# Using Elevation Data to Produce an Updated Hydrography Dataset for the State of Pennsylvania

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pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

PENNSYLVANIA GEOLOGICAL SURVEY EST. 1836

# Outline

# Project Intent

The Pennsylvania Department of Conservation and Natural Resource's Bureau of Geological Survey will use quality level (QL) 2 Lidar derivatives to produce a *scale-equivalent and dynamic* hydrography dataset for the state of Pennsylvania.

# Basis of Research

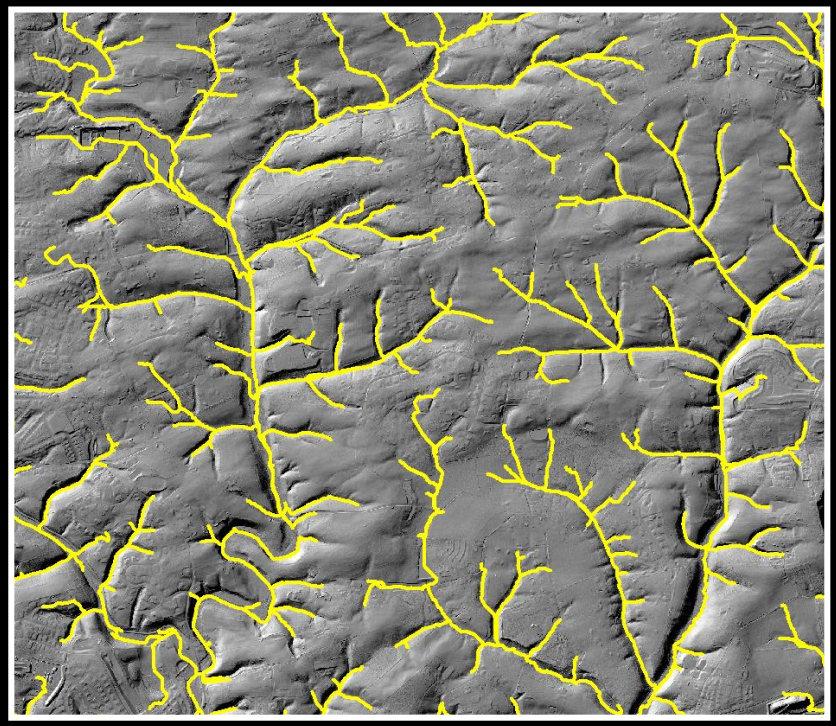
- **Geomorphons and landform classification**
  (Stepinski and Jasiewicz - 2011, 2013)
- **Application of geomorphon products**
  (Chesapeake Conservancy; Matthew Baker, David Saavedra, and Michael Norton - 2018)
- **Tile-by-tile flow accumulation workflow**
  (Lancaster County GIS Department; Lisa Mirth - 2016)
- **Project "levels"**
  (Quantum Spatial; Andrew Brenner, Cathy Power, Mischa Hey, and Tim Marcella - 2019)

# Project Scope

- Level 1 – Cartographic
- Level 2 – Ele-hydro
- Level 3 – Geo-hydro

# Level 1

- Cartographic product showing distribution and relationships of water features
- Designed as a dynamic dataset that is intended to be updated with:
  - New cycles of Lidar data
  - Field verification/correction
  - Professional edits/corrections

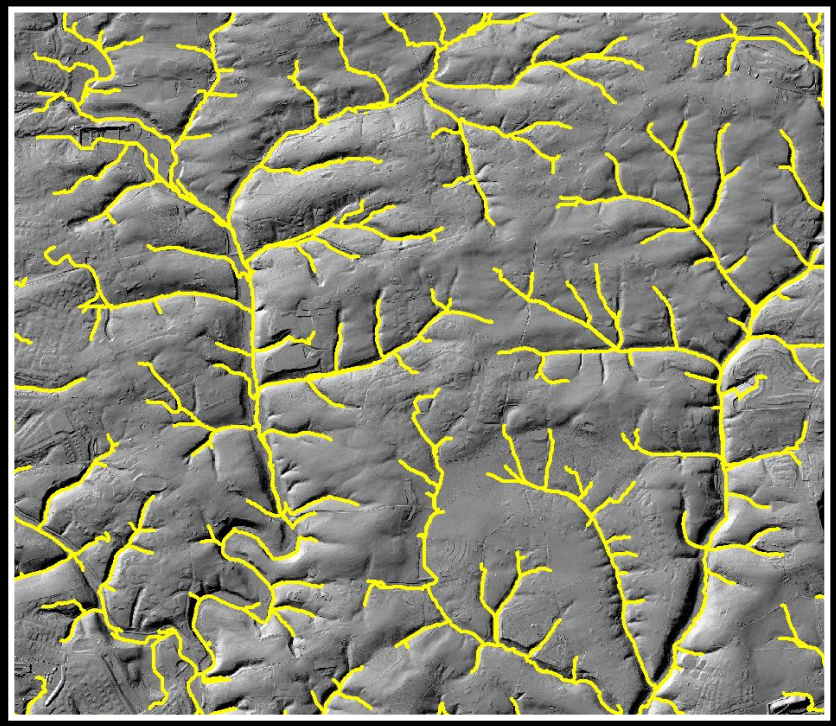


# Level 1: Products

- Waterbodies (2 acre+)
- Wide rivers (30m+)
- Flowlines

→ All 3D products

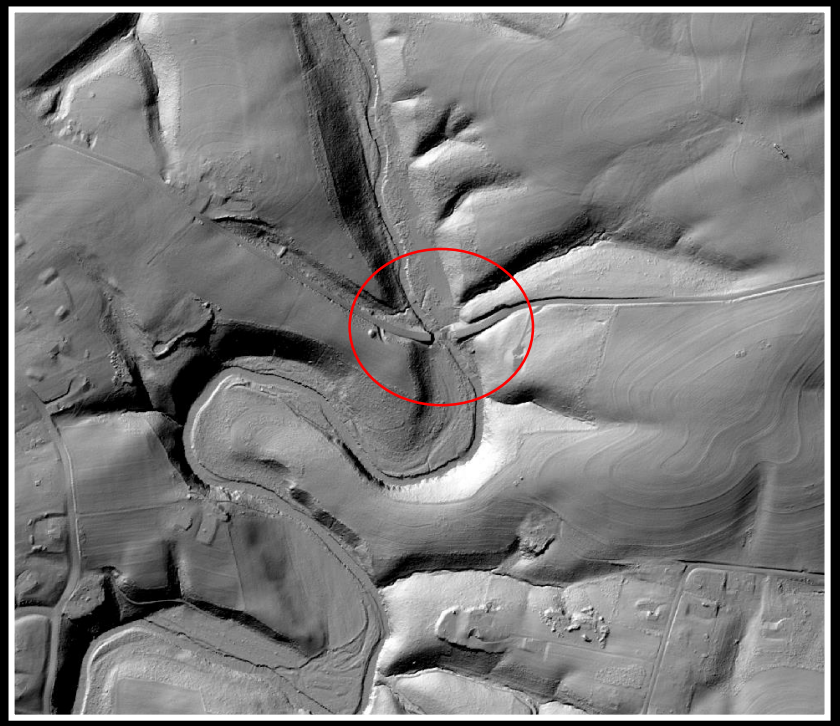
→ Horizontal accuracy to 1m



# Level 2

- LAS point cloud with all bridges classified
- DEM has been (additionally) hydro-flattened and hydro enforced with products from Level 1

→ Vertical accuracy to 0.5m



# Level 3

- DEM has been hydro-conditioned
- Allows for the creation of flowlines based on intended use

# Workflow

| STEPS | Examine Lidar deliverables | Geomorphon processing | Flow Accumulation | Combine networks | Field verification |
|---|---|---|---|---|---|

**Scale**

Subwatershed (HU12)

**Derivative**

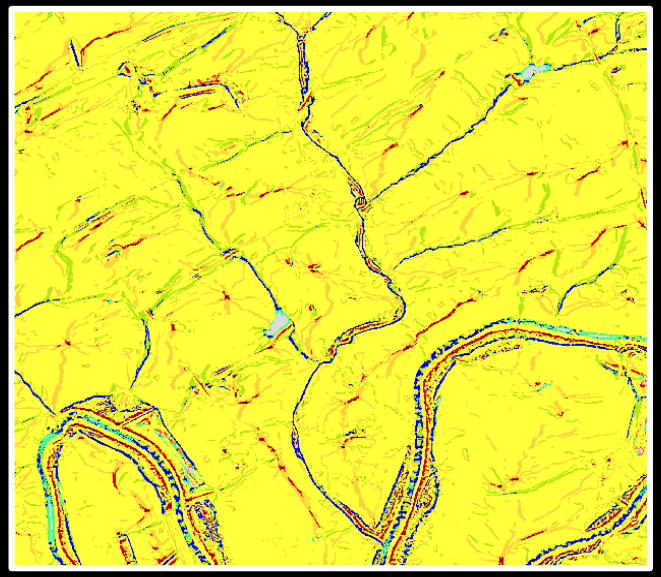
DEM burned with dam features (e.g. bridges, culverts)

**Products**

Breaklines used to delineate wide (30m+) flow features and their centerlines

# Workflow

| STEPS | Examine Lidar deliverables | Geomorphon processing | Flow Accumulation | Combine networks | Field verification |
|---|---|---|---|---|---|



**Scale**

Subwatershed (HU12)

**Derivative**

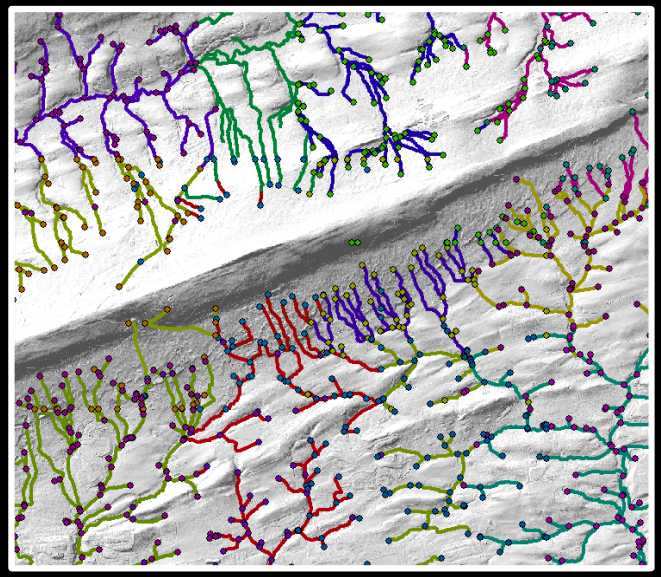
Classified landforms and initial flow paths

**Products**

Waterbodies (identified and delineated using geomorphon map)

# Workflow

| STEPS | Examine Lidar deliverables | Geomorphon processing | Flow Accumulation | Combine networks | Field verification |
|---|---|---|---|---|---|



**Scale**

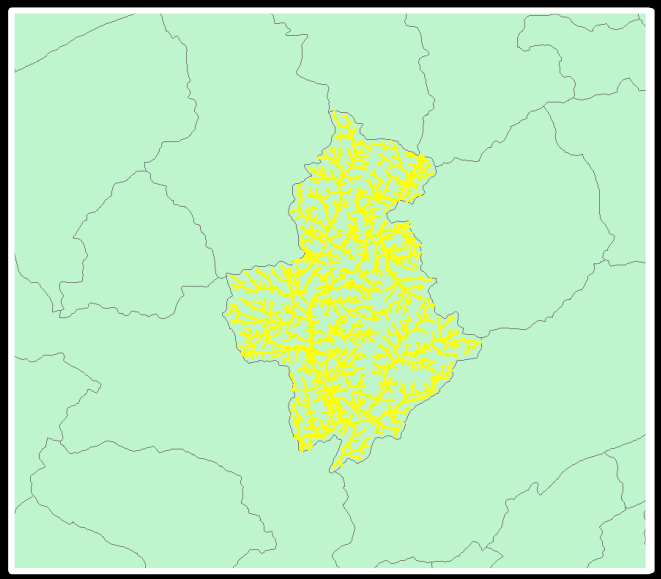
Lidar tiles

**Derivative**

Flowlines and nodes (on the scale of individual Lidar tiles)

# Workflow

| STEPS | Examine Lidar deliverables | Geomorphon processing | Flow Accumulation | Combine networks | Field verification |
|---|---|---|---|---|---|



**Scale**

Subwatershed (HU12)

**Derivative/Products**

Flowline networks

# Workflow

| STEPS | Examine Lidar deliverables | Geomorphon processing | Flow Accumulation | Combine networks | Field verification |
|---|---|---|---|---|---|

**Scale**

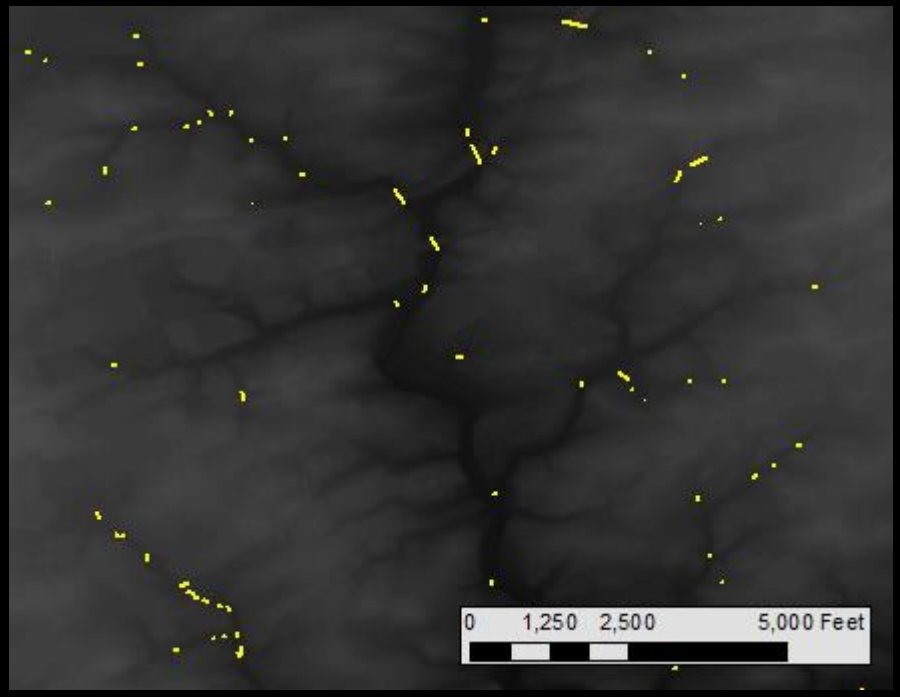
Variable

**Derivative/Product**

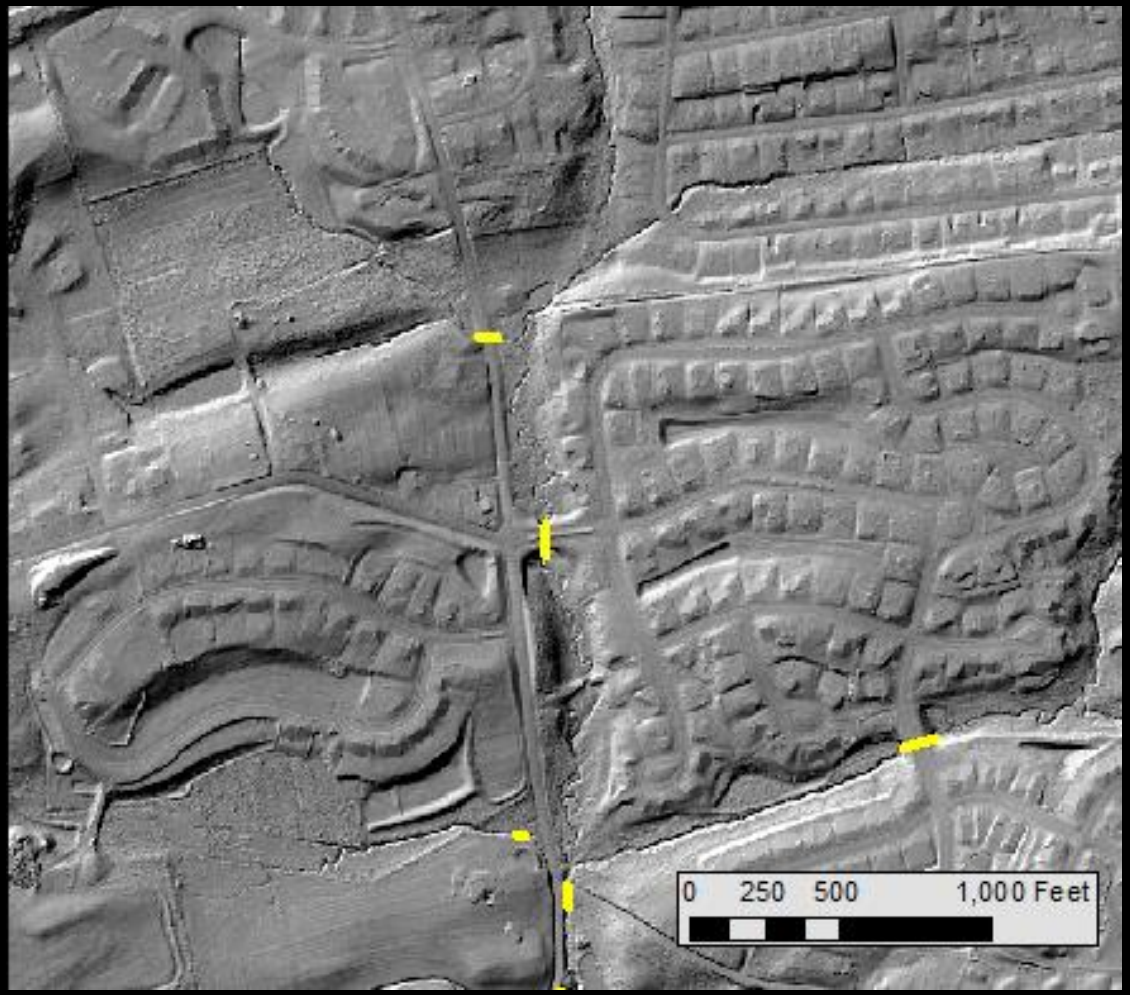
More accurate flowline networks (appropriate study size)

# Examine Lidar Deliverables

- Create a “close enough” culvert dataset
  - PennDOT bridges
  - DEP culverts
  - Intersection of NHD flowlines and PennDOT roads
- From this, produce a more accurate culvert dataset
- Burn the accurate culverts into the DEM

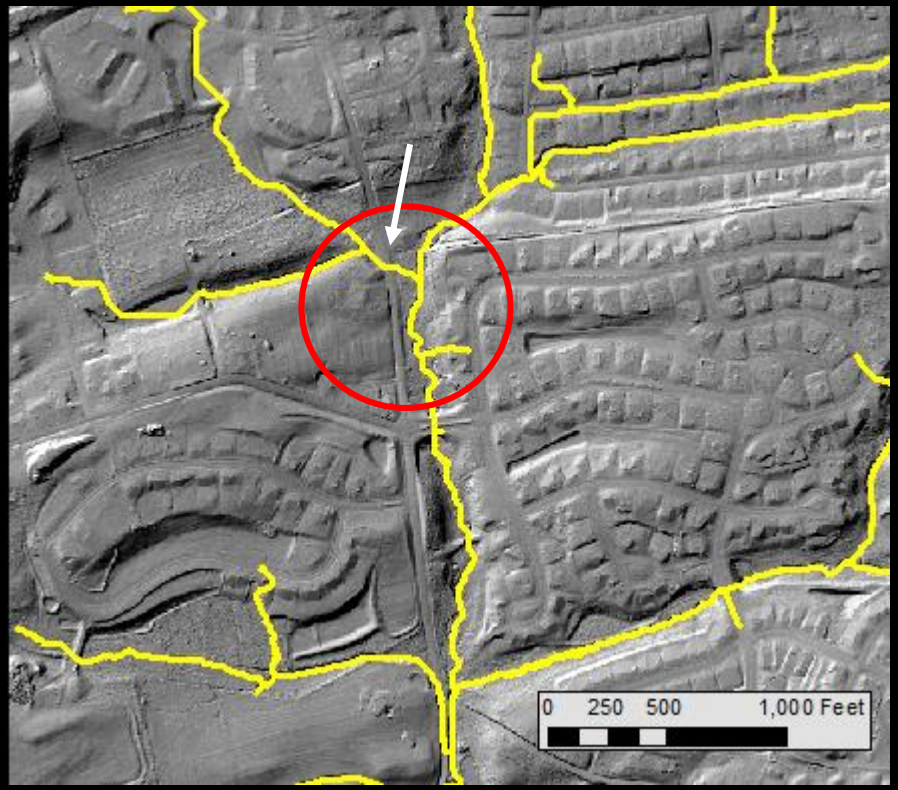


# DEM Examination

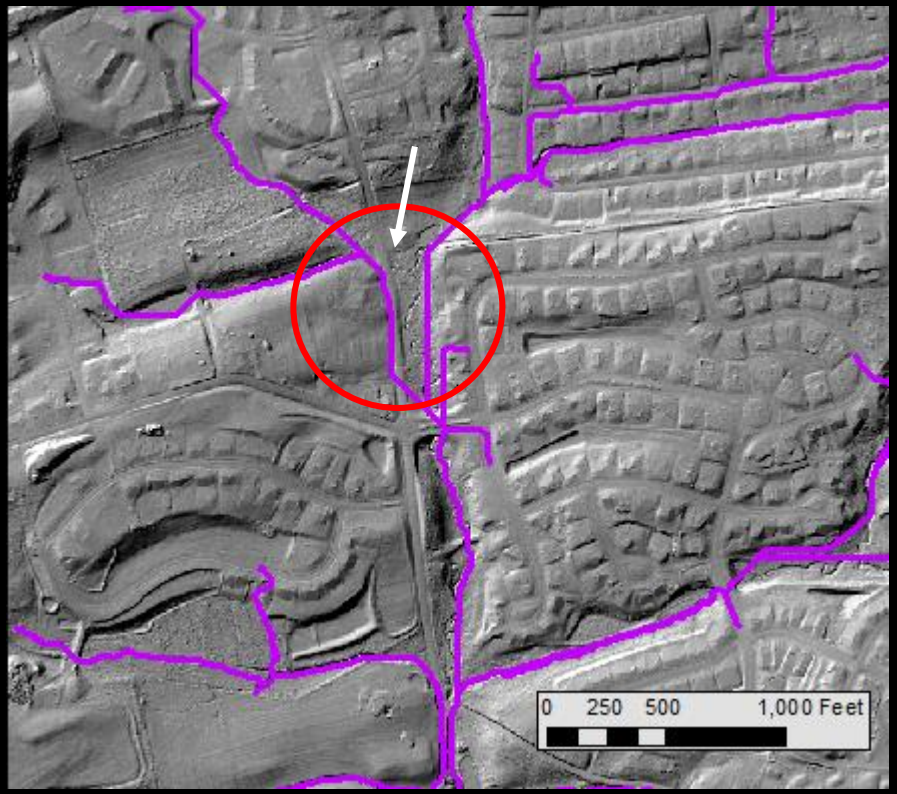


# DEM Examination

WITH culvert burn

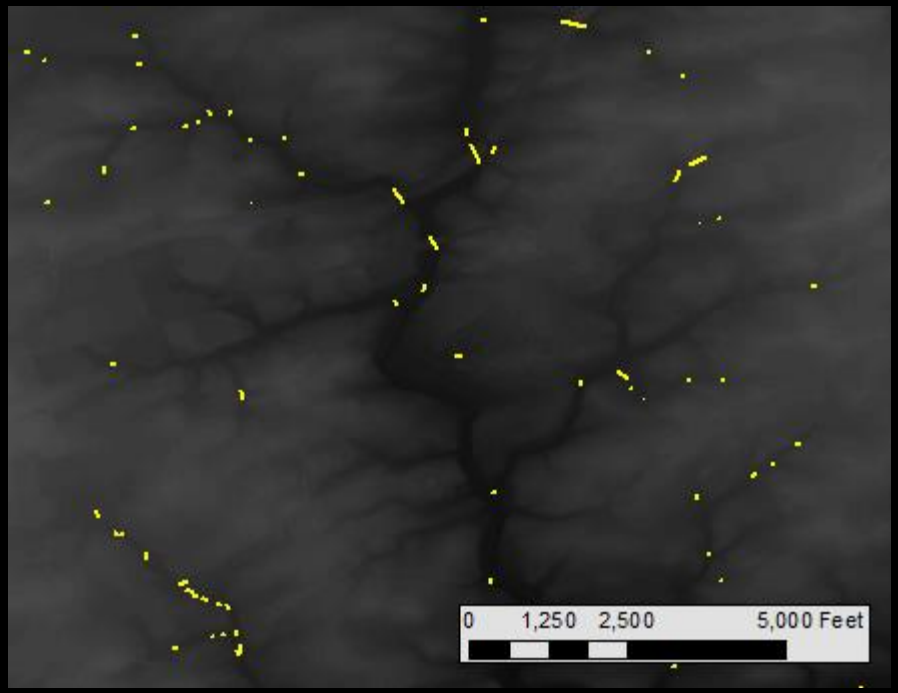



WITHOUT culvert burn



# DEM Examination

- Apply smoothing filter to DEM
- Burn accurate culvert dataset into filtered DEM



# Geomorphons

## “Geomorphologic phonotype”

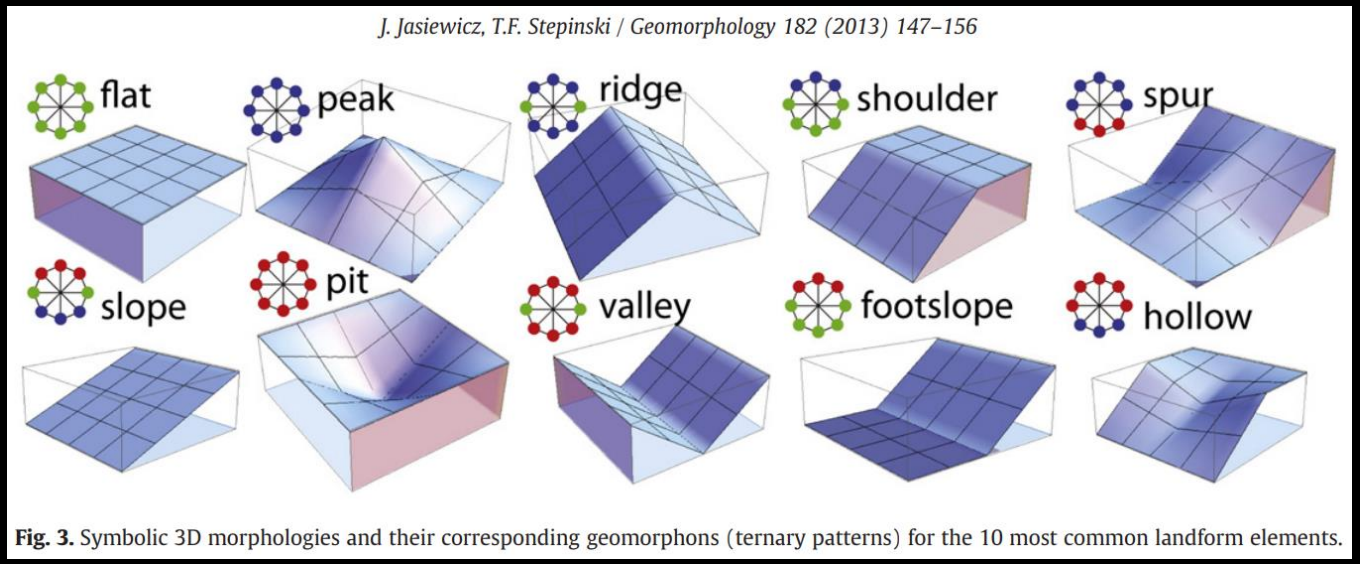
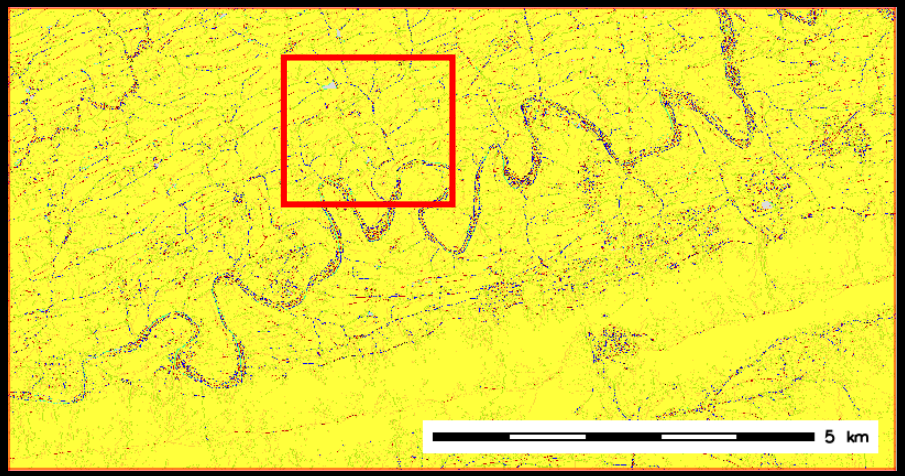


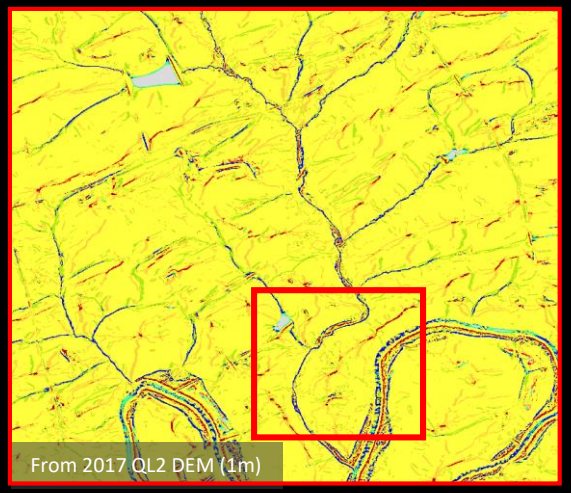

**Fig. 3.** Symbolic 3D morphologies and their corresponding geomorphons (ternary patterns) for the 10 most common landform elements.

- flat
- summit (peak)
- ridge
- shoulder
- spur
- slope
- hollow
- footslope
- valley
- depression (pit)

# Geomorphons

- flat
- summit
- ridge
- shoulder
- spur
- slope
- hollow
- footslope
- valley
- depression

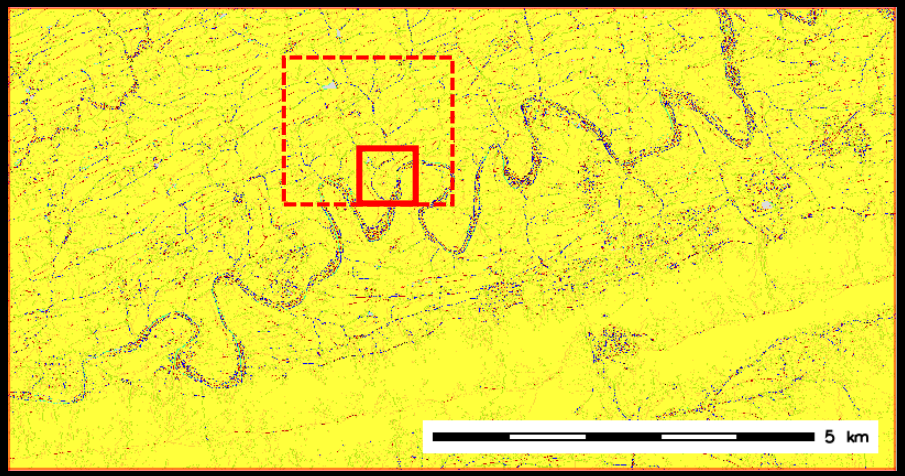


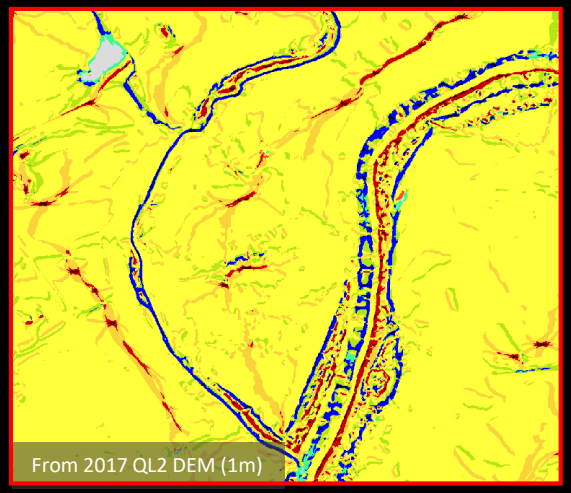





# Geomorphons

- flat
- summit
- ridge
- shoulder
- spur
- slope
- hollow
- footslope
- valley
- depression



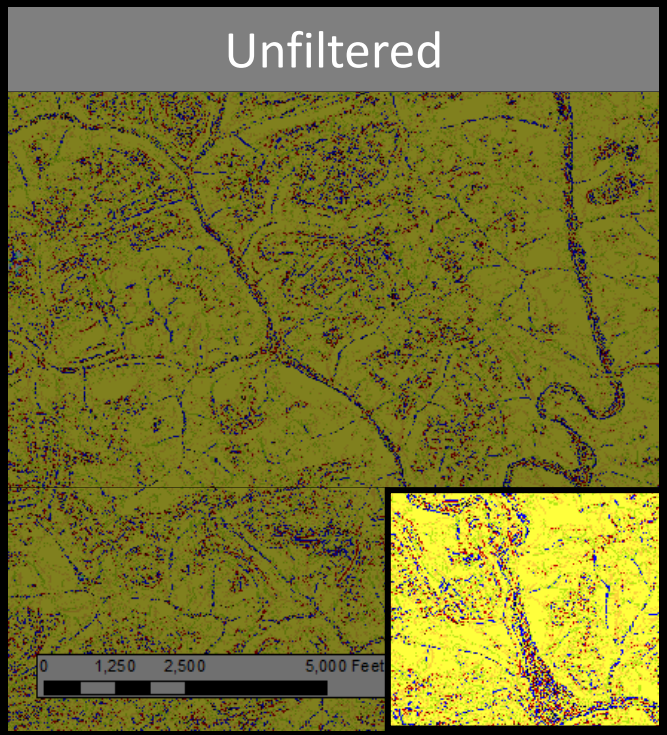



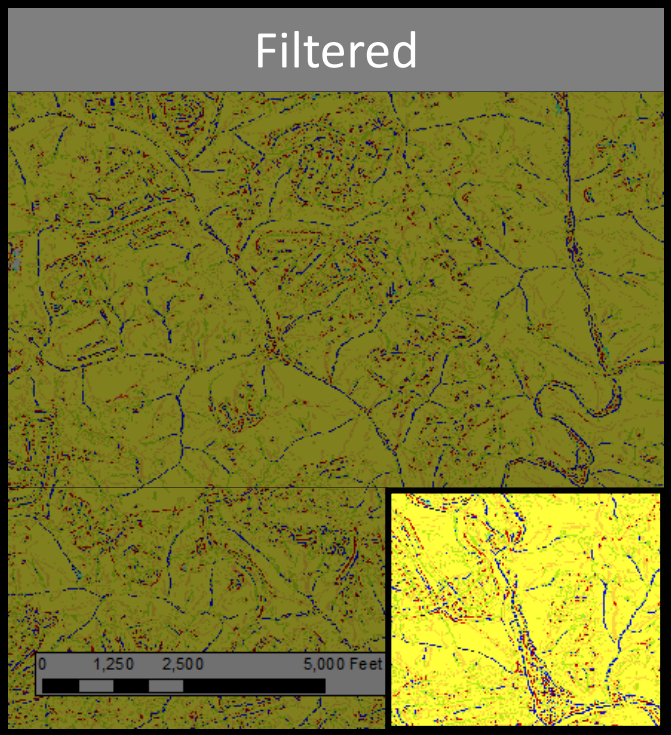


# Geomorphons

## Geomorphon processing in GRASS

- flat
- summit
- ridge
- shoulder
- spur
- slope
- hollow
- footslope
- valley
- depression



# Geomorphons

## Geomorphon processing in GRASS

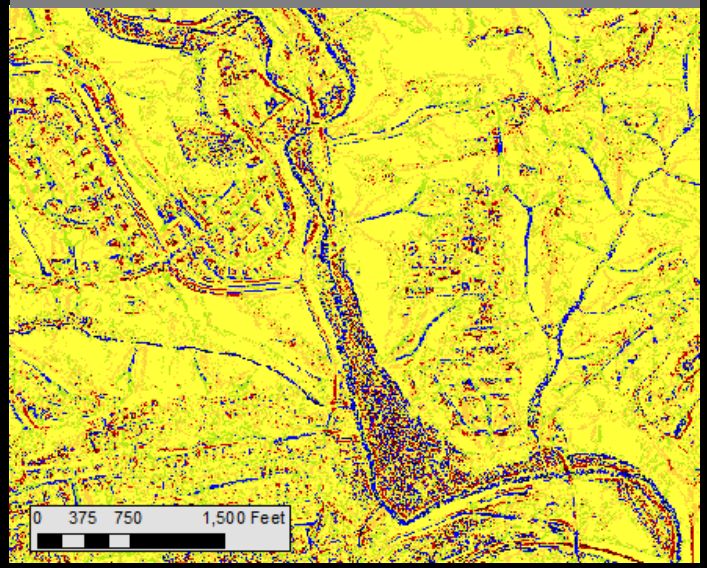
flat

footslope

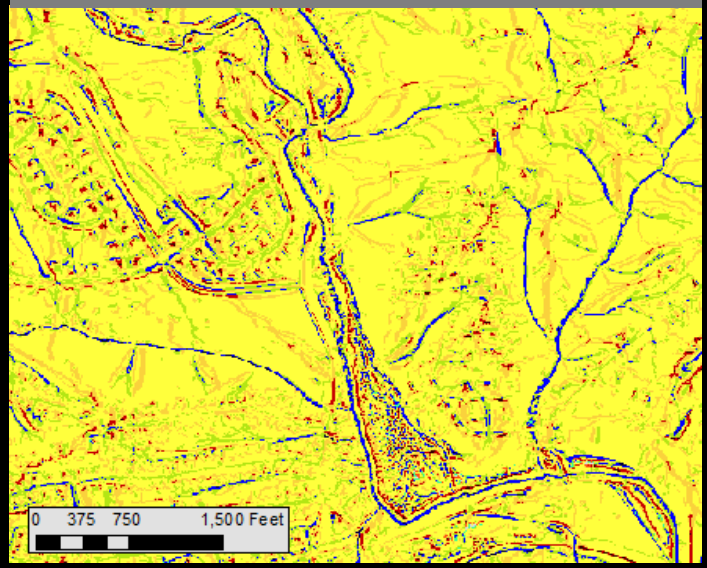
valley

depression

Unfiltered




Filtered

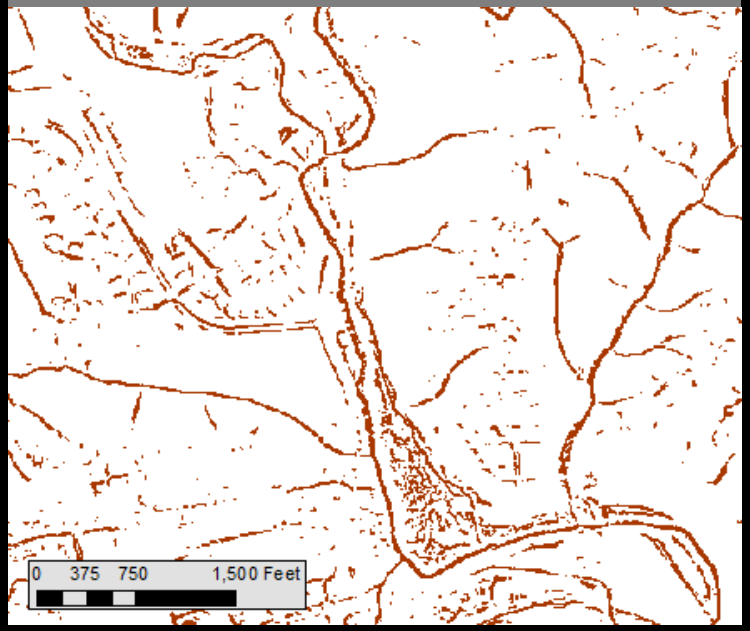


# Geomorphons

Reclassification/extraction → Burn in initial flowlines

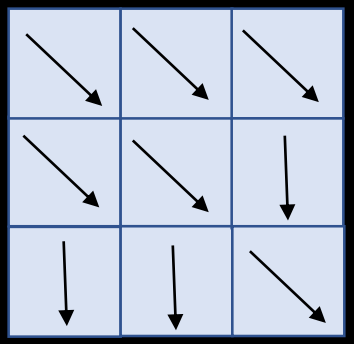
Unfiltered


Filtered



# Flow Accumulation

## Flow direction/accumulation



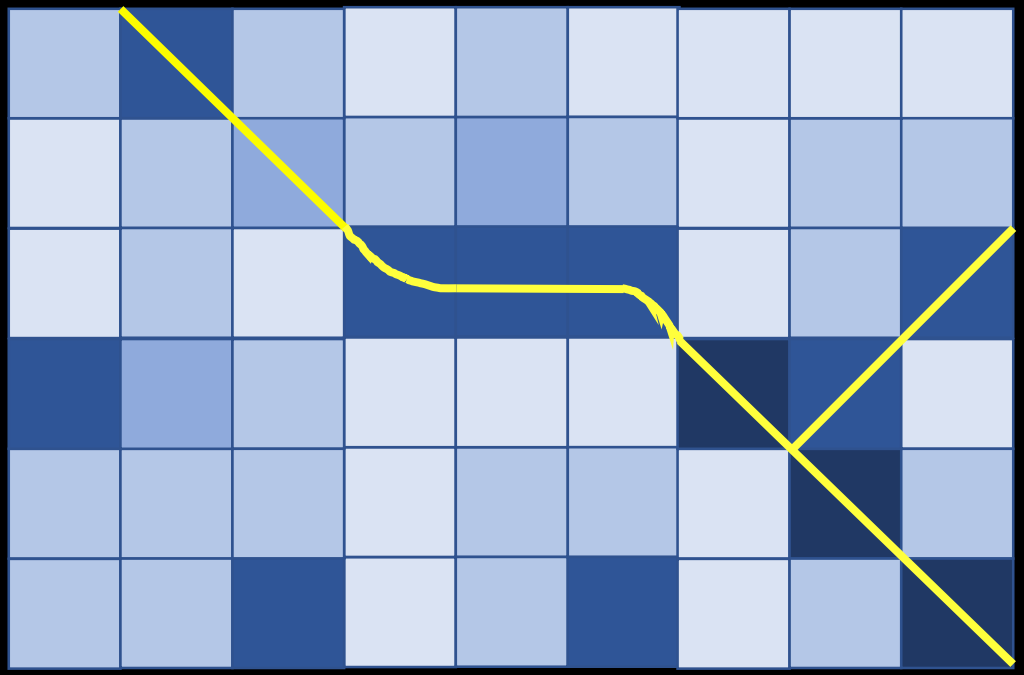
Flow direction

| | | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 0 | 1 | 4 |

Flow accumulation

# Flow Accumulation

## Stream definition



# Process Steps (General)

**Examine DEM**

*Create "close enough" culvert dataset*

*→ Produce more accurate culvert dataset*

*→ Apply smoothing filter*

*→ Burn in culvert dataset*

**Geomorphons**

*→ Geomorphon processing in GRASS GIS*

*→ Reclassification/extraction*

**Flow accumulation**

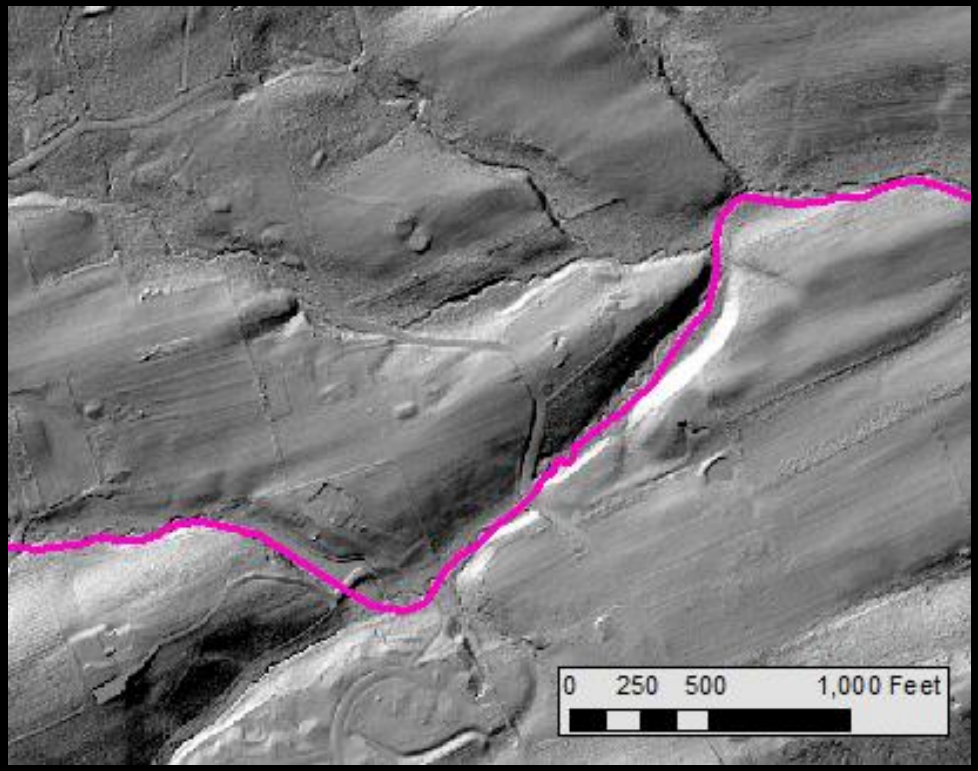
*Burning in streams*

*→ Flow direction/accumulation*

*→ Stream definition*

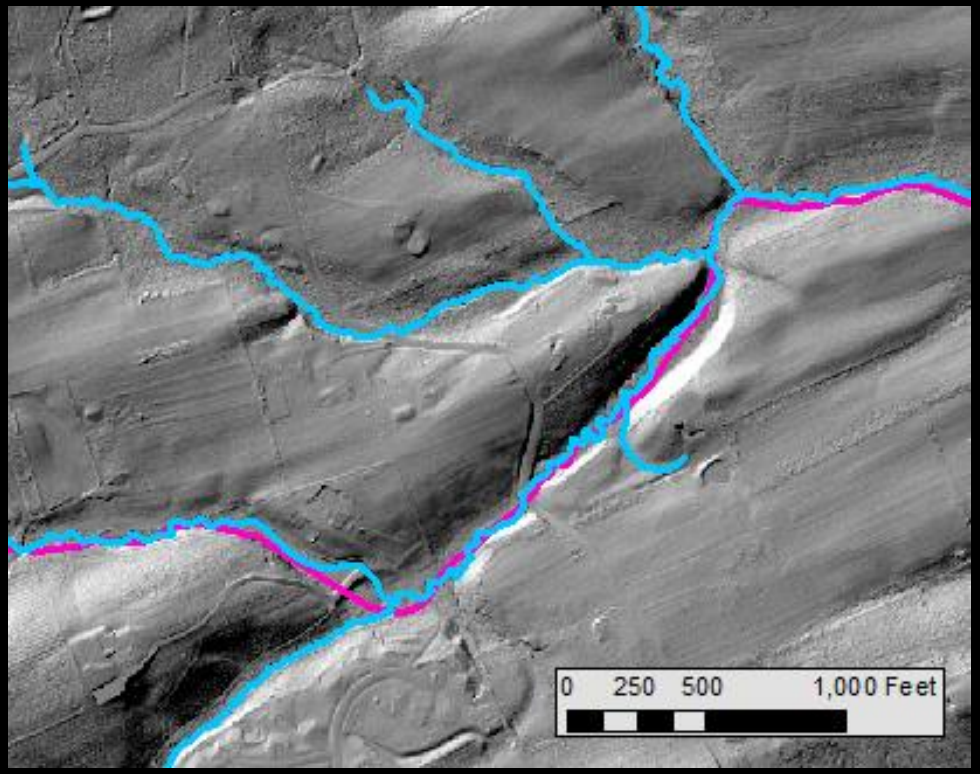
# The product so far… Example 1

Current NHD



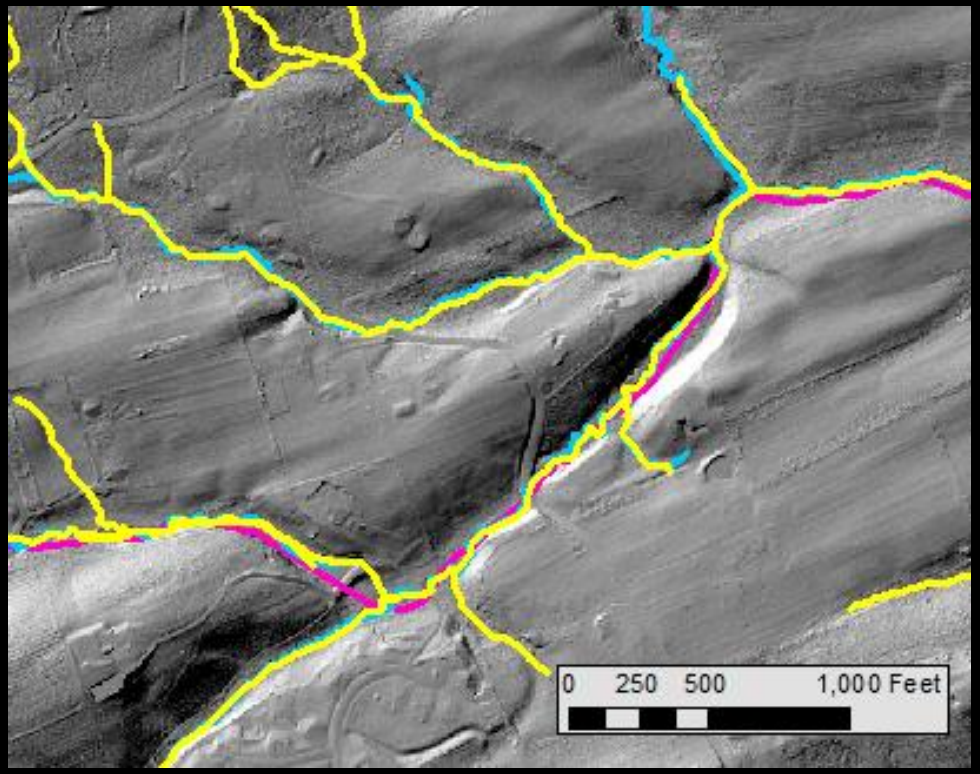
# The product so far… Example 1

Current NHD
Manual lines



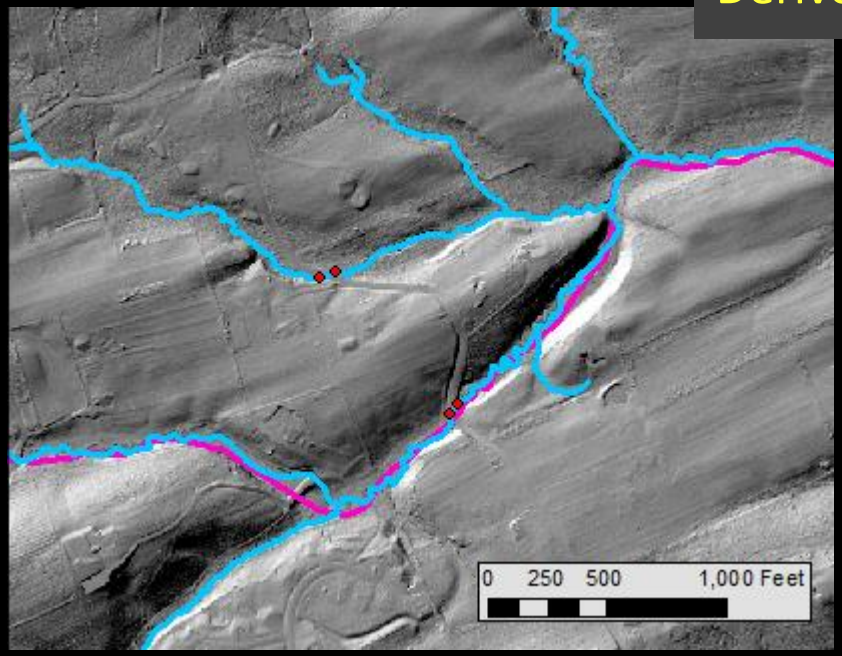
# The product so far… Example 1

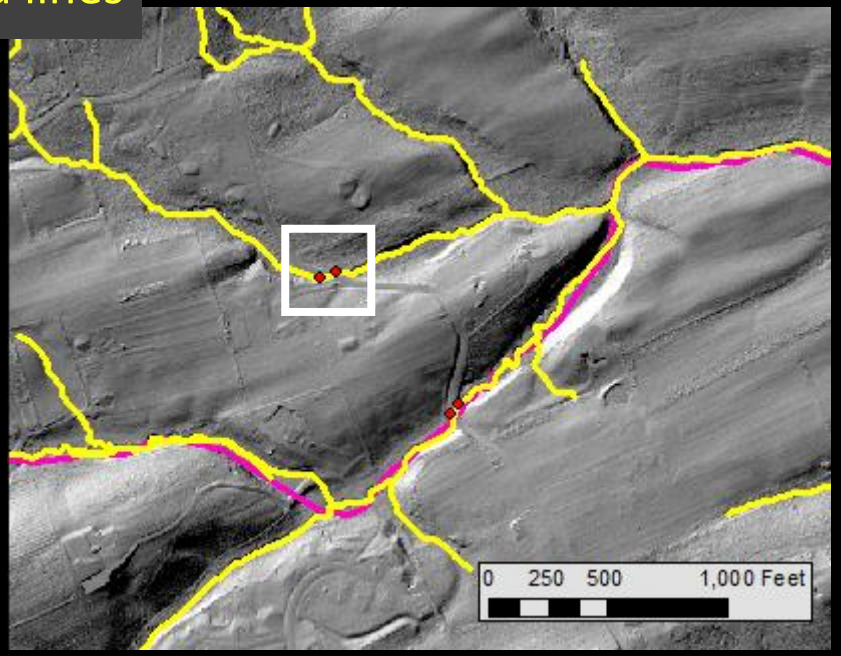
Current NHD
Manual lines
Derived lines



# The product so far… Example 1

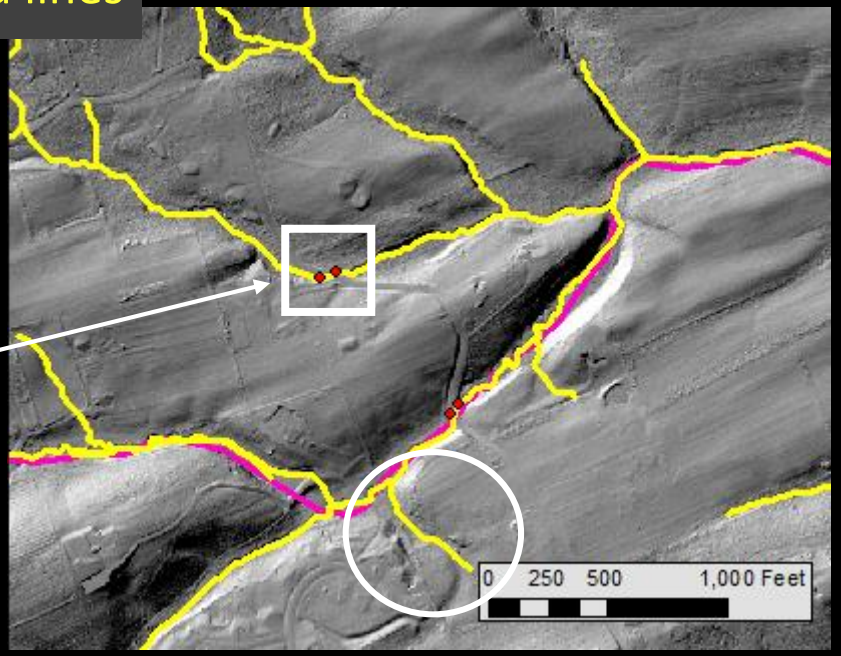
Current NHD
Manual lines
Derived lines



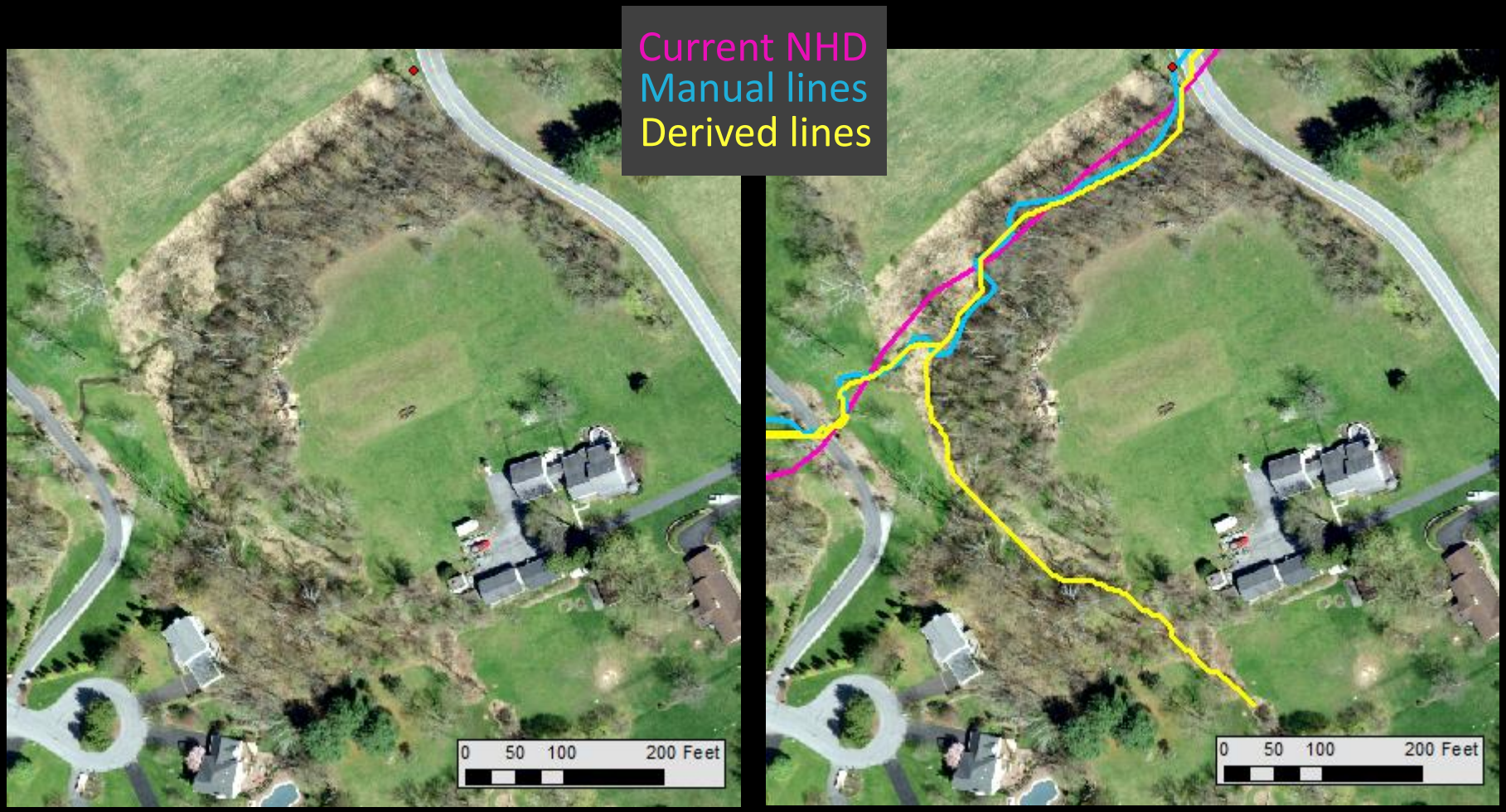



# The product so far… Example 1

Current NHD
Manual lines
Derived lines

# The product so far… Example 1

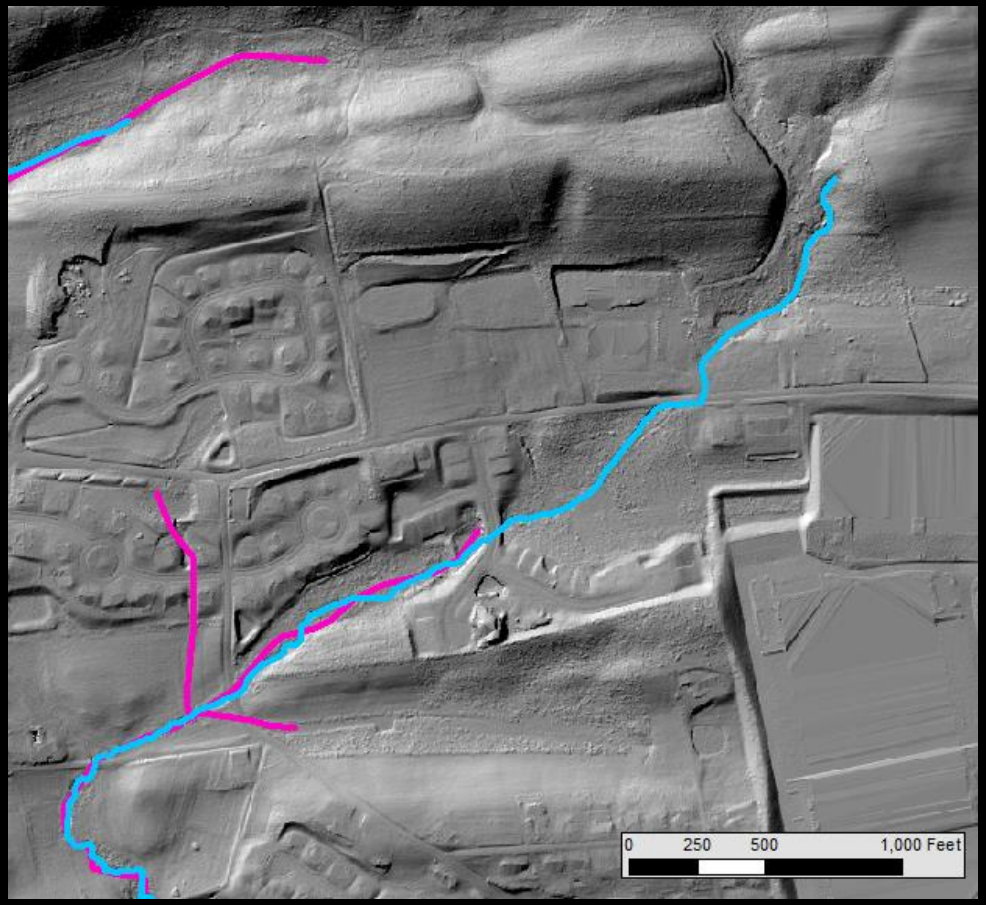


# The product so far… Example 2

Current NHD

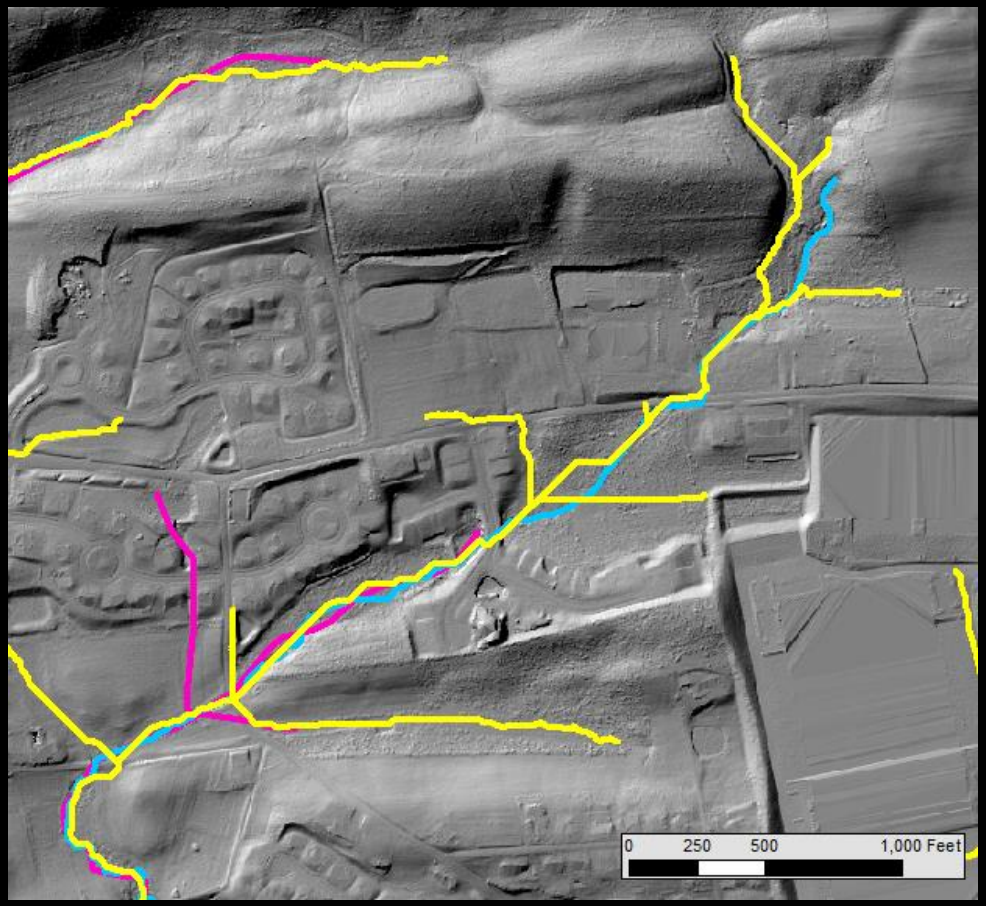
# The product so far… Example 2

Current NHD
Manual lines

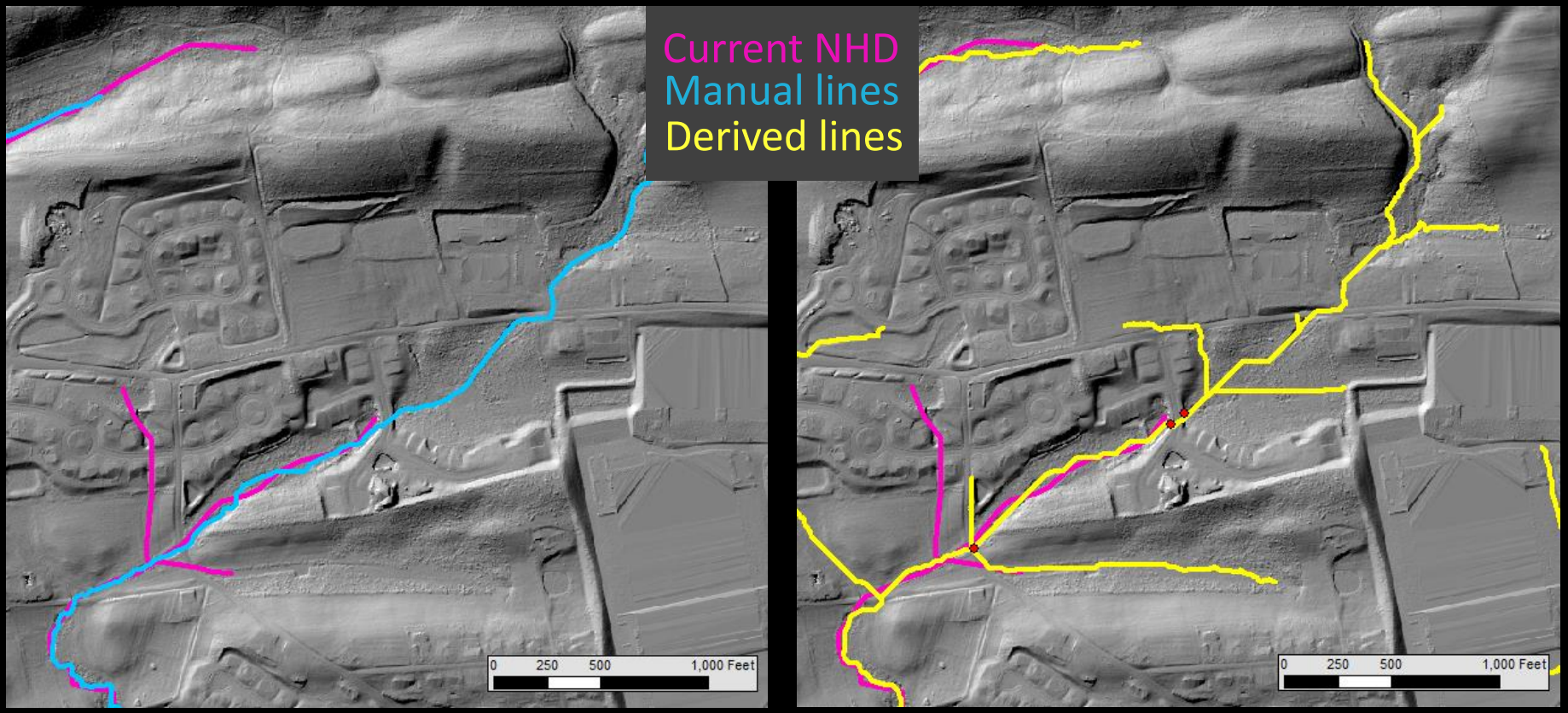


# The product so far… Example 2

Current NHD
Manual lines
Derived lines



# The product so far… Example 2



# The product so far… Example 2

Current NHD
Manual lines
Derived lines

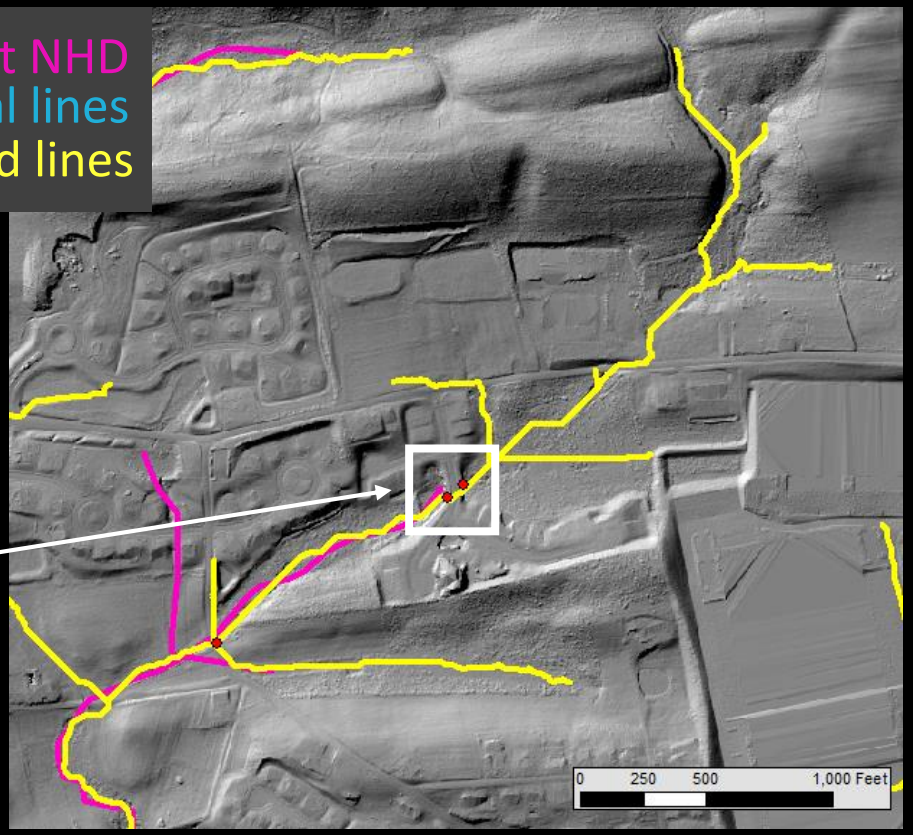




Photo taken at GPS station (West side)

# The product so far… Example 2

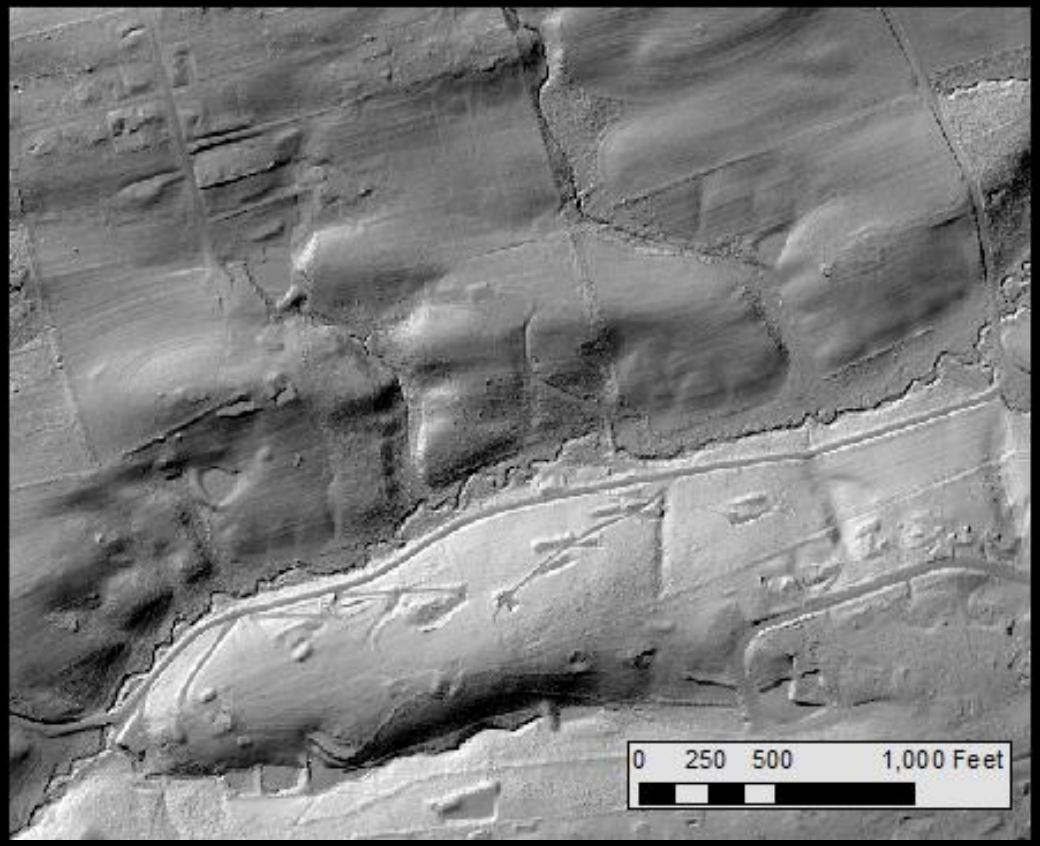
Why does current NHD flow path stop here?
Previous dam? Delineation from topo maps?

Photo taken at GPS station (West side)

Photo taken at GPS station (East side)

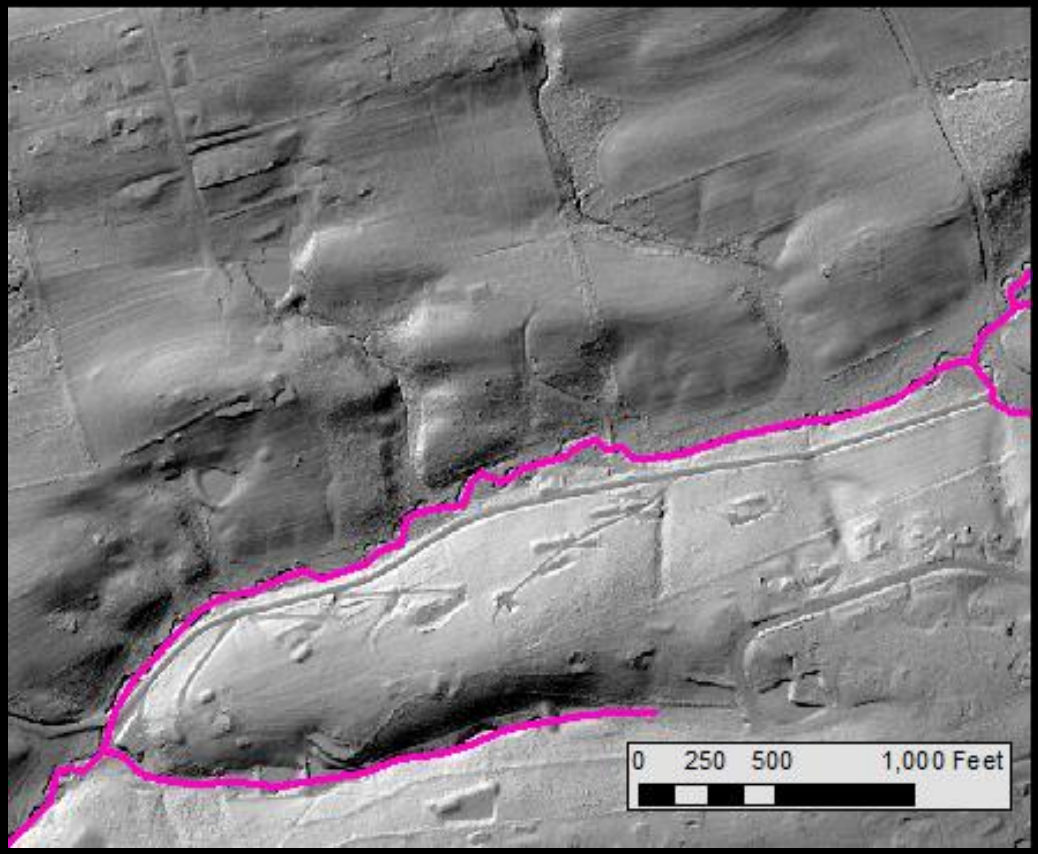
# The product so far… Example 3

Current NHD
Manual lines
Derived lines



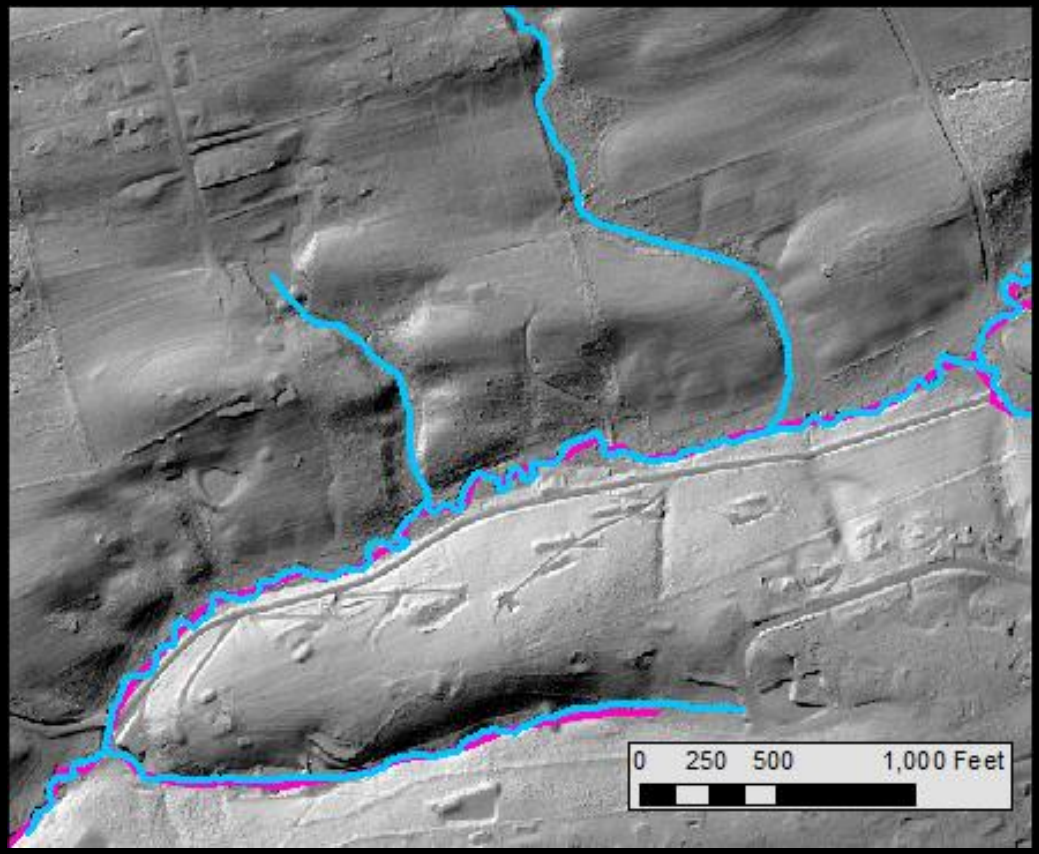
# The product so far… Example 3

Current NHD
Manual lines
Derived lines

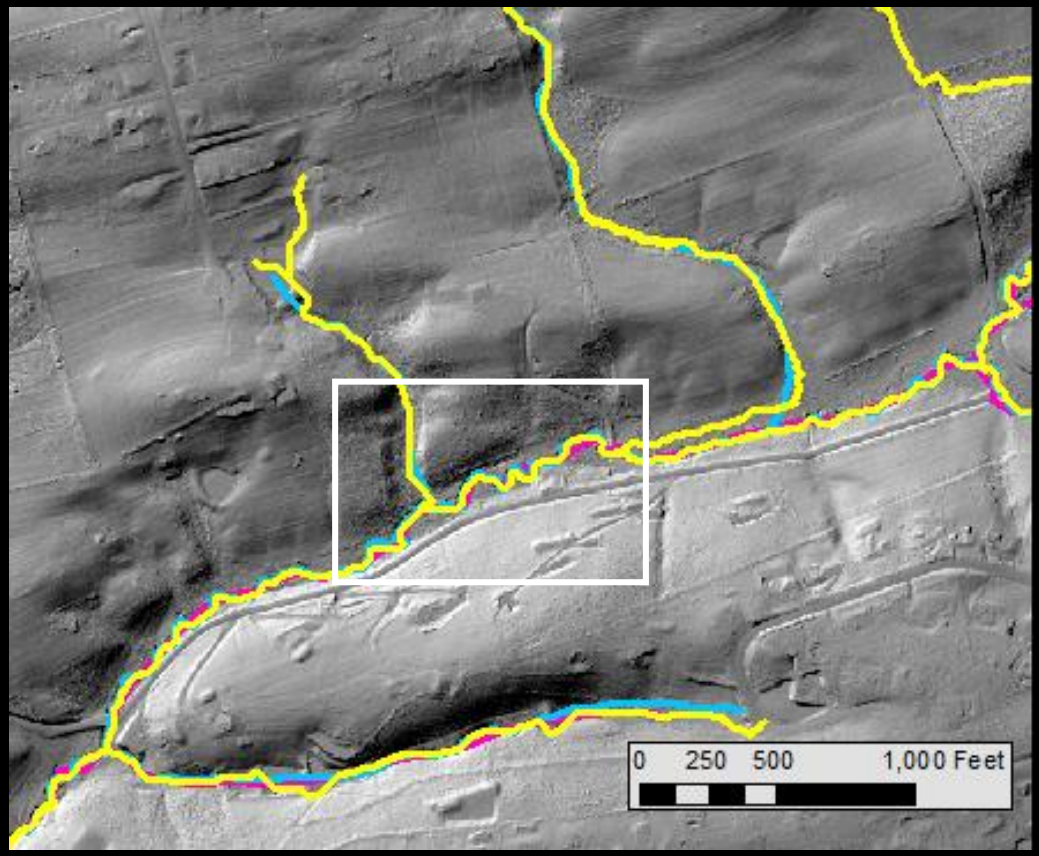


# The product so far… Example 3

Current NHD
Manual lines
Derived lines



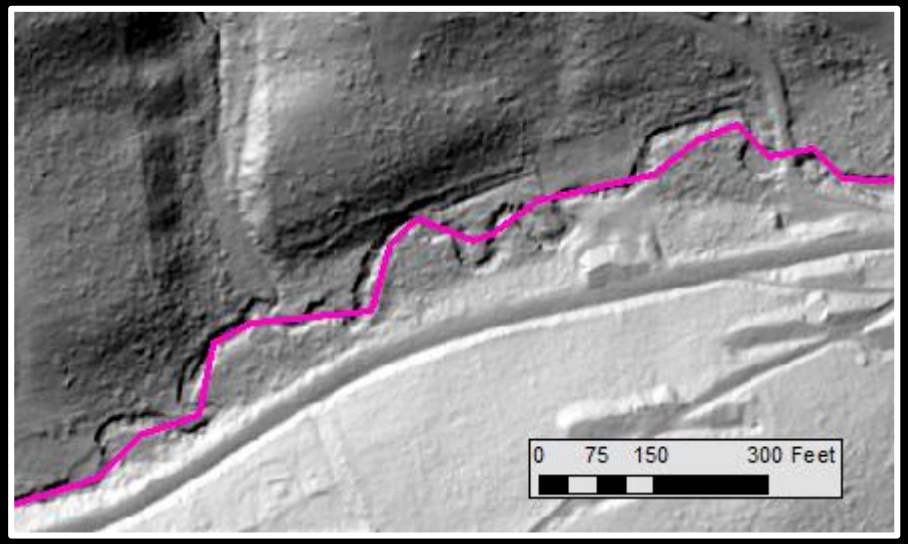
# The product so far… Example 3

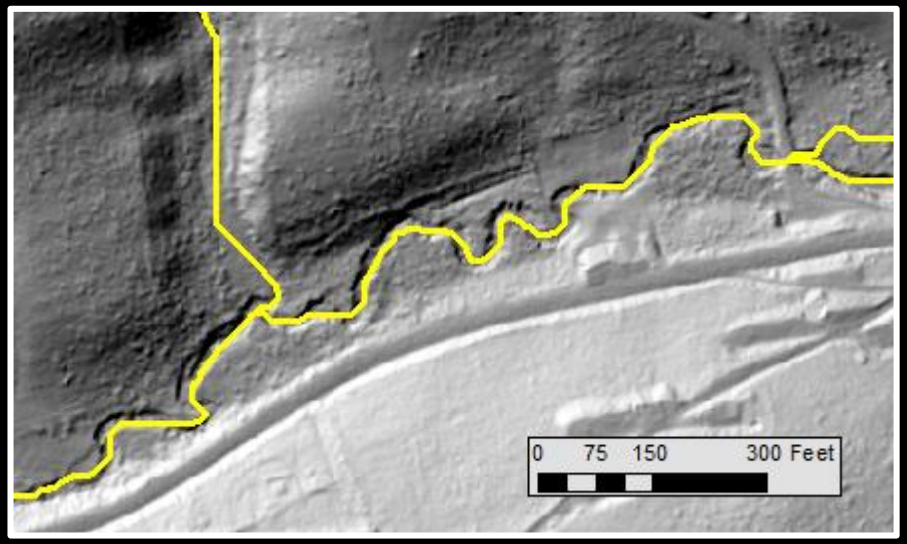



Current NHD
Manual lines
Derived lines

# The product so far… Example 3

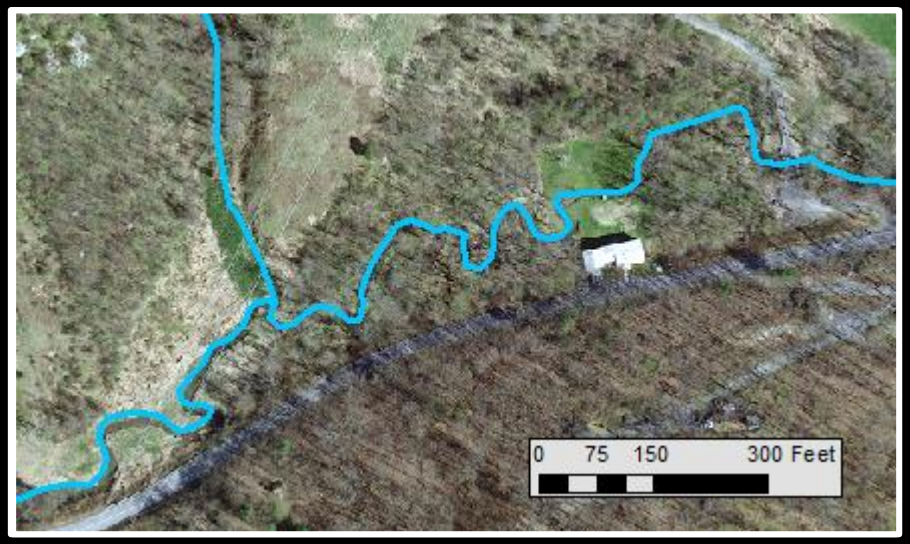
Current NHD
Manual lines
Derived lines

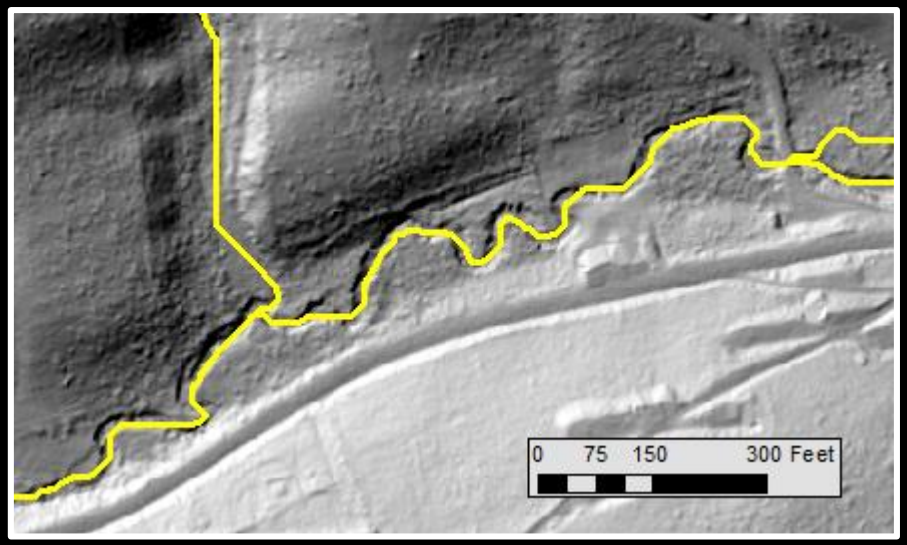


# The product so far… Example 3

Current NHD
Manual lines
Derived lines



# Projected Timeline for Level 1

| **Product** | **Time** |
|---|---|
| Manual culvert dataset(s) | 1-2 hours |
| Geomorphon processing | 15 minutes |
| Flow accumulation | 15 minutes |
| Network conflation | 1 hour |
| | |
| TOTAL: | 2.5-3.5 hours |

→ *3 hours per HU12*

# Projected Timeline for Level 1

1454 HU12's overlapping Pennsylvania

1454 HU12's * 3 hours work → 4362 hours of work

4362 hours / 7.5 hour day → 582 work days

252 work days in a year… → ***just over 2 years***

# Projected Timeline for Level 1

| **Product** | **Time** |
|---|---|
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| | |
| TOTAL: | 2.5-3.5 hours |

~~→ *3 hours per HU12*~~

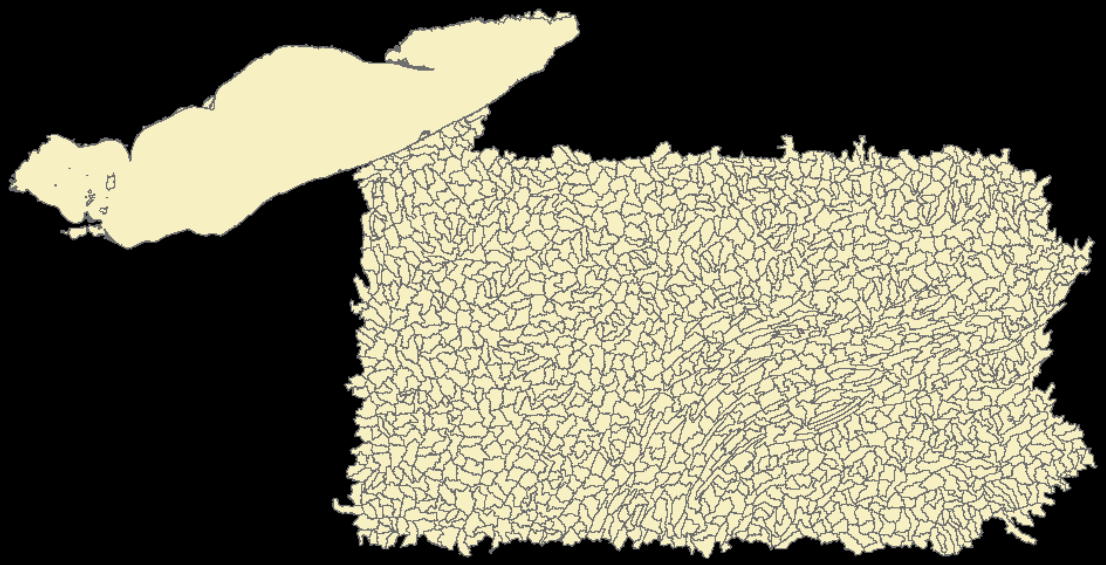
→ *2 hours per HU12(?)*

# Concerns

- Extent of dataset
- Watershed boundaries
- Automation
- Field verification
- Updates

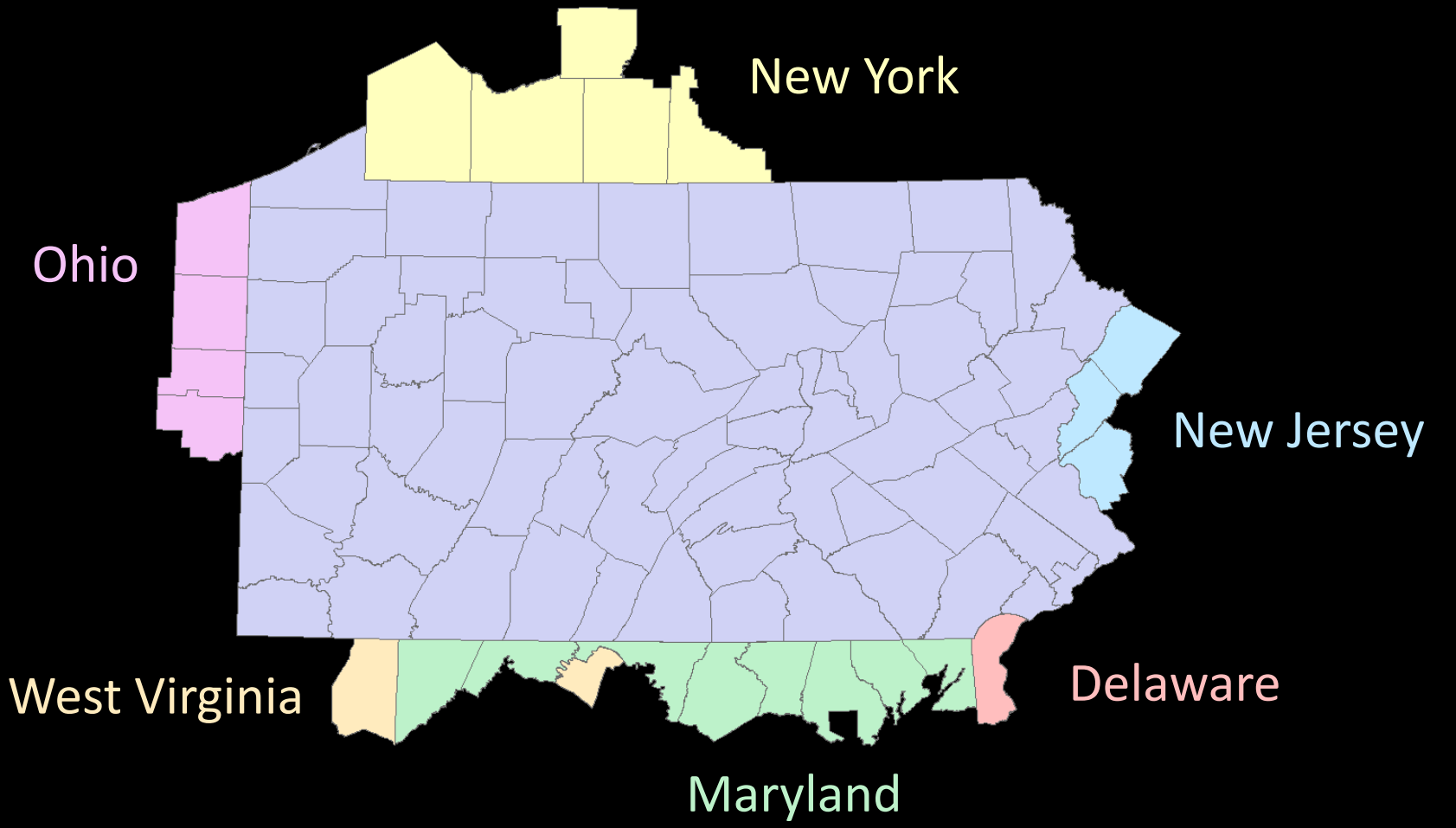
# Extent of Dataset

How far outside of Pennsylvania should we apply this analysis?



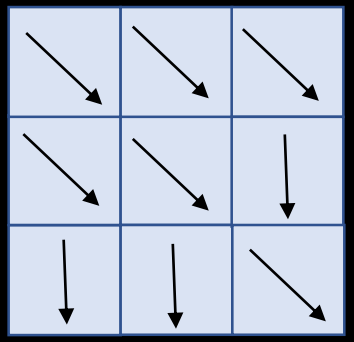
What data is available?

# Extent of Dataset



# Extent of Dataset

How far outside of Pennsylvania should we apply this analysis?



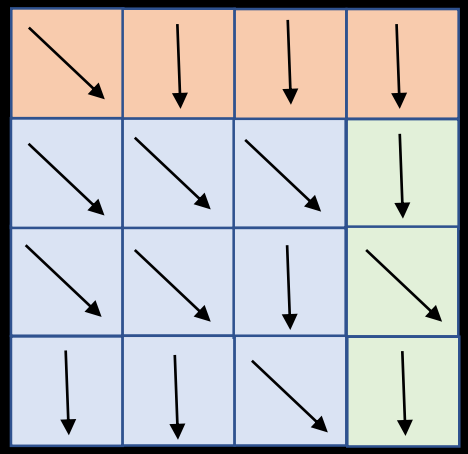
Flow direction

| | | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 0 | 1 | 4 |

Flow accumulation

# Extent of Dataset

How far outside of Pennsylvania should we apply this analysis?



Flow direction

| | | | |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 2 | 1 | 1 |
| 0 | 1 | 3 | 4 |
| 0 | 1 | 6 | 0 |

Flow accumulation

# Extent of Dataset

How far outside of Pennsylvania should we apply this analysis?

| | | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 0 | 1 | 4 |

Flow accumulation
(without neighboring data)

| | | | |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 2 | 1 | 1 |
| 0 | 1 | 3 | 4 |
| 0 | 1 | 6 | 0 |

Flow accumulation
(with neighboring data)

# Extent of Dataset

How far outside of Pennsylvania should we apply this analysis?

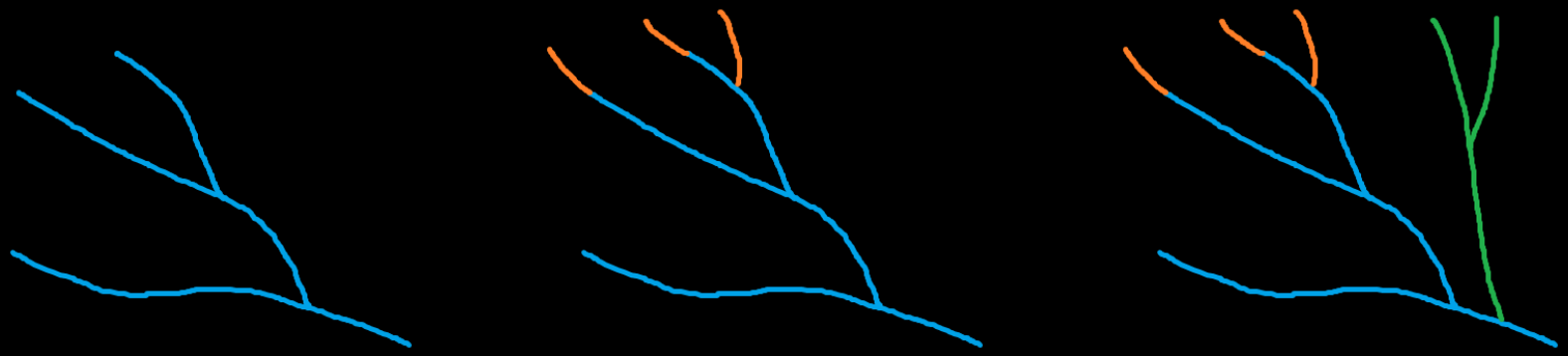
| | | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 0 | 1 | 4 |

Flow accumulation
(without neighboring data)

| | | |
|---|---|---|
| 0 | 2 | 1 |
| 0 | 1 | 3 |
| 0 | 1 | 6 |

Flow accumulation
(with neighboring data)

# Watershed Boundaries



# Automation

**ModelBuilder**

- Cannot export to Python if model uses iterators
- Depends on ArcMap not crashing
- Models within models (modelception) to facilitate iterators
- Have to run ArcMap to run the model

**Python**

- Not a lot of experience
- Not a lot of available Python resources that focus on Arc Hydro commands


*Li Cheng Shih, "Python bivittatus" – from Wikimedia Commons.*

# Field Verification

# Attributes

- Incorporate existing attribute information
- Manual editing
- Care not to conflate features that are environmentally, geologically, and ecologically distinct

# Updates

- Don’t want to re-apply the entire process multiple times
- Looking into methods of “difference detection”

# Collaboration

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