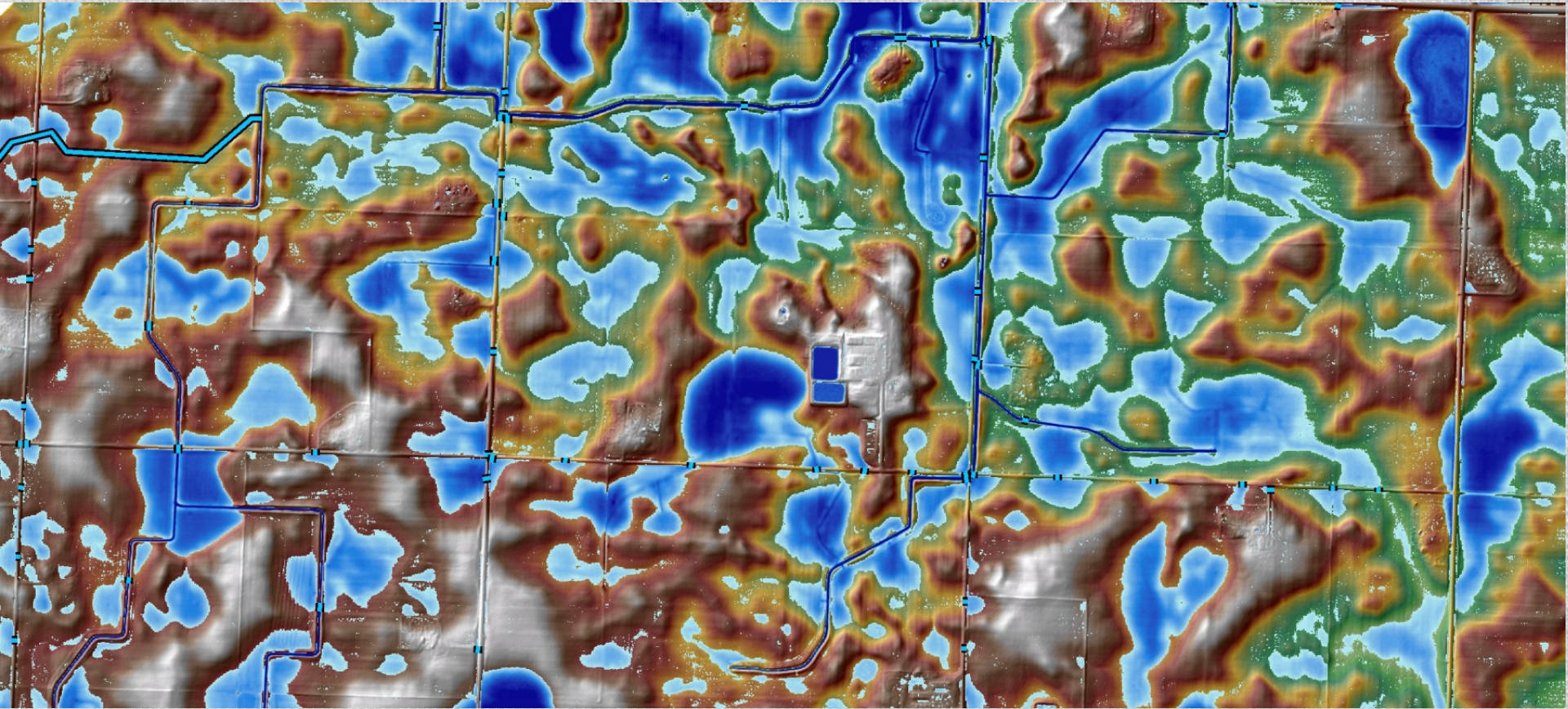


# Terrain Analysis

Watson Creek – Root River

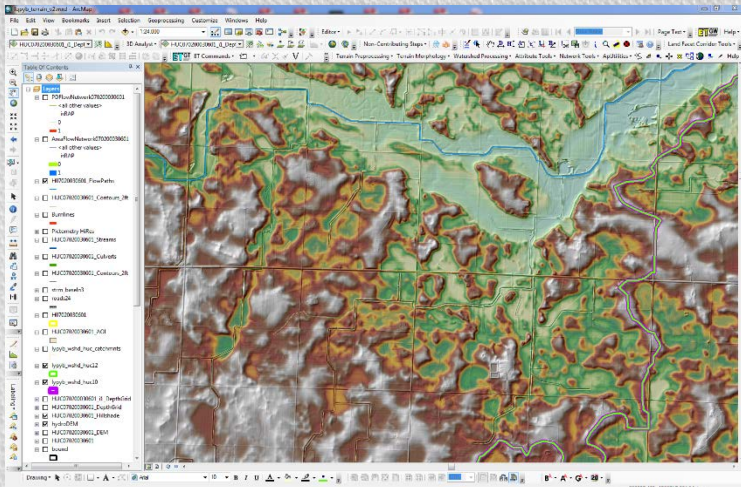


Water Resources Center Minnesota State University, Mankato  
Jessica Nelson, Rick Moore, Andrew Meyer

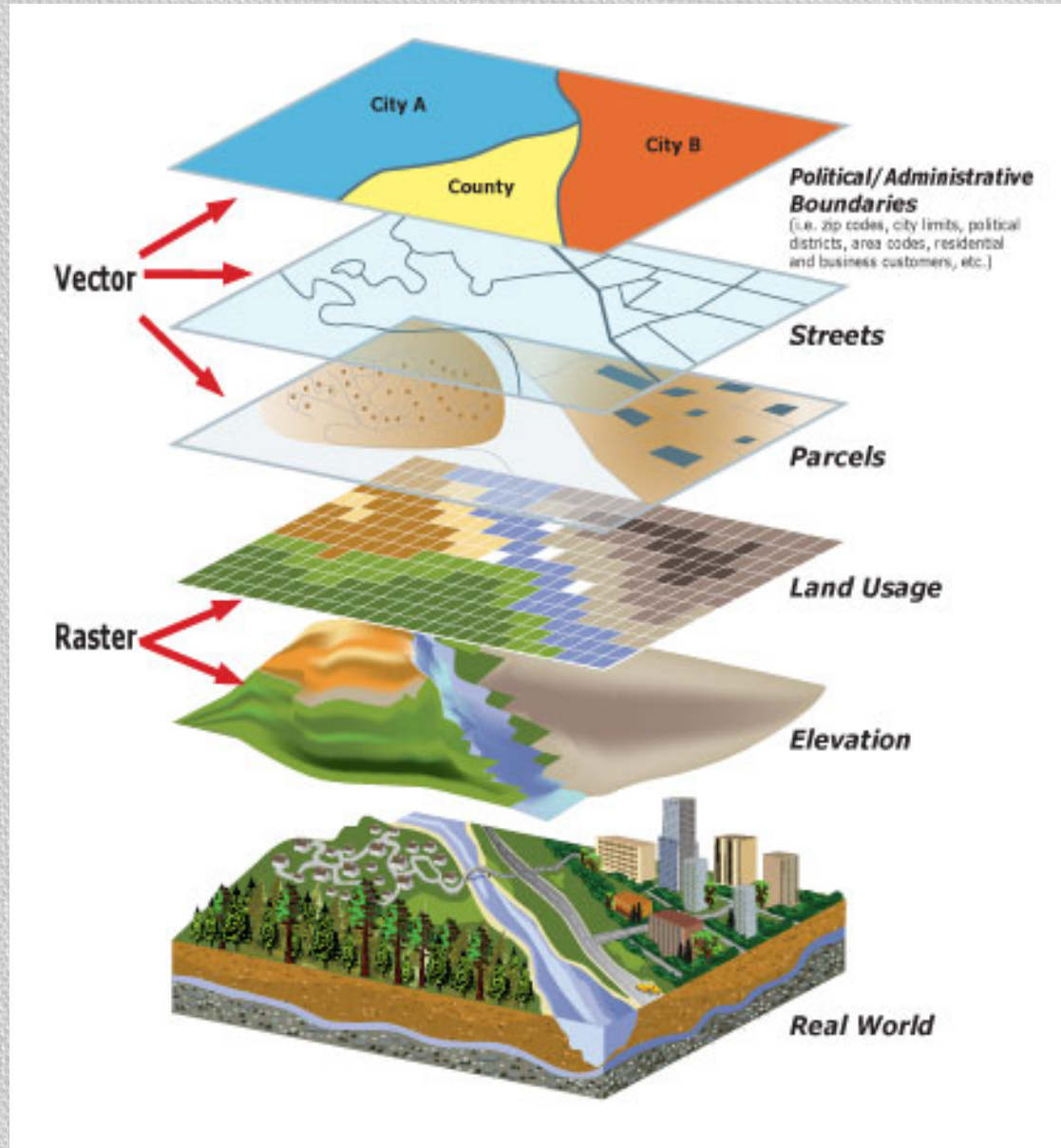
Agricultural Conservation Planning Framework  
National Laboratory for Agriculture and the Environment  
U.S. Department of Agriculture, Agriculture Research Service  
Mark Tomer, Sarah Porter, David James, and Kathy Boomer (TNC)



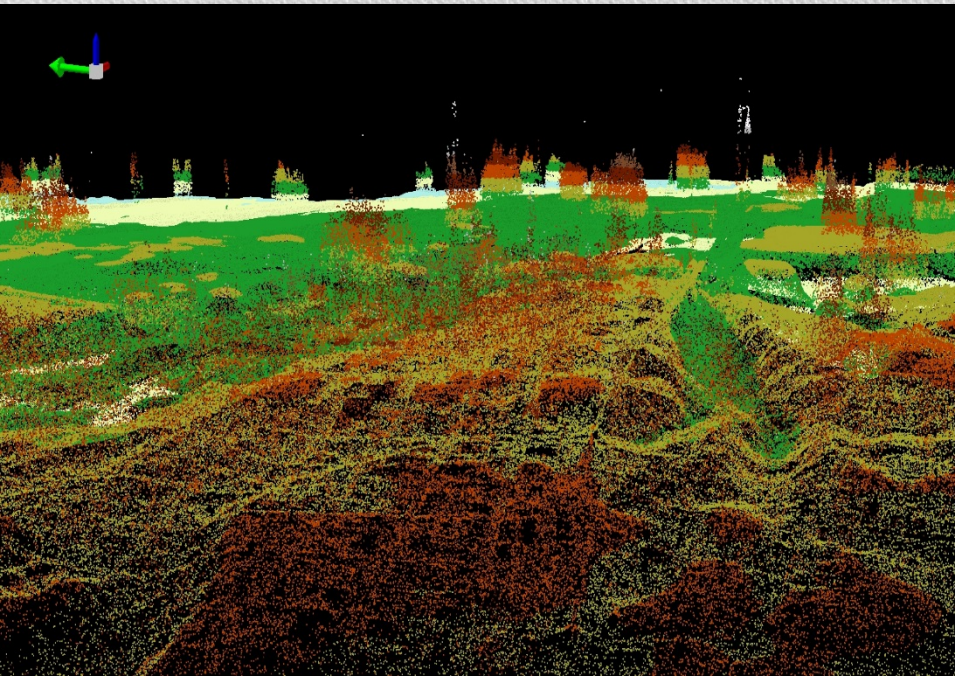
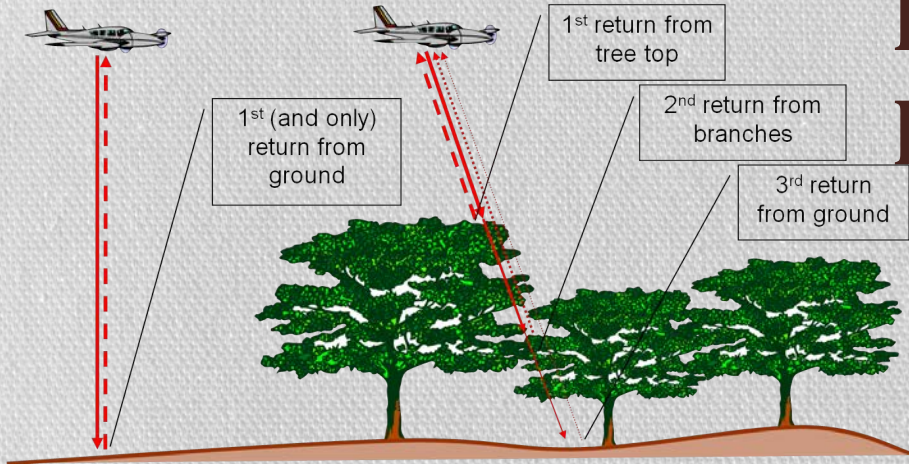
# Geographic Information Systems (GIS)



A GIS combines layers of information about a place to give you a **better understanding** of that place.



# Light Detection and Ranging (LiDAR)

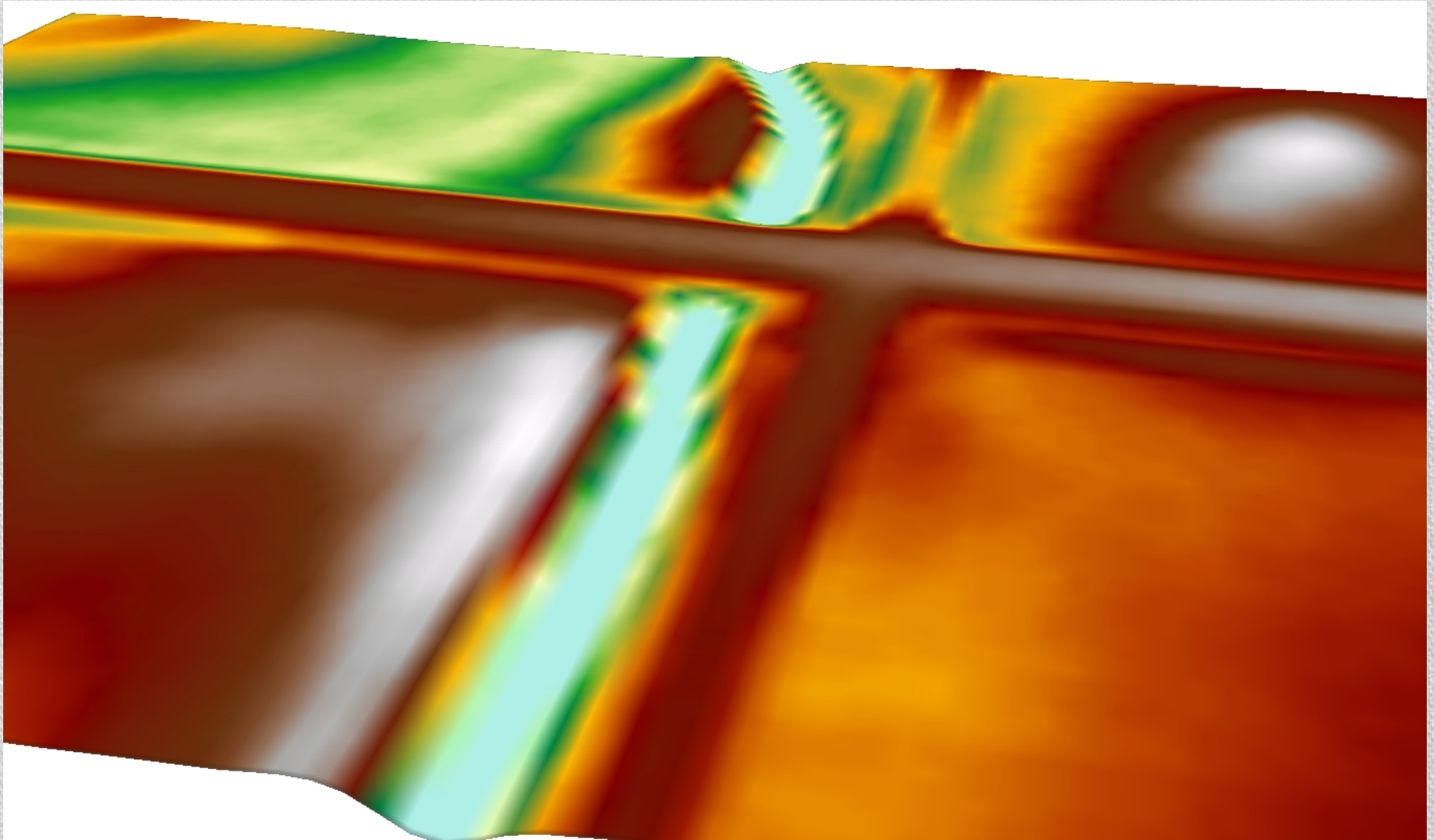


- Lidar: pulsed laser used to measure ranges (distance)
- Lidar data can be used to vegetation intensity through series of algorithms

# Terrain Analysis

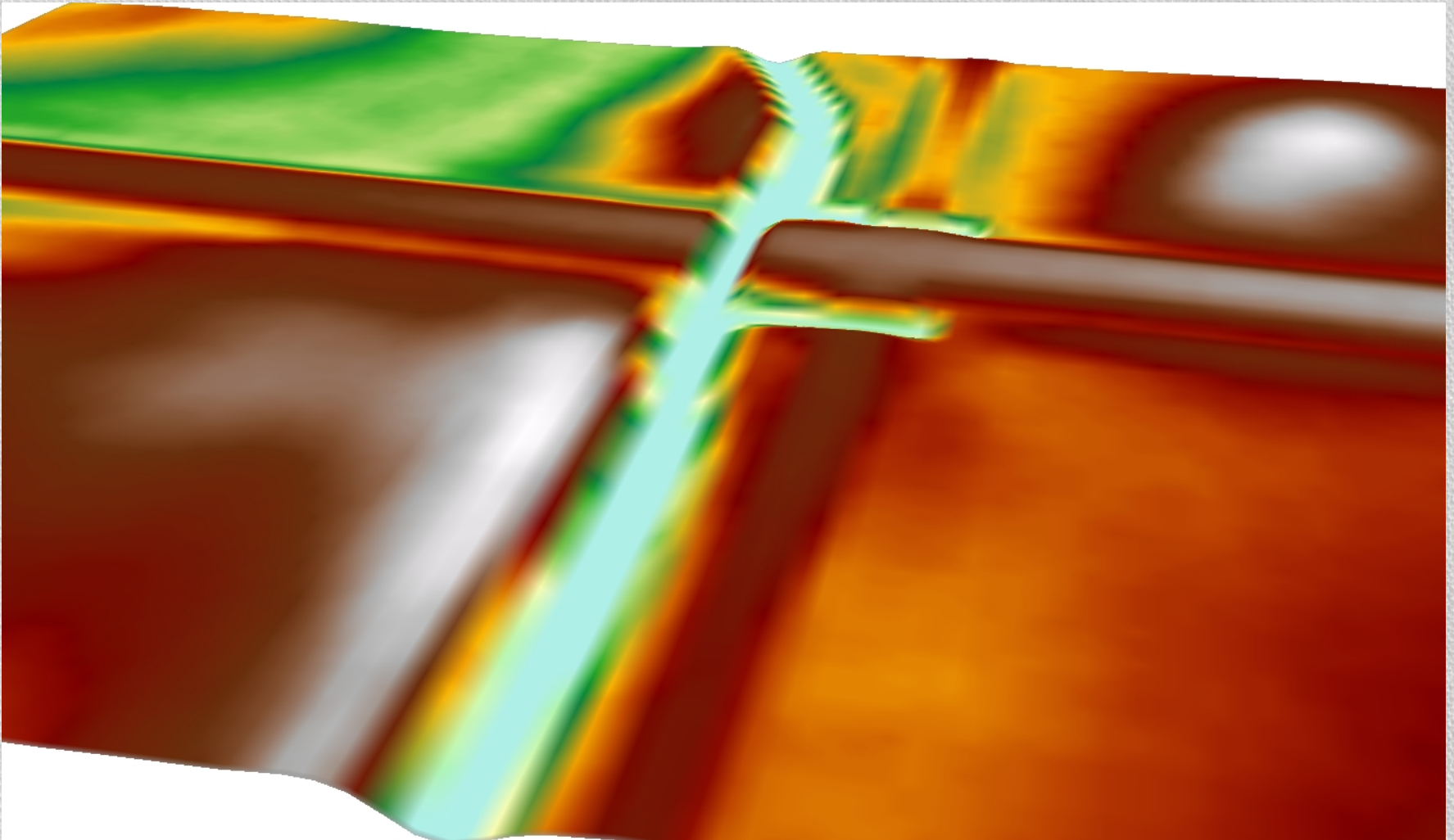


# Hydrologic Conditioning Digital Dams



- “Digital Dams”
  - Culverts, bridges, any subsurface drainage alterations
  - Creates errors in subwatershed areas at points downstream

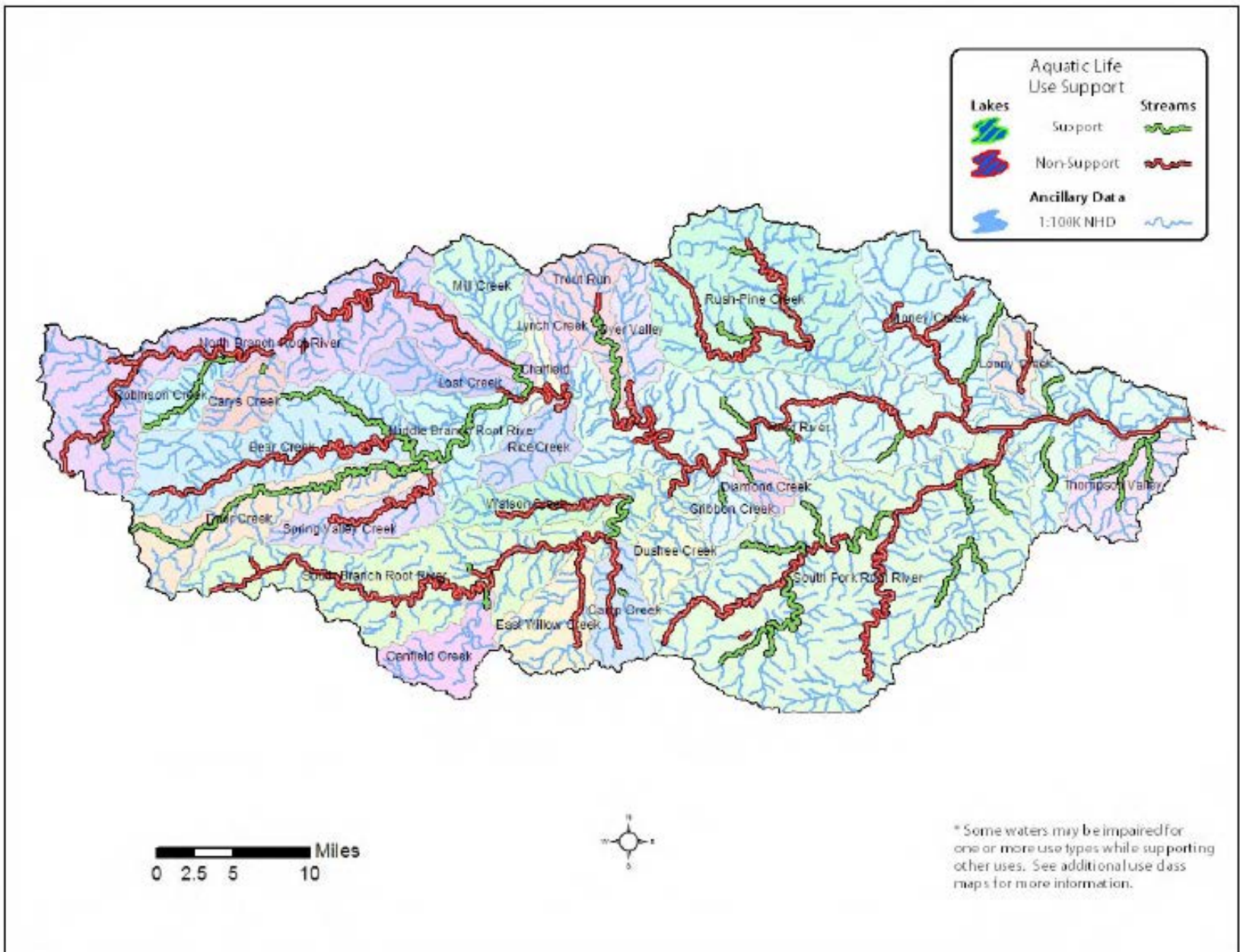
# Hydrologic Conditioning Digital Dams



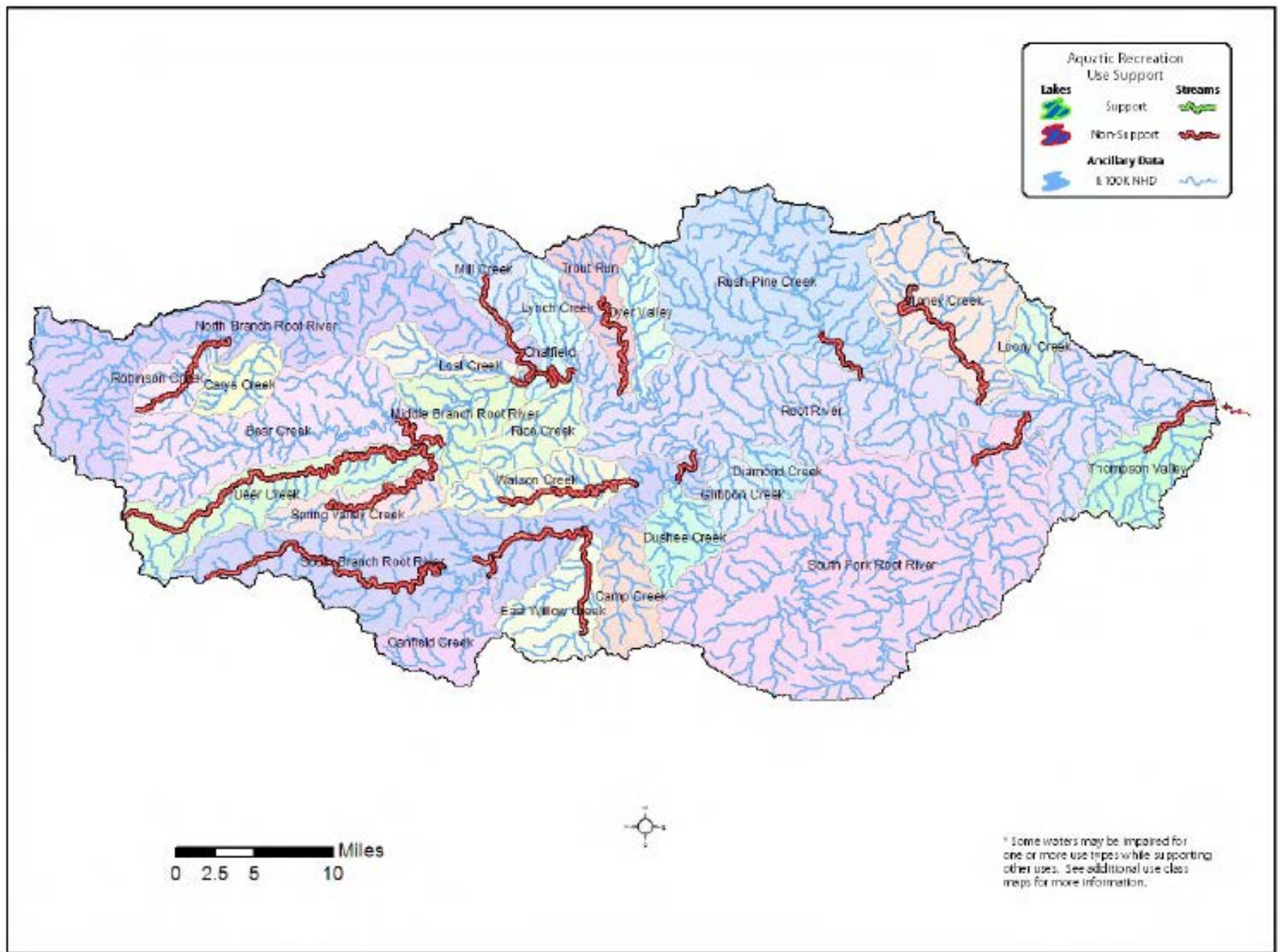
- “Digital Dams”
  - Culverts, bridges, any subsurface drainage alterations
  - Creates errors in subwatershed areas at points downstream



# HUC12 Targeting

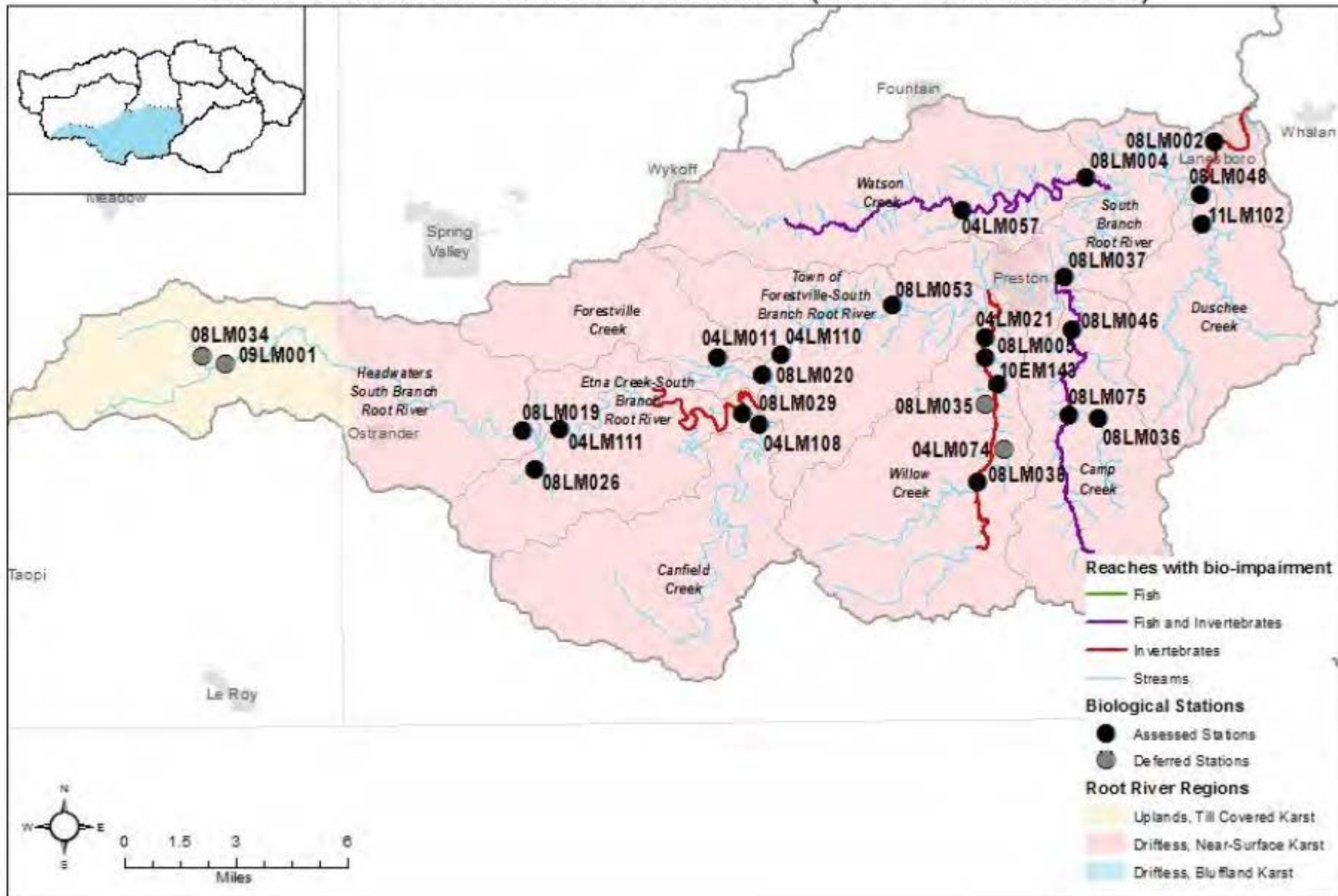


# HUC12 Targeting



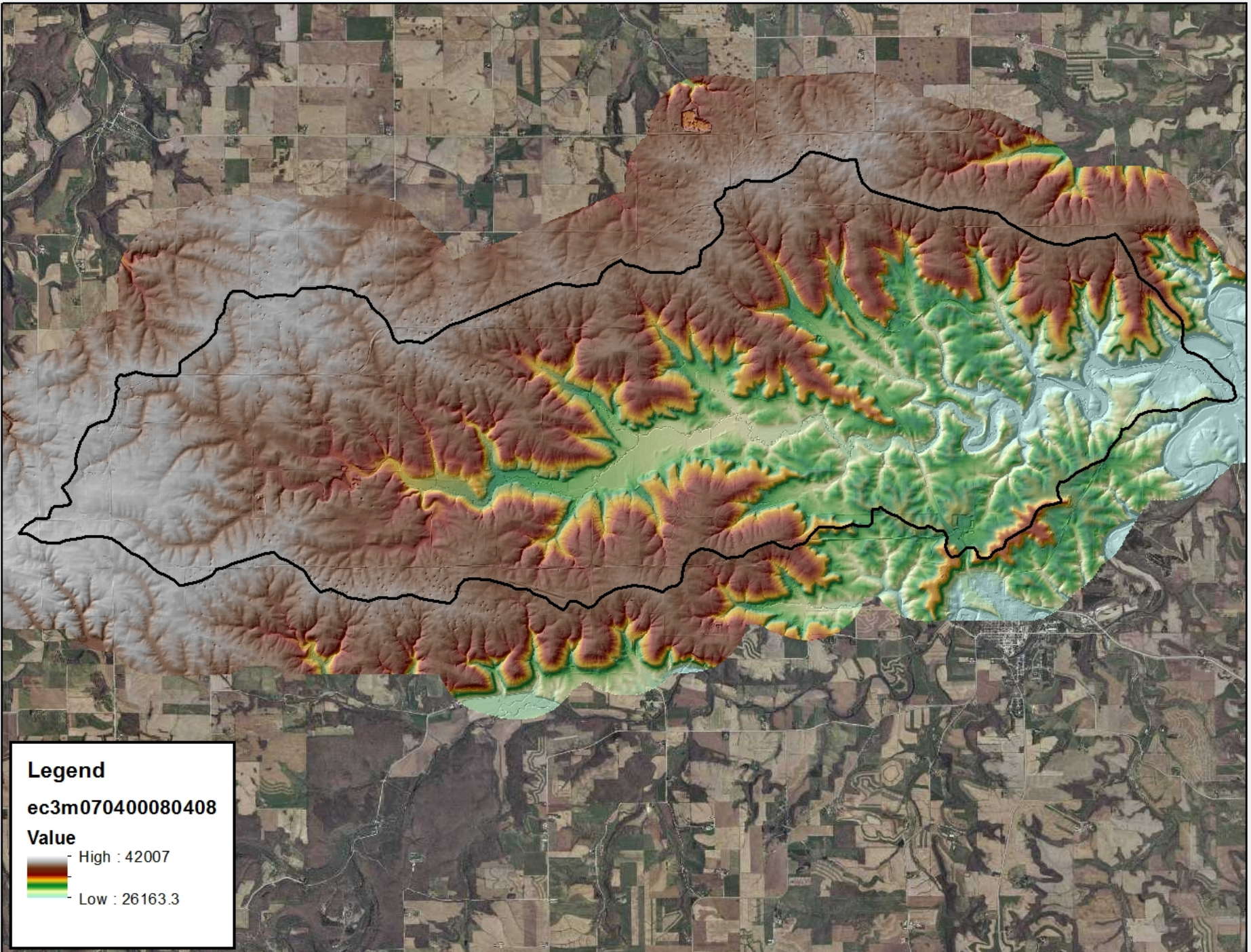
# HUC12 Targeting

## South Branch Root River Watershed (HUC - 0704000804)





# Data Sets

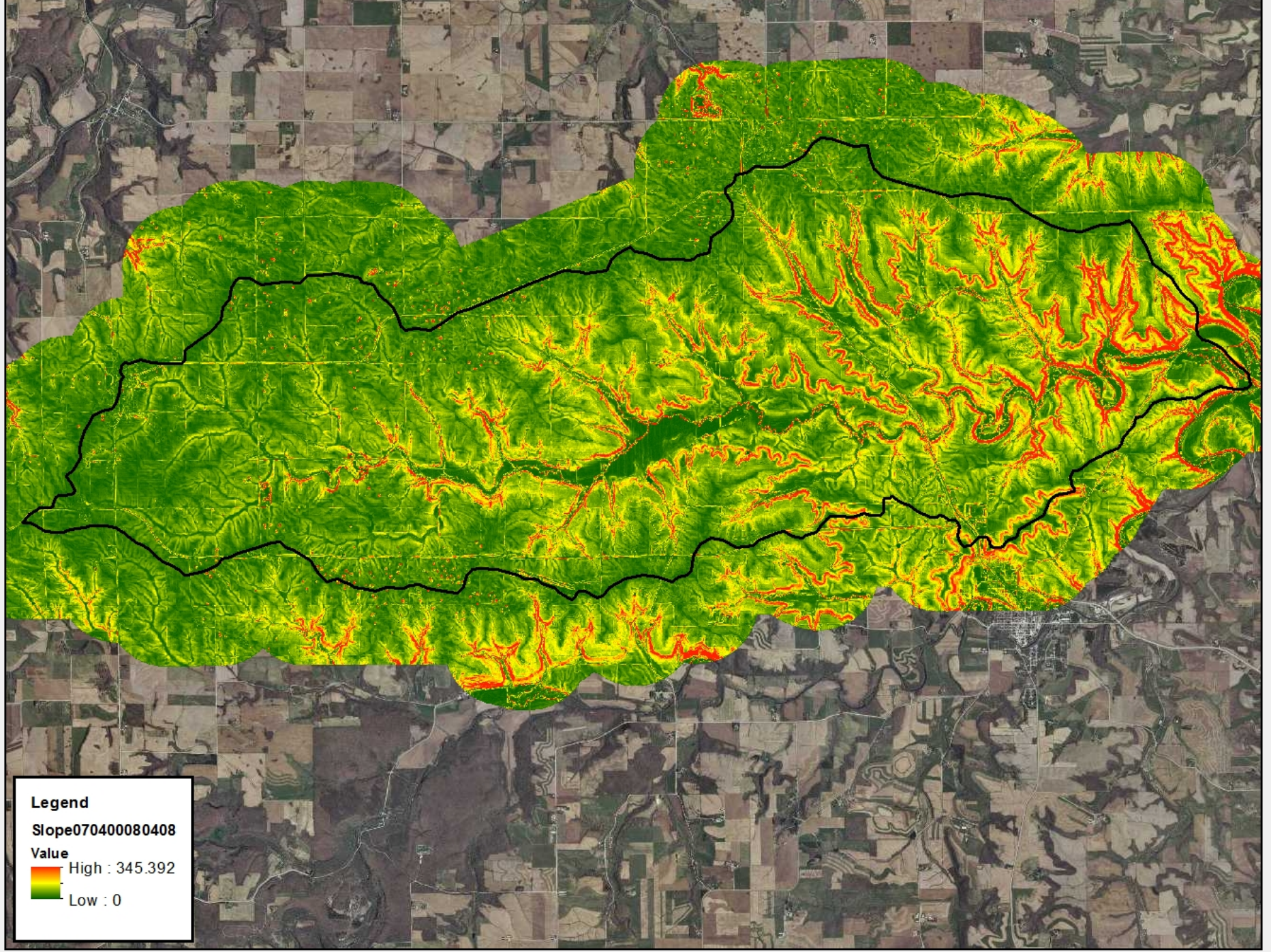
Input data include a LiDAR-derived digital elevation model (DEM), agricultural field boundaries with land use information, and SSURGO soil survey data.



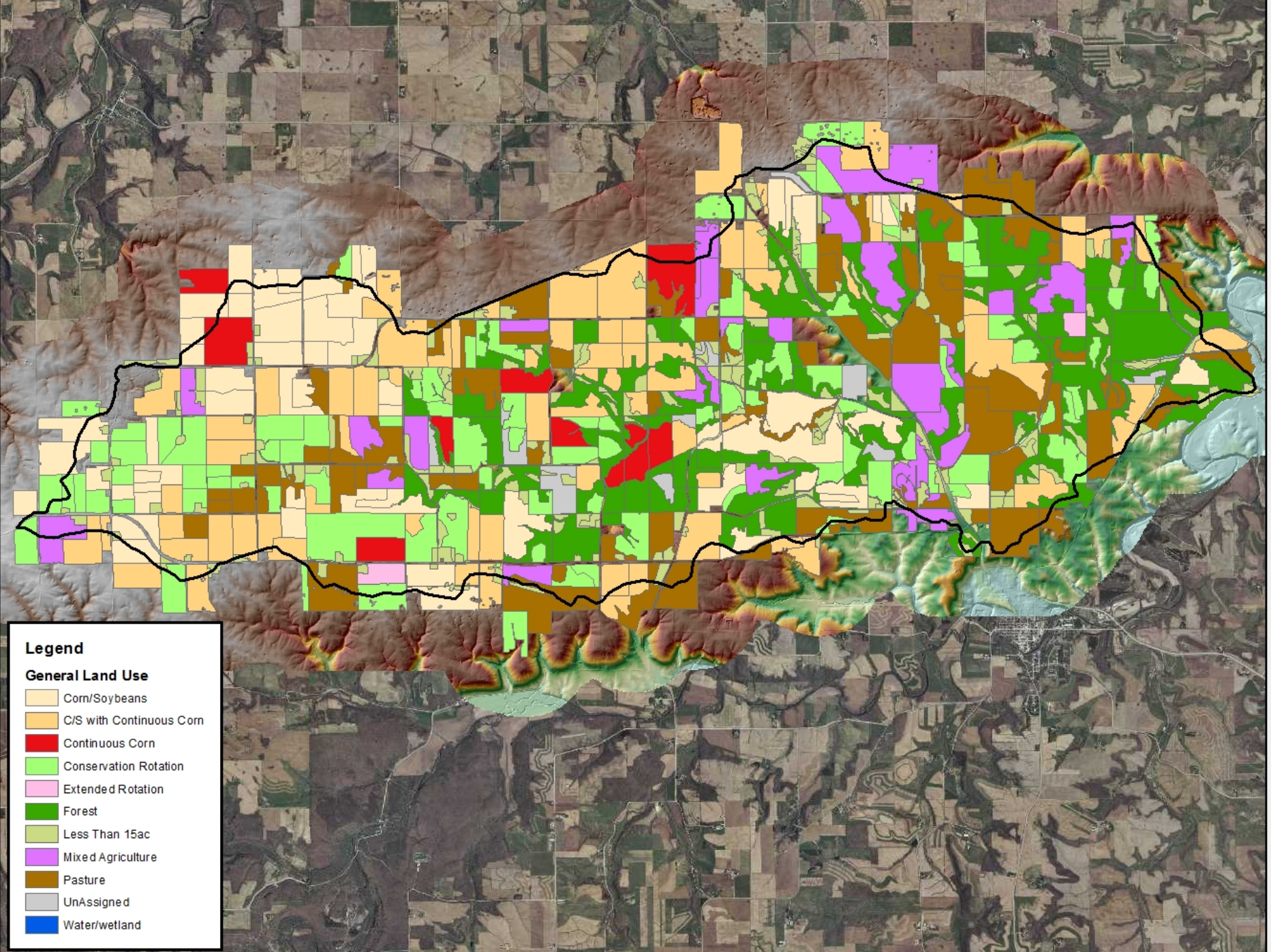
**Legend**  
ec3m070400080408

**Value**

	High : 42007
	Low : 26163.3



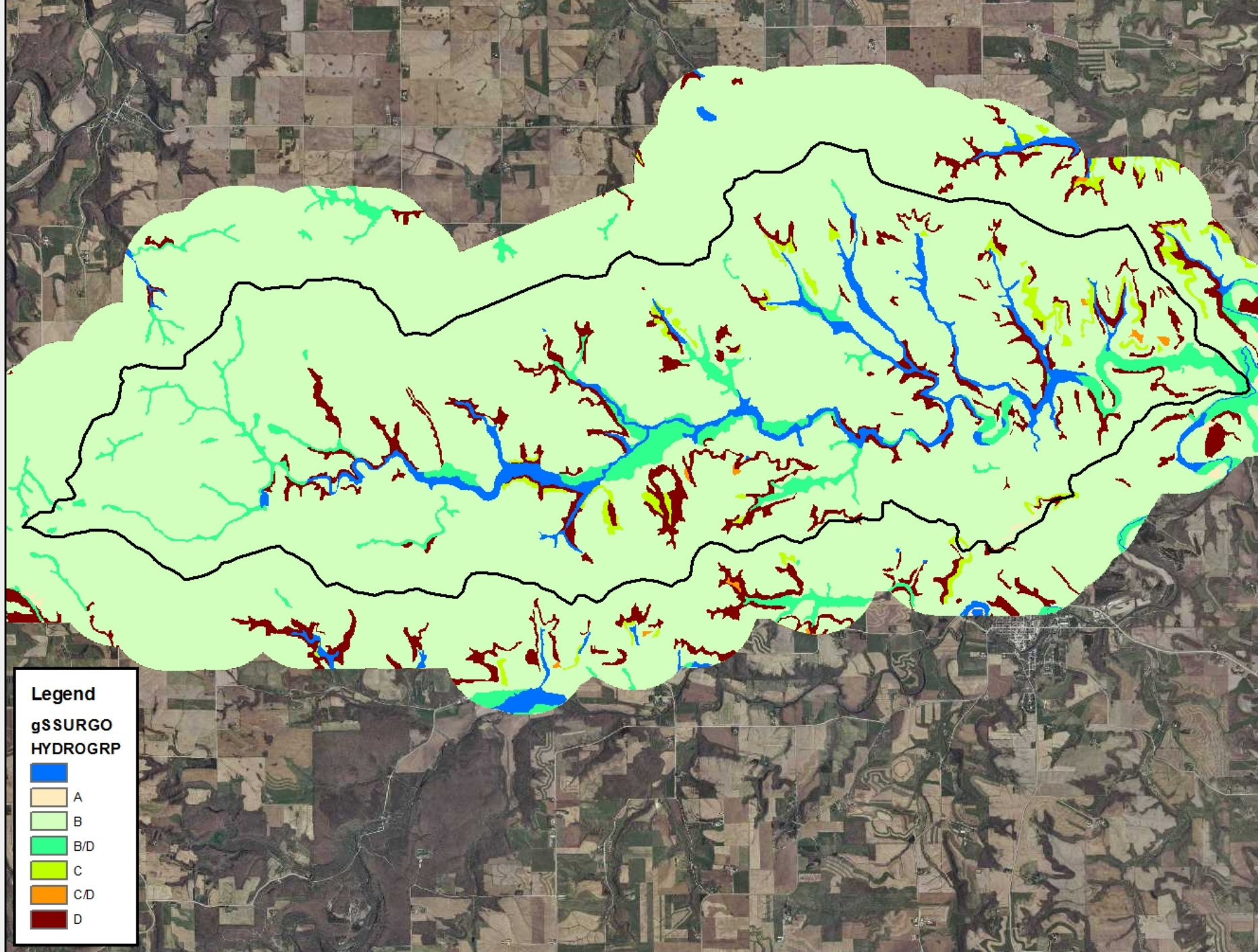
**Legend**  
**Slope070400080408**  
**Value**  
High : 345.392  
Low : 0










**Legend**

**General Land Use**

- Corn/Soybeans
- C/S with Continuous Corn
- Continuous Corn
- Conservation Rotation
- Extended Rotation
- Forest
- Less Than 15ac
- Mixed Agriculture
- Pasture
- UnAssigned
- Water/wetland



**Legend**  
gSSURGO  
HYDROGRP

	
	A
	B
	B/D
	C
	C/D
	D



**SPI -  
Stream Power  
Index**

# Stream Power Index

Measurement of potential energy of water as it flows over bare ground

$$SPI = \ln[\underbrace{(\text{flow accumulation})}_{\text{Amount of water expected}} \times \underbrace{(\text{slope})}_{\text{Slope of flow path}}]$$

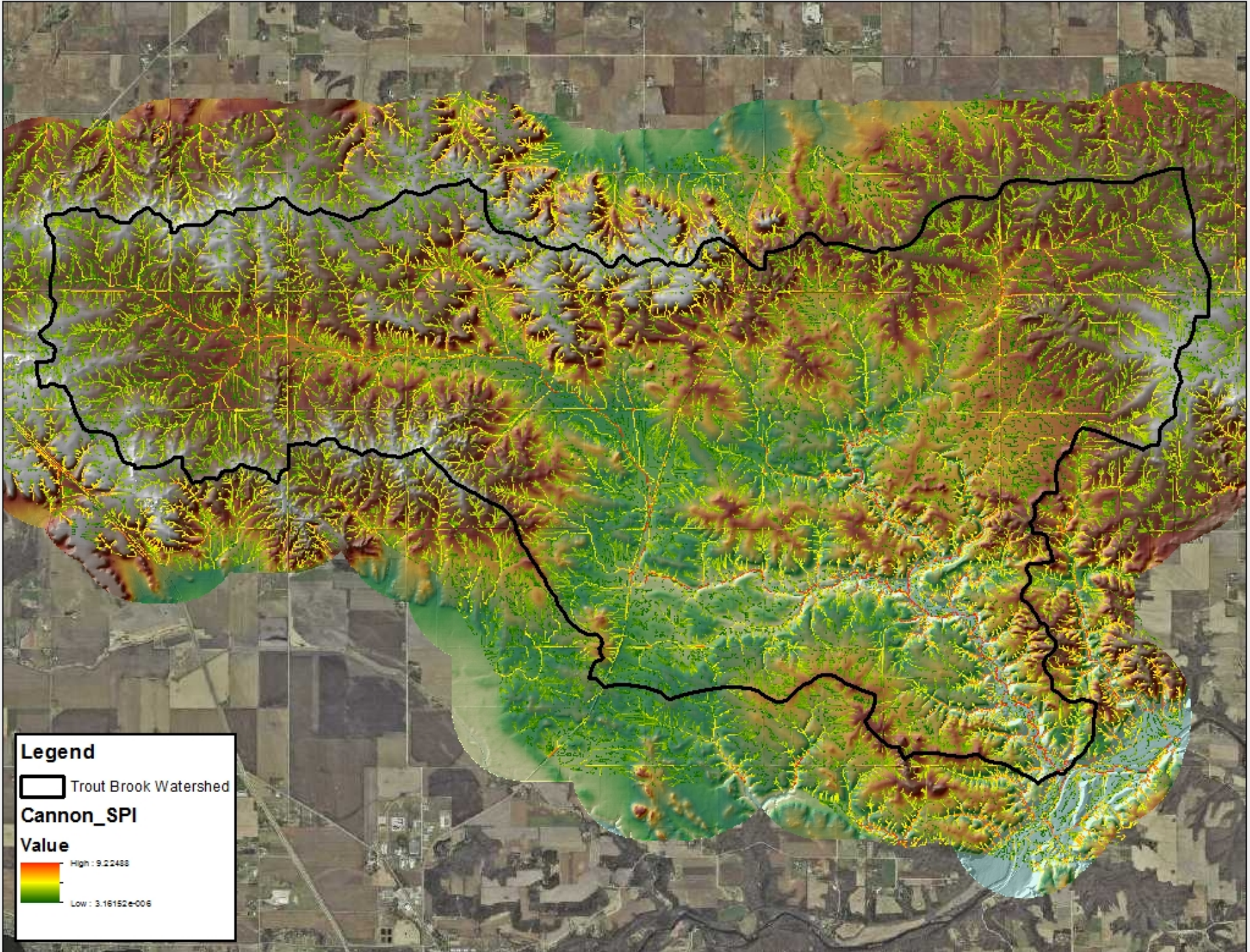
Amount of  
water  
expected

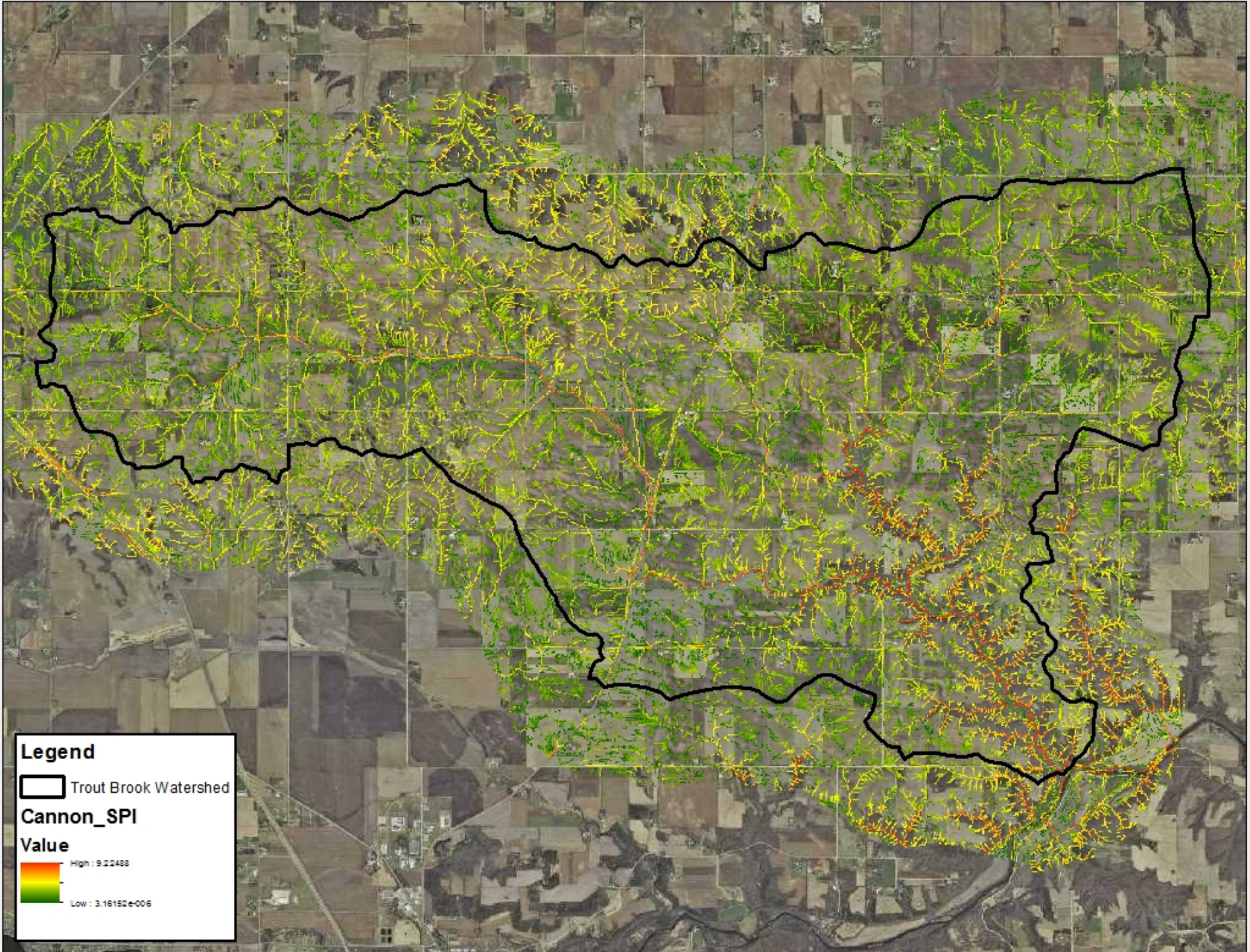
Slope of  
flow path

*Purpose: Identify locations with high potential for gully erosion*




Photo credit: [http://www.mngeo.state.mn.us/chouse/elevation/uses/lidar\\_uses\\_waterquality.html](http://www.mngeo.state.mn.us/chouse/elevation/uses/lidar_uses_waterquality.html)






**Legend**

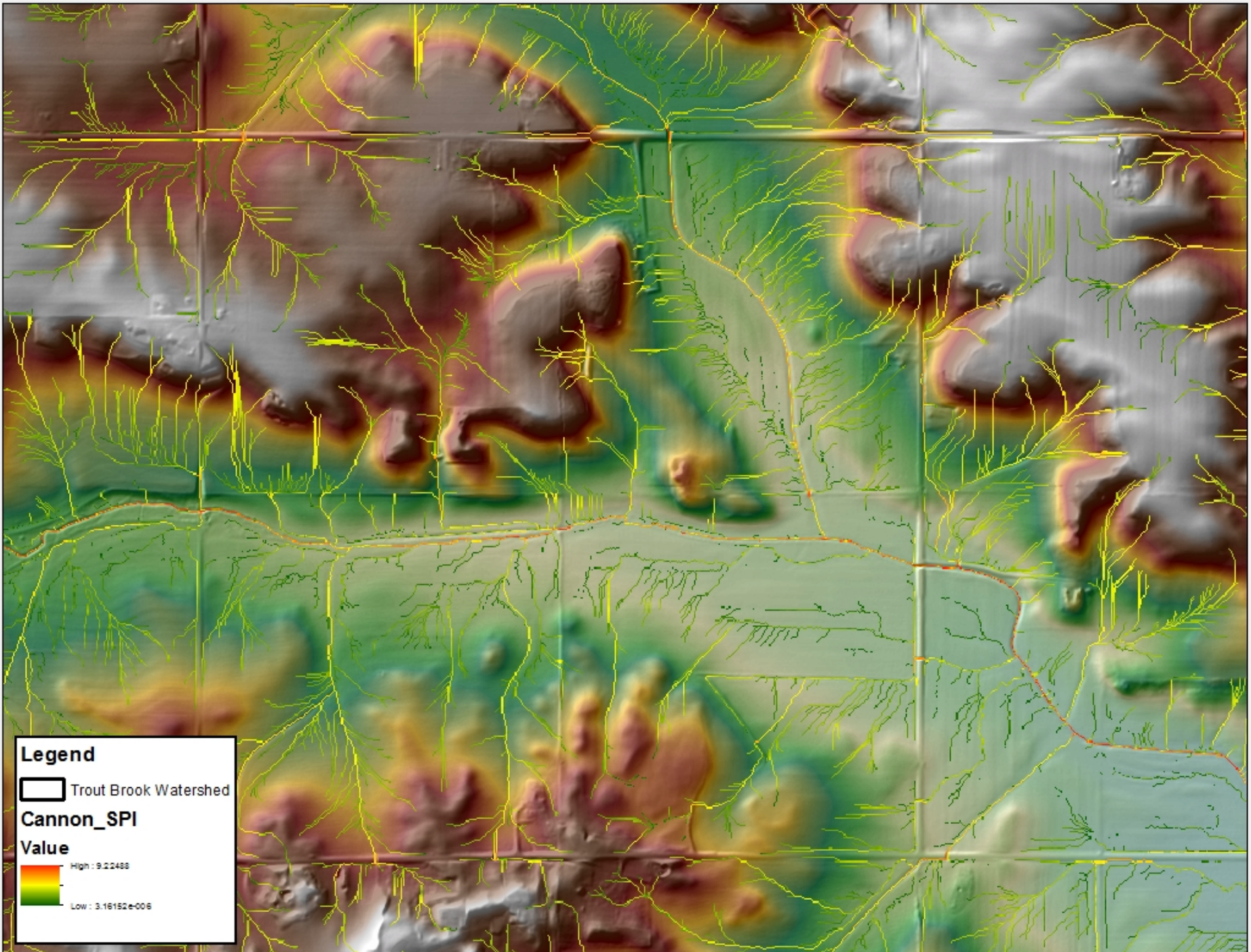
 Trout Brook Watershed

**Cannon\_SPI**


**Value**

 High : 9.22488

Low : 3.16152e-006




**Legend**

 Trout Brook Watershed

**Cannon\_SPI**


**Value**

 High : 9.22488

Low : 3.16152e-006




**Legend**

 Trout Brook Watershed

**Cannon\_SPI**

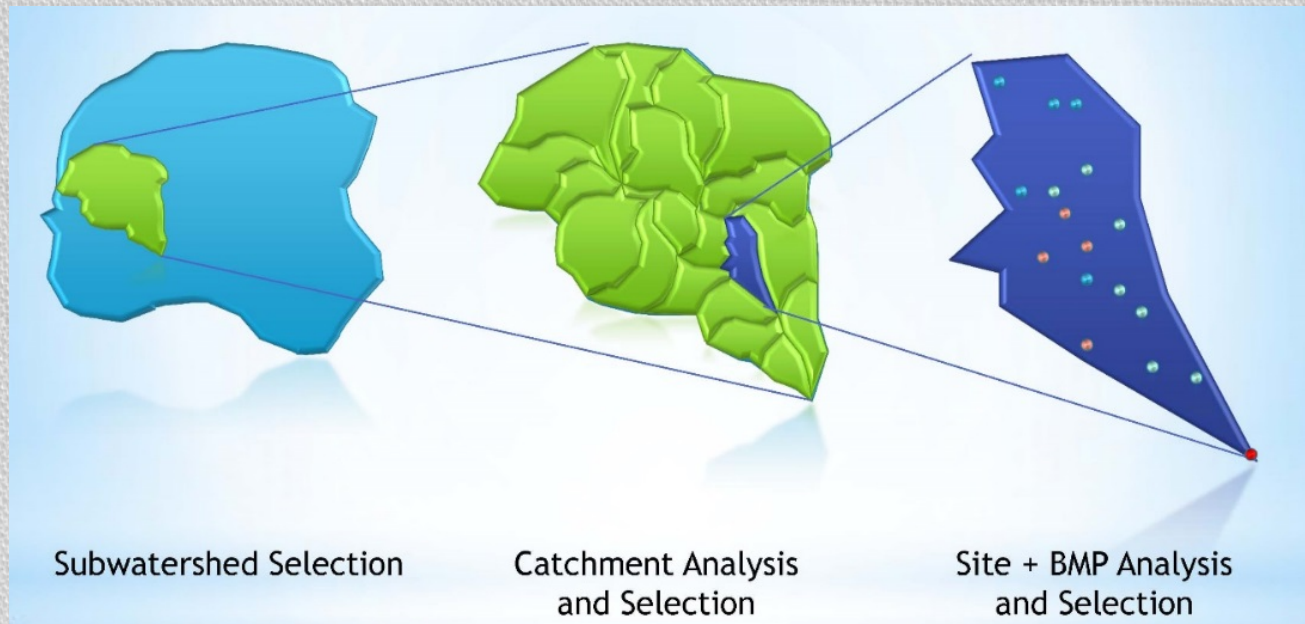
**Value**

 High : 9.22488

Low : 3.16152e-006

# Precision Conservation Framework

By Mark Tomer, ARS, Ames, IA



**Figure 2**

A framework for watershed-scale conservation planning using precision technologies.

**Process for conservation planning to improve water quality in agricultural watersheds using precision technologies**

DATA REQUIRED: LIDAR-based digital elevation model; Soil survey, Field boundaries, Land use

Assessments for prioritization and design of practices

**Runoff risk assessment:**  
Prioritize fields where multiple erosion control practices are most needed

Close to stream?

		Yes	No
Slope steepness	H	A	B
	M	B	C
	L	C	

**Riparian assessment:**  
Identify riparian function by stream reach

Shallow water table?

		Yes	No
Runoff delivery	H	i	ii
	M	ii	iii
	L	iv	v

**1 AVOID and CONTROL:** Improve soil health within cropped fields to avoid and control pollutant losses by Protecting soils from erosion with zero or minimum tillage; Limiting excess nutrients through rates and timing of fertilizer and manure applications; Building soil organic matter and rejuvenating compacted soils with intensified crop rotations

**2 CONTROL, TRAP, and/or TREAT**

	TILE DRAINAGE	SURFACE RUNOFF
--	---------------	----------------

<b>IN FIELDS</b> Place water control/ filter practices ↓	<b>3</b> Controlled drainage where slopes are least	<b>5</b> Contour filter strips, terraces, conservation cover where slopes are steep  Grassed waterways where gullies may form
	<b>4</b> Surface intake filters or restored wetlands where depressions occur	

<b>BELOW FIELDS</b> Place water detention/nutrient removal practices ↓	<b>6</b> Bioreactors or small wetlands constructed above field-tile outlets	<b>7</b> Perennial crops and novel practices to intercept flows where soils stay wet
	<b>8</b> Water detention using impoundments of varying designs Nutrient removal wetlands      Sediment detention basins farm ponds	

<b>RIPARIAN ZONE</b> Place/design practices for ecosystem function and nutrient removal ↓	<b>9</b> Resaturated buffers	<b>11</b> <u>Design of riparian buffers:</u> i. Critical zone/sensitive sites ii. Diversify vegetation for nutrient and water uptake iii. Trap runoff and sediment with stiff-stemmed grasses iv. Use deep rooted vegetation v. Stabilize banks, shade stream
	<b>10</b> Ditch design: <b>Two-stage ditches;</b> novel practices for detention/diversion of tile drainage	

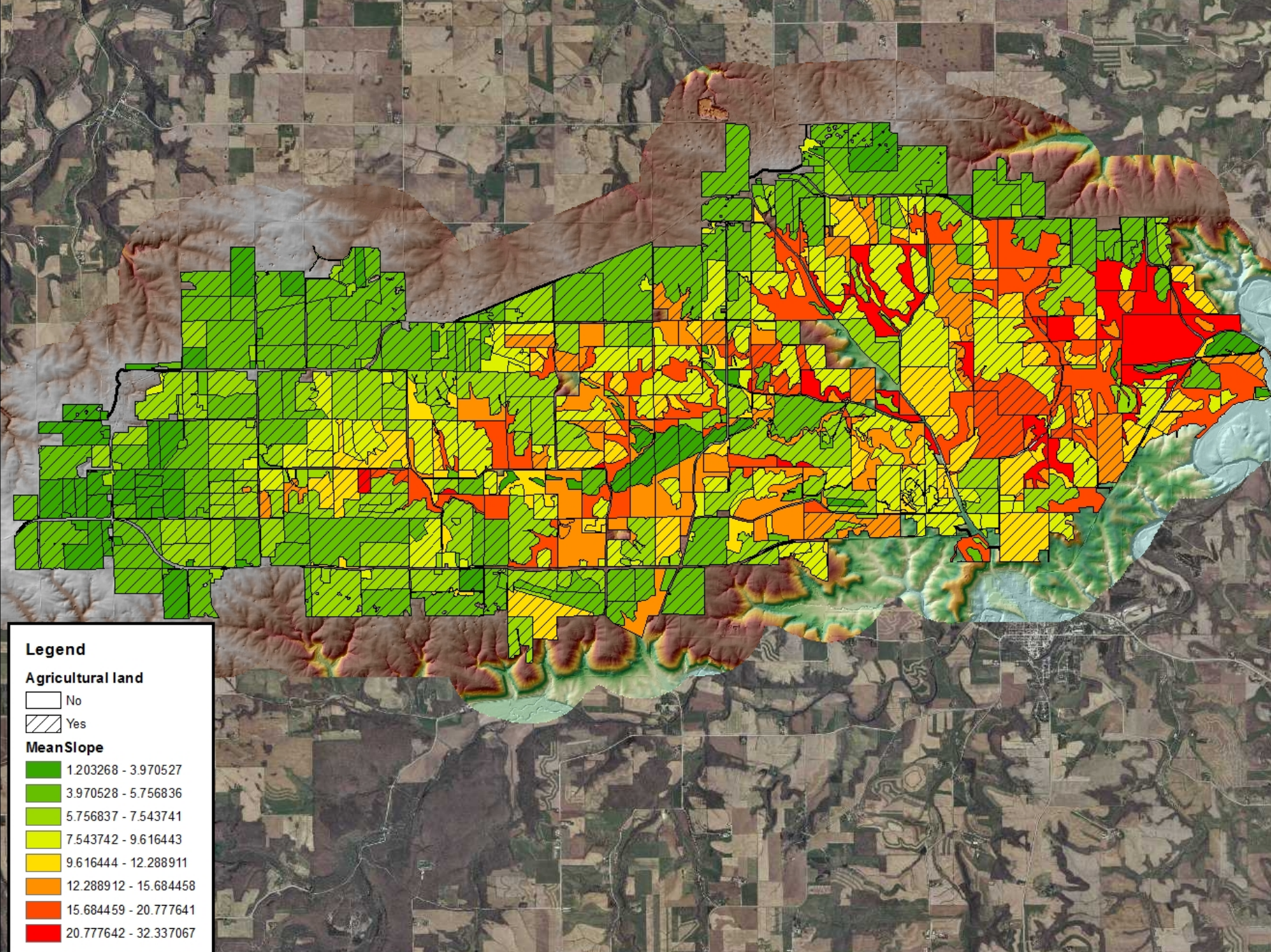
**12** Downstream/In-stream: River restoration (e.g., pool-riffle structures, re-meandering, oxbow rehabilitation)

**APPLICATION:** Scenario development/ stakeholder feedback/ implement/ monitor/ adapt



# **By-Field Slope Statistics**

**Field Characterization**



**Legend**

**Agricultural land**

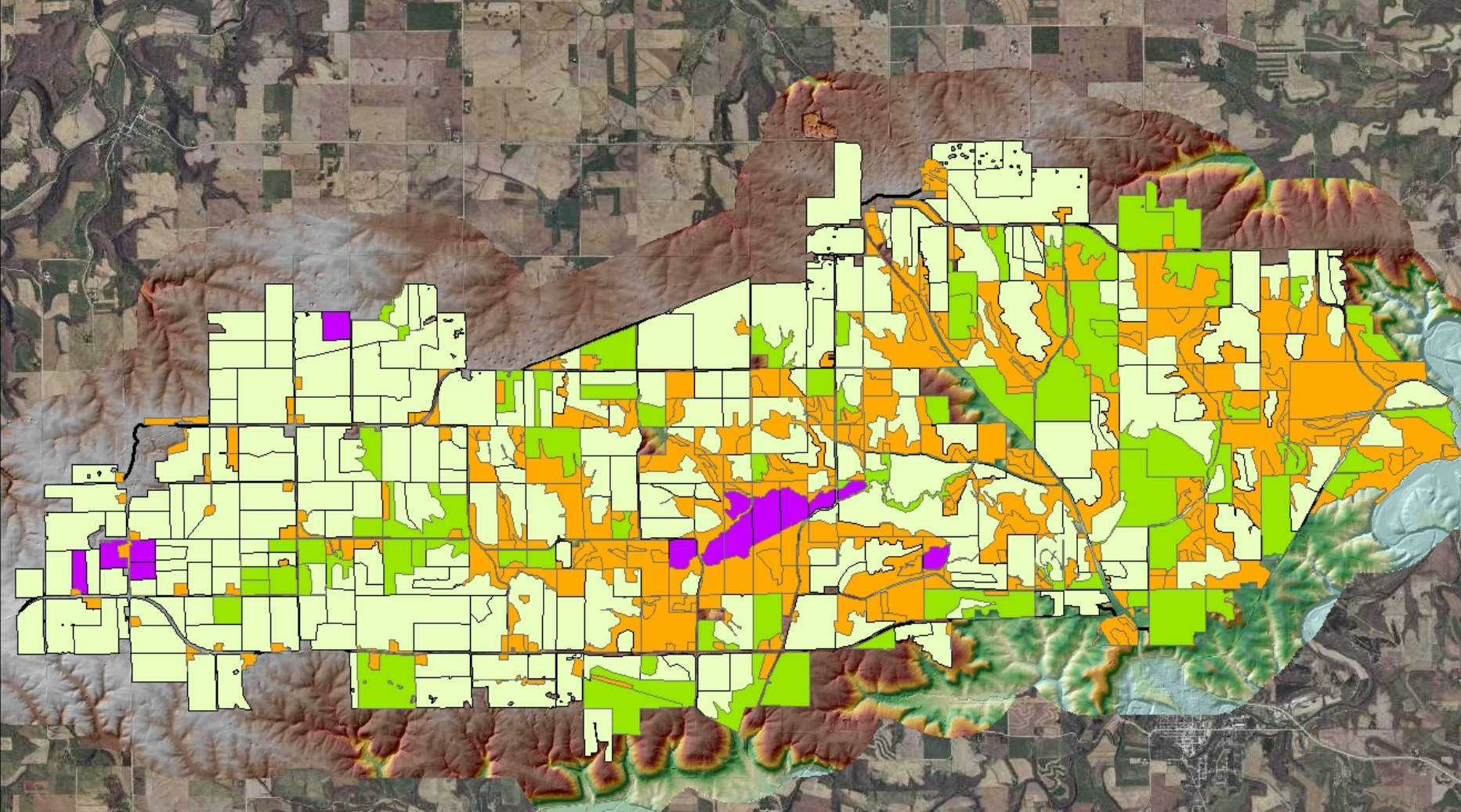
- No
- Yes

**MeanSlope**

- 1.203268 - 3.970527
- 3.970528 - 5.756836
- 5.756837 - 7.543741
- 7.543742 - 9.616443
- 9.616444 - 12.288911
- 12.288912 - 15.684458
- 15.684459 - 20.777641
- 20.777642 - 32.337067

# **Tile Drainage Determination**

**Field Characterization**



**Legend**

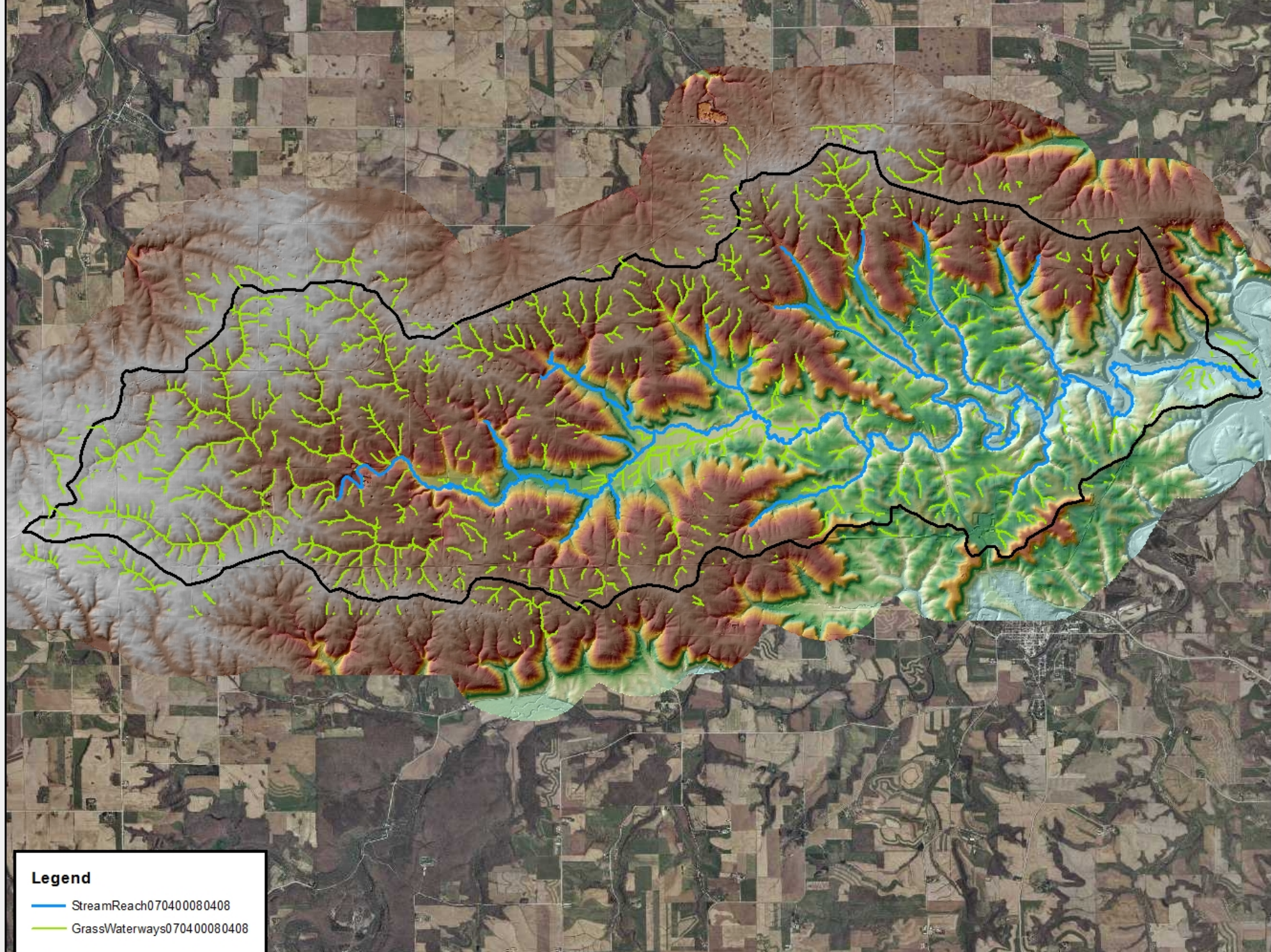
**Drained**

- <Null>
- NO
- NonAg
- Pasture
- YES

# Runoff Risk Assessment & Grassed Waterways

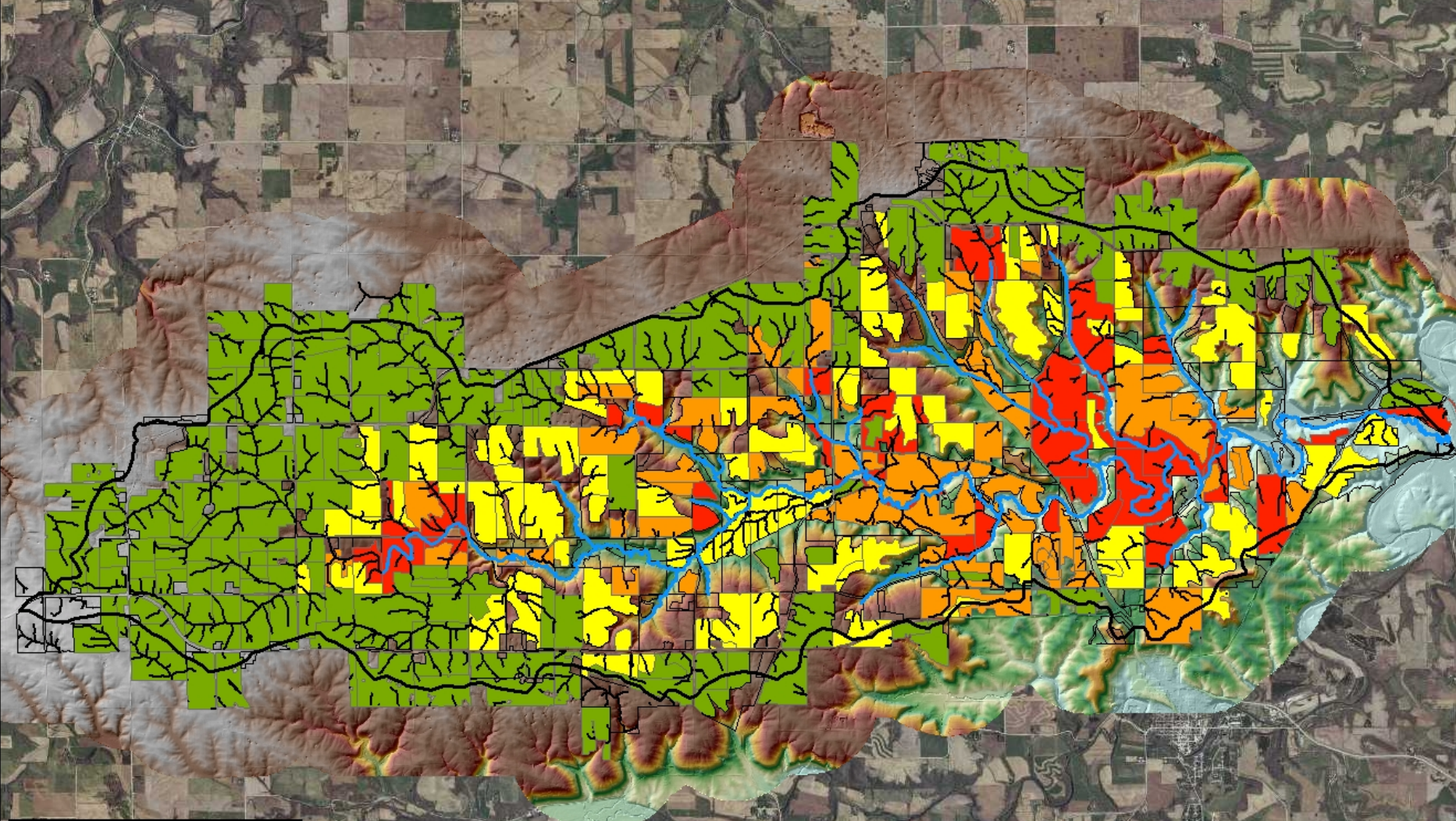
## Field Characterization

The cross classification of the “Runoff Risk Assessment” matrix classifies each field according to its runoff risk. A more-detailed look at the within field topography and flow accumulation can then identify which conservation practices may be most suitable in a given field. This image shows possible locations for grassed waterways, located along areas where channelized flow may occur .



**Legend**

- StreamReach070400080408
- GrassWaterways070400080408

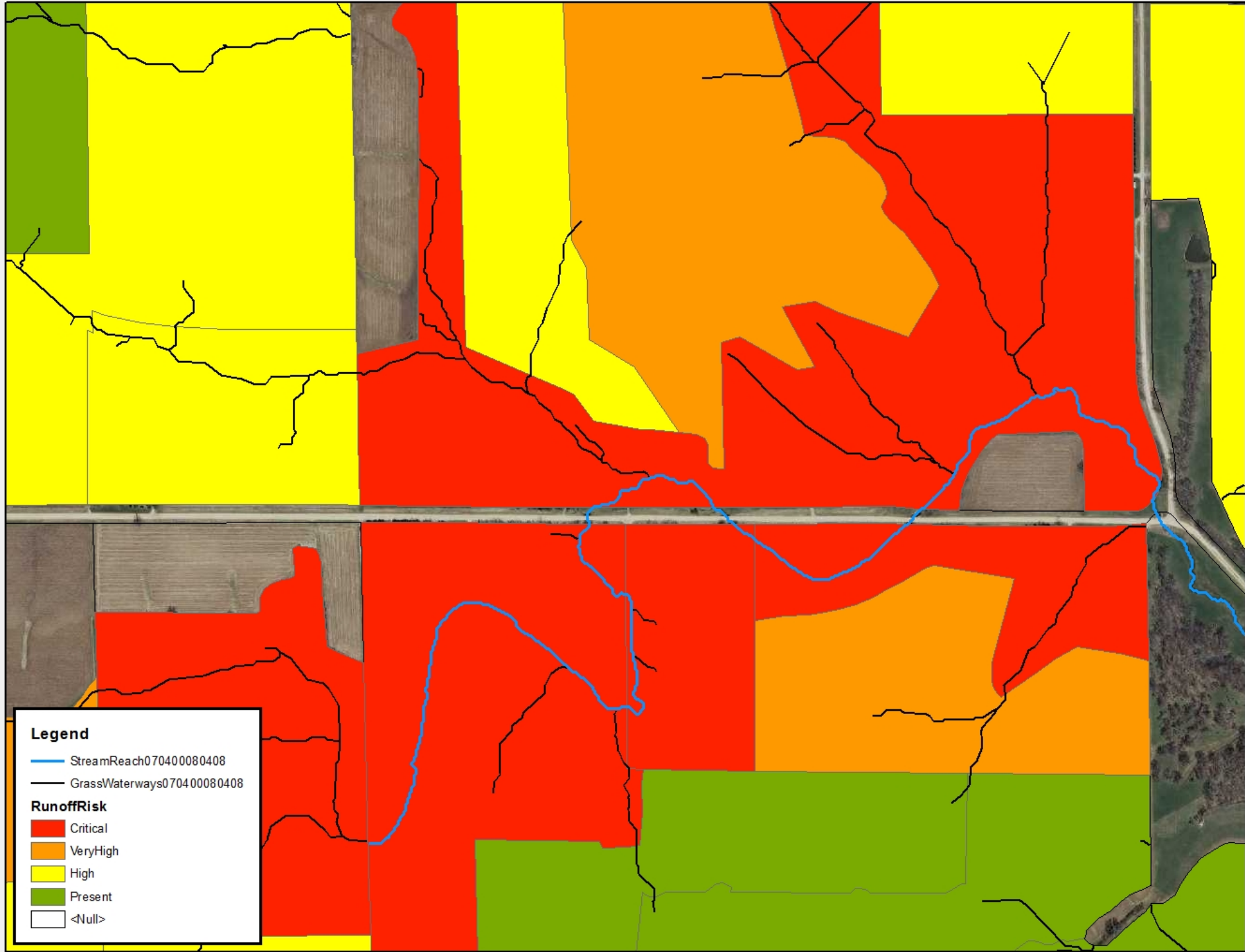


**Legend**

- StreamReach070400080408
- GrassWaterways070400080408

**RunoffRisk**

- Critical
- VeryHigh
- High
- Present
- <Null>



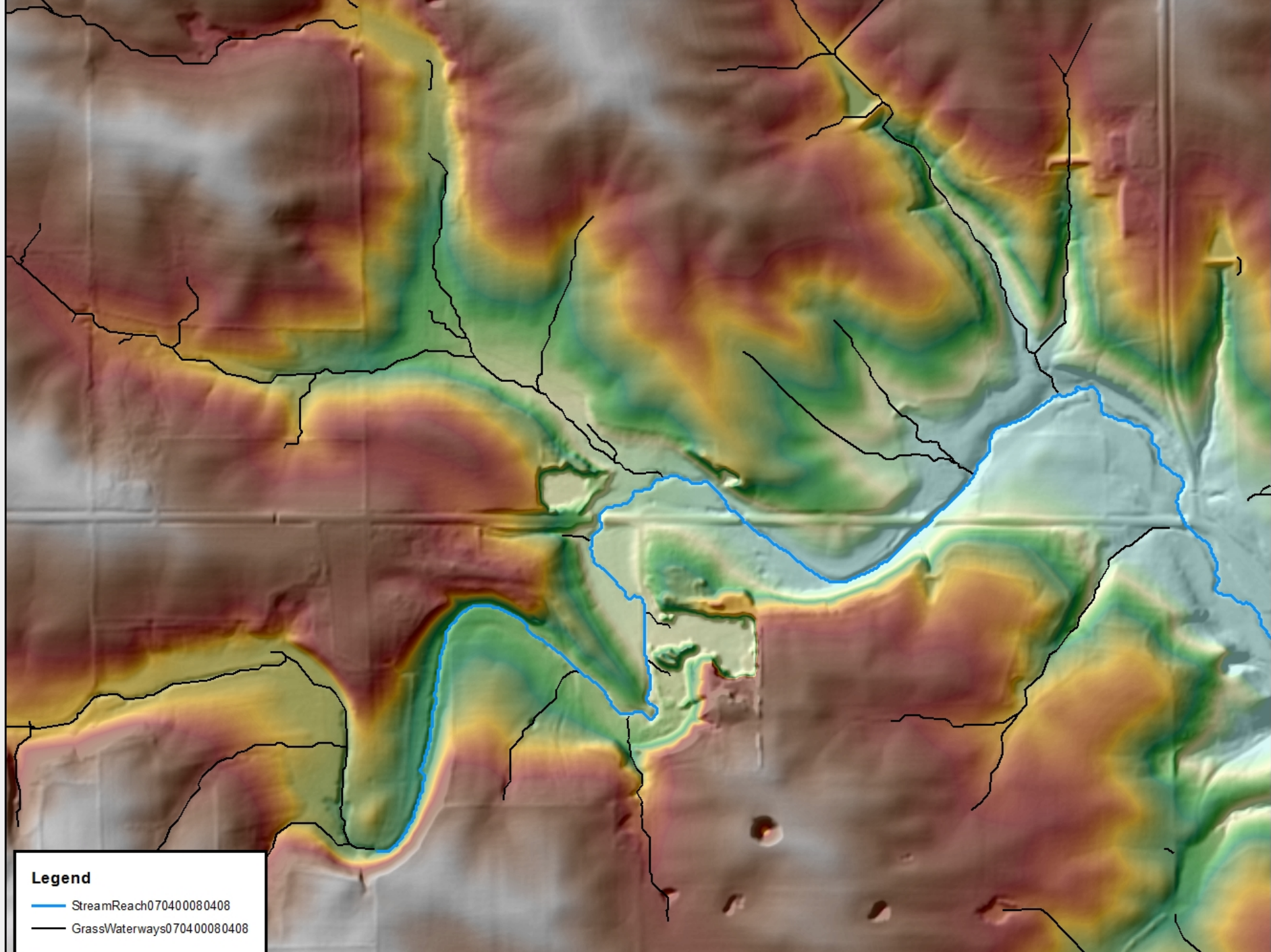
**Legend**

- StreamReach070400080408
- GrassWaterways070400080408



**RunoffRisk**

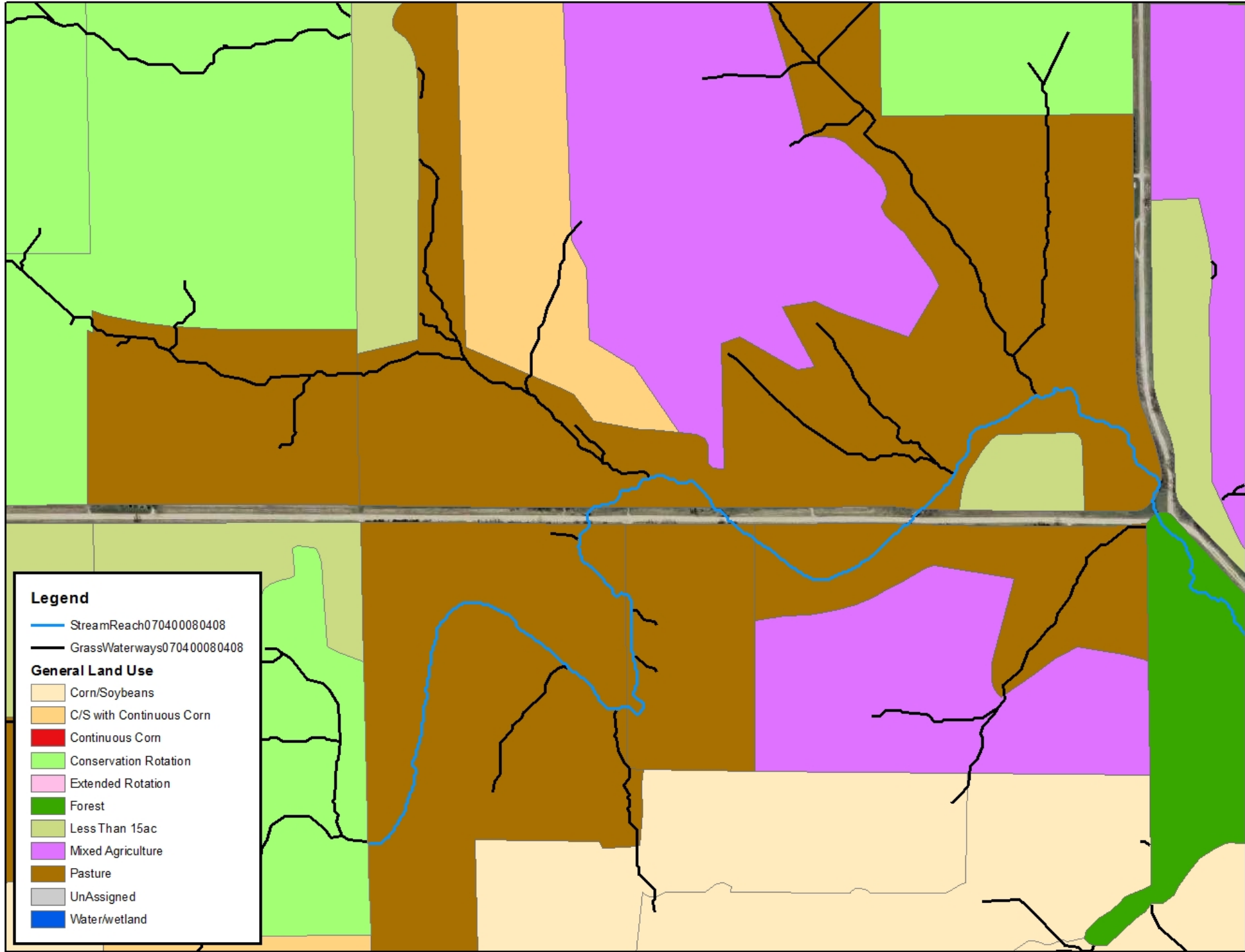
- Critical
- VeryHigh
- High
- Present
- <Null>





**Legend**

-  StreamReach070400080408
-  GrassWaterways070400080408

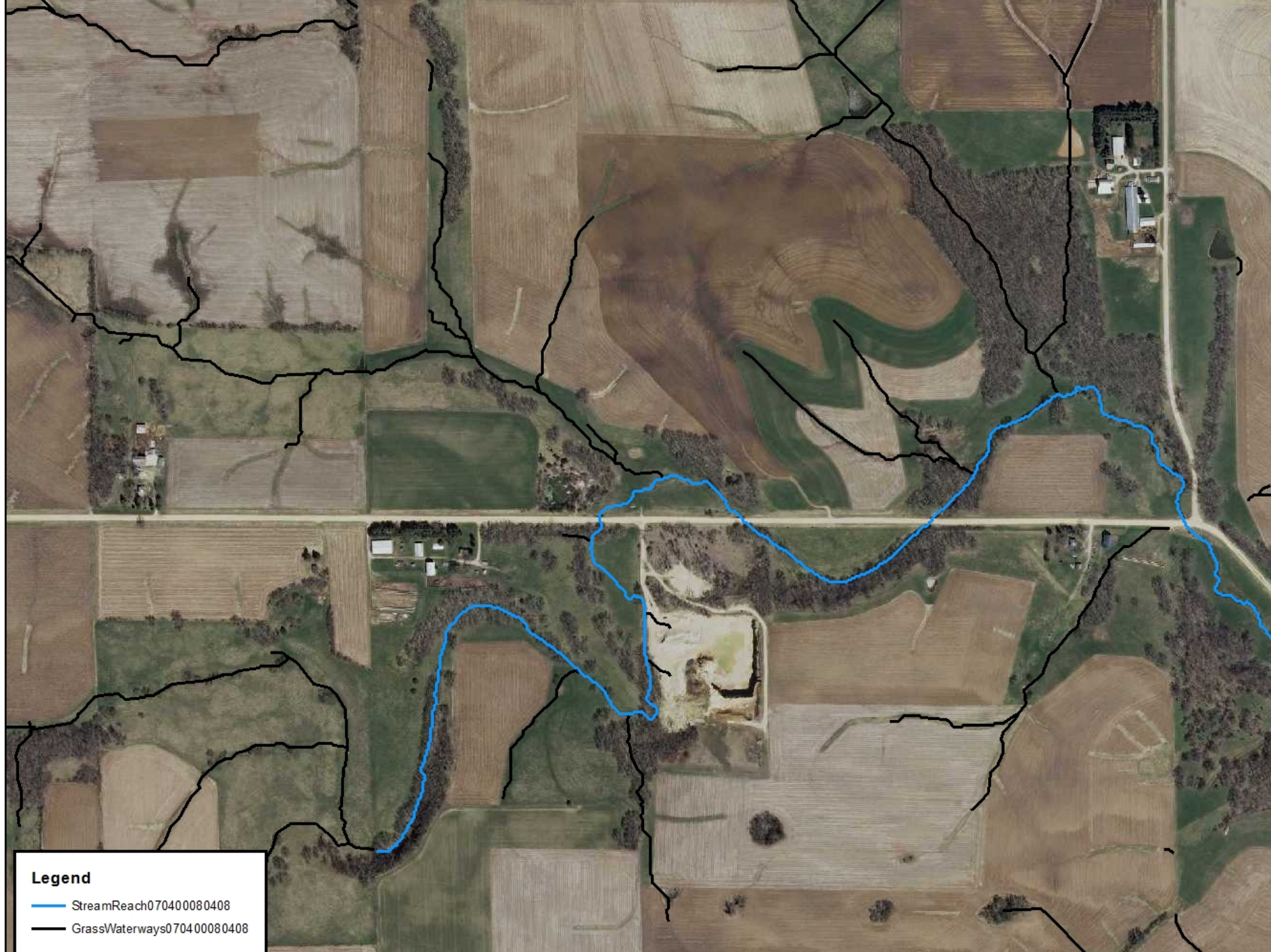


**Legend**



- StreamReach070400080408
- GrassWaterways070400080408

**General Land Use**

- Corn/Soybeans
- C/S with Continuous Corn
- Continuous Corn
- Conservation Rotation
- Extended Rotation
- Forest
- Less Than 15ac
- Mixed Agriculture
- Pasture
- UnAssigned
- Water/wetland



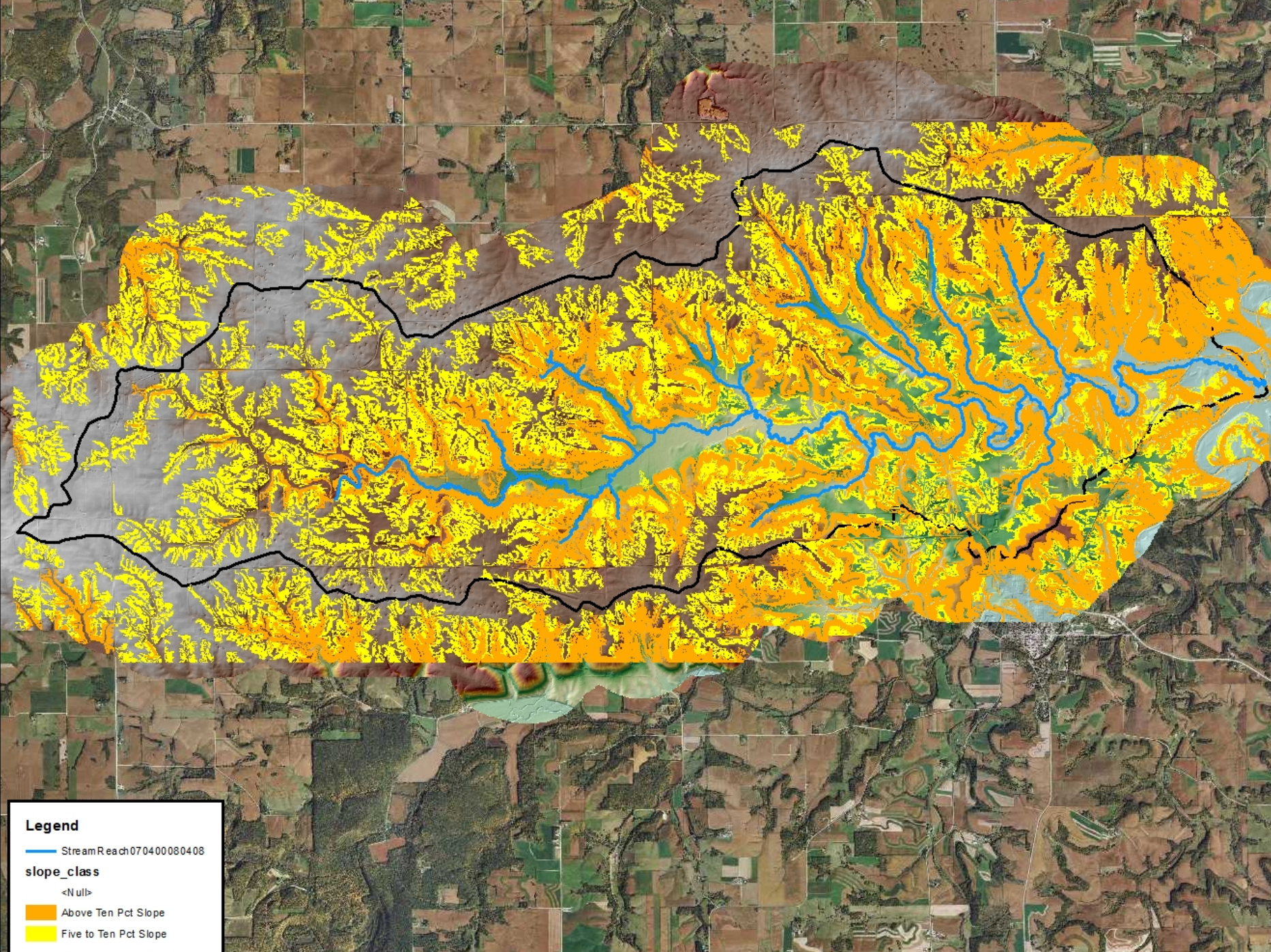
**Legend**

-  StreamReach070400080408
-  GrassWaterways070400080408

# Contour Filter Strips

## Precision Conservation Practice Siting

- Contour filter strips are strips of perennial vegetation alternated down a slope with wider cultivated strips that are farmed on the contour. Similar to grassed waterways, contour filter strips are in-field runoff control practices, designed to decrease the occurrence of concentrated flow and reduce sheet and rill erosion.
- The contour filter strip tool identifies contiguous areas of high slopes (> 5%) in agricultural fields. Contour buffer strips and/or terraces (more suited to steeper ground) placed within these areas are beneficial for reducing sheet and rill erosion.



**Legend**

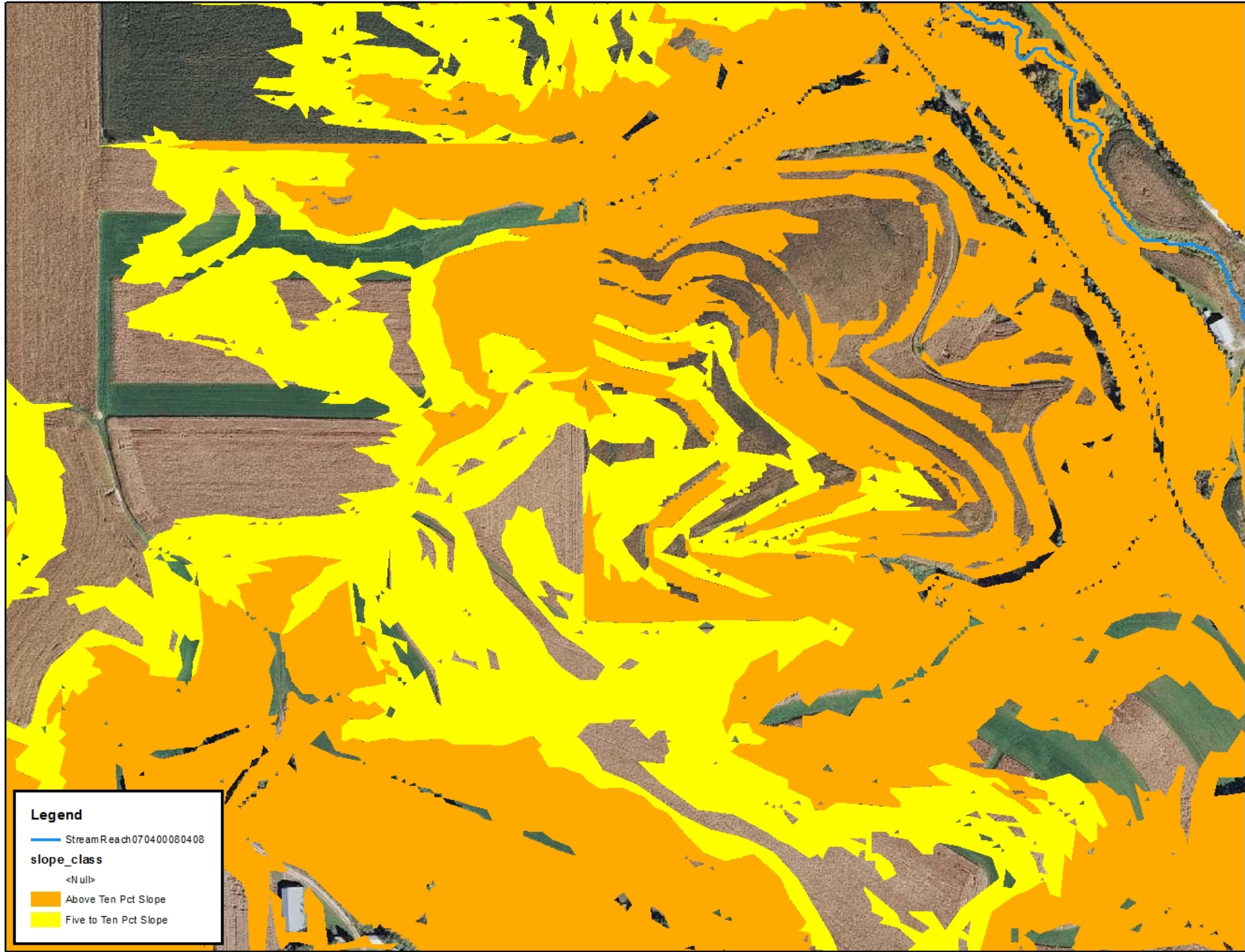
— StreamReach070400080408

**slope\_class**

<Null>

— Above Ten Pct Slope

— Five to Ten Pct Slope

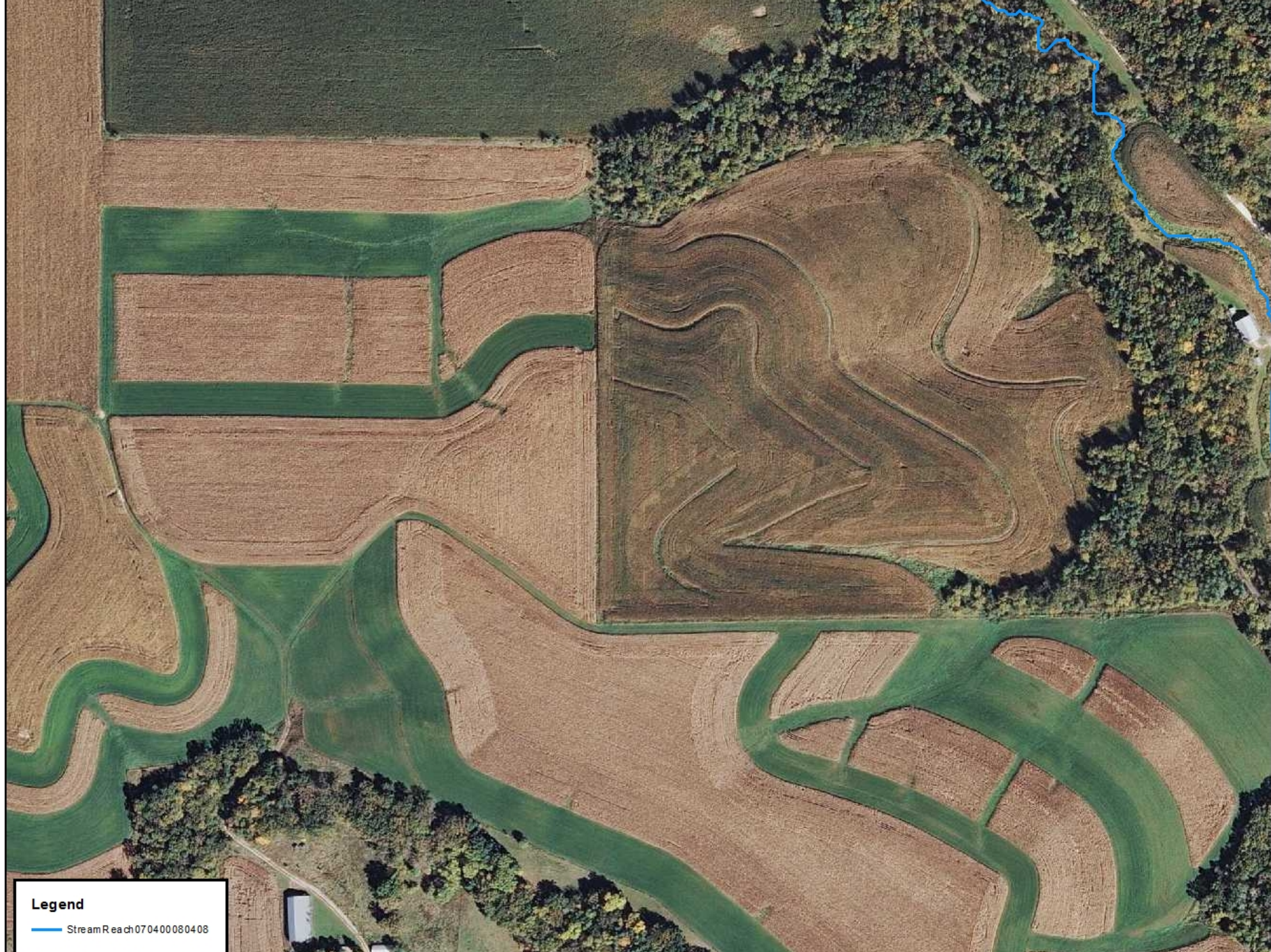


**Legend**

— StreamReach070400080408

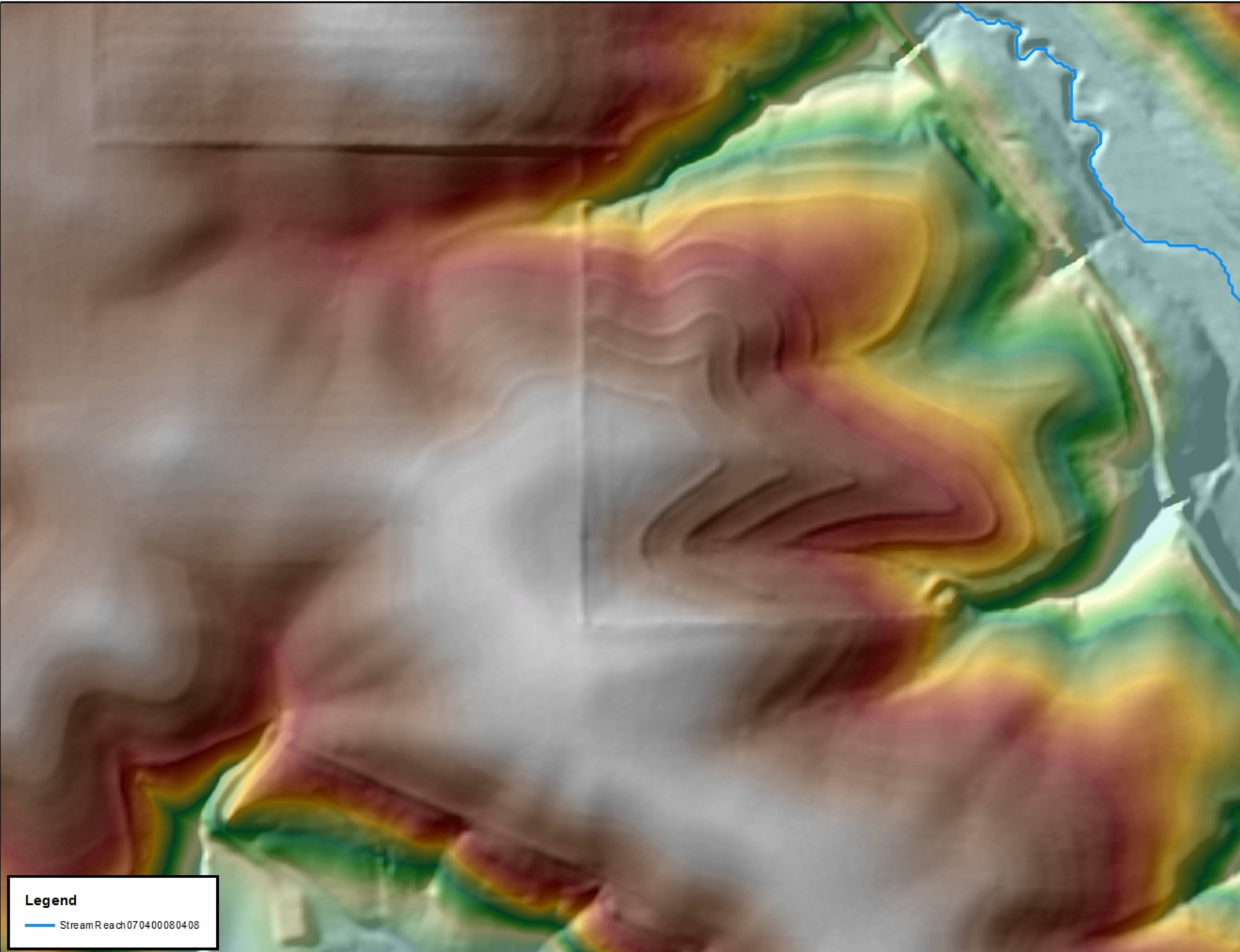
**slope\_class**

- <Null>
- Above Ten Pct Slope
- Five to Ten Pct Slope



**Legend**

— Stream Reach 070400080408



**Legend**

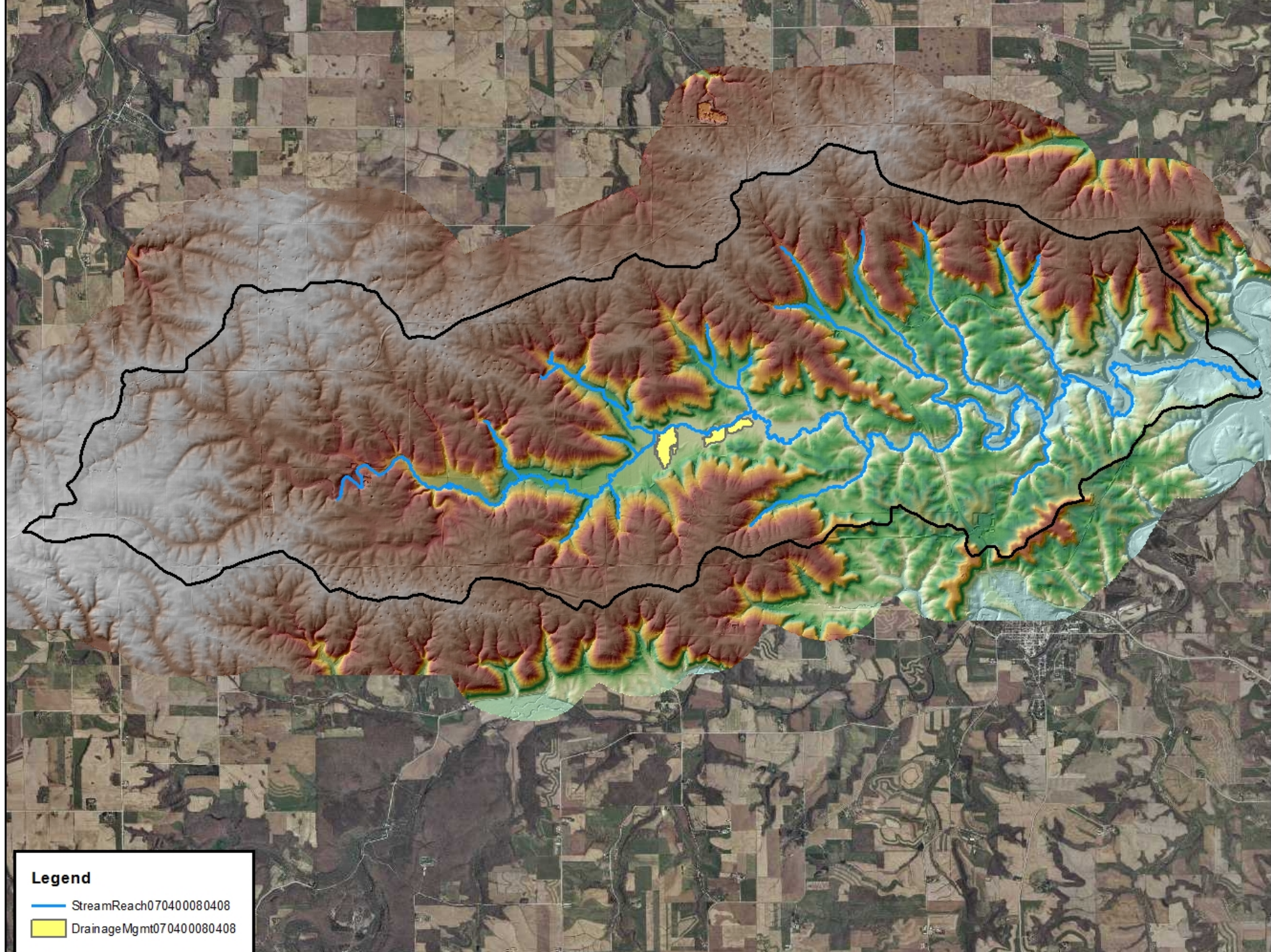
— Stream Reach 070400080408





# Drainage Water Management

## Precision Conservation Practice Siting

Controlled drainage may be used on fields with flat topography (typically one percent or less slope, such as in flood plains and on flat fields typical of the large areas of the glaciated Midwest). The practice can be expensive to design and install in areas with slopes steeper than about one percent because of the number of control structures required in a typical field. A single control gate (dependent on its size) can influence the water table within approximately .5 meter change in elevation. To identify fields potentially suited to this practice, the Drainage Water Management tool identifies the largest area within any 1-meter (3.3 ft) contour interval (representing the addition of 2 control-gate structures), within each tile-drained, agricultural field.



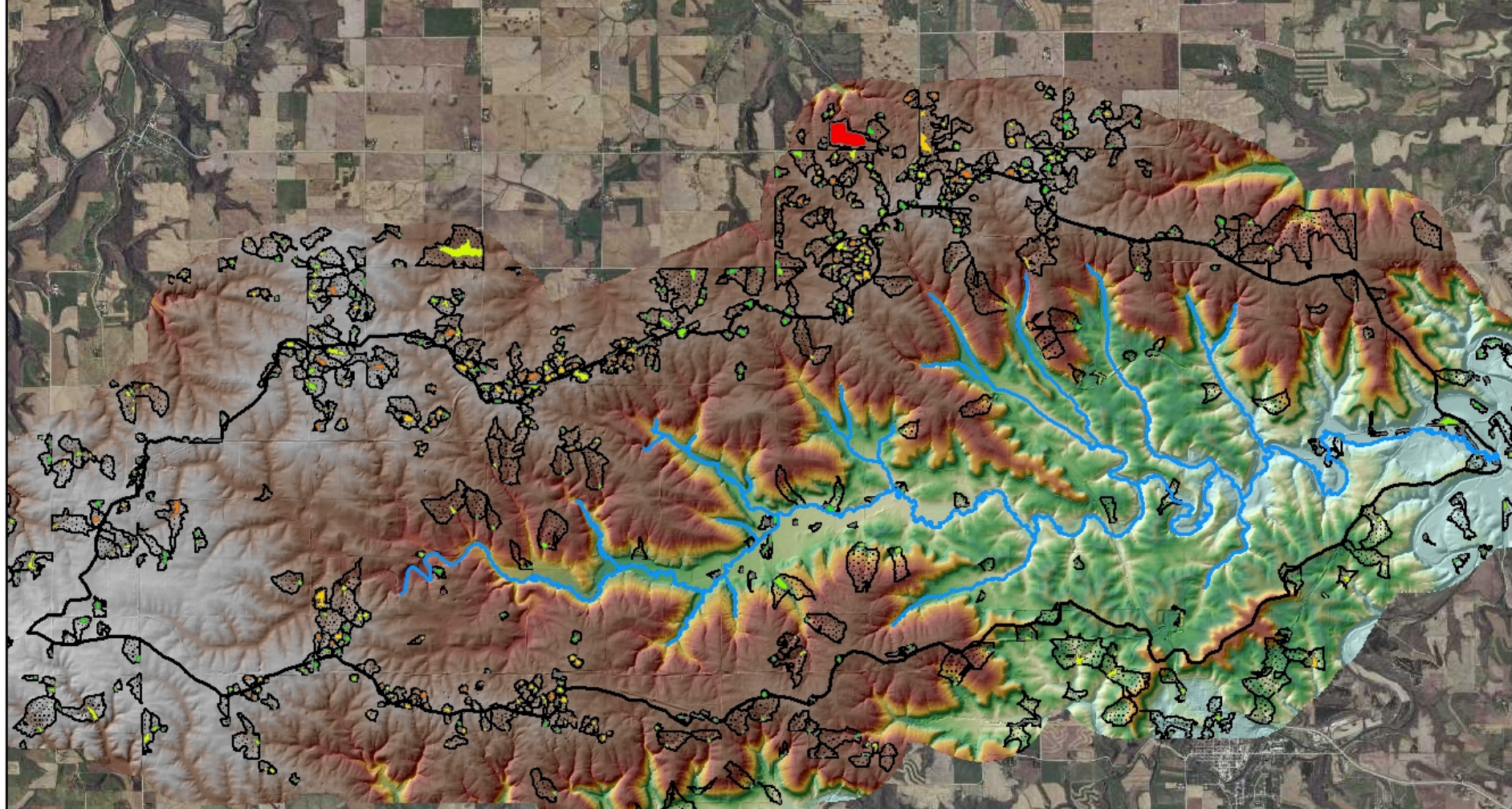
**Legend**

-  StreamReach070400080408
-  DrainageMgmt070400080408

# Pothole Identification

## Precision Conservation Practice Siting

Depressions are common in the glacial landscapes of the Midwest and present challenges for managing water quality and wetness of fields. We have shaded depressions based on the depth of the depression observed using LiDAR imagery. Installation of filter strips could be prioritized for those depressions receiving runoff from the largest drainage areas.



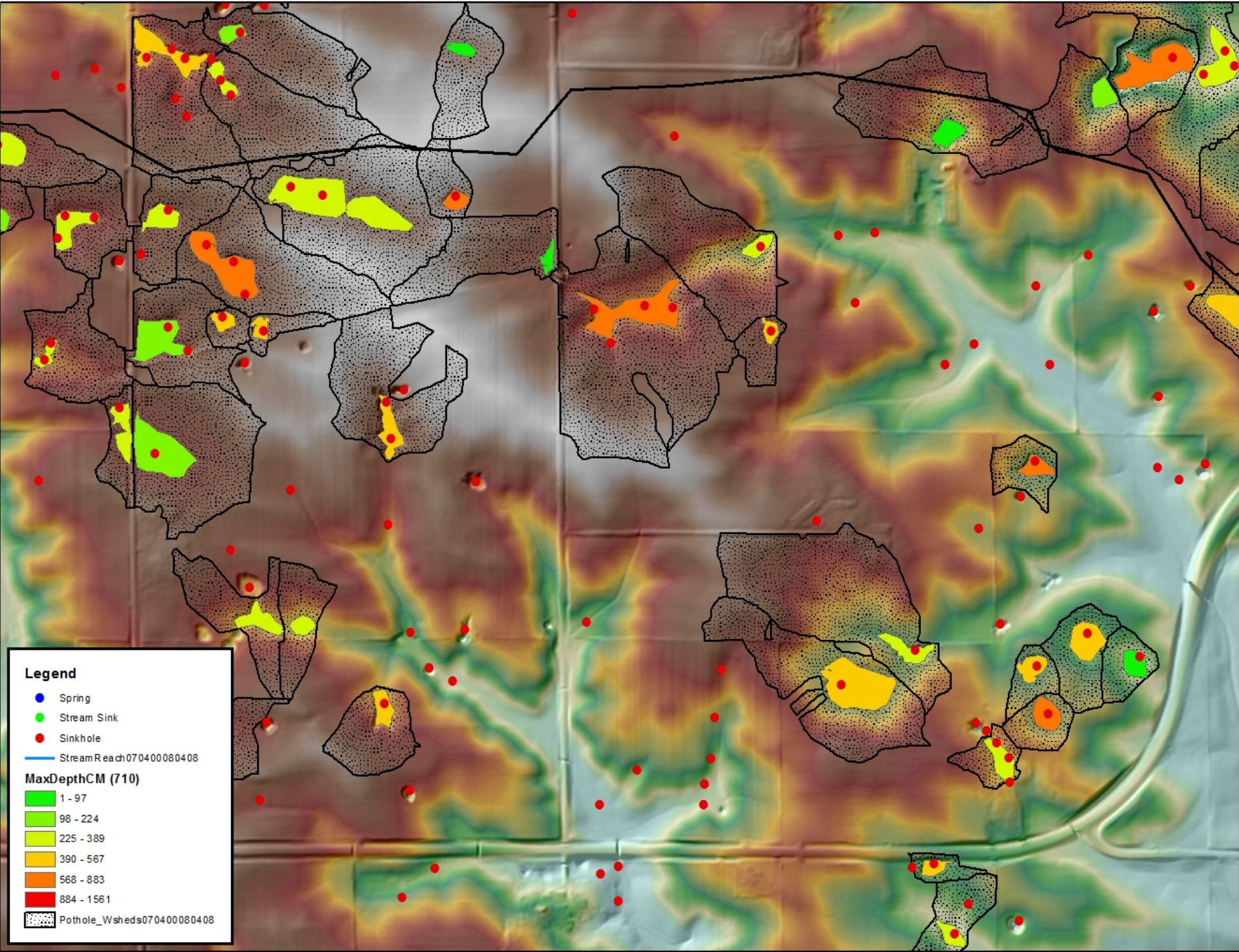
**Legend**

— StreamReach070400080408

**MaxDepthCM (710)**

- 1 - 97
- 98 - 224
- 225 - 389
- 390 - 567
- 568 - 883
- 884 - 1561

▨ Pothole\_Wsheds070400080408



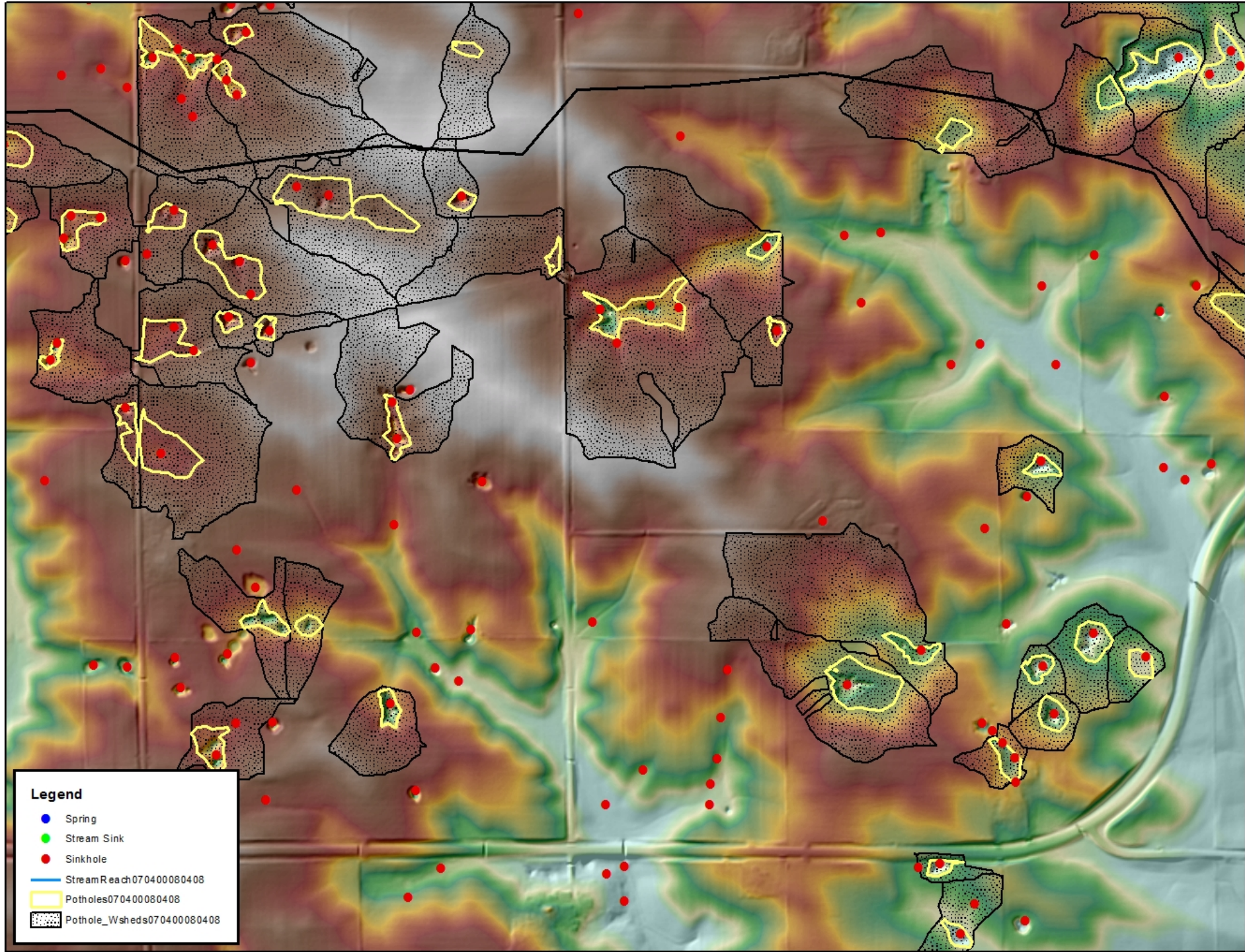
**Legend**

- Spring
- Stream Sink
- Sinkhole
- Stream Reach 070400080408

**MaxDepthCM (710)**

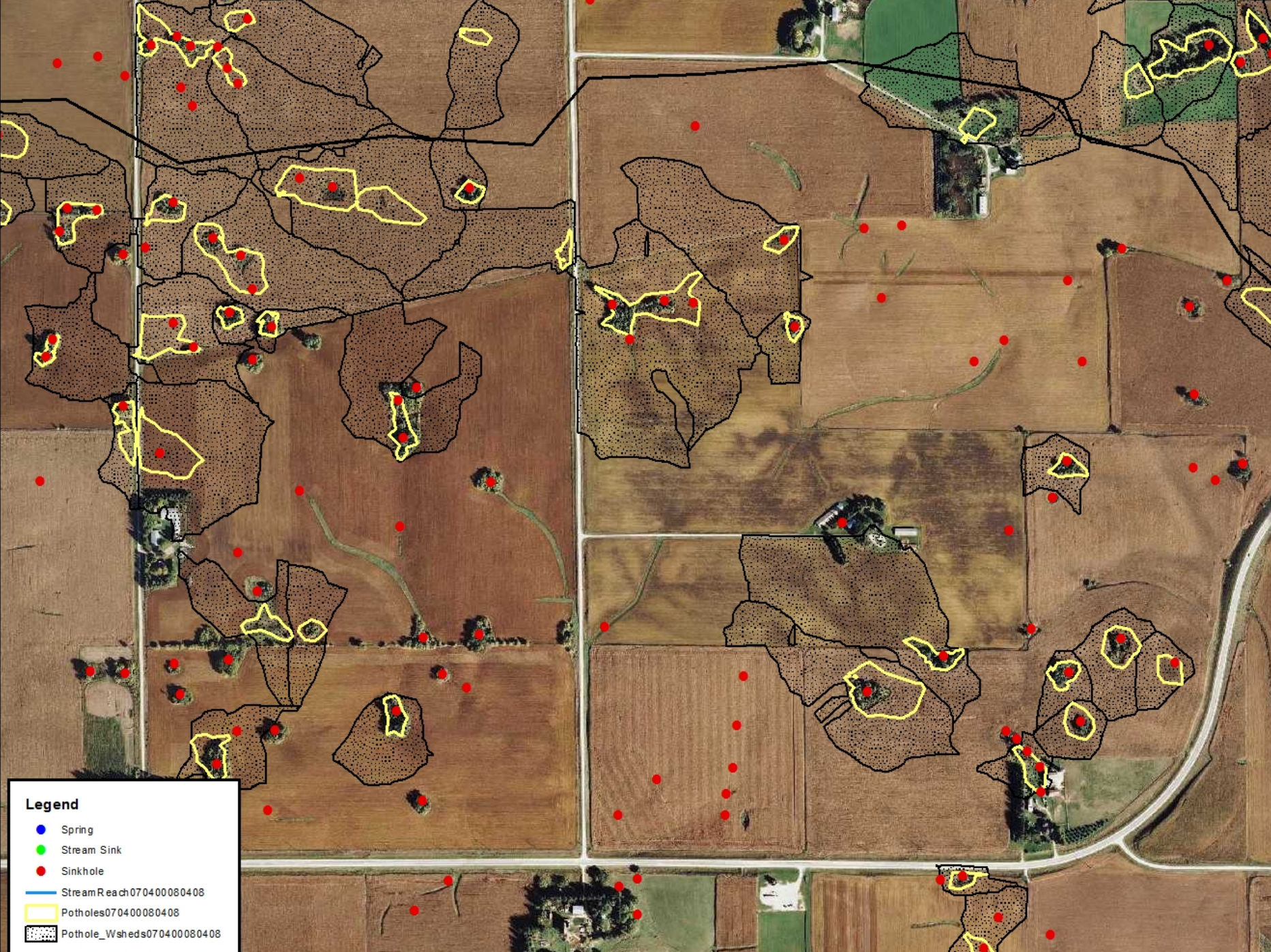
- 1 - 97
- 98 - 224
- 225 - 389
- 390 - 567
- 568 - 883
- 884 - 1561

▨ Pothole\_Wsheds070400080408



**Legend**

- Spring
- Stream Sink
- Sinkhole
- StreamReach070400080408
- ▭ Potholes070400080408
- ▭ Pothole\_Wsheds070400080408



**Legend**

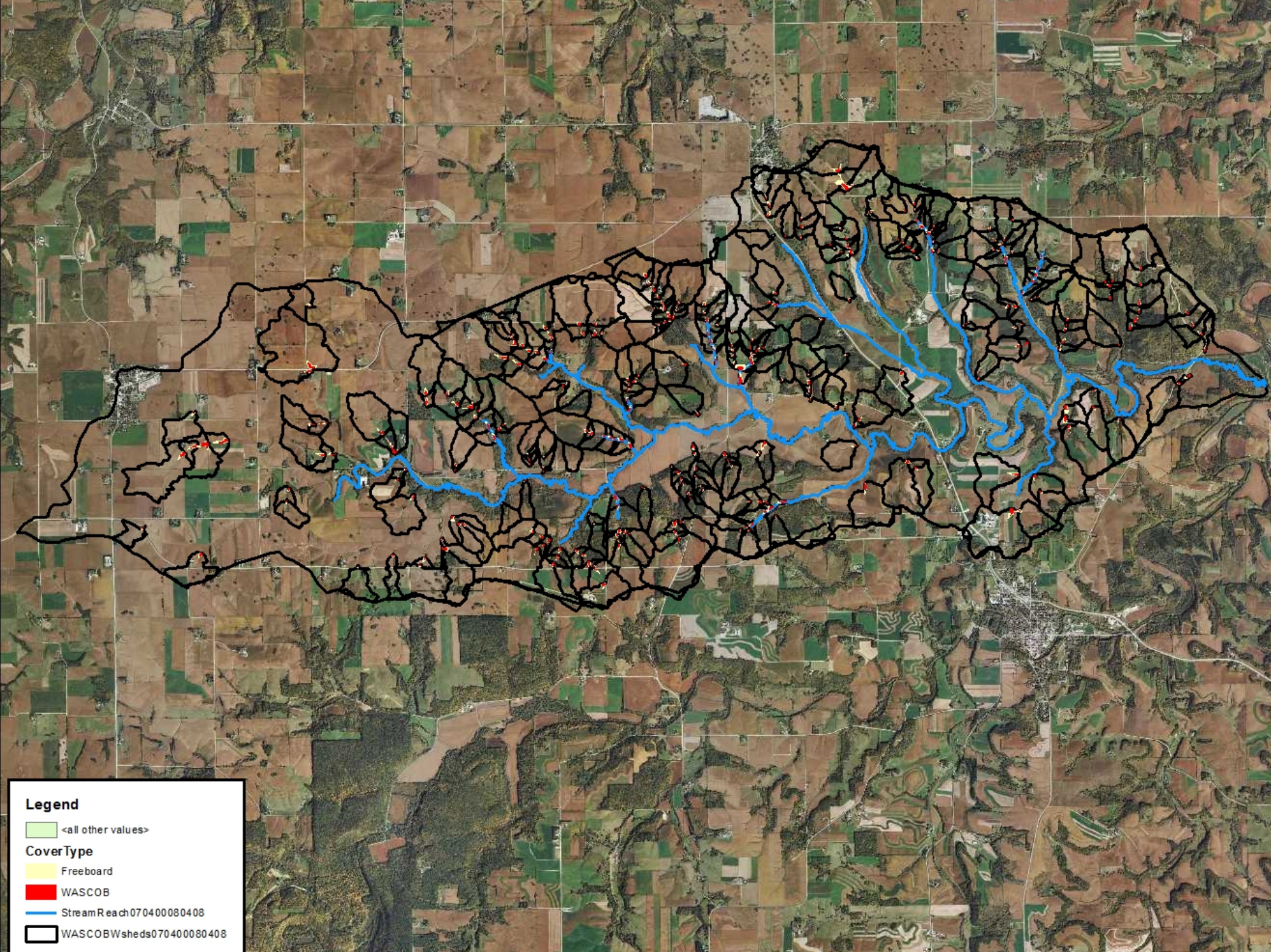
- Spring
- Stream Sink
- Sinkhole
- Stream Reach 070400080408
- ▭ Potholes 070400080408
- ▭ Pothole\_Wsheds 070400080408

# **WASCOB's - Water and Sediment Control Basins**


## **Impound Siting**

Water and sediment control basins (WASCOBS, or 'sediment detention basins) are placed along waterways to detain runoff water the opportunity for sediment to settle out to avoid its delivery to the stream channel. The set of criteria used are similar to that used to locate wetlands, but the idea is to have somewhat deeper water (to provide a depth and storage volume for sediment to settle to the bottom) and a smaller surface area. These basins can (and should) be placed along ephemeral drainage ways that are somewhat more incised than those selected for wetlands.








**Legend**


 <all other values>

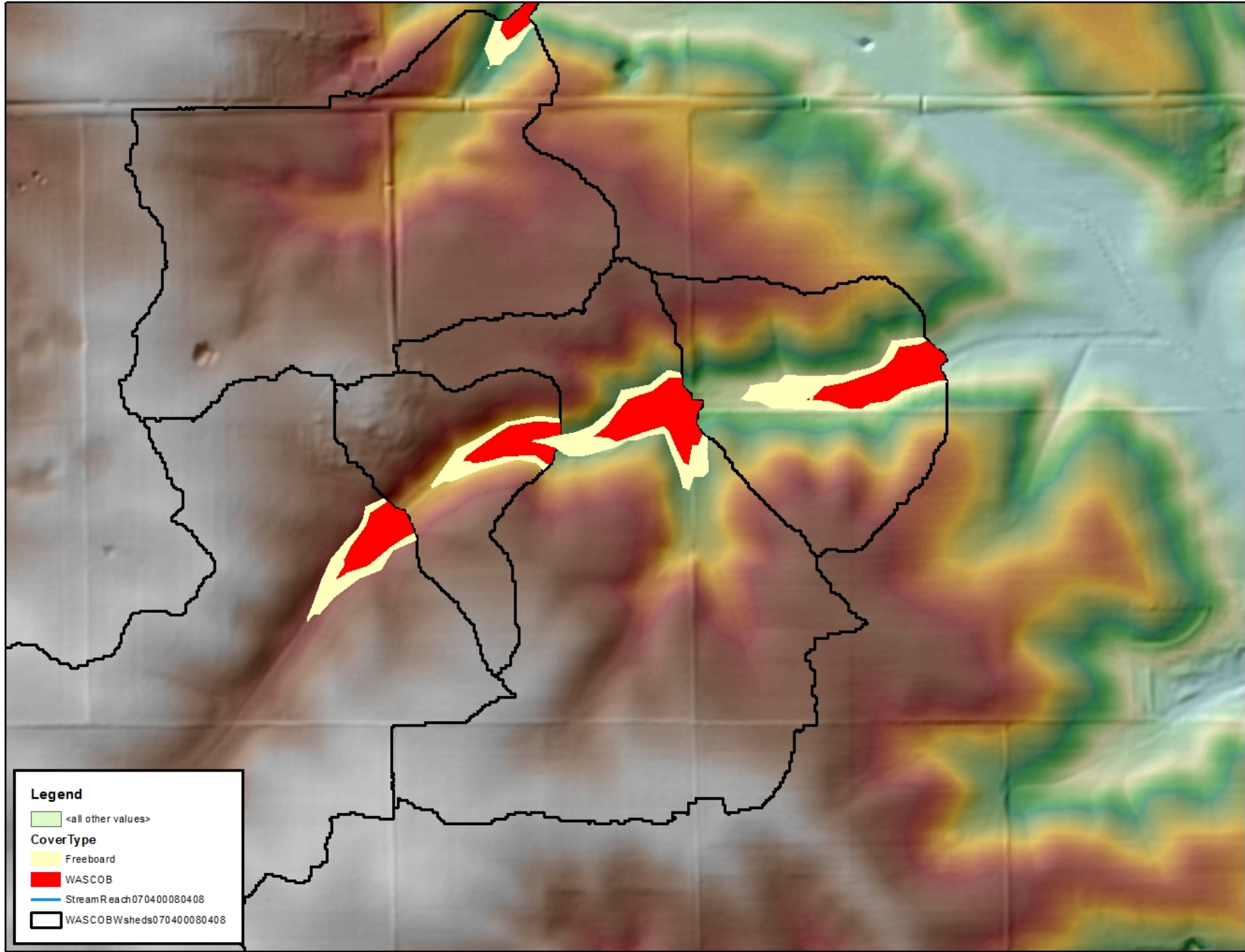
**Cover Type**

 Freeboard


 WASCOB

 Stream Reach 070400080408

 WASCOB Watersheds 070400080408





**Legend**


 <all other values>

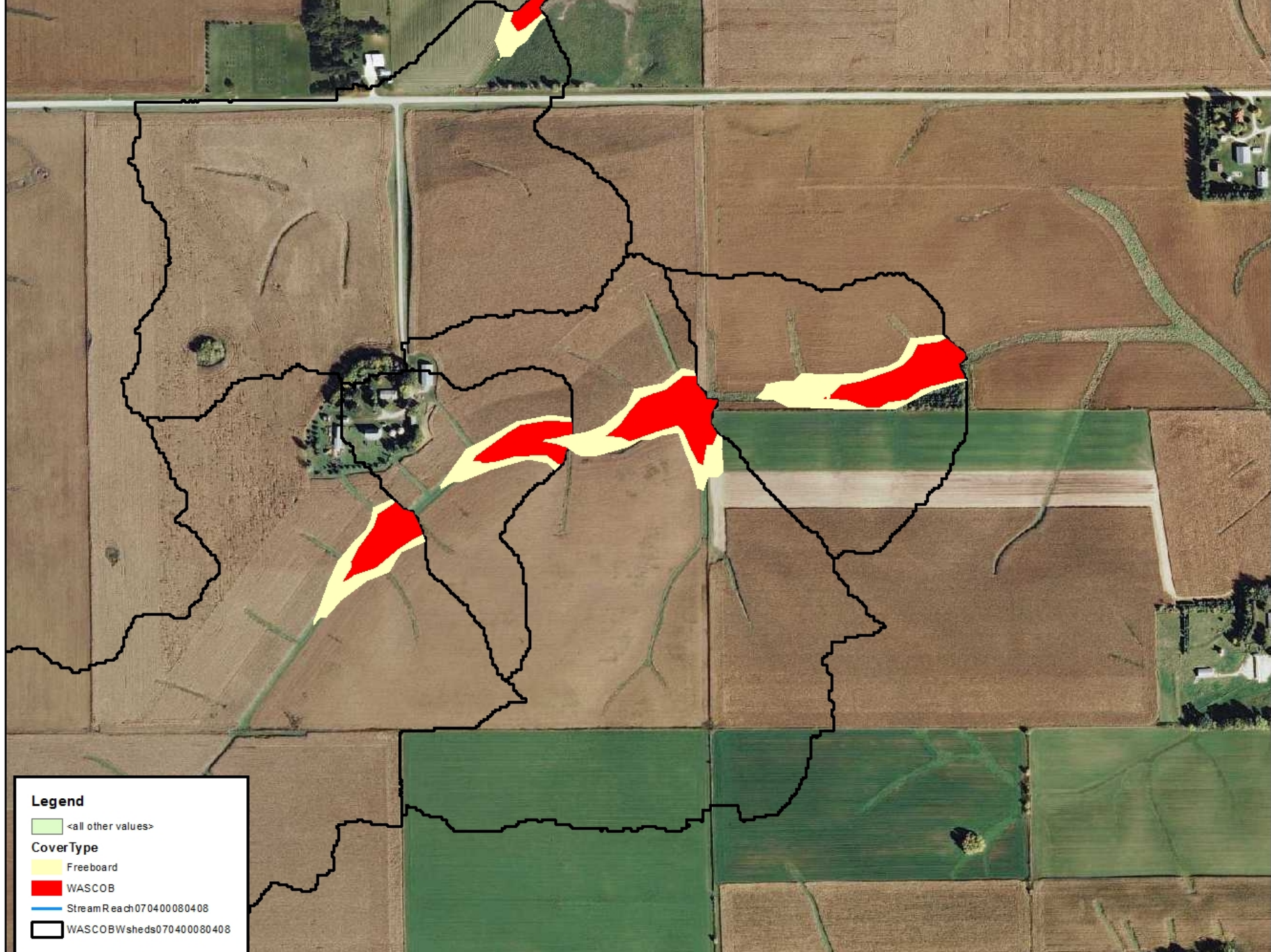
**CoverType**

 Freeboard

 WASC0B

 Stream Reach 070400080408

 WASC0B Wsheds 070400080408



**Legend**

<all other values>

**Cover Type**

Freeboard


WASCOB


Stream Reach 070400080408

WASCOB Watersheds 070400080408



**Legend**

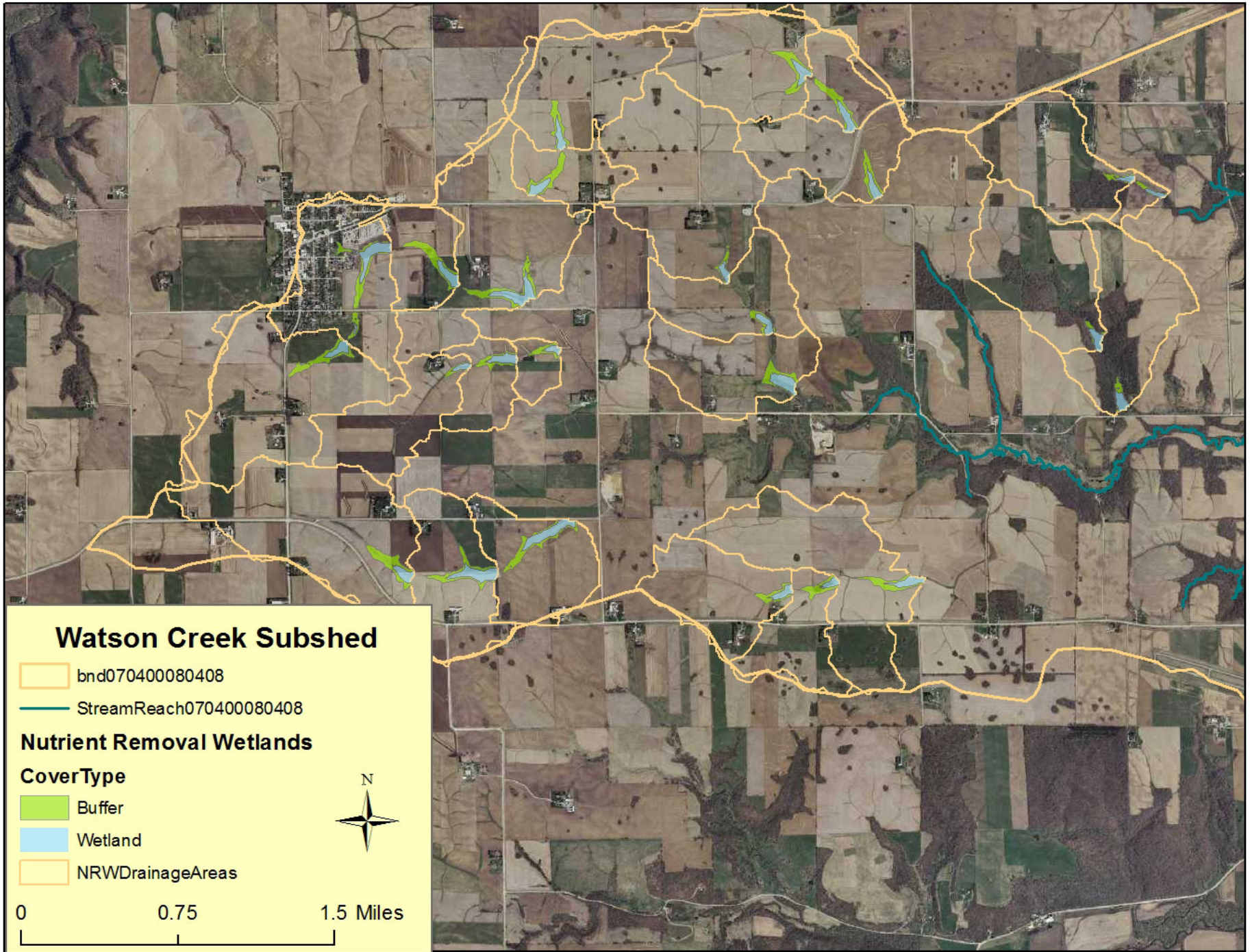
 Stream Reach 070400080408

 WASCOWsheds070400080408



# Nutrient Removal Wetlands

## Impound Siting




- Wetlands can be strategically located below tile drained fields and designed to provide an off-site strategy for reducing nitrate from tile drainage water. It may also be possible to place sediment detention structures in these areas to reduce phosphorus loss from the watershed. This map shows nutrient removal wetlands that could be placed below fields in this watershed that are most likely to be tile drained. We recognize that this is a highly permeable landscape and that the feasibility of installing wetlands may be low in some of these locations.



### Watson Creek Subshed

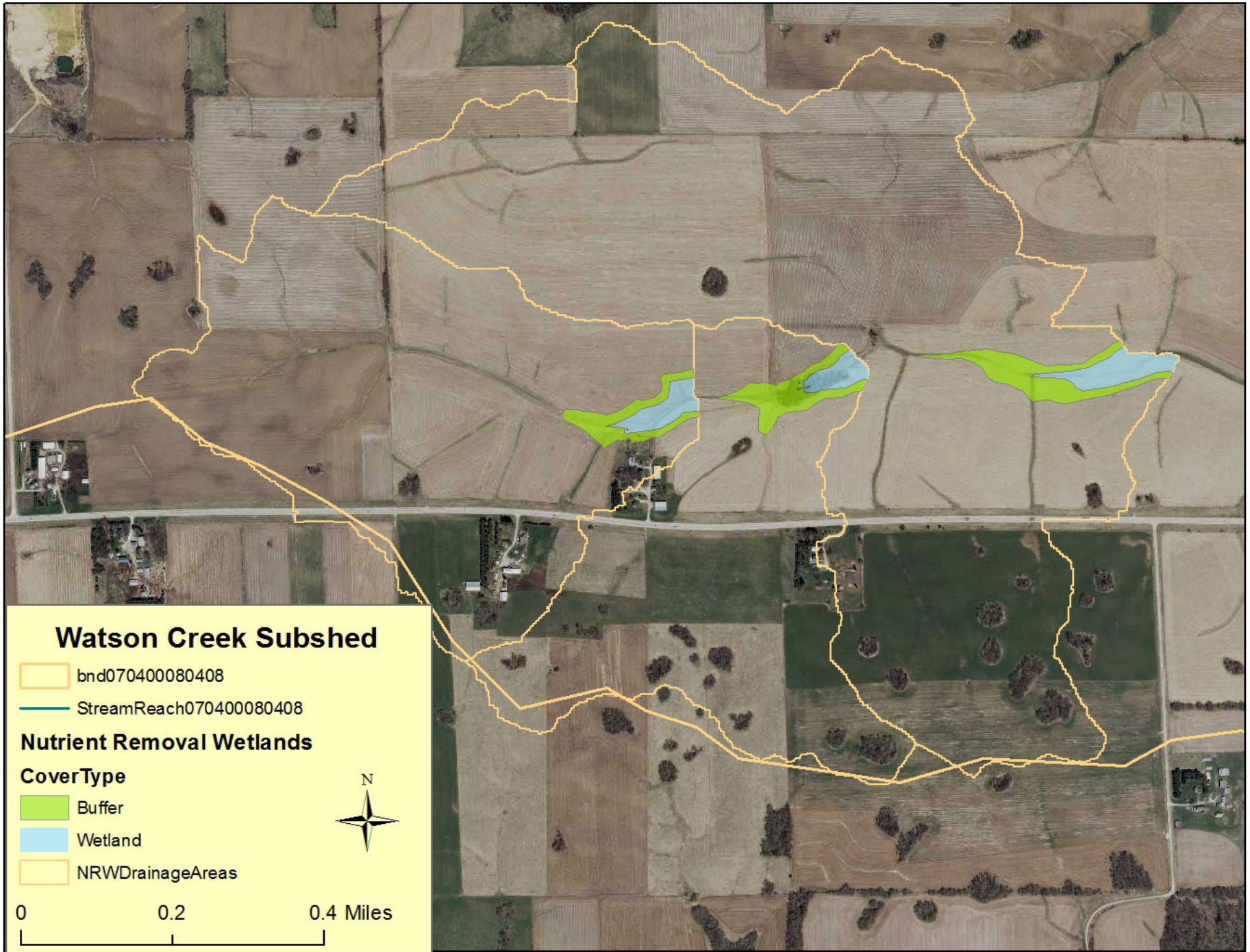
-  bnd070400080408
-  StreamReach070400080408

### Nutrient Removal Wetlands



- CoverType**
-  Buffer
  -  Wetland
  -  NRWDrainageAreas



0                      0.75                      1.5 Miles



### Watson Creek Subshed

-  bnd070400080408
-  StreamReach070400080408

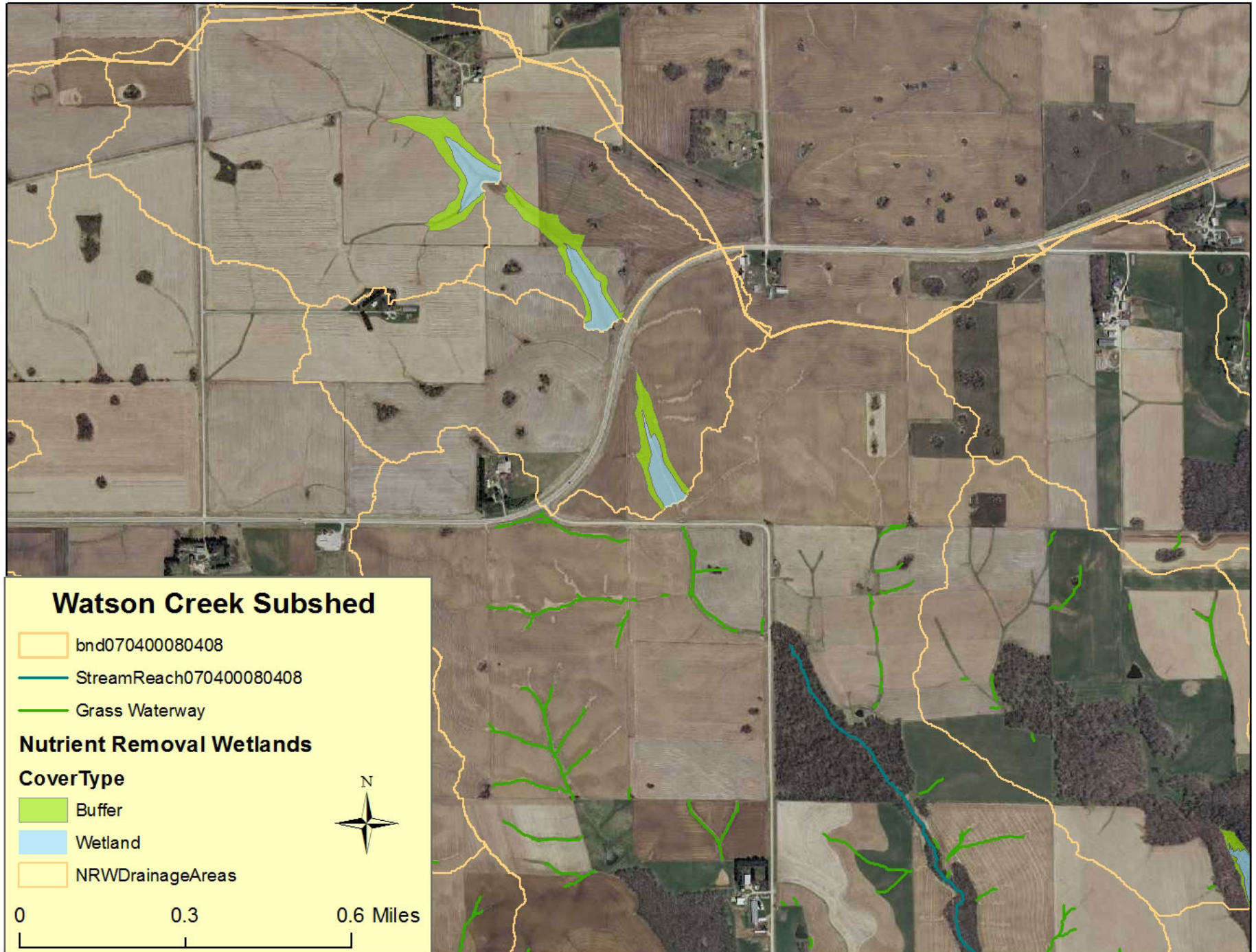
### Nutrient Removal Wetlands

#### CoverType

-  Buffer
-  Wetland
-  NRWDrainageAreas



0 0.2 0.4 Miles

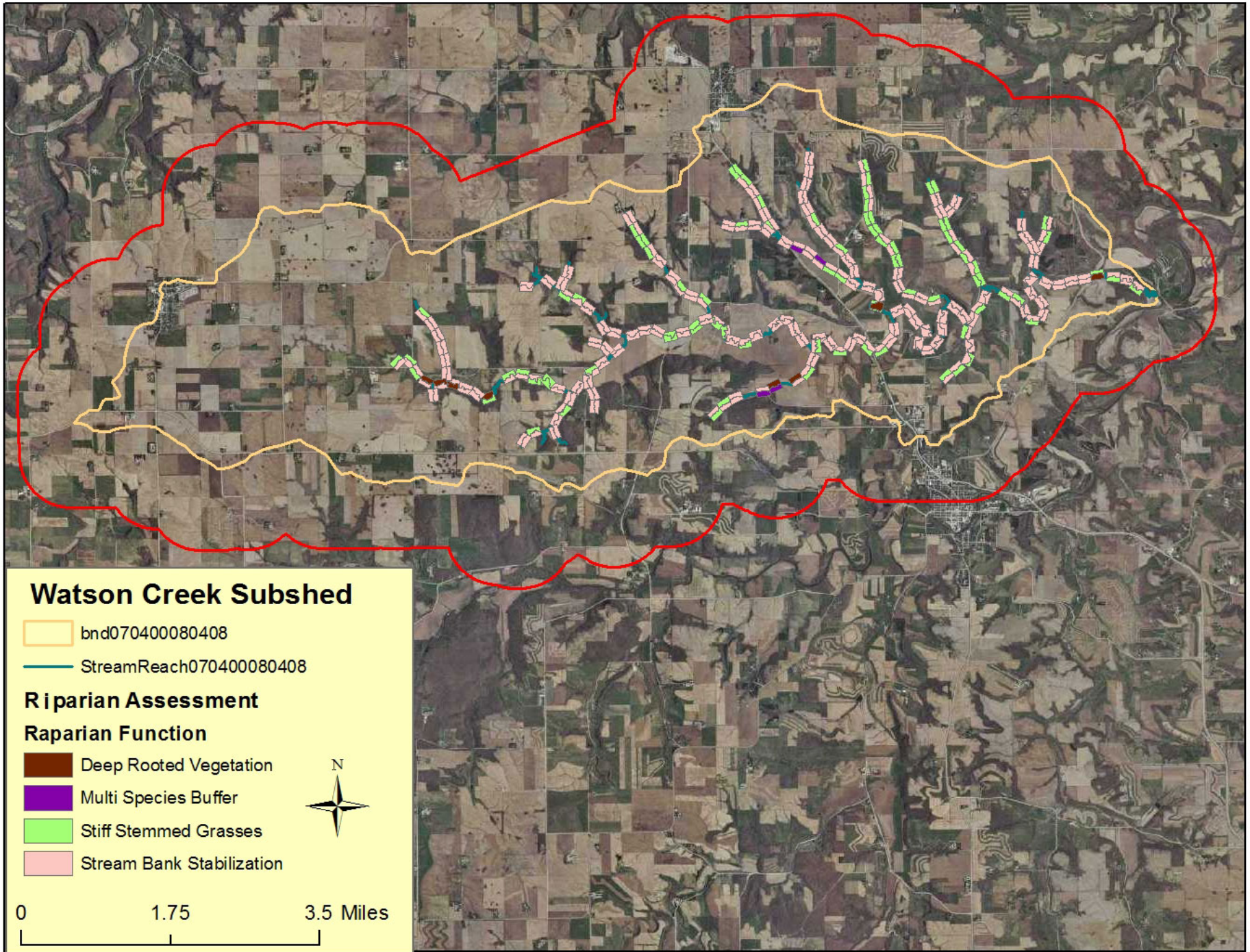





# Riparian Function Assessment


## Riparian Characterization

Along a watershed's network of riparian corridors, there are varying opportunities to stabilize streambanks, intercept surface runoff, and influence shallow groundwater. Our objective was to classify these riparian management opportunities and develop a mapping aid for watershed planning. This approach identifies the likely distributions of surface runoff contributions and shallow water tables in a watershed, delineates and tabulates results along both banks of the channels, and applies a cross classification that conveys recommendations for buffer vegetation and width.




## Watson Creek Subshed


 bnd070400080408


 StreamReach070400080408


### Riparian Assessment

#### Riparian Function

 Deep Rooted Vegetation

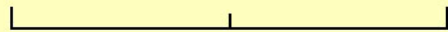
 Multi Species Buffer

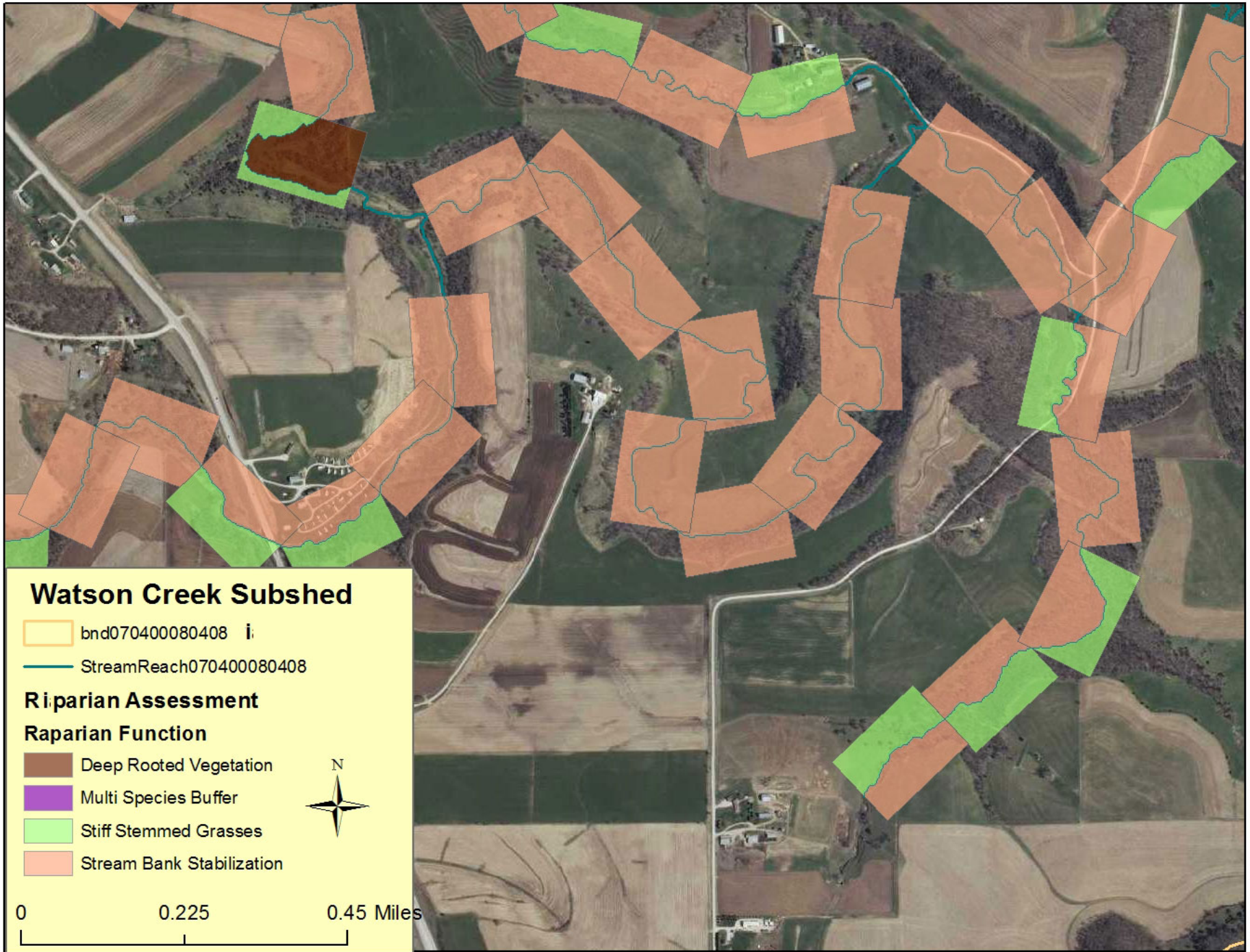
 Stiff Stemmed Grasses

 Stream Bank Stabilization

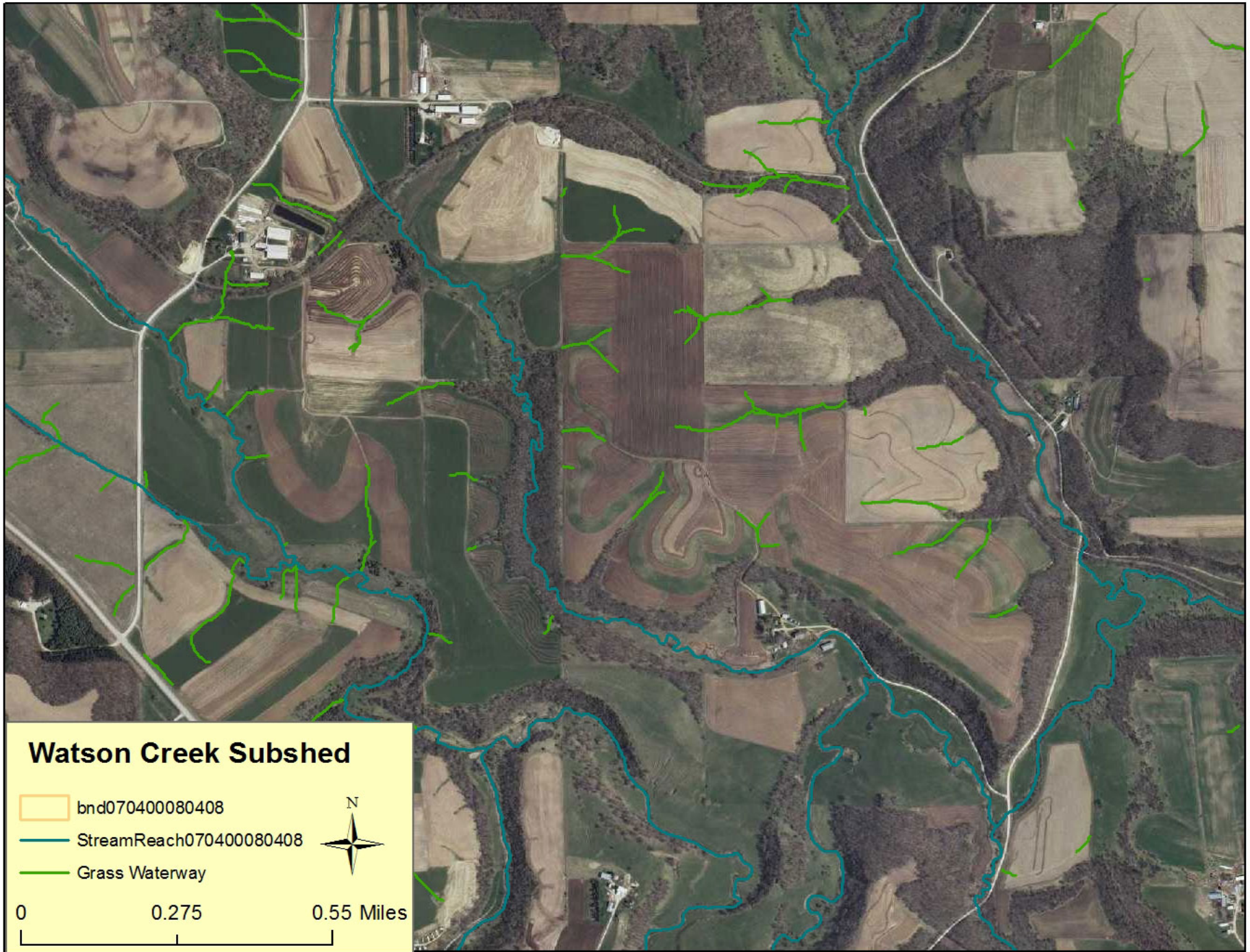


0 1.75 3.5 Miles








# Grass Waterways




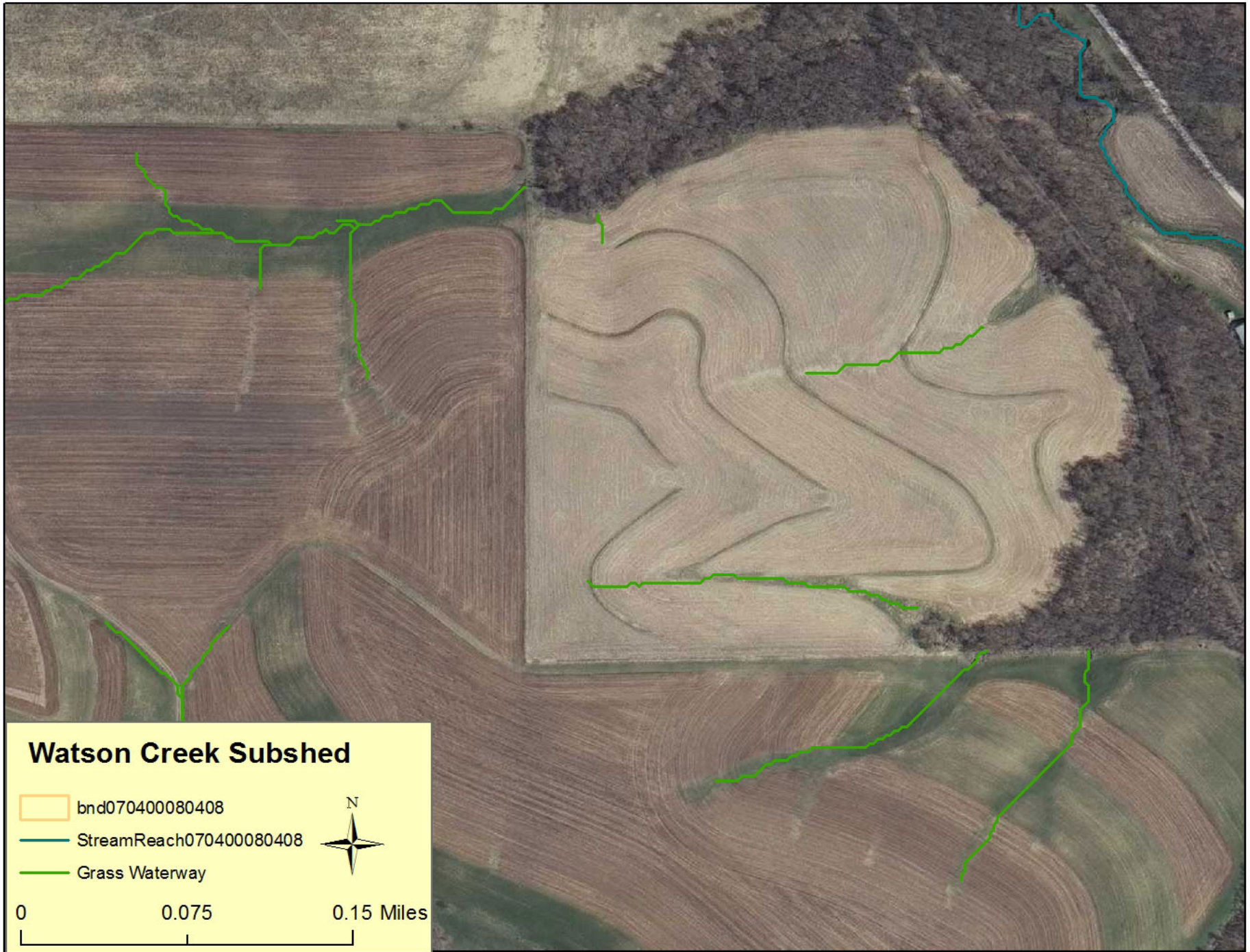
### Watson Creek Subshed

-  bnd070400080408
-  StreamReach070400080408
-  Grass Waterway






0                      0.275                      0.55 Miles

A horizontal scale bar with vertical tick marks at 0, 0.275, and 0.55 miles.




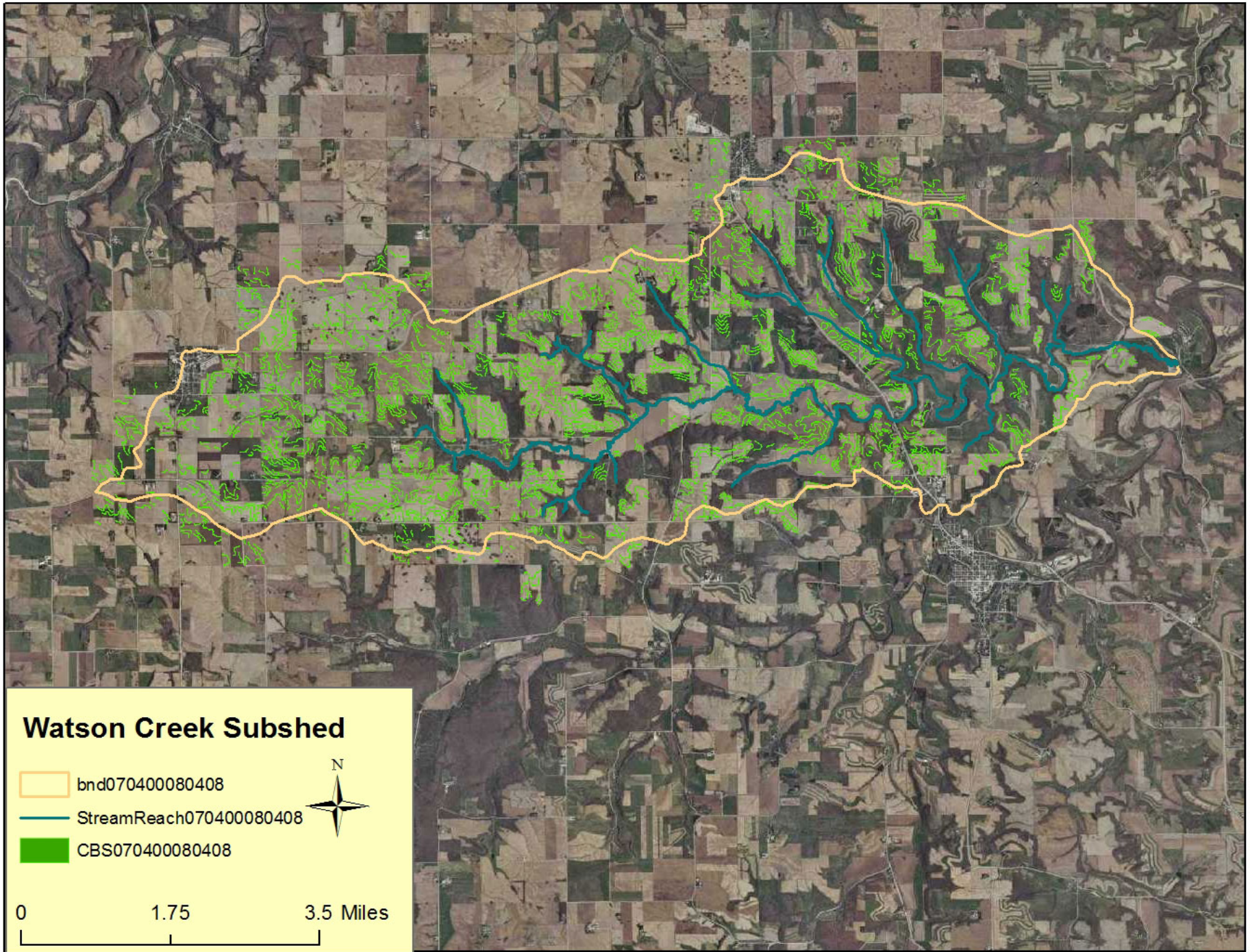
### Watson Creek Subshed

-  bnd070400080408
-  StreamReach070400080408
-  Grass Waterway





0                      0.075                      0.15 Miles


A horizontal scale bar with tick marks at 0, 0.075, and 0.15 miles.

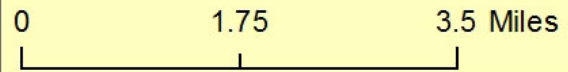


## Watson Creek Subshed

 bnd070400080408

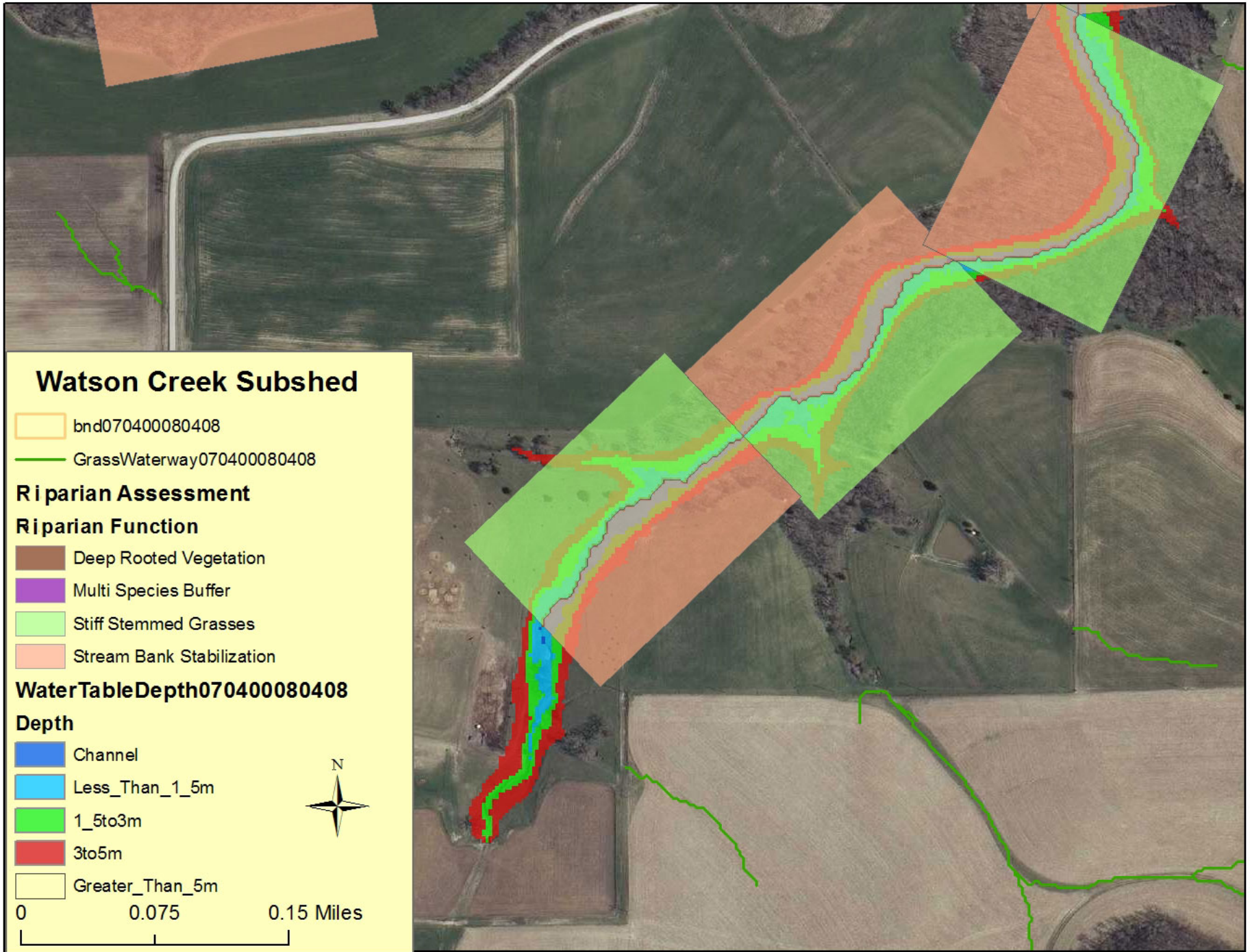
 StreamReach070400080408

 CBS070400080408





# Multiple Parameters





### Watson Creek Subshed

-  bnd070400080408
-  GrassWaterway070400080408

### Riparian Assessment

#### Riparian Function

-  Deep Rooted Vegetation
-  Multi Species Buffer
-  Stiff Stemmed Grasses
-  Stream Bank Stabilization

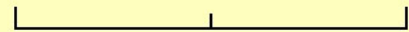
### WaterTableDepth070400080408

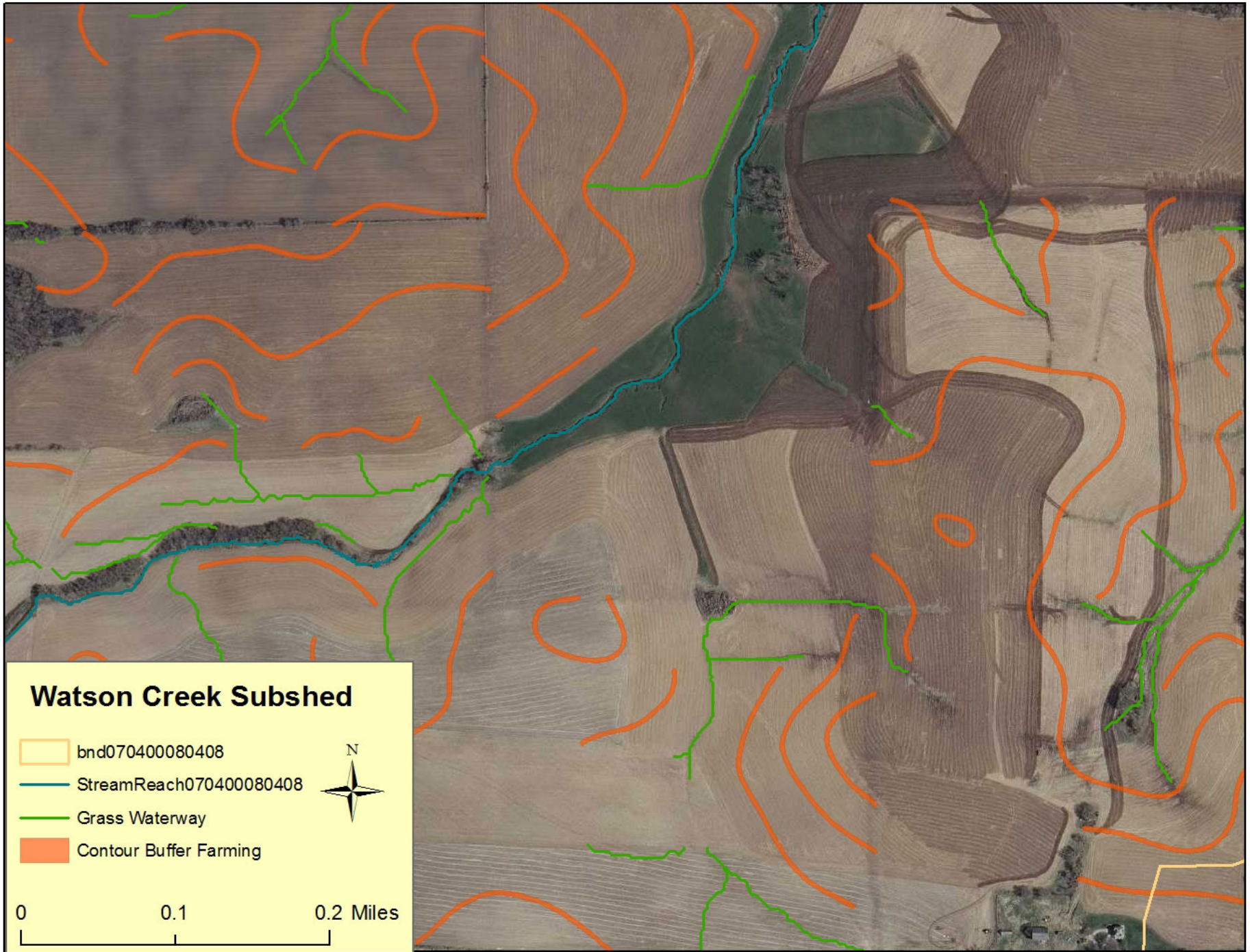
#### Depth

-  Channel
-  Less\_Than\_1\_5m
-  1\_5to3m
-  3to5m
-  Greater\_Than\_5m







0 0.075 0.15 Miles





### Watson Creek Subshed

-  bnd070400080408
-  StreamReach070400080408
-  Grass Waterway
-  Contour Buffer Farming



0 0.1 0.2 Miles

# Terrain Analysis Applications

## *Value-added LiDAR Analysis*

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- Andrew Meyer
- Jessica Nelson
- Water Resources Center
  - [507-389-5492](tel:507-389-5492)