

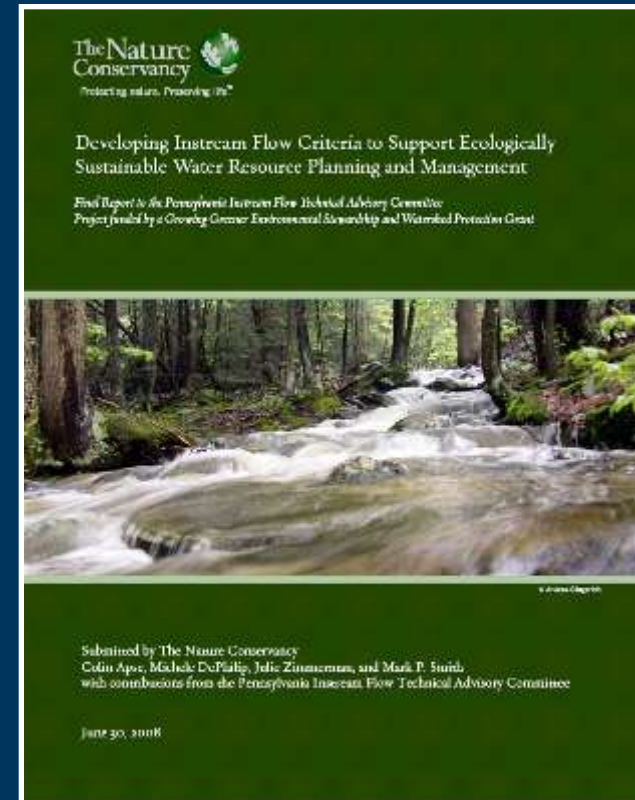


River Classification for Environmental Flow Standards Development: Pennsylvania Case Study

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Pennsylvania Instream Flow Recommendation Project and Report

- PA state grant provided to TNC for recommendations on state policy & information resource development
- Included recommendations on hydrologic foundation, classification, flow-ecology relationships, and standard development
- Pilot work on flow-ecology relationship and hydrologic classification included
- Available on website or by request



<http://www.depweb.state.pa.us/watershedmgmt/cwp>

- Classify streams into small number of similar hydrologic types
- Identify a set of statistically and ecologically based hydrologic indices for each stream type that characterizes the major components of the flow regime
- Ultimately use to define reference conditions for each stream type and to assist in development of flow-ecology relationships

Summary of Steps to Develop Draft Classifications

Worked with USGS Ft Collins to implement HIP

Developed reference set of gages (136)

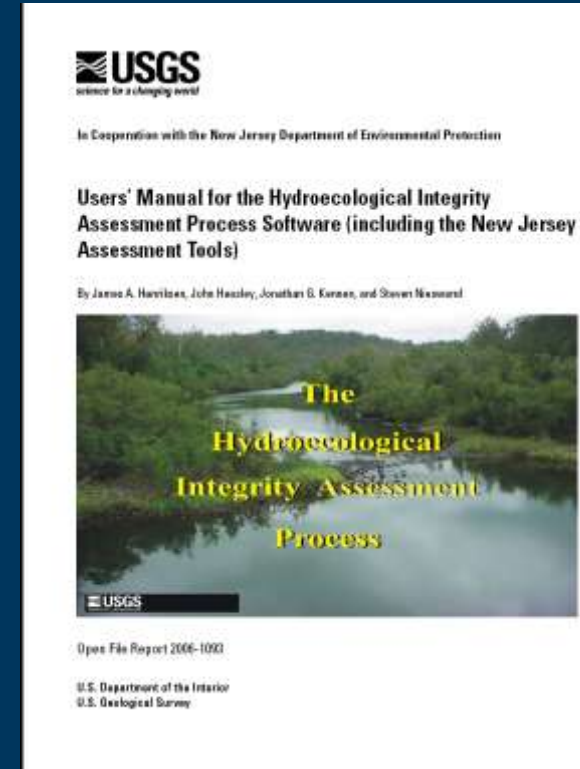
- Minimally influenced by water management (USGS PA, originally 195)
- < 15% urban land cover
- > 15 years of record

Calculated 205 hydrologic indices for reference gages using HIT software (171 HIP + EFCs from IHA)

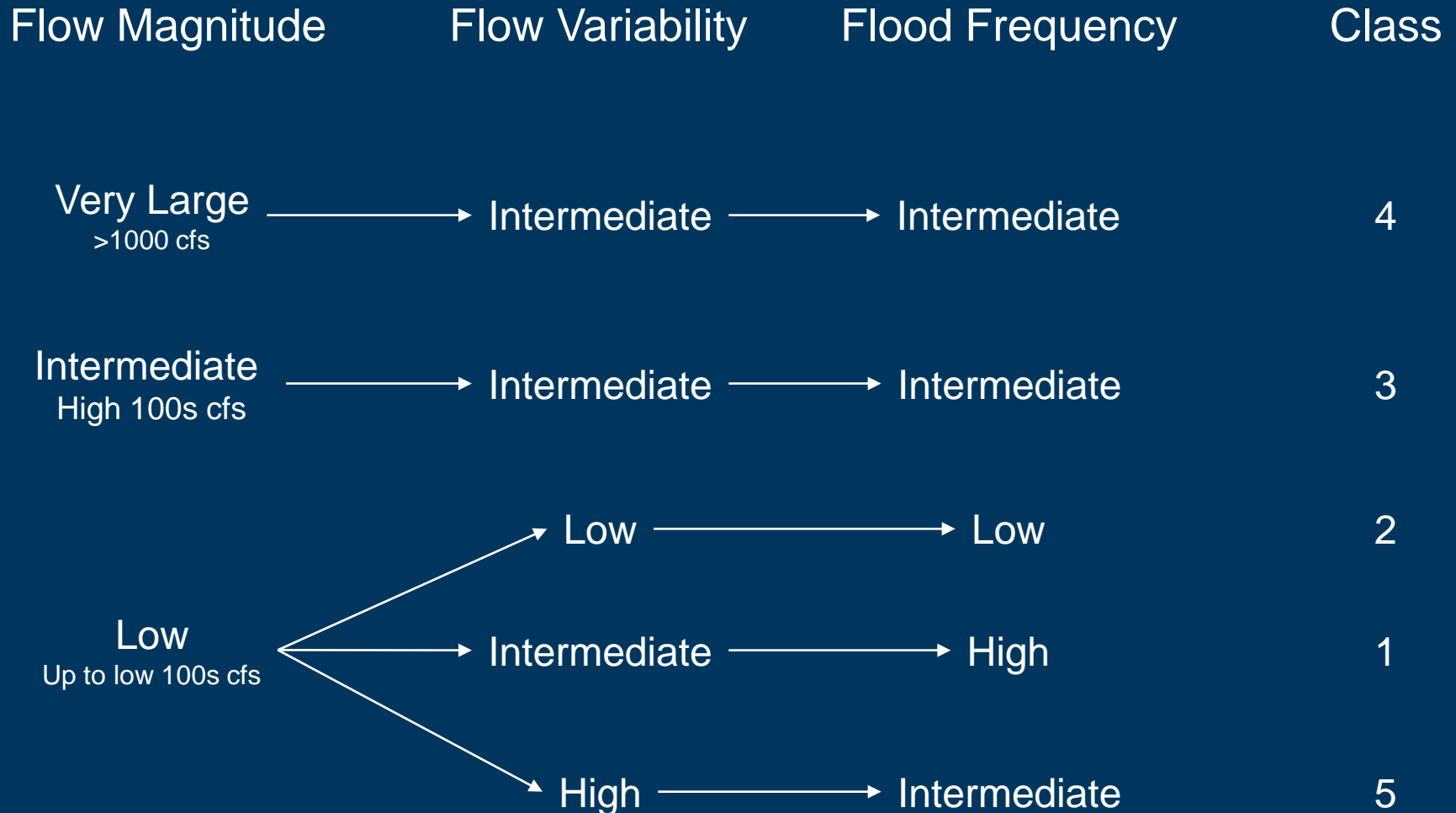
Used PCA to reduce number of indices

Applied clustering algorithms to develop classes (**simultaneous**, 2 stage, no drainage area correlates)

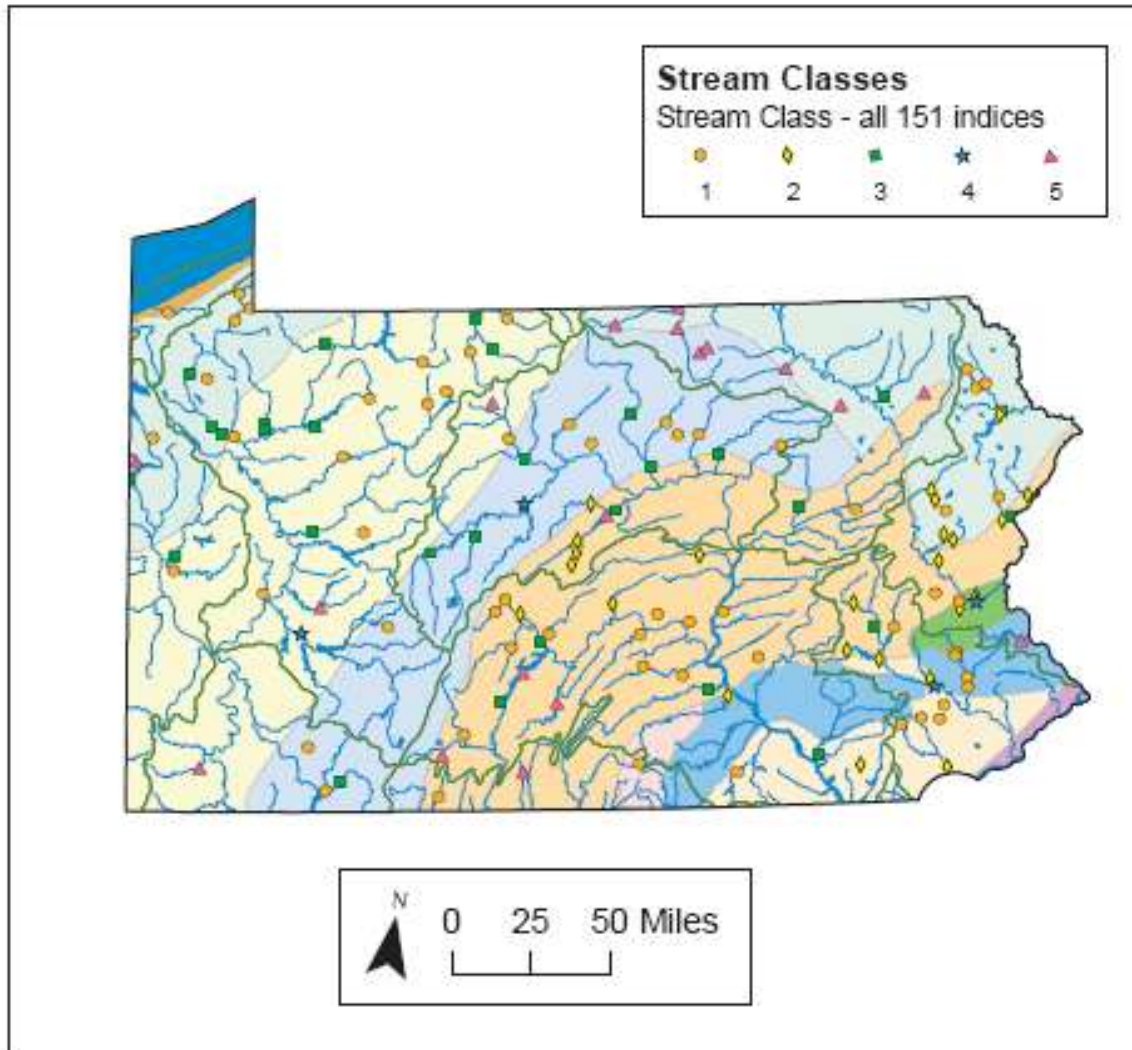
Used PCA to define non-redundant stats for each class



Pilot Statewide Hydrologic Classification



Hydrologic Classification Map



- Geographic locations of the 5 stream classes in Pennsylvania resulting from simultaneous classification approach
- Colored bands represent physiographic sections

Predicting Types for Ungaged Streams

- Critical step, with little guidance in literature
- Used discriminant function analysis to predict stream classes for ungaged sites (and non-index gages)
- Model included variables derived from GIS
- Model applied to index gages to determine correct classification

Variable	Partial R ²
Drainage area	0.80
% Carbonate	0.29
Precipitation	0.34
Channel slope	0.14
Groundwater head	0.14
% wetlands	0.11
Depth to bedrock	0.09
Permeability	0.08
Longitude	0.07

The number of index gages that were predicted to occur in each stream class, and correct classification rate for each stream class

Actual stream class	Predicted stream class					Correct classification rate
	1	2	3	4	5	
1	44	3	0	0	12	75%
2	6	18	1	0	0	72%
3	2	3	23	1	0	79%
4	0	0	0	4	0	100%
5	7	0	0	0	12	63%

Responses to Pilot Classification & Extrapolation

- Hydrologic classification provided statistically rigorous approach to defining hydrologic stream types for index gages in PA
- Index gages only represent a limited set of stream types within PA (e.g. “largest” class (n=4) is <10% drainage area of Susquehanna basin)
- Correct classification rate using DFA good (avg 78%) but still high likelihood of assigning streams to incorrect classes
- Final PCA analysis to define non-redundant hydrologic indices by class resulted in a number of non-intuitive hydrologic statistics
- Hydrologic types not obviously related to any classification scheme currently applied in water management
- Classes may be useful in developing flow-ecology response relationships

Susquehanna Ecosystem Flow Study

Goal: To describe the flow needs of aquatic ecosystems within subwatersheds of the Susquehanna River (27,486 sq miles)

Major project elements:

- Identify flow-sensitive species, communities, and habitats
- Complete basinwide assessment of flow alteration
- Relate flow alteration to potential ecological response
- Develop ecosystem flow recommendations

Project partners: Susquehanna River Basin Commission, US Army Corps, TNC

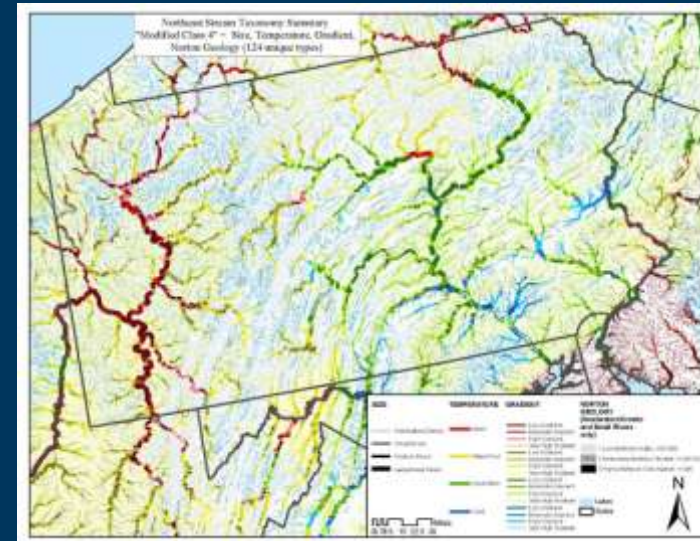
March 2009 - April 2010



Susquehanna Basin River Classification:

- Need classification that applies across several states
- Need to assign to all streams and rivers within basin
- Intend to complement Susquehanna River Basin Commission existing rules for headwater trout streams
- Should capture major variables distinguishing among stream types in HIP classification: drainage area and flow variability (baseflow)
- Draw on existing classifications (state and regional)

- Created draft maps using:
 - the cold and warmwater stream designations for Pennsylvania
 - the Northeast Aquatic Habitat Classification (Anderson et al 2007)
- Used existing species and community distribution information to associate each group of flow-sensitive taxa with general river types or mainstem reaches within the basin

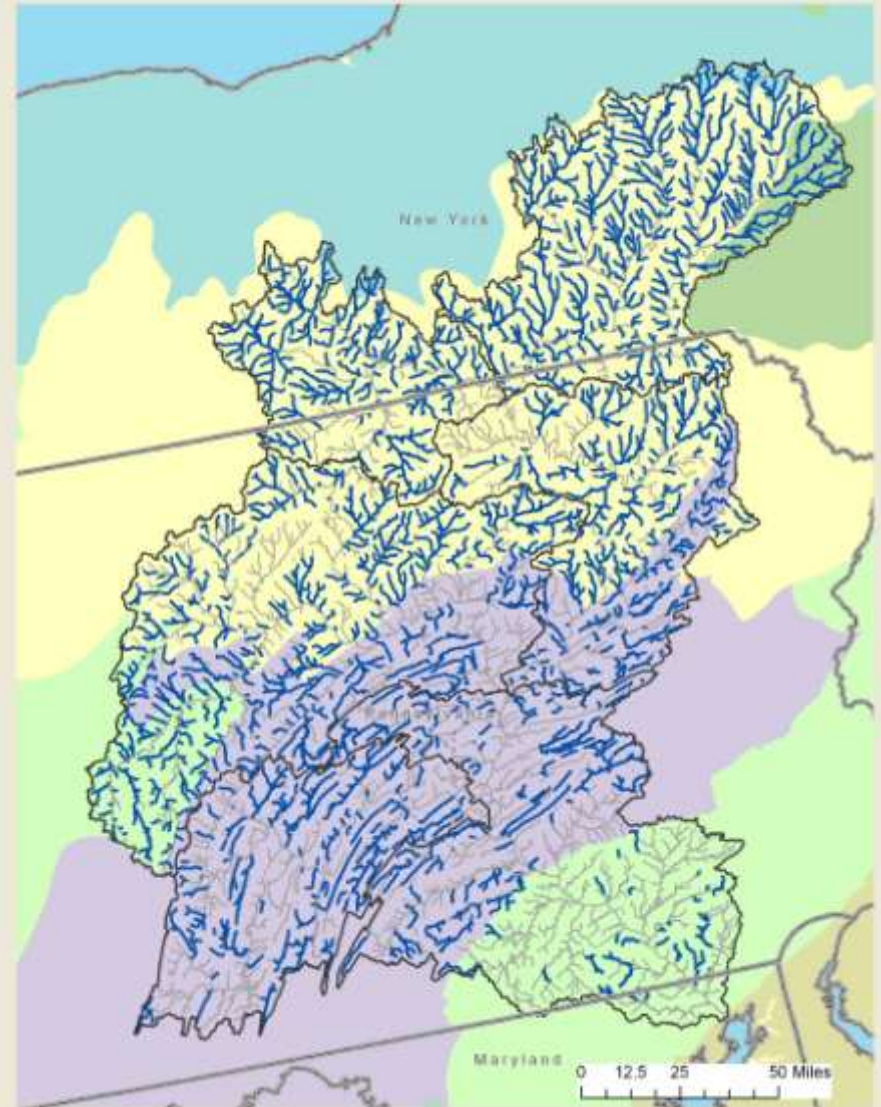


<http://rcngrants.org/node/38>

We identified **seven general river types or reaches** within the basin:

Headwaters and small streams (<200 sq mi)

1. Cold headwater and small streams
2. Calcareous headwaters and small streams
3. Warm headwater and small streams

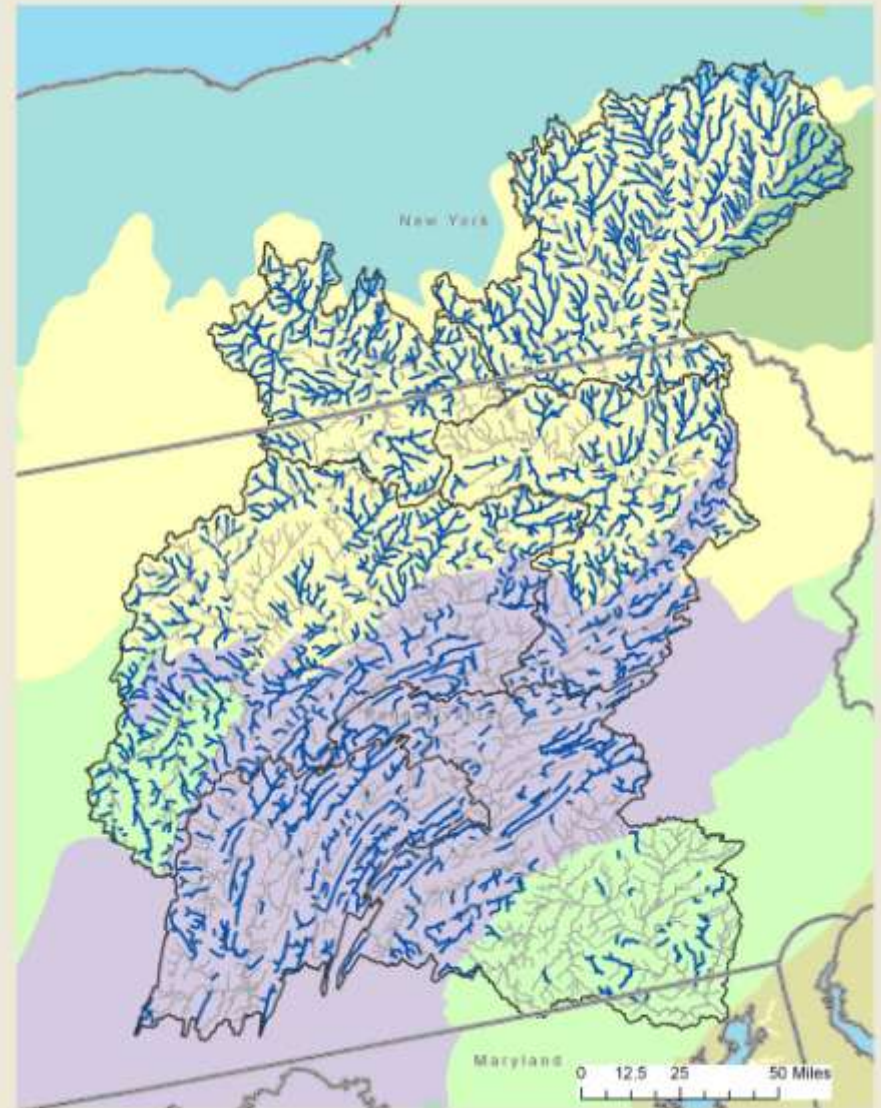


Cold headwater and small streams

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Headwaters and small streams (<200 sq mi)

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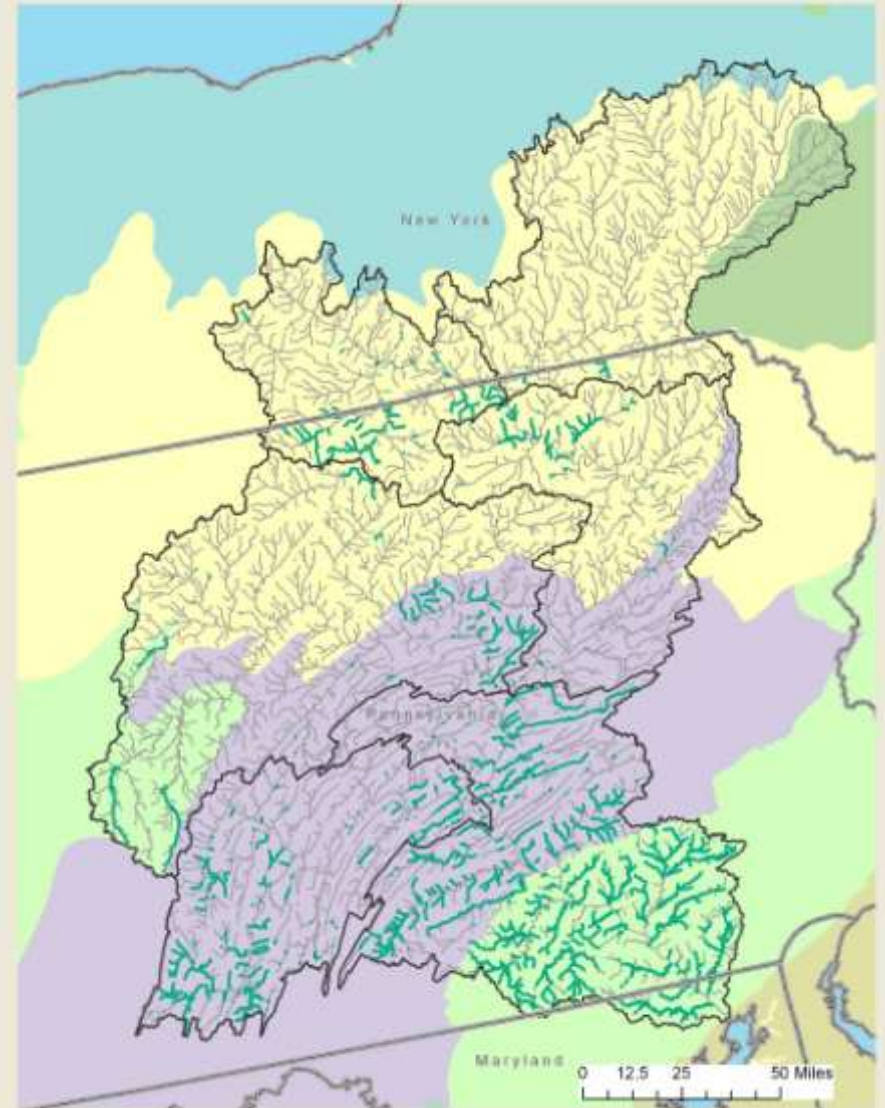


Warm headwater and small streams

We identified **seven general river types or reaches** within the basin:

Headwaters and small streams (<200 sq mi)

1. Cold headwater and small streams
2. Calcareous headwaters and small streams
3. Warm headwater and small streams

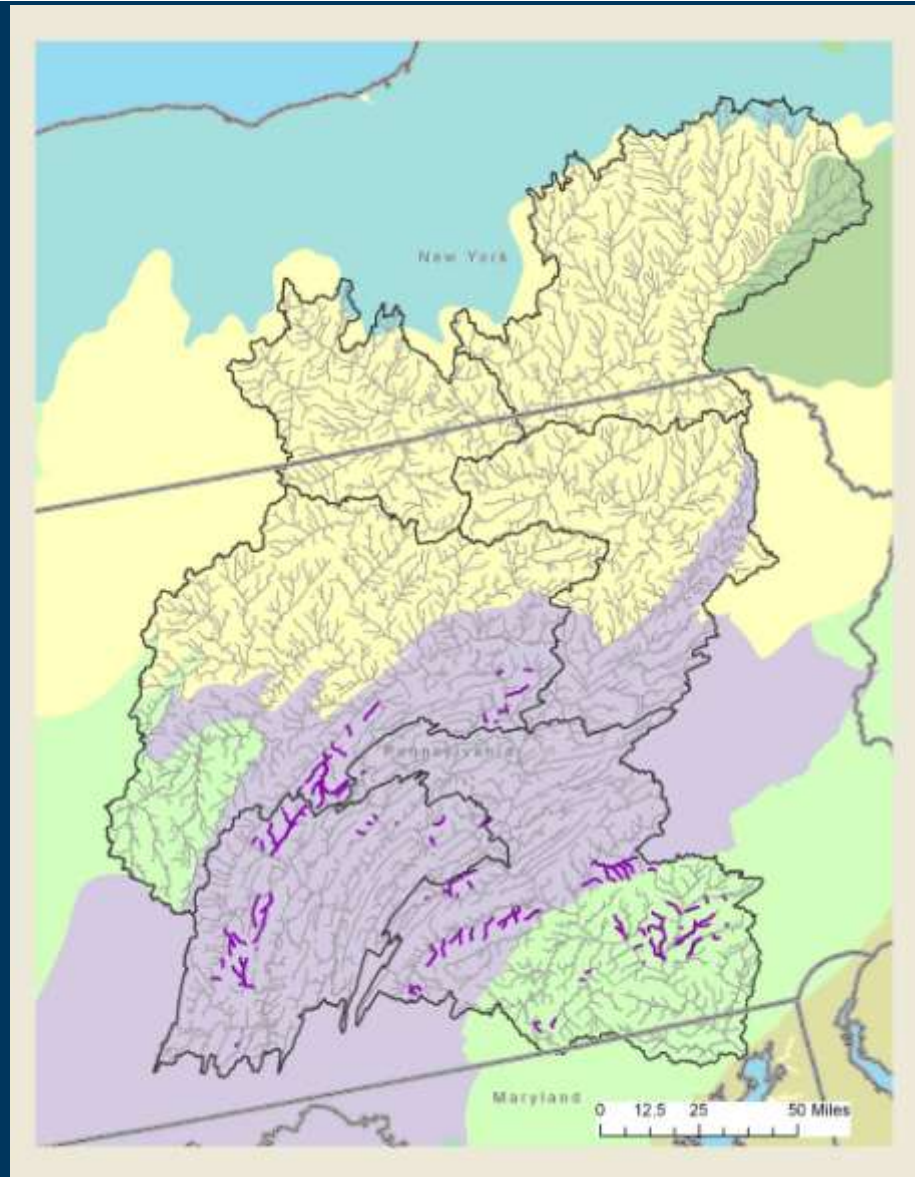


Calcareous / limestone streams

We identified **seven general river types or reaches** within the basin:

Headwaters and small streams (<200 sq mi)

1. Cold headwater and small streams
2. Calcareous headwaters and small streams
3. Warm headwater and small streams



Large Tributaries and Mainstem Reaches

Large Rivers (>200 sq mi)

4. Upper Susquehanna and Chemung
5. West Branch and Juniata
6. Middle Susquehanna
7. Lower Susquehanna



	Headwaters and small streams (< 200 square miles)			Major tributaries (>200 square miles)		Mainstem	
	Cold headwater and small streams	Calcareous headwaters and small streams	Warm headwaters and small streams	Upper Susquehanna and Chemung	West Branch and Juniata	Middle mainstem	Lower Mainstem
Fishes							
Cold headwater	X	X					
Riffle obligate	X	X	X	X	X	X	X
Riffle associate	X	X	X	X	X	X	X
Nest builders	X	X	X	X	X	X	X
Migratory					X	X	X
Mussels							
Primarily riverine	X	X	X	X	X	X	X
Facultative riverine	X	X	X	X	X	X	X
Primarily lentic				X	X	X	X
Aquatic vegetation							
Emergent					X	X	X
Herbaceous					X	X	X
Scrub/shrub					X	X	X
Floodplain forest					X	X	X
Aquatic insects							
Pool					X	X	X
Pool-riffle	X	X	X	X	X	X	X
Riffle	X	X	X	X	X	X	X

- Intuitive and relatively familiar to managers
- Easily extrapolated to unengaged sites
- May not represent hydrologic types
- Modestly increases strength of relationship between macroinvertebrate scores and flow alteration metric
- Should be further tested and refined