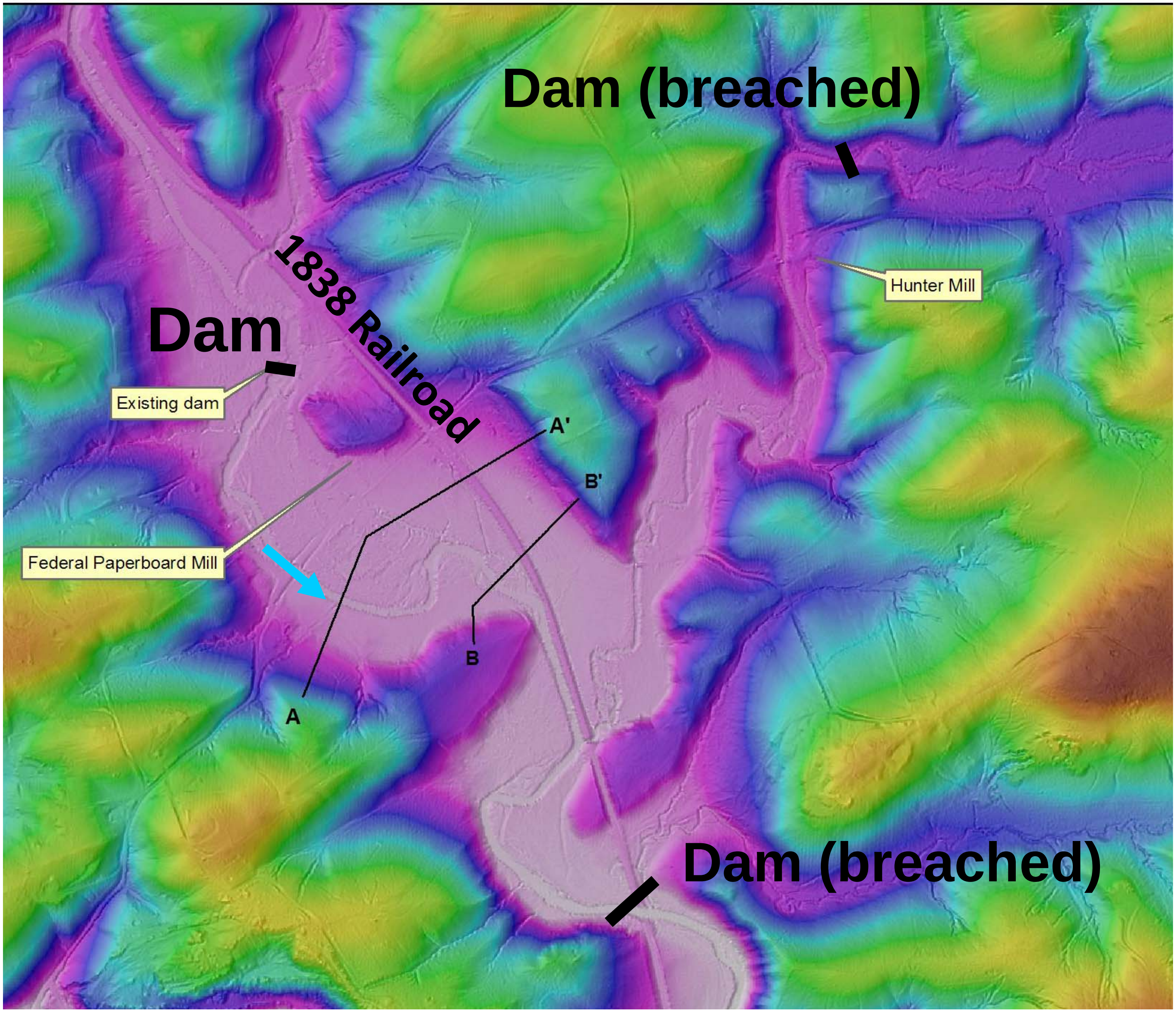
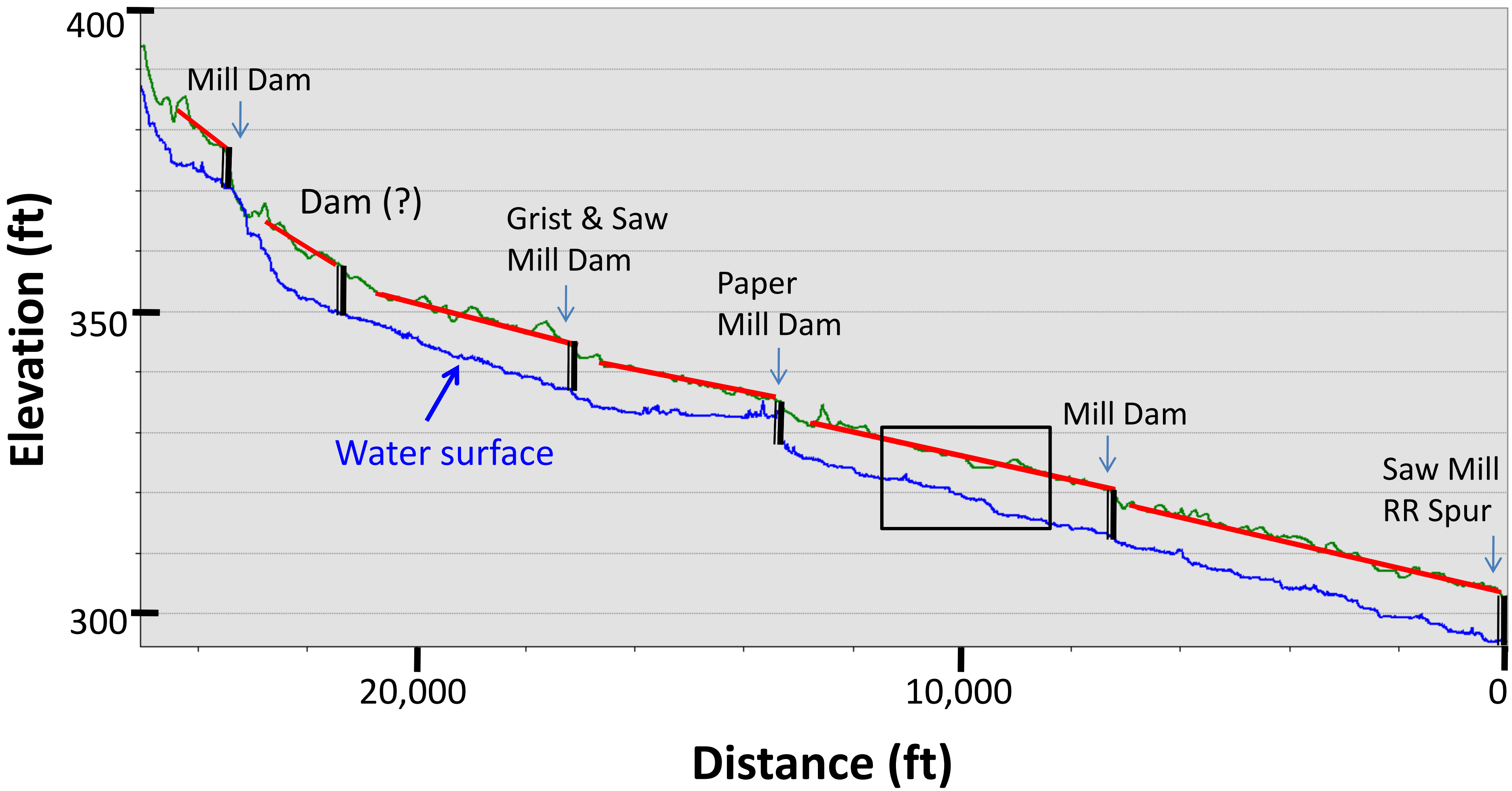


Backwater Effects and Mill Pond Sediment, Little Falls, MD



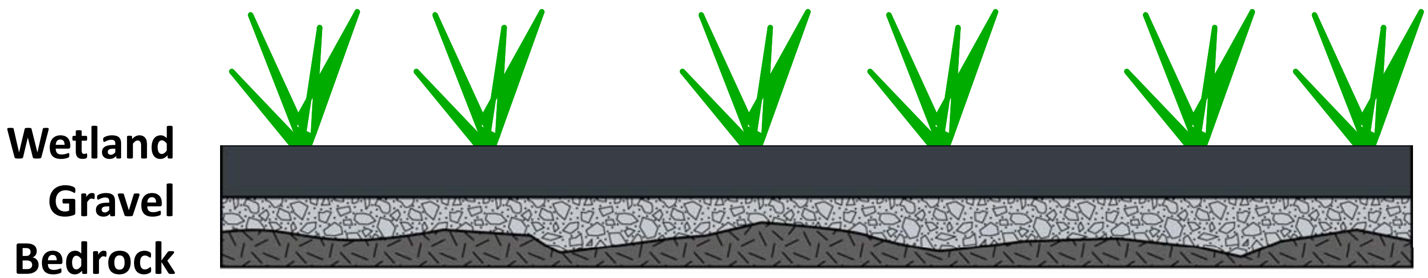
Historic Mill Dams and Reservoir Fill Surfaces, Little Falls, MD

Can trace pond surfaces (fill terraces) to crests of dams



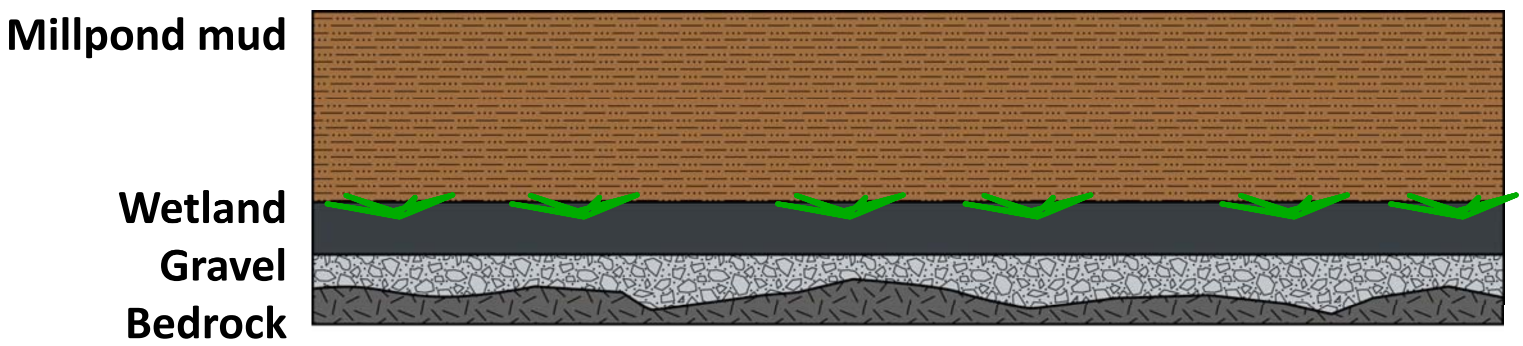
Long profiles from LiDAR

Holocene (pre-settlement) wetlands on Pleistocene gravel



Wetlands from valley wall to valley wall,
and no evidence of buried single-thread stream channels

Post-settlement millpond mud on Holocene wetlands on Pleistocene gravel



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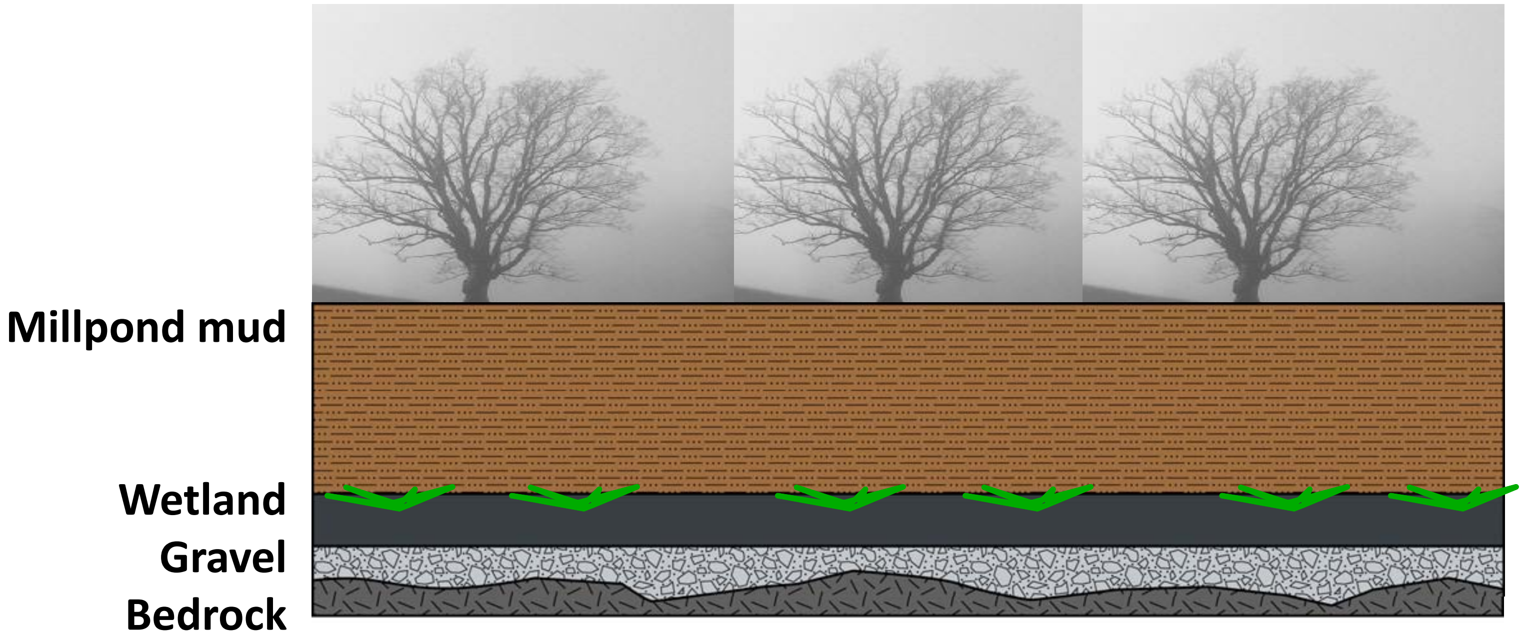

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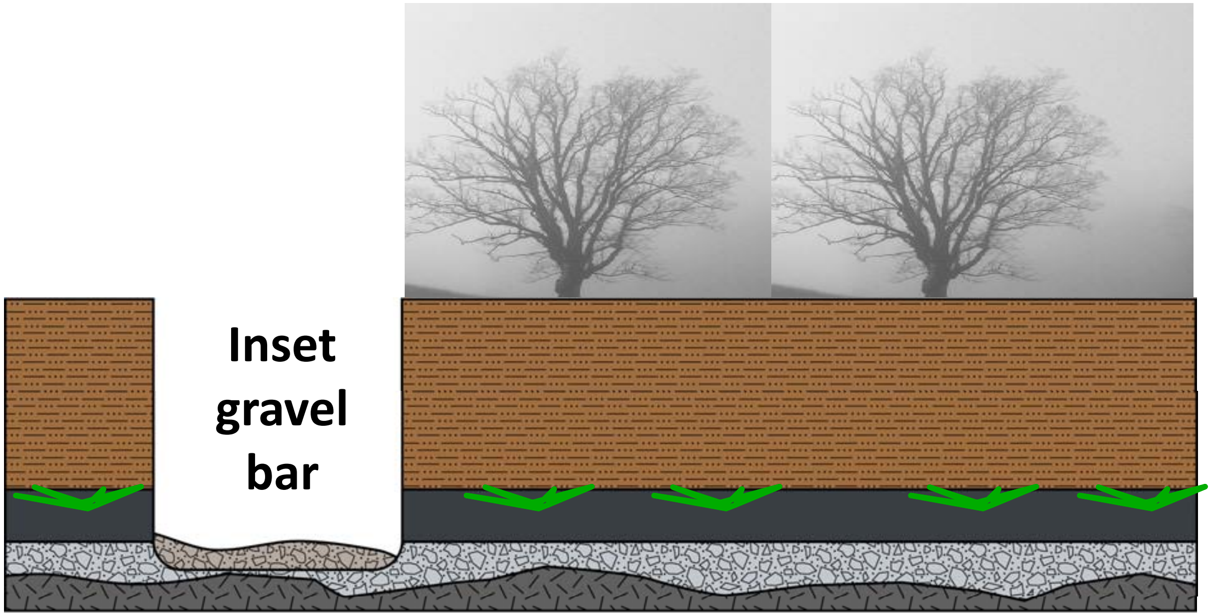
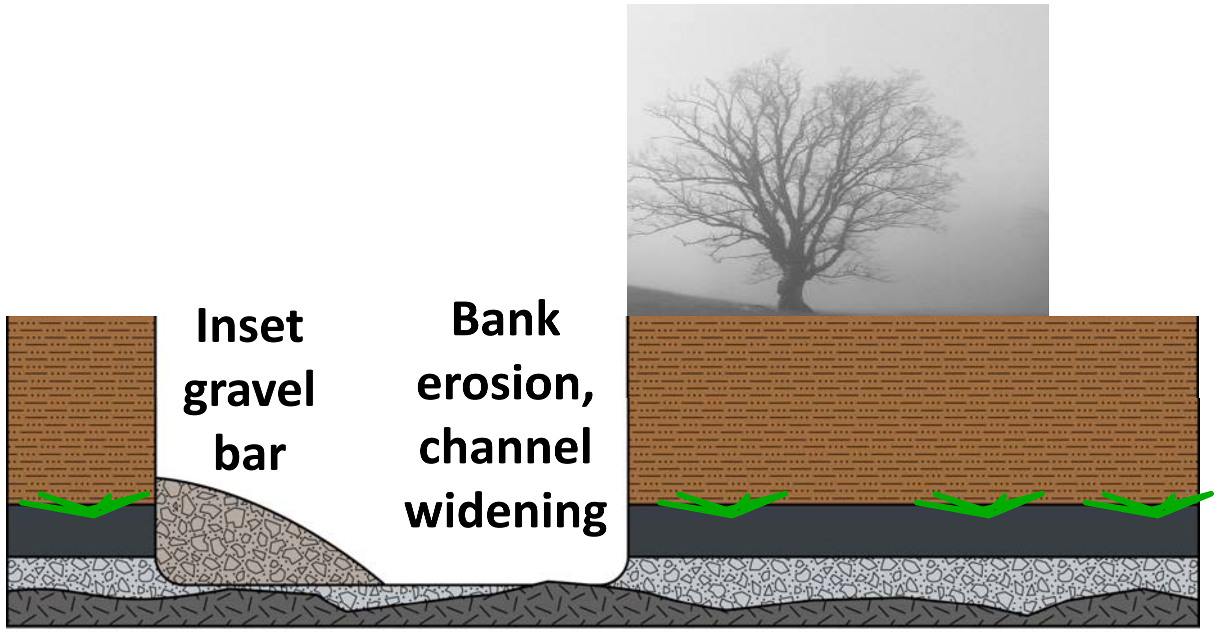


Modern inset
sand/gravel bars

DAM BREACH



With time, width increases and depth decreases for a given runoff event, thus shear stress decreases.

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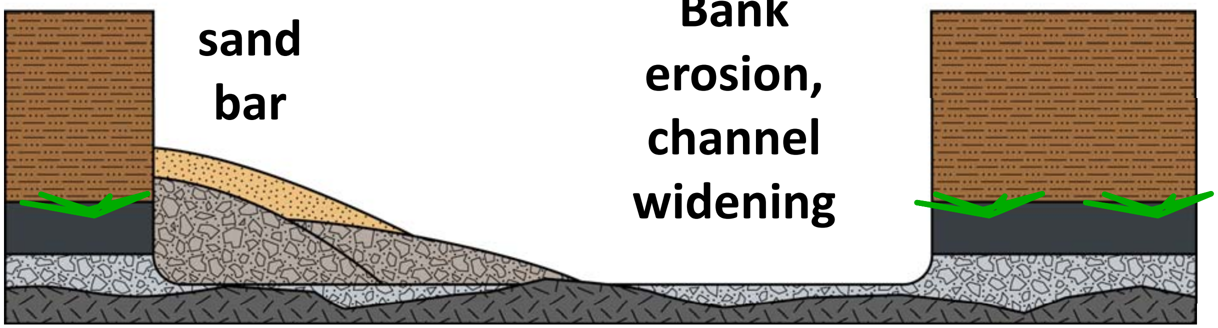

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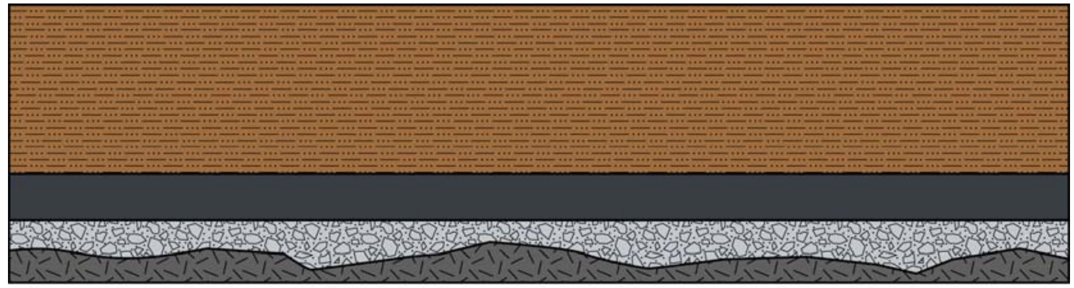
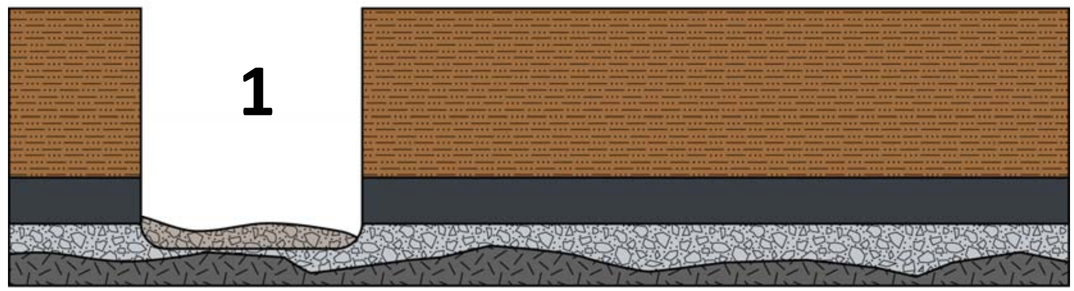
Modern Landscapes

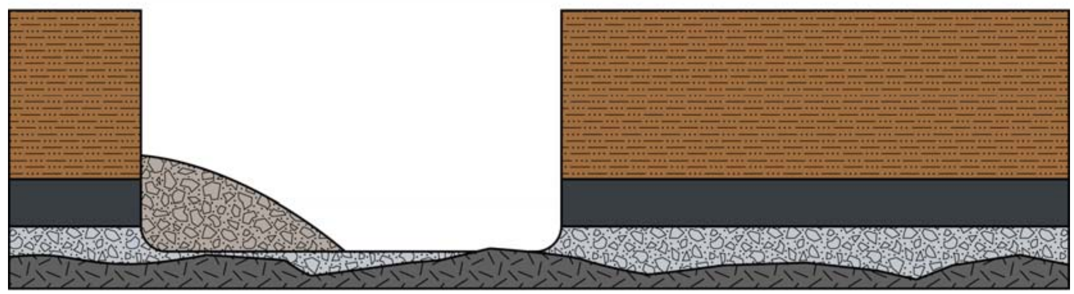
Dam in place; pond



Recent dam breach

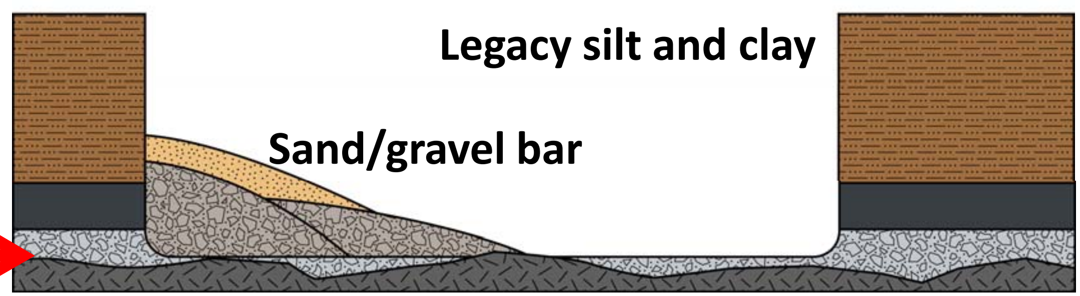


Widened channel with
gravel bars



Large channel; gravel transport
diminishing; buried wetland gone

GROUNDWATER/BASE FLOW →



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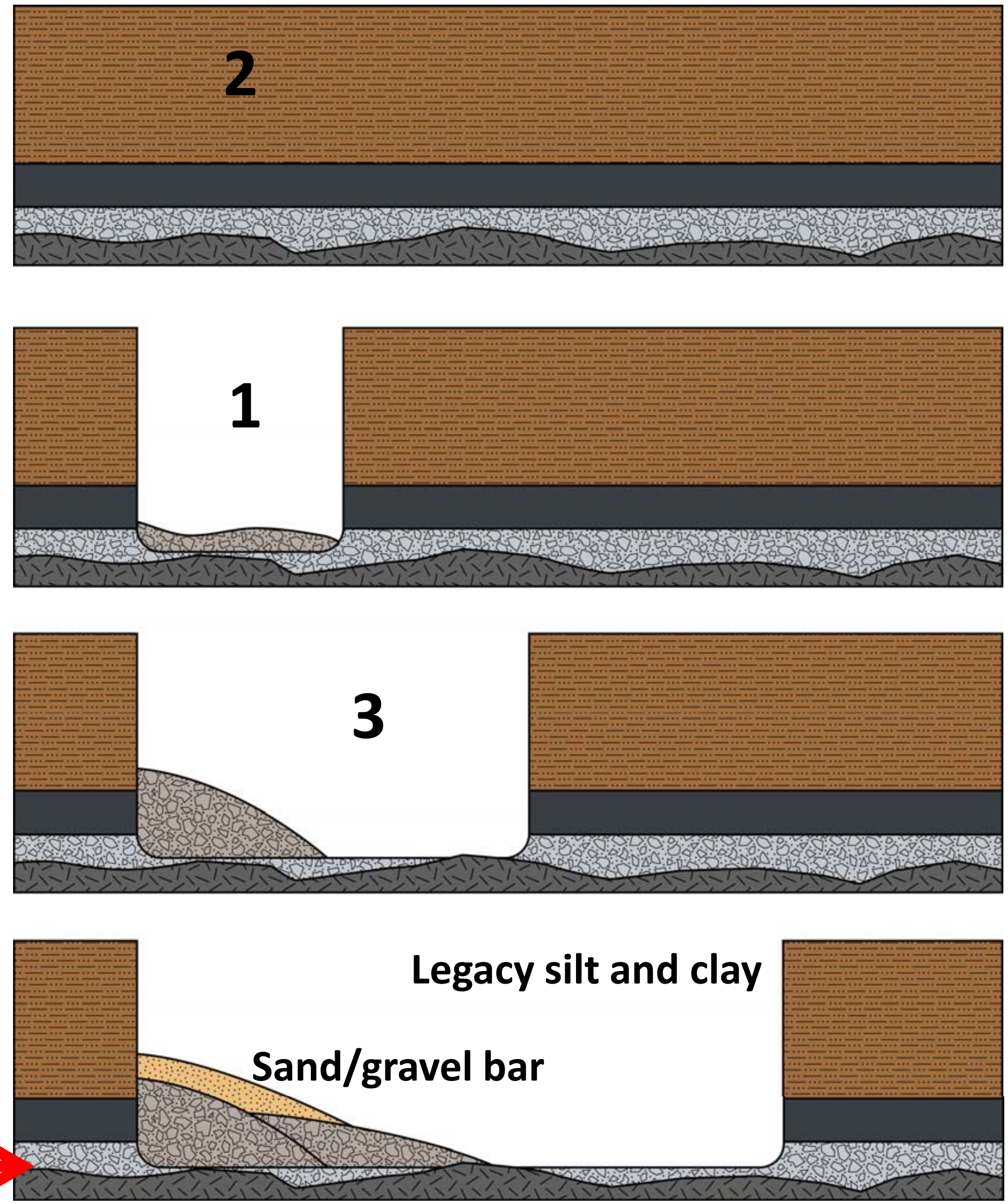
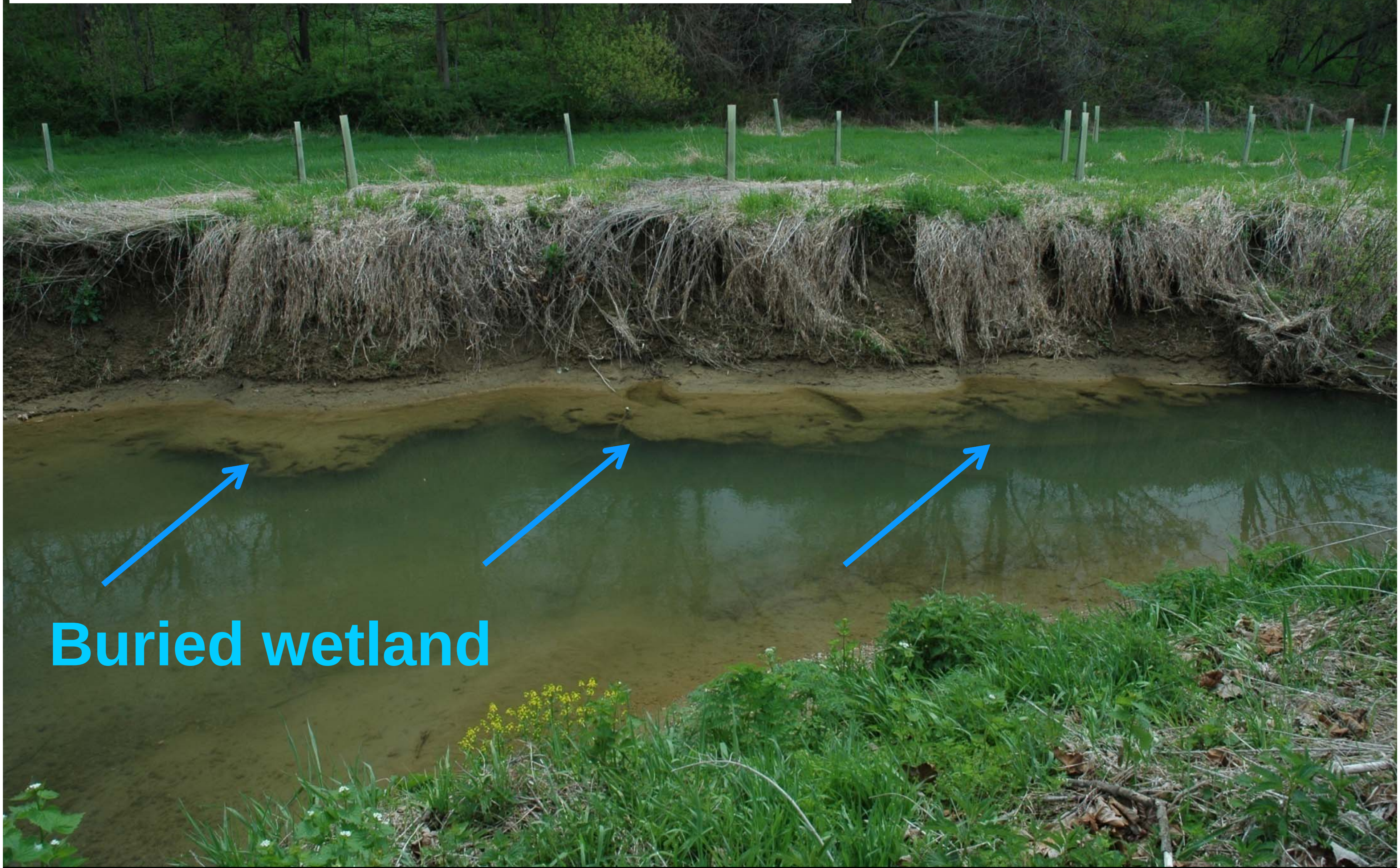


EXAMPLE 1: RECENT BREACH

Incision 6 months after dam removal, April 2009

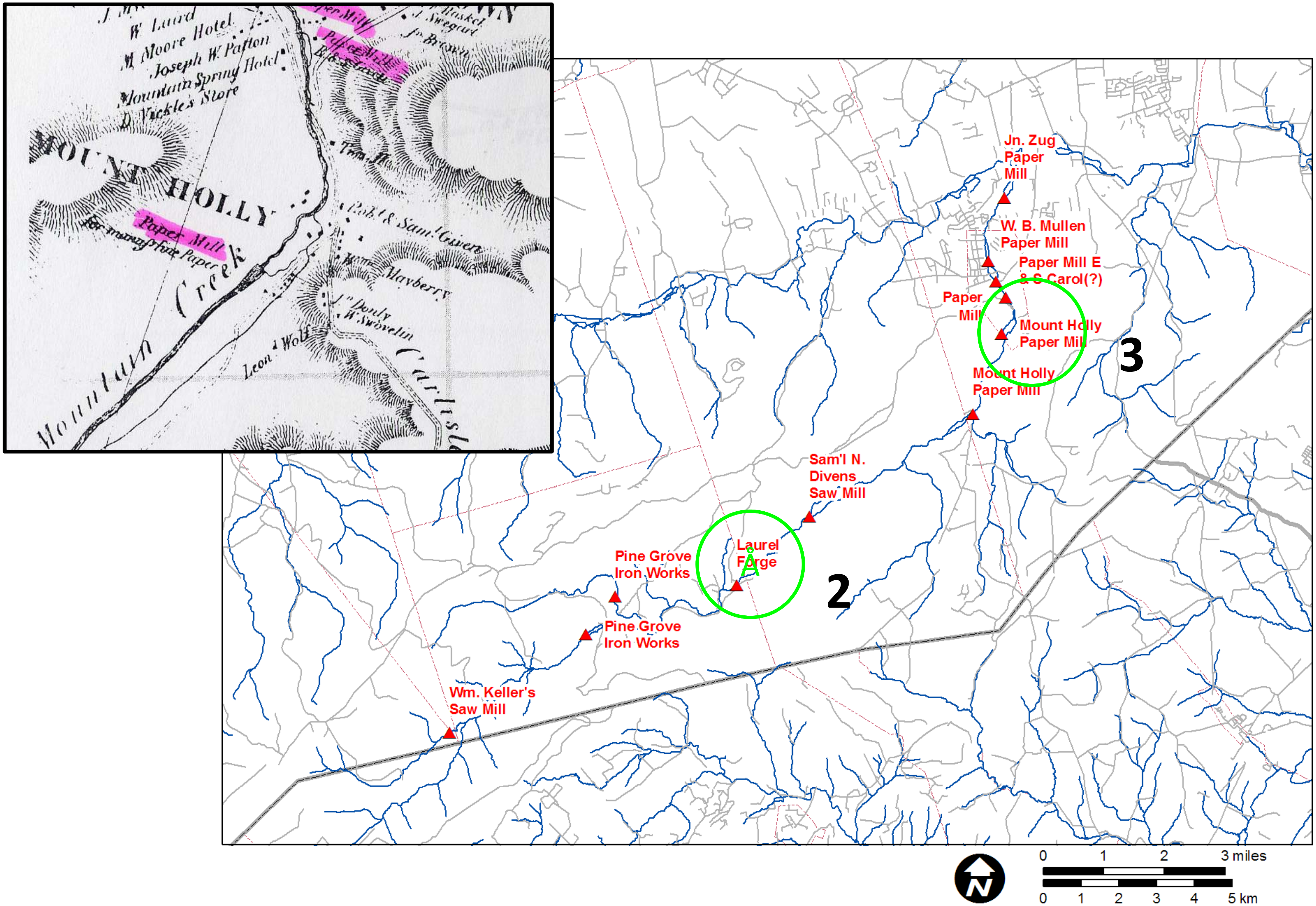
Boulders and tree planting 6 months after dam removal

Legacy Sediment Buries Stable, Resilient Wetlands

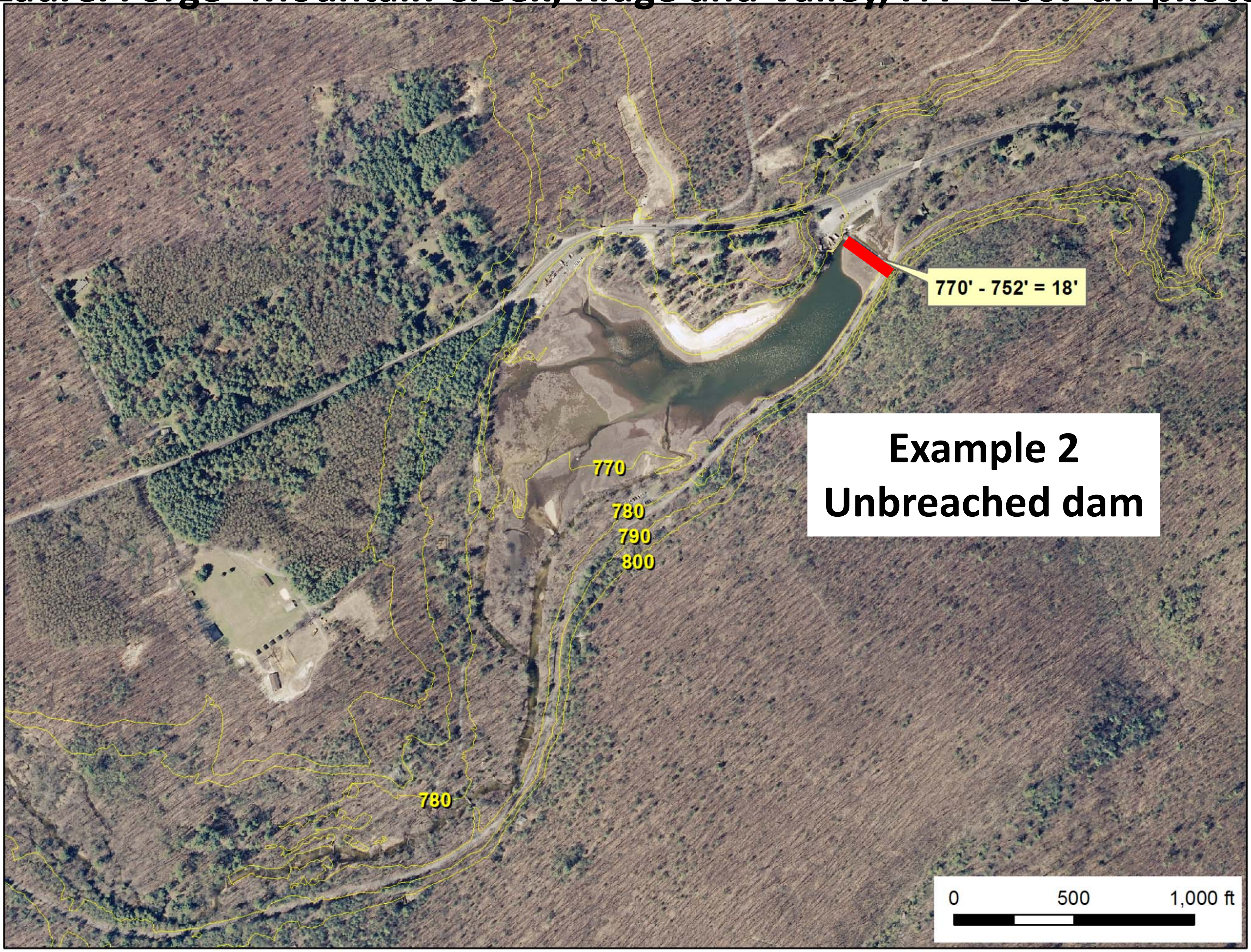


Post-dam removal stream incised below pre-settlement wetland, 2009

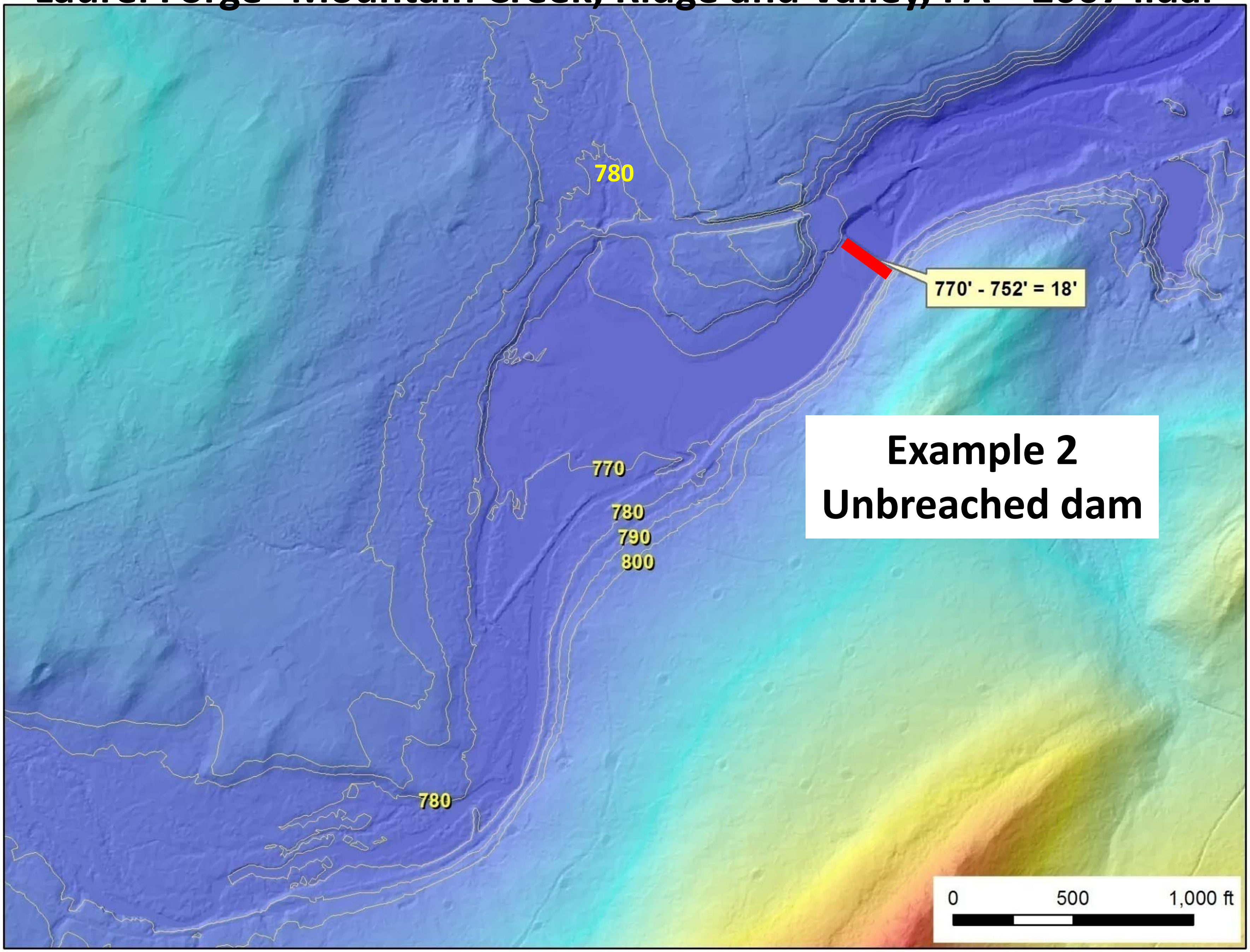
Mill Dams on Mountain Creek, Mt Holly Springs, Ridge &Valley, PA



Laurel Forge--Mountain Creek, Ridge and Valley, PA—2007 air photo

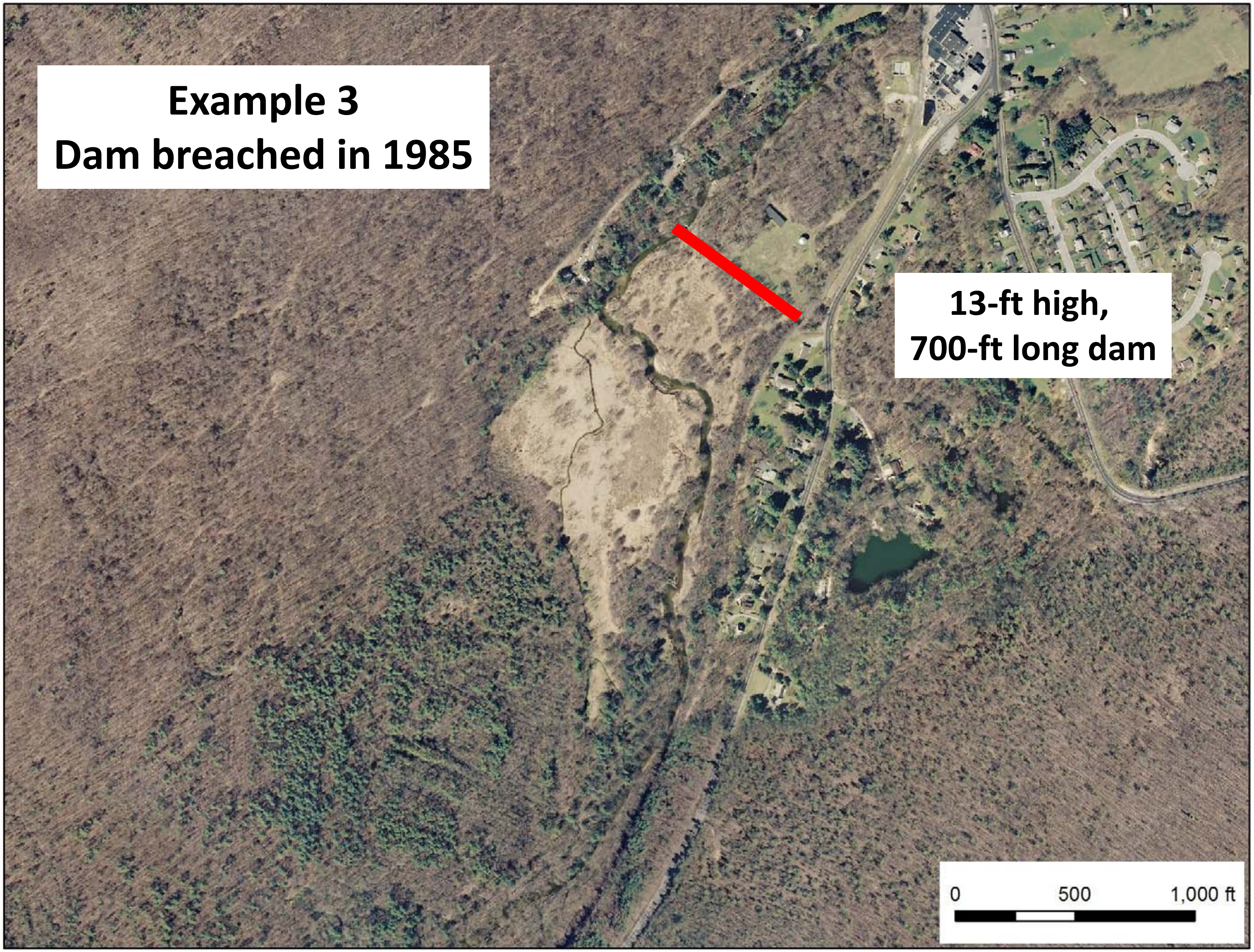


Laurel Forge--Mountain Creek, Ridge and Valley, PA—2007 lidar

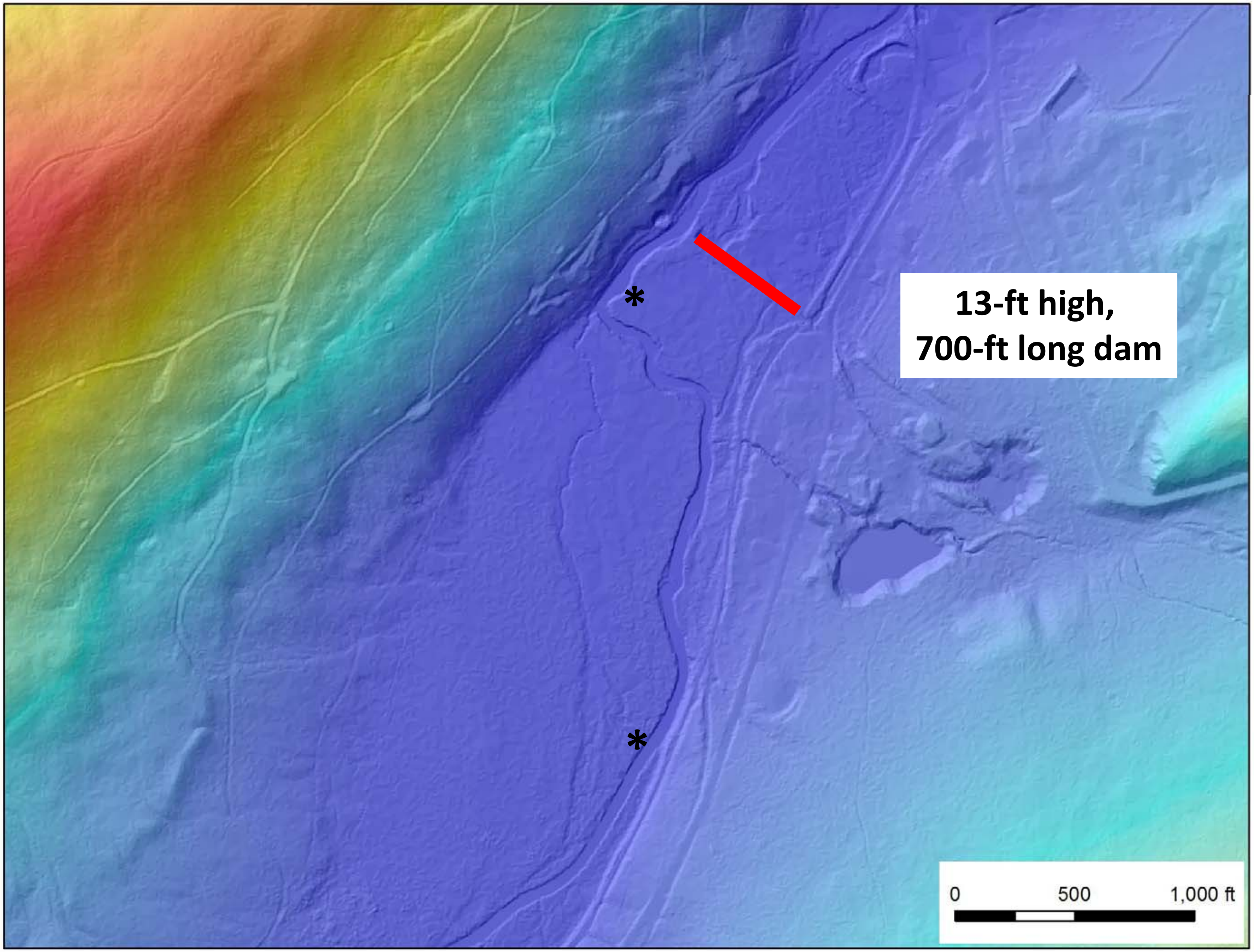


Mt Holly--Mountain Creek, Ridge and Valley, PA—1968 air photo

Mt Holly--Mountain Creek, Ridge and Valley, PA—2007 air photo



Mt Holly--Mountain Creek, Ridge and Valley, PA—2007 lidar



Sediment-filled Reservoir
Mt Creek, Mt Holly Springs, PA

Photos courtesy of Jeff Hartranft, PA DEP

Breached Dam on Mt Creek, Mt Holly Springs, Cumberland County


March 27, 1985


June 18, 1985


February 1986


May 7, 2007

Photos courtesy of PA DEP

Breached Dam on Mt Creek, Mt Holly Springs, Cumberland County

May 7, 2007


ORIGINAL MILL POND SURFACE PRIOR TO 1985


06 18 1985
3

Incision, Channel Bank Erosion, Tree Collapse

ORIGINAL MILL POND SURFACE PRIOR TO 1985

Channel Bank Erosion, Tree Collapse,
Debris Jams, and Accelerated Bank Erosion

What's to be done?

Mt. Holly Springs,

Cumberland County, PA, 2007

Previous assumptions of natural:

- Single channel
- Meandering
- Narrow channel
- Wide valley
- High banks
- Bank erosion
- Bar formation
- Bedload (gravel) transport

Big Spring Run, Lancaster County, PA, 2006

Ecological Potential and Impairment

Original wetlands

Incised streams

TUSSOCK SEDGE PRAIRIE (WET MEADOW)

MARSH CREEK MEADOW, PA, WINTER 2008-2009
[Note: Formed on periglacial boulder field]


WET MEADOW

BEFORE, 2004, Impaired with legacy sediment

Banta Mill Floodplain/Wetland Restoration, Lititz Creek, PA

Upstream urban watershed

LandStudies, Inc.

Viable Holocene wetlands—contrast with Watts Br approach to restoration

AFTER, 2007, Legacy sediment removed

Banta Floodplain/Wetland Restoration, Lititz Creek, *LandStudies, Inc.*

Banta Floodplain/Wetland Restoration, Lititz Creek, *LandStudies, Inc.*

Photo Courtesy Landstudies, Inc.

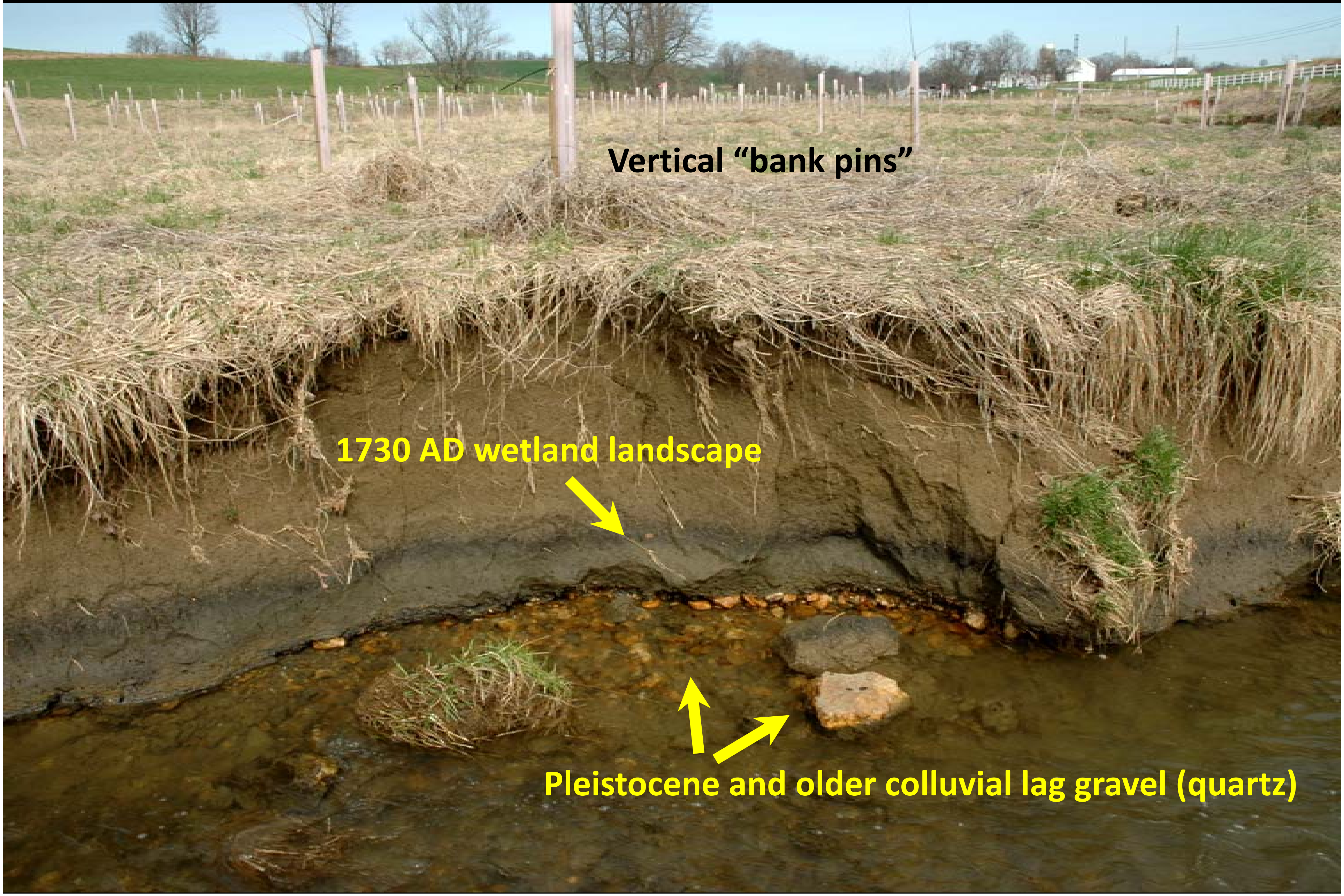
Channel-centered view of stream restoration (2005) and meandering streams, Watts Branch, MD ($1.6 million)

Image courtesy of Andrew Miller, University of MD

Watts Branch stream restoration 3 years later in 2008

Natural Stream Chanel Design: "Morphologically defined as the *ability of the stream to maintain, over time, its dimension, pattern, and profile* in such a manner that it is neither aggrading nor degrading and is able to transport *without adverse consequences* the flows and detritus of its watershed". (From Rosgen, Applied River Morphology, 1996)

Big Spring Run, PA: What is the ecological potential?



What is ecological "restoration" ?

The National Research Council – 1992:
Restoration of Aquatic Resources

"Return of an ecosystem to a close approximation of its condition prior to disturbance. The term restoration means the reestablishment of pre-disturbance aquatic functions and related physical, chemical and biological characteristics."

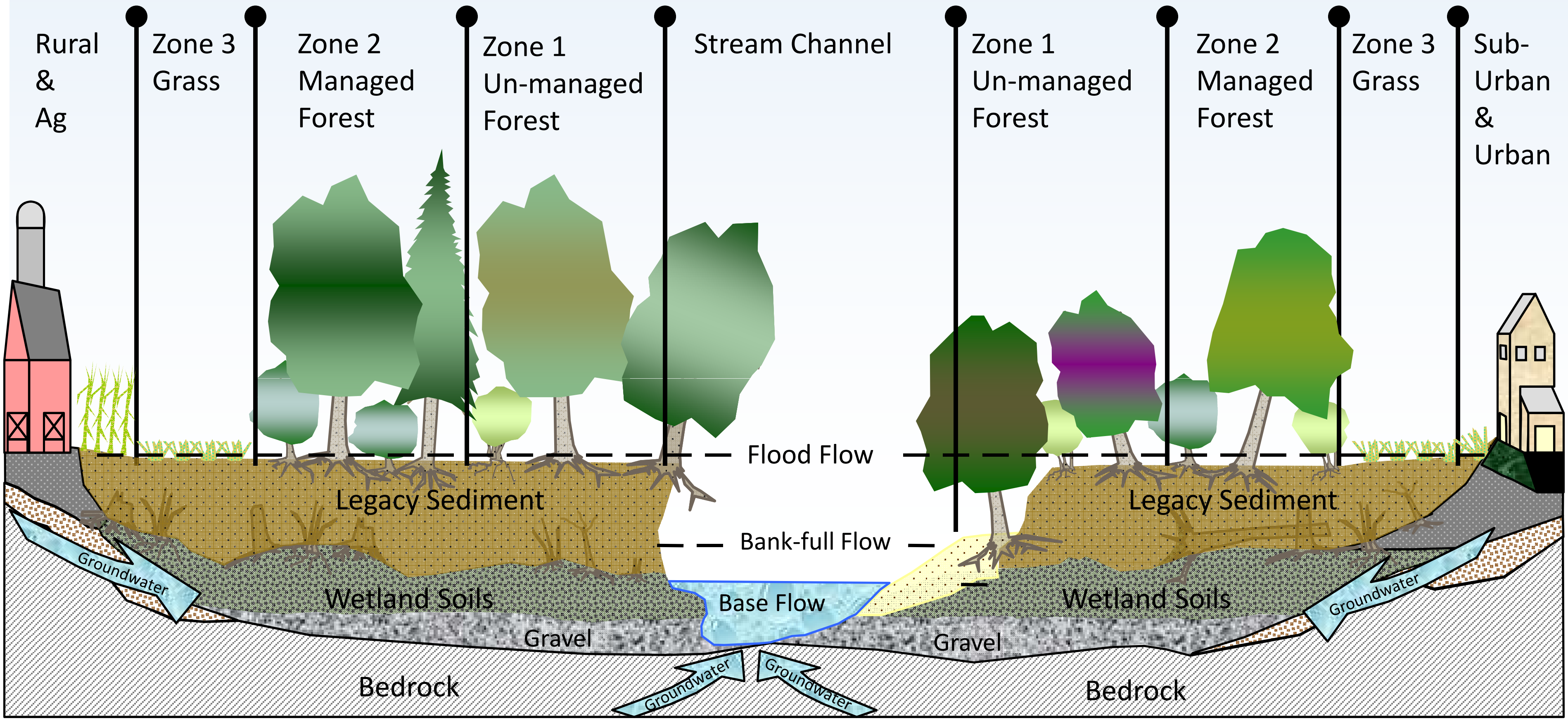
http://www.epa.gov/owow/wetlands/restore/defs.html#Fed

EPA Ecological Restoration Guiding Principles

1. Identify and address ongoing causes of degradation.
    - Restoration efforts are likely to fail if the sources of degradation persist.
    - It is essential to identify the causes of degradation and eliminate or remediate them.

Riparian Forest Buffers - “Three-zone Concepts”

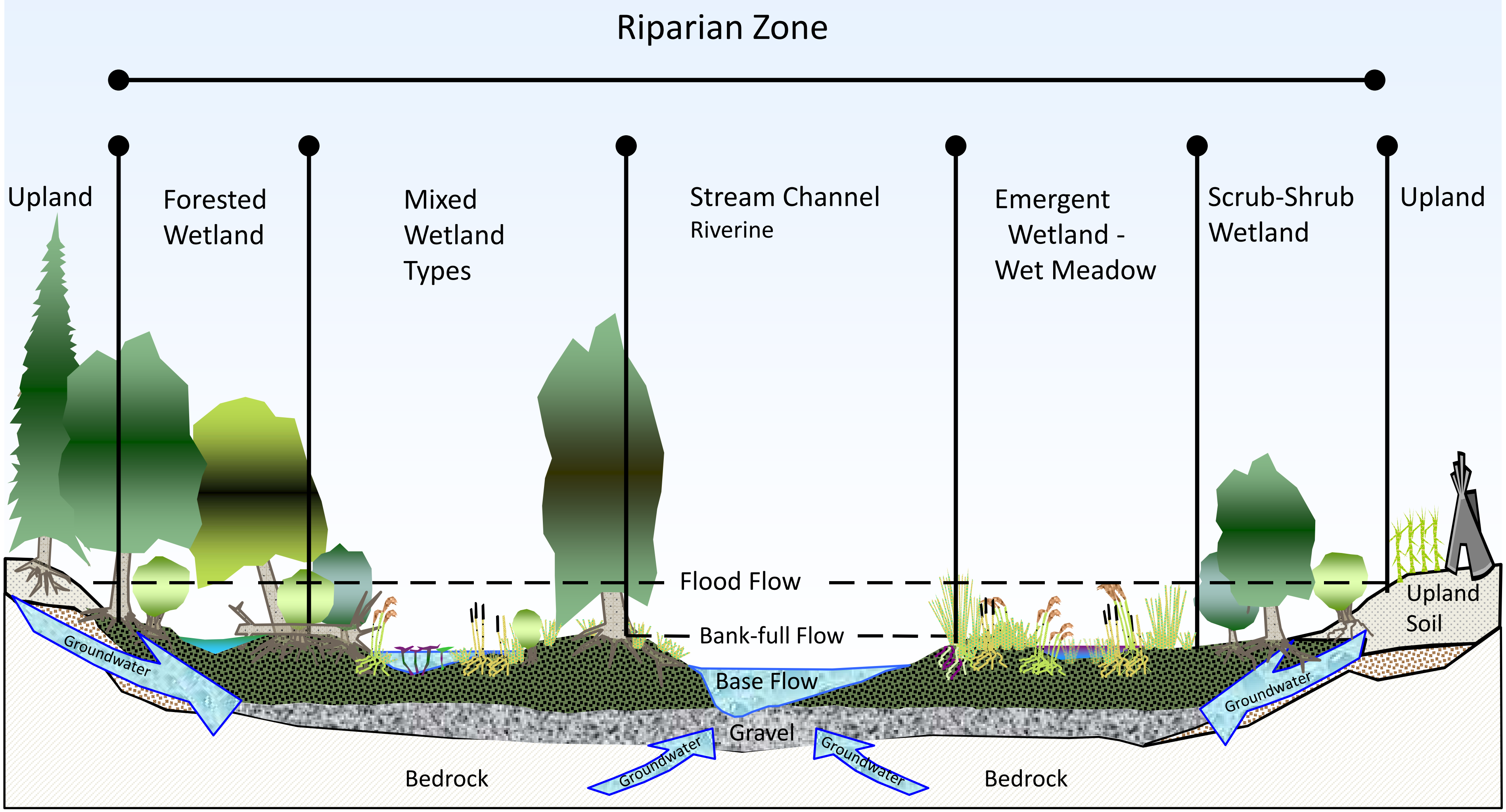
University of Maryland, Maryland Cooperative Extension, 1998.



> 2,500 miles of “Riparian Buffer Restoration” in Pennsylvania’s Chesapeake Bay Watersheds reported to EPA. Chesapeake Bay Forestry Workgroup, 2008.

Natural Riparian Buffer Zones

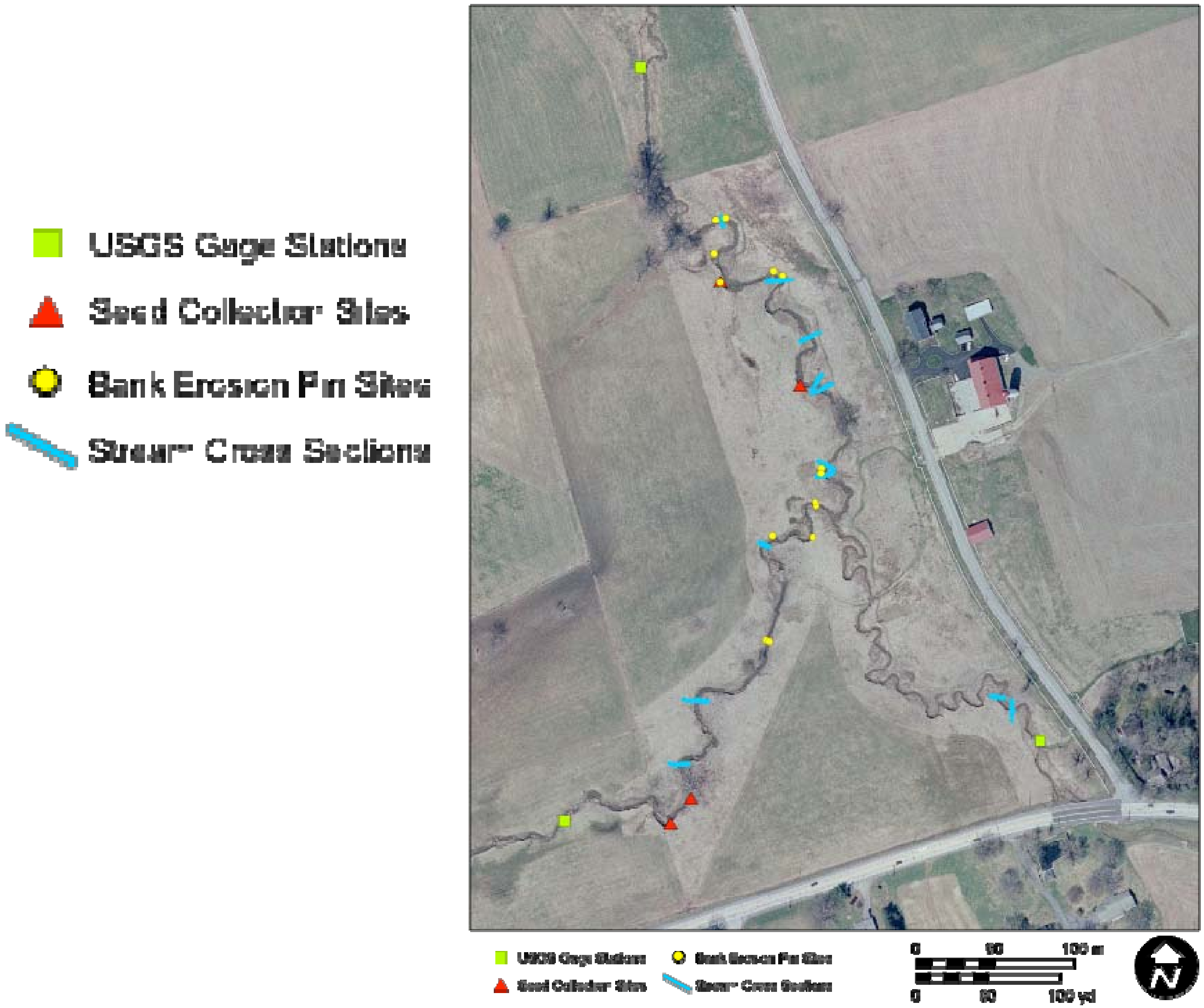
Palustrine and Riverine Classifications (Cowardin, et. al. 1979)



Natural Potential

BIG SPRING RUN, LANCASTER COUNTY, PA,WETLAND-FLOODPLAIN RESTORATION EXPERIMENT

Partners: USGS, PA DEP, US EPA, F&M COLLEGE, LANDSTUDIES, PEC



IN CLOSING

The value of building teams of collaborators that include students of different ages and levels of background and experience, and of merging scientific understanding with policy and engineering.

The importance of thinking outside the box and acknowledging the ways in which scientists develop and revise ideas.

The modern environmental challenge of figuring out how to restore streams and wetlands in landscapes that have been disturbed in multiple ways for centuries. Diagnosing the problem is difficult and we are saddled with misconceptions.

US EPA's Principles for Ecological Restoration of Aquatic Resources and a New and Innovative Best Management Practice To Address Legacy Sediment Impairments

PA Legacy Sediment Workgroup *2009*

Jeffrey Hartranft
Bureau of Waterways Engineering
Division of Dam Safety

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PA Legacy Sediment Workgroup

Student Collaborators:

Lauren Manion ‘04, Graham Boardman ‘05, Christina Arlt ’05, Caitlin Lippincott ‘05, Sauleh Siddiqui ‘07, Yoanna Voynova ‘06, Andrey Voynov ‘05, Adam Ross ‘07, Mark Voli ‘08, Chris Scheid ‘08, Julie Weitzmann ‘08, Zain Rehman ‘09, Zach Stein ‘08, Erik Ohlson ‘10, Franklin Dekker ‘10, and Colette Buchanan ’08, Stacey Sosenko ‘09, Liz Cranmer ‘09, Matt Jenschke ’09, Wanlin Deng ‘12, Katie Datin ‘12, Laura Kratz ‘11