Preliminary State-Identified Healthy Watersheds Vulnerability Assessment for the Chesapeake Bay Watershed

Kickoff Meeting/Conference Call Oct. 27, 2017

Hosted by CBP

Meeting Minutes

Participants

Renee Thompson, CBP-USGS
Katherine Wares, CBP-CRC
Doug Norton, EPA-OWOW/Healthy Watersheds
Angel Valdez, MDE, HWGIT Chair
Hannah Martin, CBT
Nancy Roth, Tetra Tech
Peter Cada, Tetra Tech
Chris Wharton, Tetra Tech
Mark Southerland, AKRF

Introductions / Roles

All participants introduced themselves and roles.

Review Scope of Work and Schedule

Renee began with an overview of the project and its purpose in support of the Chesapeake Bay Program's Maintain Healthy Watersheds Goal Implementation Team (HWGIT). Nancy gave a brief overview of the major work elements:

- Apply the Preliminary Healthy Watersheds Assessment (PHWA) Framework to Assess The Current Condition of State-Identified Healthy Watersheds Within the Chesapeake Bay Watershed
- Develop an Approach to Use the PHWA Framework to Assess the Health of State-Identified Healthy Watersheds Over Time
- Apply the PHWA Framework to Identify Vulnerabilities in State-Identified Healthy Watersheds

Nancy noted that data compilation will be (by its nature) adaptive, depending what data are available. Renee noted that as work progresses, it will be helpful to note what information we have now and what we would like to have in the future. New Chesapeake data sets and CBP indicators may be available during the project or in future. State-identified Healthy Watersheds will provide a baseline for assessing future change. With this project, Renee noted, the program will be able to develop a point-in-time assessment and a plan for a 2-5 year (or more) reassessment, with indicators or a framework that will enable the program to move forward in considering how best to maintain healthy watersheds.

Nancy reviewed the proposed project schedule. Renee suggested that the team should plan for an in-person meeting or webinar with key state contacts and the larger HWGIT in January, but also an intermediate meeting in December with the core group participating in this kickoff, plus state data contacts. Nancy will modify the schedule to reflect this plan.

Following initial assessment of current condition, the team will work on the second key element: developing an approach for tracking changes in condition over time. Jason Dubow of Maryland Department of Planning (HWGIT Vice Chair) is very interested in this issue. Nancy said the December meeting will be a good time to brainstorm and get ideas from the group to help develop approach.

Doug pointed out that a key part of this project will be this second element, setting up a framework or approach to look at change over time. Enhancements to the PHWA to look at change will provide an opportunity to move forward, particularly as there is no expectation currently for repeating the national PHWA soon.

On vulnerability assessment, Renee noted some data are readily available but some may be more difficult or not possible to obtain. USGS has data on energy development. Other available data include land use and climate change, from Integrated Climate and Land-Use Scenarios (ICLUS). Water demand data may be harder to find, but USGS might have something. Data on invasive species may be harder to track down. Information on future transportation corridors could possibly be found in transportation improvement plans developed by state agencies.

Peter noted EPA's 20 Watersheds and EnviroAtlas projects may have useful data, including a year 2050 scenario, and SWAT and HSPF modeling of effects on future water quality. Renee said the CBP land use team is looking at a future land use scenario for year 2025 and this should be published by Nov. 15.

Renee pointed out that if a large proportion of the healthy watersheds are found to be vulnerable, that could affect management approaches. Doug noted that PHWA downplayed the vulnerability assessment because only limited data were available nationally. Land use, water use, and fire were considered. The national assessment also looked at changes going back in time.

Doug emphasized it will be important to look at individual vulnerabilities rather than try to combine into one index. If factors are averaged or combined into a multi-metric indicator, a strong, overriding vulnerability factor may not be detected, or could be overlooked. Renee agreed that looking at vulnerabilities individually is more useful for management purposes in being able to identify key policies and plans to address vulnerabilities.

There is research in terms of past trends and patterns, e.g., an urban infill development study examining how much urbanization can be absorbed with infill v. green field development. Doug noted that in looking from past to present, an area may be fully built out and therefore not as susceptible to future growth.

Re project deliverables, Renee said CBP is looking for assessments of the state-identified healthy watersheds (e.g., good condition, middle, poor) and their vulnerability. She would also like the project report to note what may be done in the future, with a suggested list of next steps. The report should also include a summary of when data were collected and recommendation of when this assessment can be done again (e.g., perhaps 2-5 years, depending on data sources). She is looking for guidance on moving forward on developing an indicator of watershed health. Nancy will modify the report language in scope of work about providing a report outline.

Hannah agreed that the changes to the scope and schedule discussed today are minor and do not require any change to the contract.

<u>Data Requests - Process</u>

Renee noted that there is an updated state data contact list, which Katherine can provide to the Tetra Tech project team.

Doug noted he can provide a list of contacts from the PHWA that included state contacts in 303d TMDL and 319 NPS programs.

Katherine and Renee can help with data requests. Renee will make initial contact with state data contacts to let them know Tetra Tech may be making requests for data. Angel can help with Maryland contacts.

Katherine will provide a shapefile with boundaries of state-identified healthy watersheds. Some are stream segments, others are catchments or HUCs.

Renee is working with Peter Claggett on a land cover change model that will examine changes in metrics such as farmland and development. Renee noted the CBP has great high-resolution data and is working on high-resolution land use data, which will be useful to examine development pressure. Renee and Peter Claggett will be good contacts for this.

Regarding scale, Doug noted a lot of prior work has been on the HUC12 basis. Catchments can use StreamCAT from ORD work. He suggested that if pourpoints are available for the healthy watersheds, this would be useful to identify the specific upstream watershed area. Peter said it will be important to look at multiple states and make sure their different spatial units are addressed.

Peter also noted that when we encounter limitations in the data, it will be important to stay true to the data source to get the most information but also, when possible, remain consistent across different areas when needed.

Angel asked about example of Maryland State Highway Administration (SHA) Data, which may differ from Virginia Department of Transportation (VDOT). Peter suggested that on case-by-case basis, analysis could either work with with lowest common denominator or could perhaps extrapolate from existing data to other areas.

Angel noted high quality streams in Maryland are identified at the stream scale, but healthy watersheds at the watershed scale.

<u>Communications and Coordination</u>

- With CBP and CBT
- With Healthy Watersheds GIT
- Other partners/stakeholders

Some details on coordination with the HWGIT and other partners are discussed above.

Doug thanked Renee and others for involving EPA's Healthy Watersheds program and offered assistance if there are any questions about how PHWA was put together. Steve Epting (epting.steve@epa.gov) of Doug's team may be involved in future meetings and coordination.

The group discussed state involvement. Renee said there are no designated Healthy Watersheds in DC or Delaware but they may designate some in future, so these states are participating in the HWGIT. Each of the other states define their healthy watersheds differently.

There is a shapefile with a "mini preliminary HWA" for a portion of West Virginia, done by Misty Downing of TNC. Renee can provide this shapefile for informational purposes.

Angel noted this CBP project will be useful to Maryland in managing to reduce watershed impacts.

Renee asked about the size of Tetra Tech team. Nancy noted that the core members of team will do most of the work, but that other staff can be tapped for their knowledge of regional data.

Mark Southerland is serving as consultant, based on his past experience with healthy watershed assessments. He describing a concurrent study he is doing in partnership with Maryland, looking at condition of protected areas (v. unprotected areas) and how those have changed over time. That effort may provide information about the expected variability and biological change over time, which can inform the CBP project. Mark is coordinating with Maryland to compile state data on different classes of protected lands; Renee described Chesapeake Bay protected lands data (from MDNR, MDP, and others, with information on development rights).

Peter noted it will be great to have insights from partners on what data are likely to be useful and what data are on the horizon for future use.

Renee described partner support as three sides of triangle: CBP oversight of the project team's work, EPA technical support and guidance, and state partners. Angel will provide support in terms of state data, contact, and ideas. Renee and Nancy will communicate regularly and as needed will convene meetings or conference calls with this core team (participants on this call and others who may be added). The larger HWGIT will be involved in one meeting in the middle of project (targeted for January, to solicit input on data and indicators) and one at the end (to review draft final product). The project team will send "thought questions" to the HWGIT in advance of the January meeting.

<u>Preparation of QAPP – confirm format</u>

Renee will confer with her program's quality assurance coordinator and get back to Nancy about the proposed QAPP format.

<u>Next steps</u>

- Data compilation and review
- Prepare for December meeting

<u>Action Items</u>:

- Katherine to provide updated state data contact list to Tetra Tech.
- Doug to provide state data contact list from PHWA.
- Angel to help with Maryland contacts.

- Renee will make initial contact with state data contacts to let them know Tetra Tech may be making requests for data.
- Katherine will provide a shapefile with boundaries of state-identified healthy watersheds.
- Nancy will modify schedule and scope to reflect discussion at this kickoff meeting.
- Renee to provide shapefile with “mini preliminary HWA” for portion of West Virginia, done by Misty Downing of TNC, for informational purposes.
- Renee will confer with her program’s quality assurance coordinator and get back to Nancy about the proposed QAPP format.

Meeting minutes prepared by:

Nancy Roth
Tetra Tech
Nov. 10, 2017

Preliminary State-Identified Healthy Watersheds Vulnerability Assessment for the Chesapeake Bay Watershed

Meeting Dec. 18, 2017

Hosted by CBP

Meeting Minutes

Participants

Peter Cada, Tetra Tech
Peter Claggett, CBP
Debbie Herr Cornwell, MDP
Cassandra Davis, NYSDEP
Steve Epting, EPA-OWOW/Healthy Watersheds
Todd Janeski, Virginia DCR Healthy Watershed Program
Kelly Matthews, VDEQ Office of Watershed Programs
Nancy Roth, Tetra Tech
Mark Southerland, AKRF
Matthew Stover, MDE
Peter Tango, CBP
Renee Thompson, CBP-USGS
Angel Valdez, MDE, HWGIT Chair
Katherine Wares, CBP-CRC
Chris Wharton, Tetra Tech
Amy Williams, PA DEP
John Wolf, CBP-USGS

Introductions

All participants introduced themselves and described their interest in the project.

Project Overview

Renee Thompson welcomed all participants and gave a brief introduction of the project and its purpose in support of the Chesapeake Bay Program's Maintain Healthy Watersheds Goal Implementation Team (HWGIT).

Nancy Roth gave a brief overview of the project's major work elements:

- Apply the Preliminary Healthy Watersheds Assessment (PHWA) Framework to Assess The Current Condition of State-Identified Healthy Watersheds Within the Chesapeake Bay Watershed
- Develop an Approach to Use the PHWA Framework to Assess the Health of State-Identified Healthy Watersheds Over Time

- Apply the PHWA Framework to Identify Vulnerabilities in State-Identified Healthy Watersheds

Approach to Address Challenges of Scale

Peter Cada discussed the proposed approach to deal with scale issues by working at the NHD+ catchment scale. He presented examples of state-identified healthy watersheds in each of the Bay states, along with HUC-12 and NHD+ catchment boundaries. Use of NHD+ catchments would facilitate use of many readily available (or readily calculated) indicators across the entire Chesapeake Bay watershed by using source data and StreamCat tools. Analysis would be able to include entire upstream watersheds for identified healthy stream segments, as needed. Using a Virginia example, he discussed decisions that will need to be made, such as how to handle cases where the downstream end of a state-identified healthy watershed extends below one catchment into another, or cases of very small state-identified watersheds (smaller than an NHD+ catchment). For Pennsylvania and New York, where entire HUC-12s have been identified as healthy watersheds, conducting the analysis at NHD+ scale may be particularly useful to focus on the portion of HUC-12 where a high quality segment of interest is located.

Peter Cada presented a list of potential datasets from PHWA, color-coded as to their availability at NHD+ scale: available (green), able to be derived via scripts (yellow), and not as simple to derive (pink). Renee noted that even for those designated green, there may be better local data to incorporate. For example, recent high-resolution land cover/land cover change data will be available for the Chesapeake watershed. These and other local indicators may be swapped in for PHWA indicators, both for assessing present-day and for updates on future condition over time. Where possible, consistency across state lines is desirable, but may depend on data availability.

Todd Janeski said that Virginia is continuing to look at identifying healthy watersheds based on fish community data, as well as vulnerability, with its Natural Heritage program, using stream conservation units from INSTAR monitoring locations. Todd would like to see more examples of the NHD+ catchments with Virginia's healthy watersheds before weighing in on the proposed scale approach.

Steve Epting noted the national PHWA effort did not identify healthy watershed thresholds, but does provide a system for relative scoring by state or ecoregion to help states or others identify watersheds that are relatively healthy.

Peter Cada pointed out Chesapeake Bay states may be farther along in the process, having already designated healthy watersheds, but that the PHWA framework still provides a suite of indicators useful for the purposes of the HWGIT. One question to address will be what is the total population of watersheds that we want to assess, whether that be by state, baywide, or through comparisons among the designated healthy watersheds.

Peter Claggett noted CBP's purpose for this project includes tracking condition and examining vulnerability for the existing suite of state-identified healthy watersheds, and that working at the smallest relevant unit would be good, and that NHD+ makes sense for that reason. He noted there is a lot of spatial variability, and differences between watershed condition and stream condition, and it would be beneficial to be able to compare proximal and distal landscape conditions within the state-identified healthy watersheds. Peter Cada asked about the watershed scale used by the Bay model; Peter Claggett said it was roughly HUC-12 but with modifications to account for County boundaries and other factors. The SPARROW model is based on NHD+ catchments.

Angel Valdez noted there needs to be clear decision rules for defining the watershed boundaries (specifically to deal with special cases such as those presented). In Maryland, MBSS data were initially used to identify high-quality segments, and then the watershed areas draining to them, designated as healthy watersheds.

Renee suggested that the project team put together a shape file showing state-identified healthy watersheds and NHD+ catchments, for participants to review.

Angel said that after this discussion, she was feeling better about using the NHD+ scale. She said that looking at whole watershed scale (e.g., Patuxent River) often didn't provide enough detail.

Nancy said the NHD+ scale would help to capture the heterogeneity within larger watersheds, enabling a visual presentation of results similar to a stained-glass window showing variation, rather than a single results over larger area.

Peter Tango brought up point about brook trout, present in streams in 11% of Bay watershed area, and the varying data available across the region. Drilling down to finer scale can provide information on highly sensitive species such as brook trout. He also said CBP is looking at benthic macroinvertebrate results from about 25,000 samples Bay-wide, which will be considered in an April 2018 workshop.

Renee asked the group about thoughts on NY, WV, and PA, where the state-identified healthy watersheds are at HUC-12 scale but where state data may indicate more specific healthy streams within those areas. Cassandra Davis will review NY watersheds with Lauren Townley.

Seeking Input on Additional Data

Nancy presented a brief list and asked the group for additional input on known data sources. Peter Claggett said there will be 10-meter aggregated data available for percent impervious and other "percent land use" classes (derived from the 1-m high resolution data). Future land use, year 2025, will be available from CBP in January. By about March, future land use for every decade to 2100 should be available. He also said U.S. Conterminous Wall-to-Wall Anthropogenic Land Use Trends (NWALT) data provide good information on changes from 1974- 2012 at 60 m resolution, and that it is often important to look at past data to understand processes (e.g., early land use affects current sediment regime in streams).

Renee suggested the project team provide an updated version of the PHWA data sources table from the presentation, showing data available now, which she and others at the Bay Program will update, with CBP data sets to augment the PHWA data. Then she will send this table to the group to add suggestions on additional state-level data.

Peter Tango asked whether Maryland included tidal waters in its Healthy Watersheds; Angel replied that in Maryland only non-tidal stream data were used to designate Healthy Watersheds. Tidal waters may be considered in the future.

Peter Claggett mentioned benthic data, which are also available from states and from Bay-wide compilation. He noted that benthic monitoring datasets also include habitat variables such as bank erosion and substrate metrics, which may be useful to consider in tracking watershed condition and vulnerability.

Peter Claggett also asked about repeatability and whether the project would be producing scripts (R, Python). Peter Cada said at the end of the project, the team would provide any scripts produced, for CBP's later use. The ability to run analysis in the future is an important feature, whether to update the framework with better data or to track watershed condition over time.

For January meeting with larger HWGIT, the project team will apply indicators and provide example results for discussion.

Peter Cada asked for thoughts on what is the appropriate population – all watersheds in Bay watersheds? All healthy watersheds? And noted that comparisons can be run by ecoregion or by state. Peter Claggett said that to assess whether the sate-identified watersheds are healthy, it would be helpful to do wall-to-wall analysis (i.e., for all catchments in Bay watershed) to start to understand how these stack up and why they are healthy.

Peter Tango pointed to a concern about single landowners (e.g., large farms) and sensitivity about how data are portrayed in results tables and visuals, since a since property may be a catchment at NHD+ scale.

Peter Tango also noted the climate indicator workgroup is currently working on narrowing list of key indicators, from 164 candidate indicators to smaller number. John Wolf said that geospatial data for the indicators of climate change are to be created in 2018.

Nancy presented two slides as "food for thought" regarding future tracking of watershed condition and vulnerabilities, which will be considered in more detail at and after the January meeting.

Peter Claggett said there will be LiDAR data for 2 million stream cross-sections, potentially providing data on bank condition that may be useful the assessment.

<u>Next steps</u>

- Decision on watershed scale
- Data compilation and review
- Prepare for January HWGIT meeting

<u>Action Items</u>:

- Peter Cada to prepare GIS files showing scale overlays (state-identified healthy watersheds, NHD+, HUC-12)
- Peter Cada and Nancy Roth provide handout with explanation and background on scale issues related to applying PHWA framework

- Peter Cada and Nancy Roth to update list of candidate data and provide to Renee Thompson. Renee and other CBP staff will update with CBP data and then Renee will send to the group for input and additional information on data available
- Renee and Katherine work on plans for HWGIT meeting in mid-January
- Renee to send today's presentation (PDF) to the group

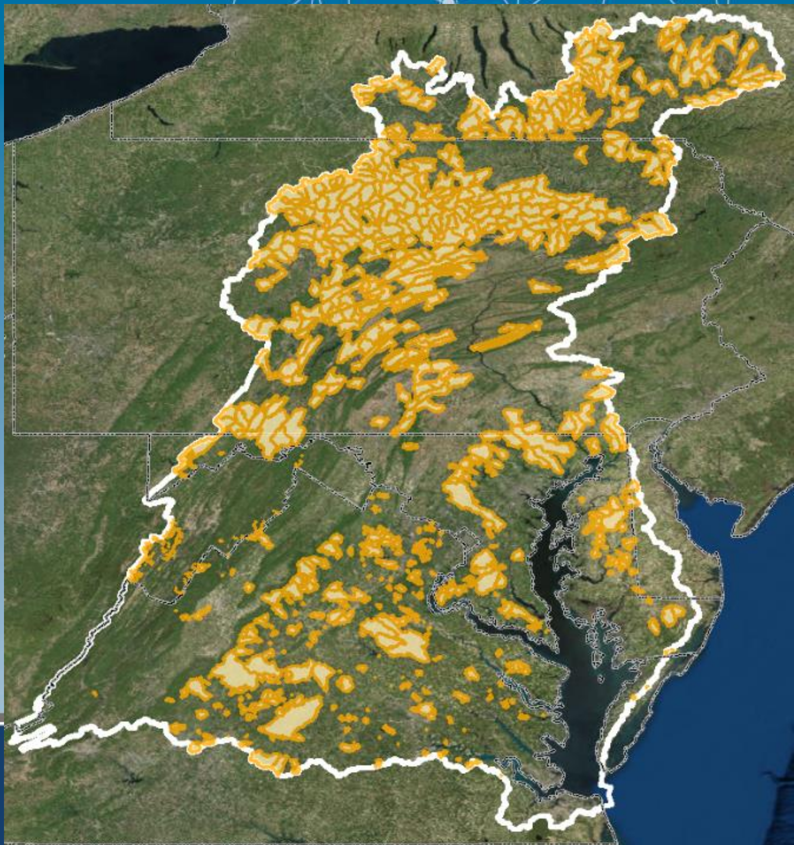
Meeting minutes prepared by:

Nancy Roth
Tetra Tech
Dec. 22, 2017

Tetra Tech

Preliminary State-Identified Healthy Watersheds Vulnerability Assessment for the Chesapeake Bay Watershed

December 18, 2017 meeting



TETRA TECH

Today's meeting

- Introduce the project
- Approach to address challenge of scale
- Seek input on additional data

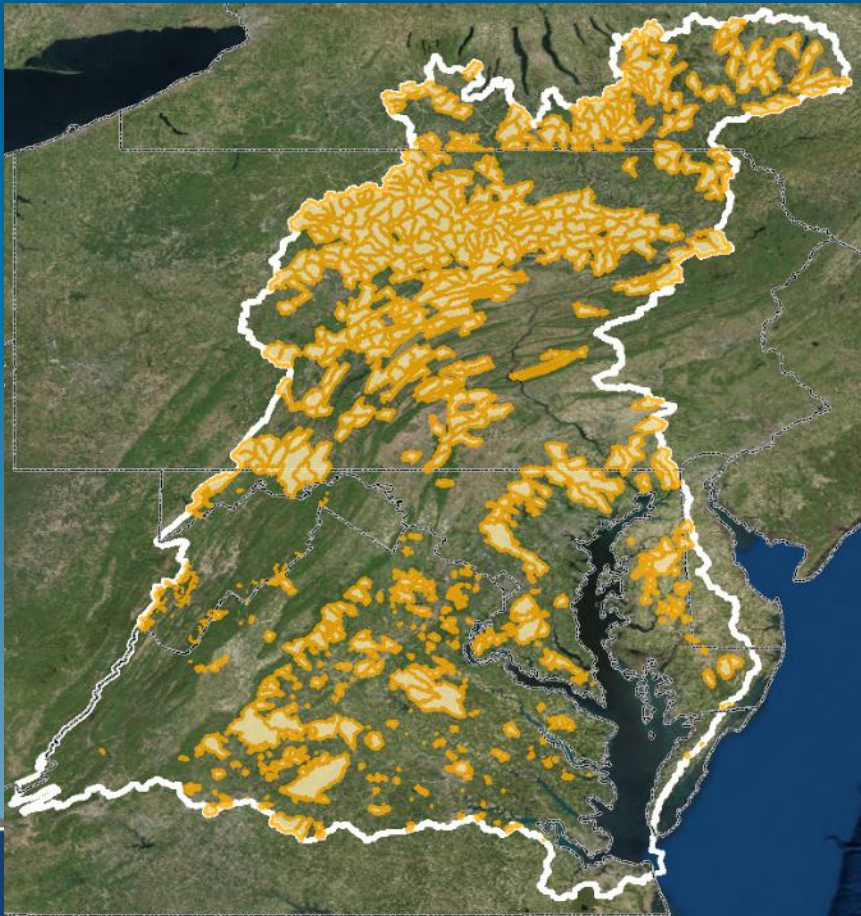
TETRA TECH

Project Overview

- **Apply the Preliminary Healthy Watersheds Assessment framework to**
  - (1) assess current condition of State-Identified Healthy Watersheds,
  - (2) develop an approach for future tracking of condition, and
  - (3) assess vulnerabilities of these watersheds.

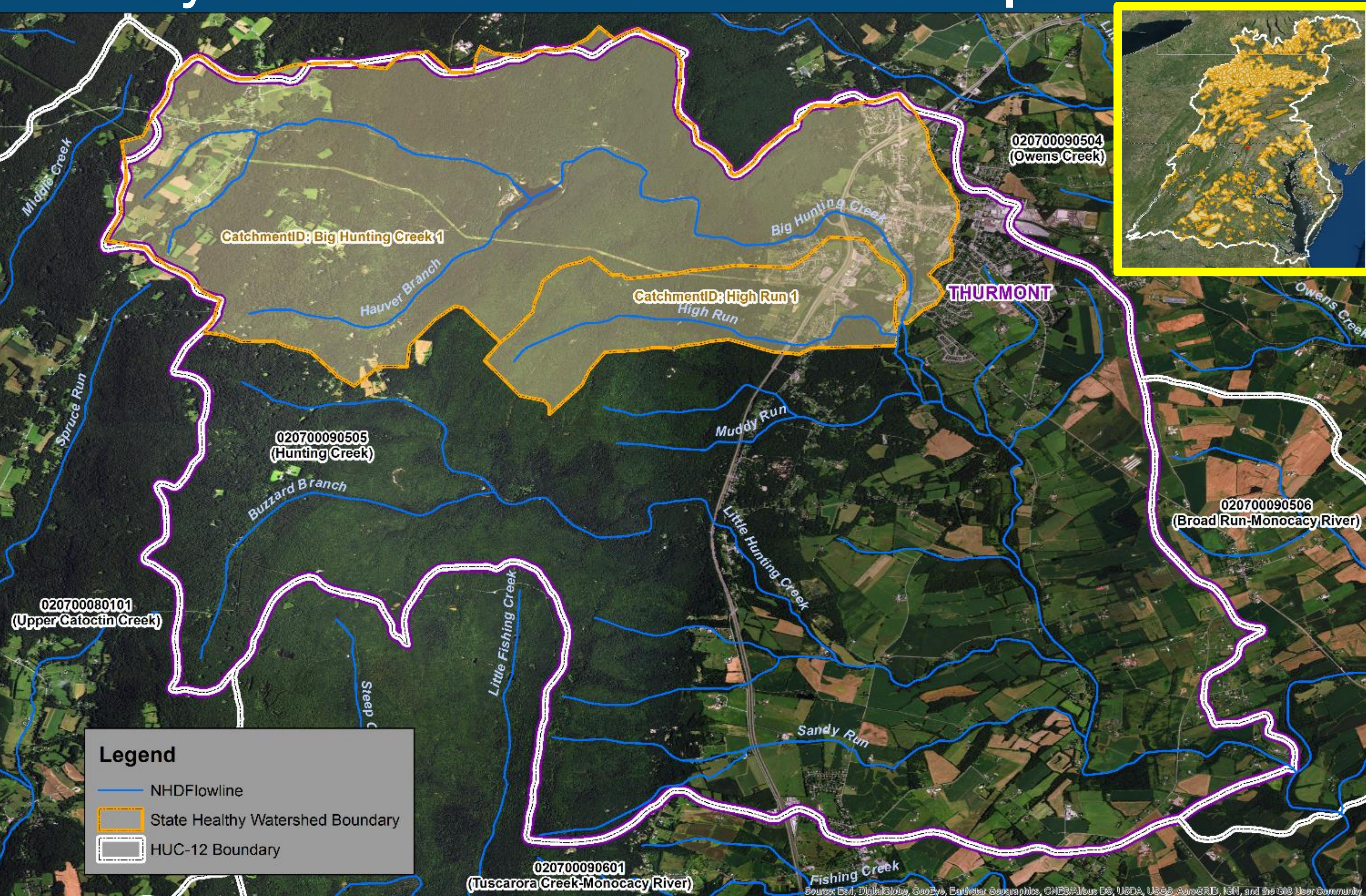
Challenge: Addressing Watershed Scale

- **PHWA developed nationally to provide data at HUC12 scale**
- **Healthy watersheds identified by Chesapeake Bay states**
  - Differing Approaches/Scales
    - Streamlines only (WV)
    - Custom (total) Watershed Boundaries (VA/MD)
    - HUC12 selections (PA/NY)

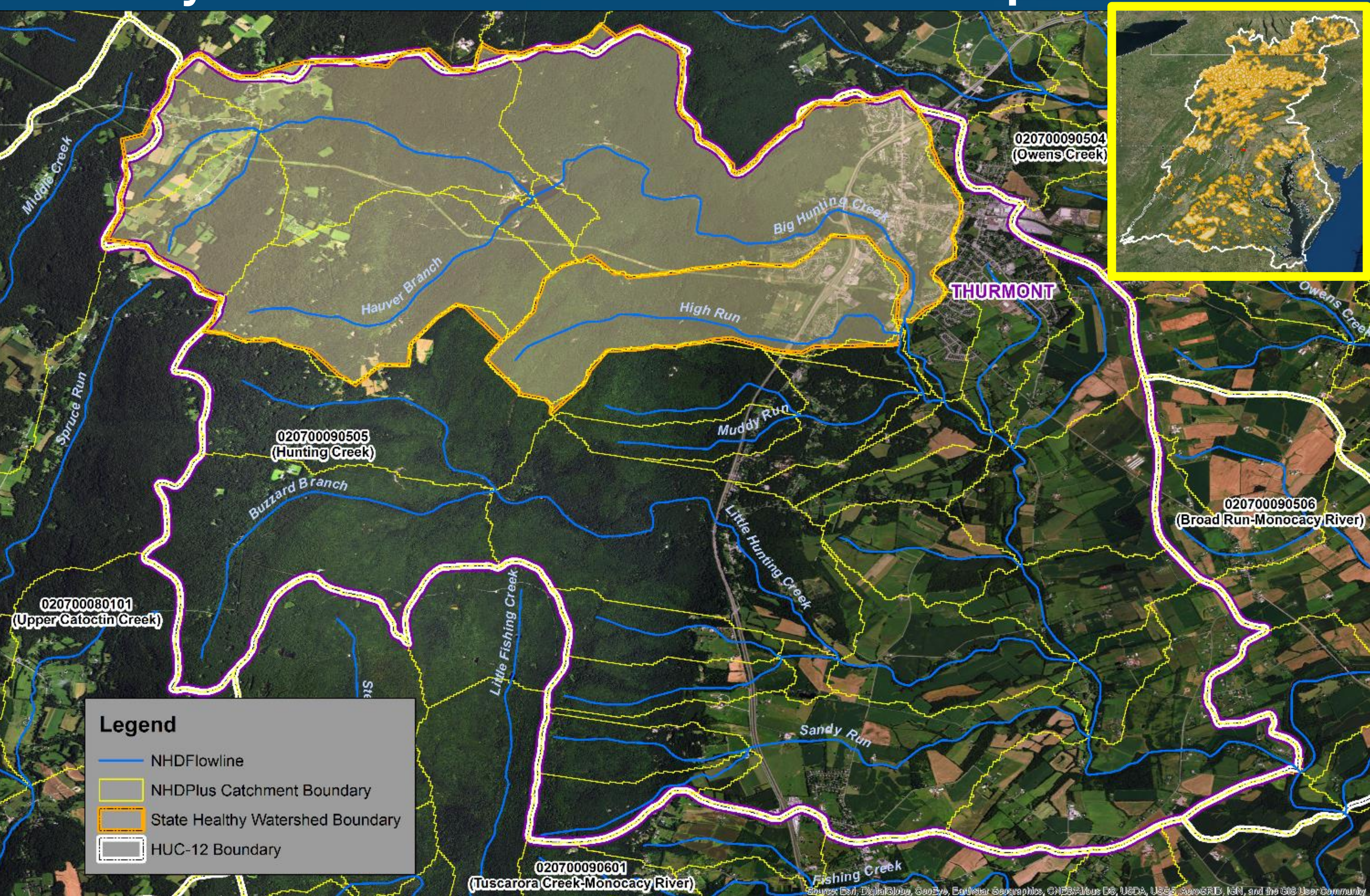


TETRA TECH

Healthy Watersheds Scale – MD example #1



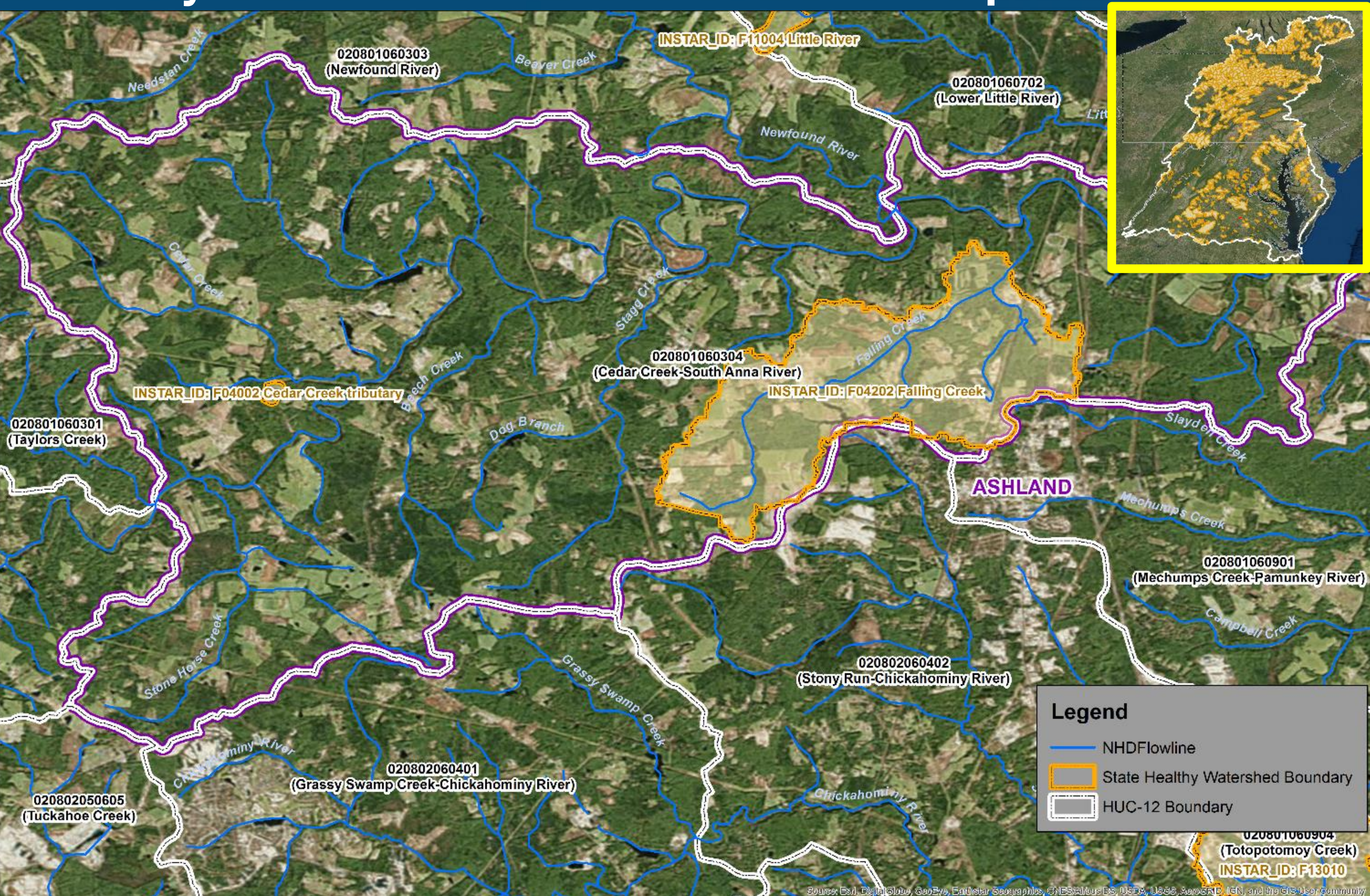
Healthy Watersheds Scale – MD example #1



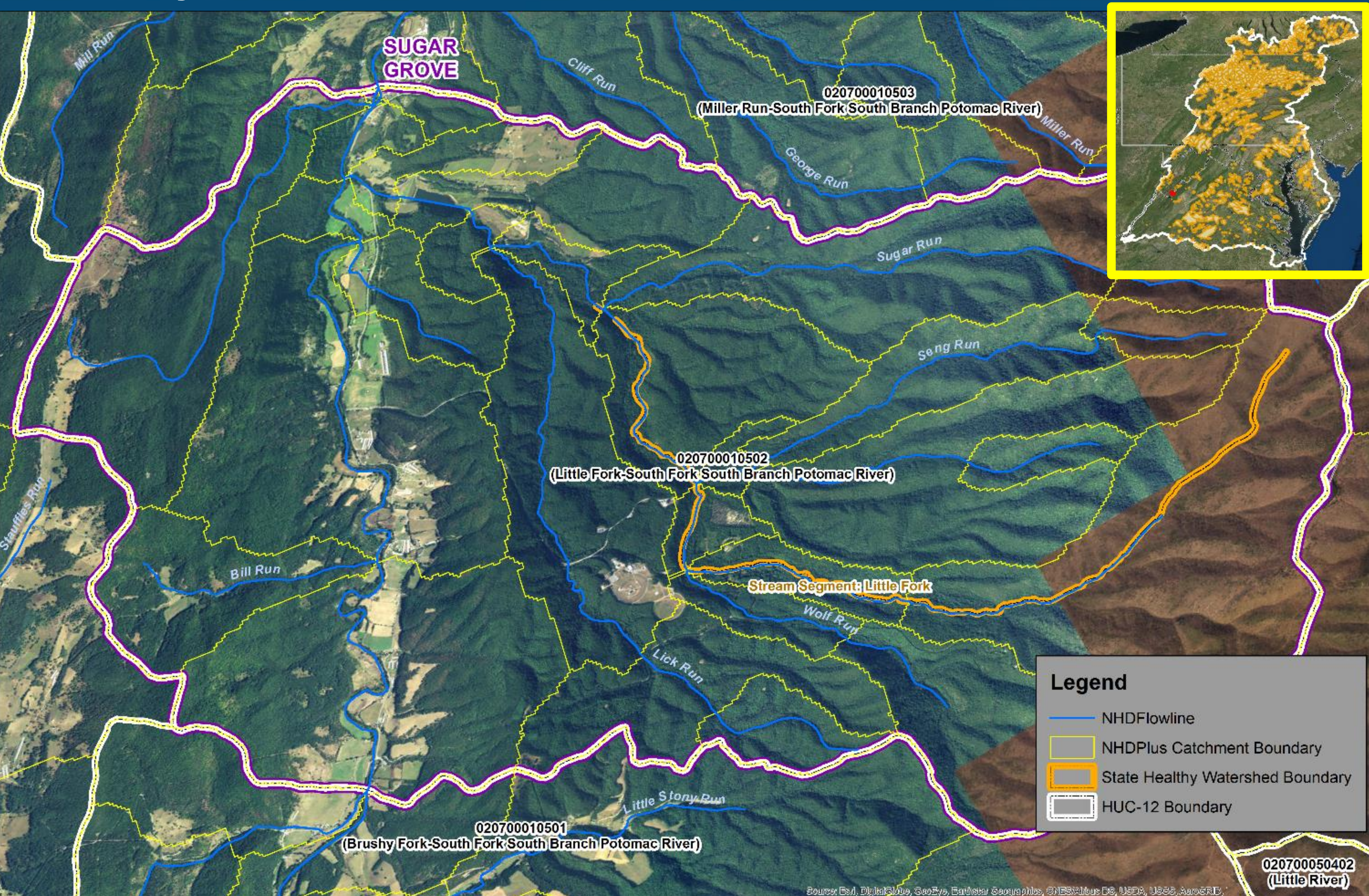
Healthy Watersheds Scale – MD example #2

TETRA TECH

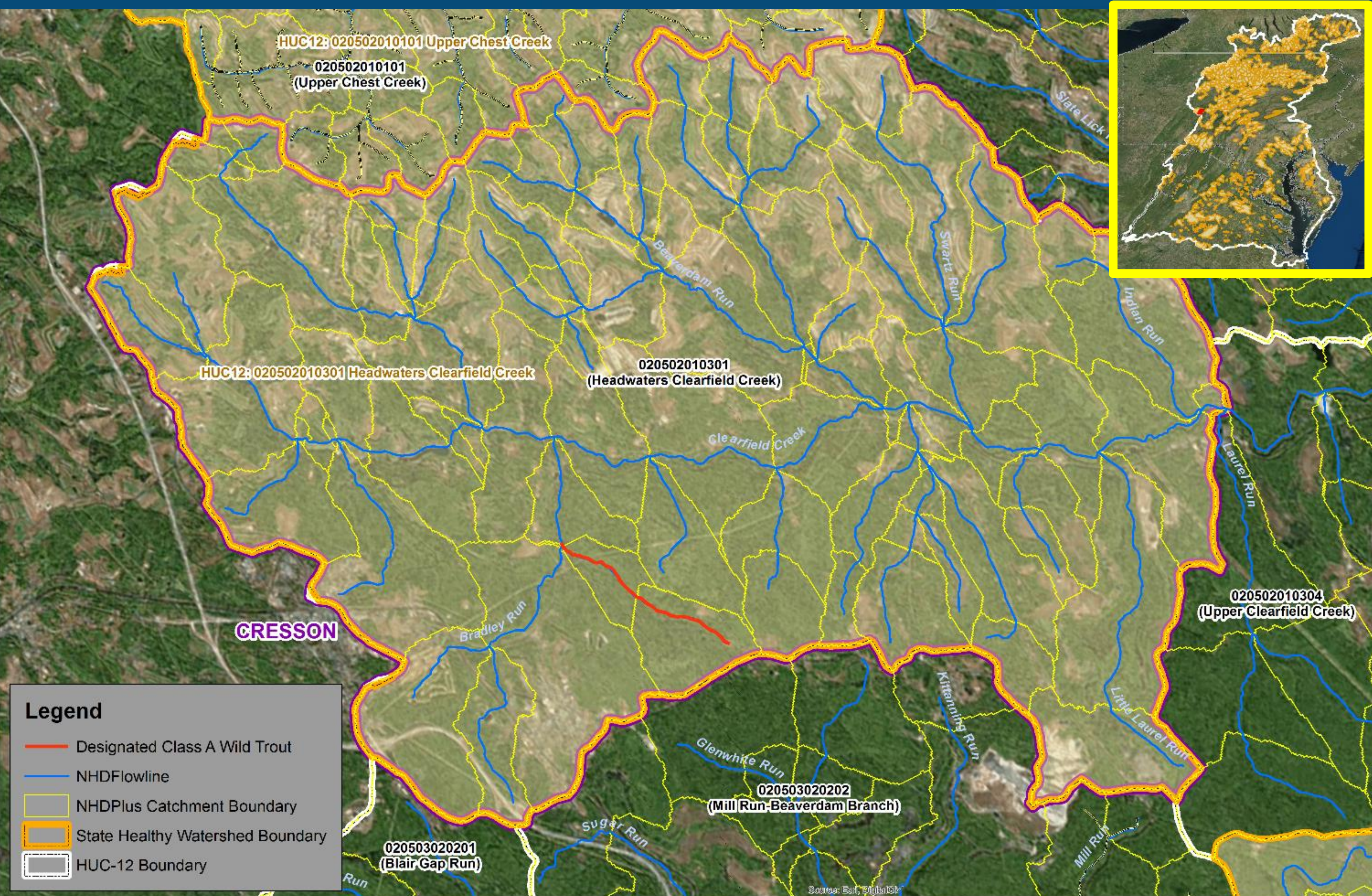
Healthy Watersheds Scale – VA example #1



Healthy Watersheds Scale – WV example (Line)

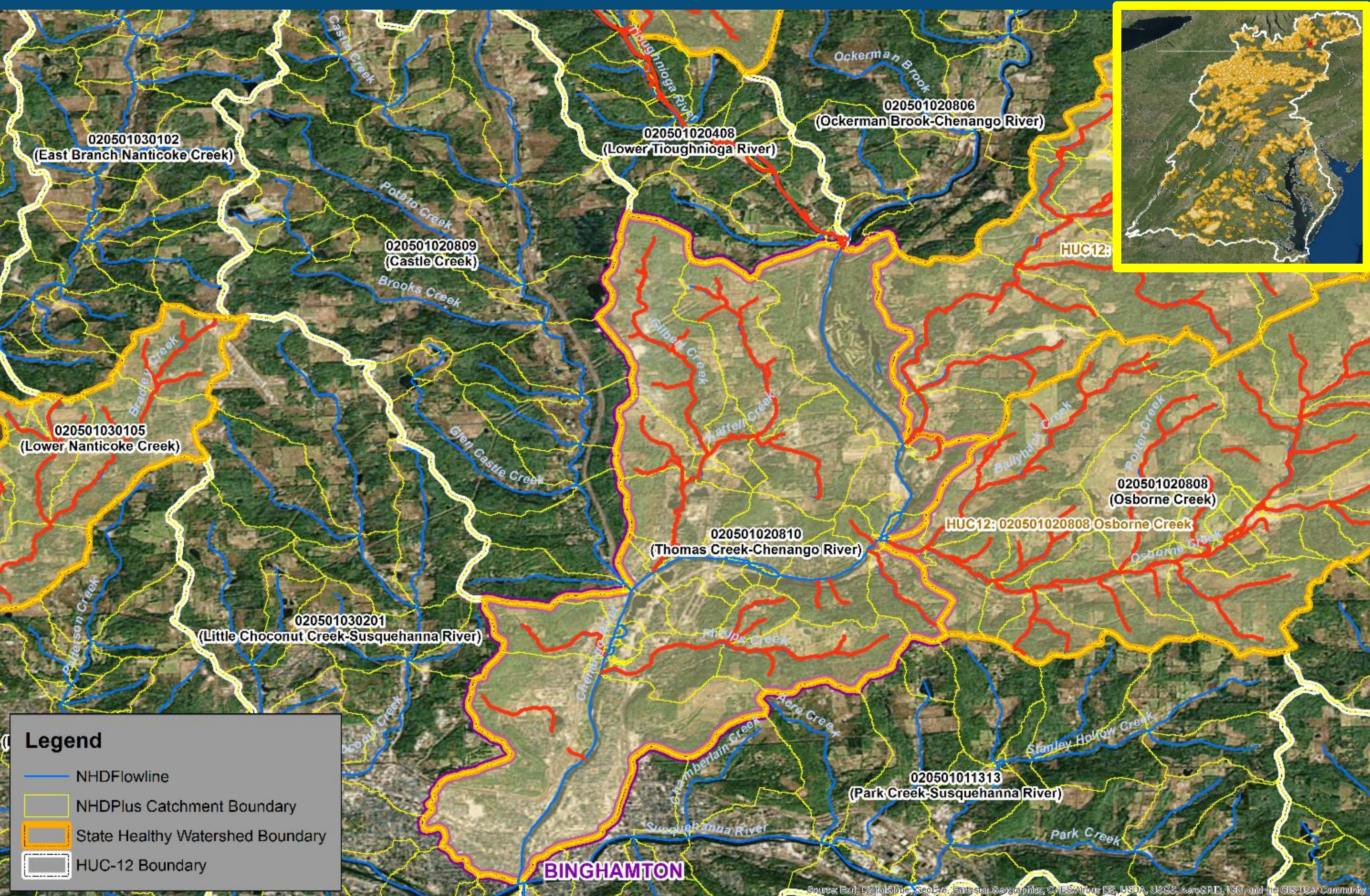


Healthy Watersheds Scale – PA example (HUC12)

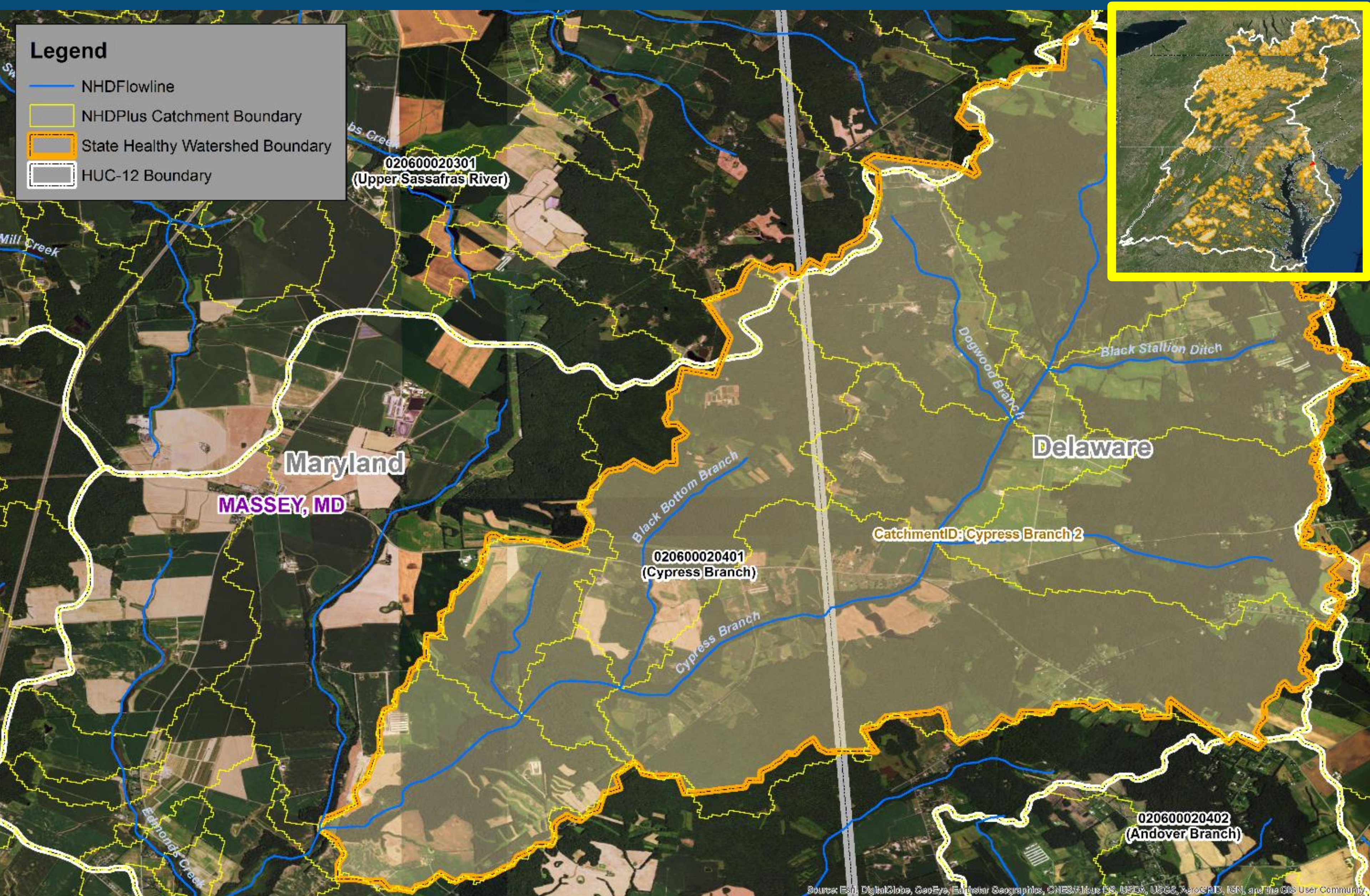


TETRA TECH

Healthy Watersheds Scale – NY example



Healthy Watersheds Scale – DE "example"



Seeking Input on Additional/Different Data to Assess Current Condition

- While the PHWA provides indicators derived from national data, at HUC-12 scale, regional application of the PHWA framework may be augmented through the use of additional data
- First: some PHWA indicators are already (or can be) calculated at NHD+ catchment scale (see next slide)
- Next: additional regional / state data may be useful to enhance the assessment of state-identified Healthy Watersheds

TETRA TECH

NHDPlus Scale – Available (Prepocessed) Data

- Are there better 'substitutions'?
- Local Data

PHWA Indicator - Description	NHDPlus-Scale, Preprocessed Data Available?	Notes
% Forest Remaining in WS	Yes	
% Wetlands Remaining in WS	No	Needs to be processed in GIS, with python (like StreamCat)
% N-Index1 in WS (2011)	Yes	
% N-Index1 in HAZ (2011)	No, but similar	StreamCat has it for 100-meter Riparian Buffer Area
% N-Index2 in WS (2011)	Yes	
% N-Index2 in HAZ (2011)	No, but similar	StreamCat has it for 100-meter Riparian Buffer Area
Habitat Condition Index WS (2015)	No	Needs to be processed in GIS, with python (like StreamCat)
Mean Aquatic Condition Score (2016)	No	Needs to be processed in GIS, with python (like StreamCat)
Outlet Aquatic Condition Score (2016)	No, but similar	StreamCat: Predicted probability that a stream segment is in good biologial condition based on a random forest model of the NRSA benthic invertebrate multimetric index (BMMI)
% Developed, High Intensity in RZ (2011)	Yes	
% Pasture/Hay in HCZ (2011)	No, but similar	StreamCat has it for 100-meter Riparian Buffer Area
Density All Roads in RZ (2015)	Yes	
Density Road-Stream Crossing in WS (2015)	Yes	
% Agriculture on Hydric Soil in WS	No, but similar	Done for EPA EnviroAtlas already
% Imperviousness, Mean in WS (2011)	Yes	
Population Density in RZ	Yes	
Housing Unit Density in WS	Yes	
Dam Density in WS	No, but similar	
Dam Storage Ratio in WS	No, but similar	
% Tile or Ditch Drained in WS	Not Really	StreamCat: Density of NHDPlus line features classified as canal, ditch, or pipeline within the catchment (km/ square km), or, Needs to be processed in GIS, with python (like StreamCat)
% Assessed Streamlength Supporting Minus Impaired (2015)	No	Needs to be processed in GIS, with python (like StreamCat)
% Assessed Waterbody Area Supporting Minus Impaired (2015)	No	Needs to be processed in GIS, with python (like StreamCat)

Potential Data Sources

- **For example,**
  - CBP current land cover / land use (high-resolution)
  - CBP future land use
  - Impervious cover
  - Forest cover, forest change
  - Stream bioassessment data

Seeking Input on Additional Data to Assess Current Condition

- **Food for thought: Key questions**
  - What are the watershed features or attributes most important to assess?
    - PHWA categories: Landscape Condition, Geomorphology, Habitat, Water Quality, Hydrology, and Biological Condition (and detailed indicators within each category)
    - What data are available to assess those attributes, perhaps in more detail than was possible in the PHWA?
    - What are the limitations (if any) of the available data?

TETRA TECH

Attributes	Data Available	Limitations/Other Notes	Who Can Provide

Next Steps

- Compile and apply additional data sets to assess current condition
- Begin to define data needs for tracking future condition and vulnerabilities
- Meeting/coordination with HWGIT

Future Steps

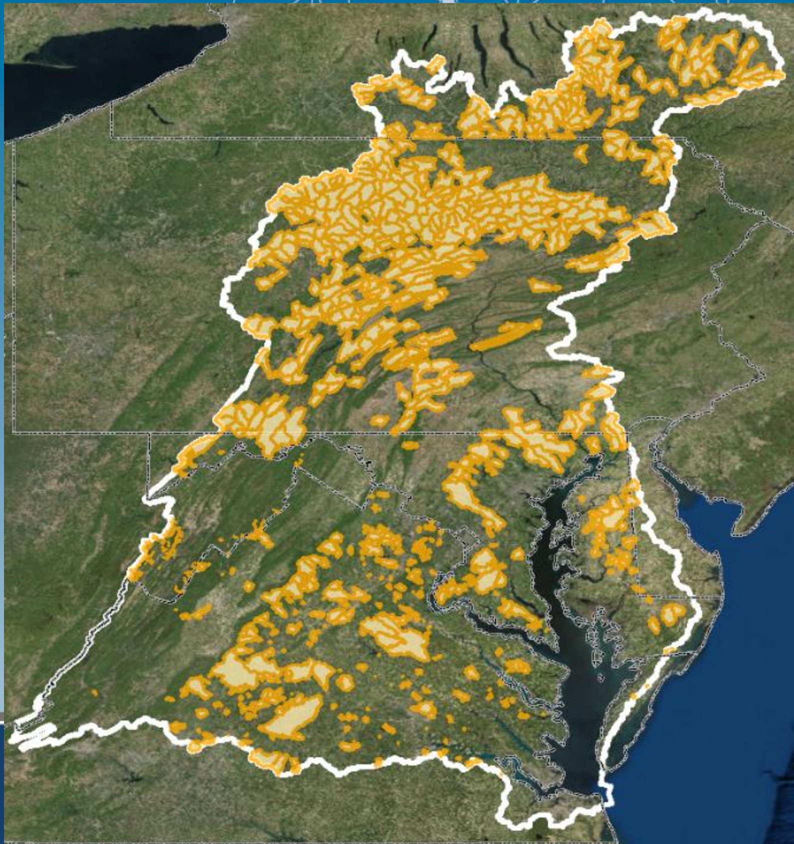
- **Develop an approach to use the PHWA framework to assess the health of state-identified healthy watersheds over time**
  - May require monitoring data or other indicators that will be updated at a frequency that will provide timely information on watershed health needed by managers
- **More food for thought:**
  - How to define when watersheds are successfully maintained as healthy?
  - Are there certain thresholds of condition that must be maintained?
  - What degree of natural variability is to be expected, and how will tracking determine whether watershed conditions remain within the expected range of natural variability, or when does a change indicate loss or degradation of watershed health?
  - Over what time period and at what intervals should watershed health be tracked?
  - Spatial and temporal resolution of data

Future Steps

- **Apply the PHWA Framework to Identify Vulnerabilities in State-Identified Healthy Watersheds**
  - Provide information will be useful to target state management efforts in healthy watersheds.
- **More Food for Thought:**
  - HWGIT has begun to consider various influences on watershed vulnerability to future risks, e.g., urban growth, energy development, water demand, invasive species, upstream activities, land ownership type and future plans, current and future transportation corridors, climate change, and sea level rise.
    - Anything else to consider? Are data available?
  - Vulnerabilities will be addressed individually, not as a combined index.
  - Available geospatial data layer within Chesapeake Bay watershed relevant to vulnerability assessments. Examples:
    - Land use projections
    - Climate change vulnerability assessment data
    - Thermal and hydrologic data
  - Spatial and temporal resolution of data

Preliminary State-Identified Healthy Watersheds Vulnerability Assessment for the Chesapeake Bay Watershed

Maintain Healthy Watersheds
Goal Implementation Team (GIT)
January 24, 2018 meeting



TETRA TECH

Today's Update

- Introduce the project
- Approach to address challenge of scale
- Seeking input on indicators of watershed condition and vulnerability

Project Overview

- **Apply the Preliminary Healthy Watersheds Assessment (PHWA) framework to**
  - (1) assess current condition of State-Identified Healthy Watersheds,
  - (2) develop an approach for future tracking of condition, and
  - (3) assess vulnerabilities of these watersheds.

Assessing Watershed Health

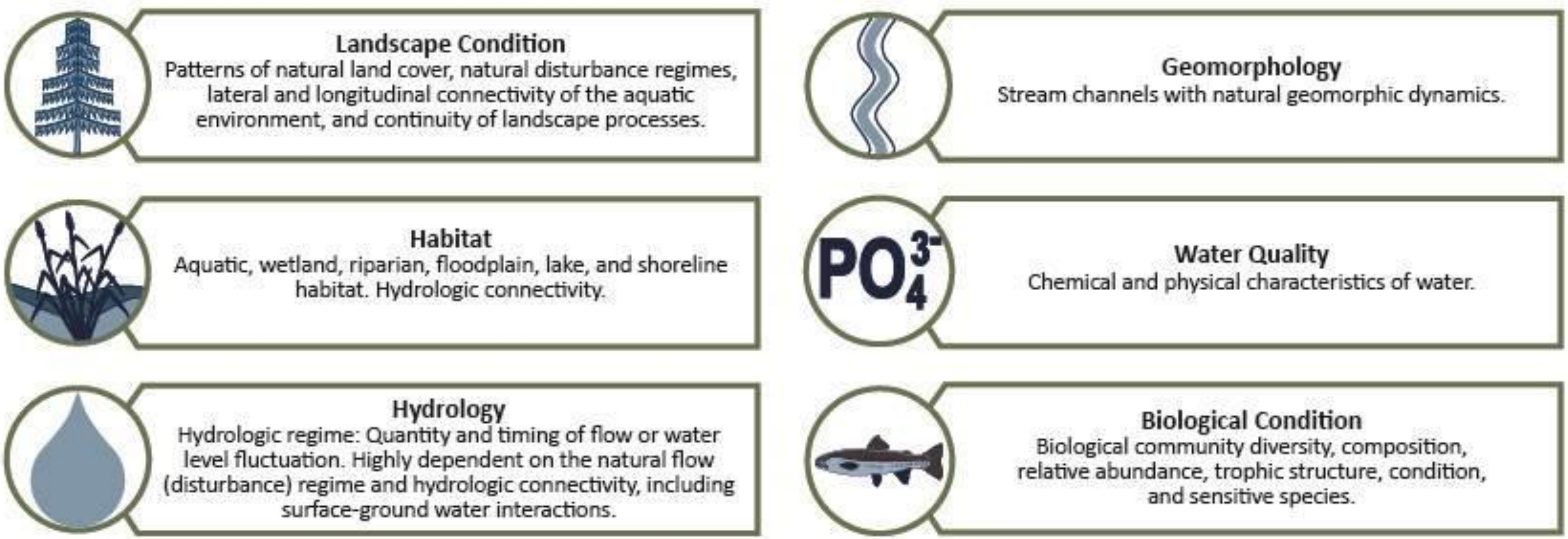


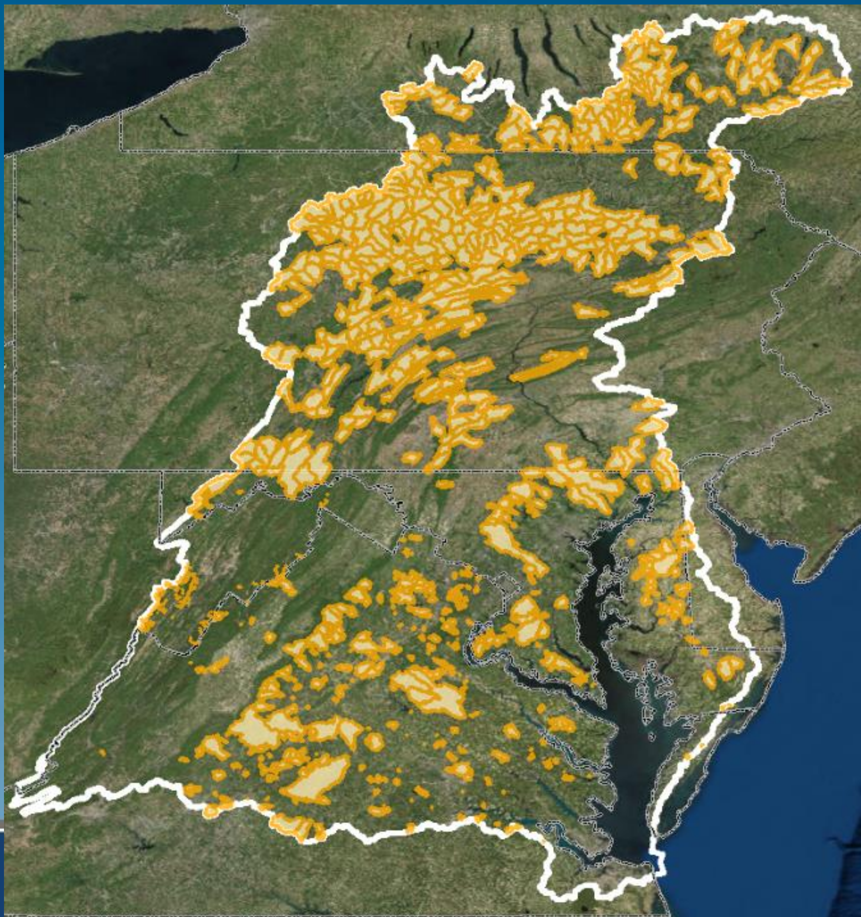
Figure 1. Six attributes of watershed health described in *Identifying and Protecting Healthy Watersheds: Concepts, Assessments, and Management Approaches* (USEPA 2012). Measurement of watershed indicators related to each attribute (i.e., "sub-index") provides the basis for the Watershed Health Index score.

EPA Office of Water Healthy Watersheds Program, March 2017

TETRA TECH

Challenge: Addressing Watershed Scale

- **PHWA developed nationally to provide data at HUC12 scale**
- **Healthy watersheds identified by Chesapeake Bay states**
  - Differing Approaches/Scales
    - Streamlines only (WV)
    - Custom (total) watersheds upstream of reaches designated as healthy waters (VA/MD)
    - HUC12 selections containing healthy reaches (PA/NY)
- **This project: Provide assessments of state-identified Healthy Watersheds, at scale finer than national PHWA (primarily NHDPlus catchment scale)**



Seeking Input on Additional/Different Data to Assess Current Condition

- While the PHWA provides indicators derived from national data, at HUC-12 scale, regional application of the PHWA framework may be augmented through the use of additional data
- Some of the original PHWA indicators are already (or can be) calculated at NHDPlus catchment scale
- Additional regional / state data may be useful to enhance the assessment of state-identified Healthy Watersheds

Seeking Input on Additional Data to Assess Current Condition

- **Food for thought: Key questions**
  - What are the watershed features or attributes most important to assess?
    - PHWA categories: Landscape Condition, Geomorphology, Habitat, Water Quality, Hydrology, and Biological Condition (and detailed indicators within each category)
    - What data are available to assess those attributes, perhaps in more detail than was possible in the PHWA?
    - What are the limitations (if any) of the available data?

Potential Data Sources

- **For example,**
  - CBP current land cover / land use (high-resolution)
  - Impervious cover
  - Forest cover, forest change
  - Stream bioassessment data

Next Steps

- Currently: getting input from state data contacts
- Compiling and applying additional data to assess current condition
- Define data needs for tracking future condition and vulnerabilities

Tracking Condition of Watershed Health Over Time

- **Develop an approach to use the PHWA framework to assess the health of state-identified healthy watersheds over time**
  - May require monitoring data or other indicators that will be updated at a frequency that will provide timely information on watershed health needed by managers
- **More food for thought:**
  - How to define when watersheds are successfully maintained as healthy?
  - Are there certain thresholds of condition that must be maintained?
  - What degree of natural variability is to be expected, and how will tracking determine whether watershed conditions remain within the expected range of natural variability, or when does a change indicate loss or degradation of watershed health?
  - Over what time period and at what intervals should watershed health be tracked?
  - Spatial and temporal resolution of data

Assessing Vulnerability

- **Apply the PHWA Framework to Identify Vulnerabilities in State-Identified Healthy Watersheds**
  - Provide information will be useful to target state management efforts in healthy watersheds.
- **More Food for Thought:**
  - HWGIT has begun to consider various influences on watershed vulnerability to future risks, e.g., urban growth, energy development, water demand, invasive species, upstream activities, land ownership type and future plans, current and future transportation corridors, climate change, and sea level rise.
    - Anything else to consider? Are data available?
  - Vulnerabilities will be addressed individually, not as a combined index.
  - Available geospatial data layer within Chesapeake Bay watershed relevant to vulnerability assessments. Examples:
    - Land use projections
    - Climate change vulnerability assessment data
    - Thermal and hydrologic data
  - Spatial and temporal resolution of data

Preliminary State-Identified Healthy Watersheds Vulnerability Assessment for the Chesapeake Bay Watershed

Geospatial Data Analyses
To Address Watershed Scale

Summary of Outputs

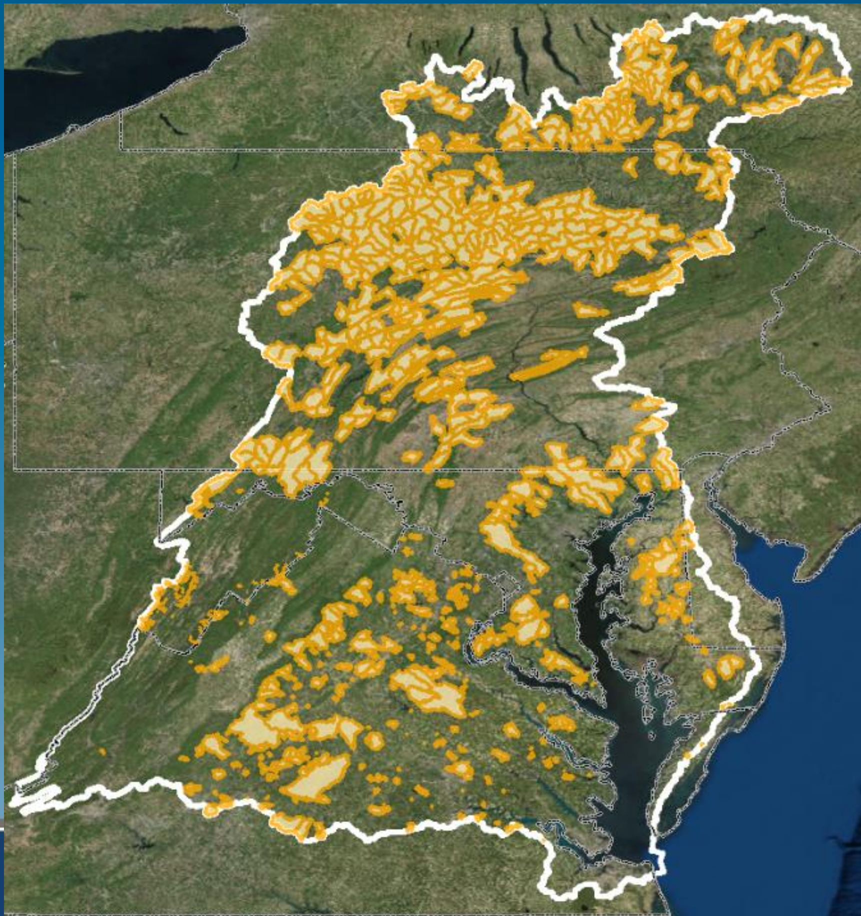
January 19, 2018

Challenge: Addressing Watershed Scale

- **PHWA was developed nationally to provide data at HUC12 scale**
  - In applying PHWA framework for our Chesapeake Bay region, need for finer scale, desire for consistent approach across states.
  - NHDPlus catchments are at finer scale and are appropriate/useful for many analysis

Challenge: Addressing Watershed Scale

- **Starting with dataset for defining Healthy Watershed boundaries: Healthy Watersheds as identified by Chesapeake Bay states**
  - Differing Approaches/Scales
    - Streamlines only (WV)
    - Custom watersheds draining to reaches designated as healthy waters (VA/MD)
    - HUC12 selections containing healthy reaches (PA/NY)



TETRA TECH

Overview - GIS Approach to Scale Issue

State	State-Identified Healthy Watersheds	Update for PHWA-Based Analyses
WV	Streamlines for healthy waters	Designate entire watersheds upstream of healthy waters, Overlay/select NHDPlus catchments, Review / visual check
MD	Custom (total) watersheds upstream of reaches designated as healthy waters	Overlay/select NHDPlus catchments, Review / visual check
VA	Custom (not always total) watersheds upstream of reaches designated as healthy waters	Designate entire watersheds upstream of healthy reaches (includes some new area, excludes land not draining to healthy reaches), Overlay/select NHDPlus catchments, Review / visual check
PA/NY	HUC12 selections containing healthy reaches	Designate entire watersheds upstream of healthy reaches (includes some new area, excludes land not draining to healthy reaches), Overlay/select NHDPlus catchments, Review / visual check
DE	(none designated)	Demonstrate using areas upstream of MD healthy waters, Overlay/select NHDPlus catchments, Review / visual check

TETRA TECH

Overview - GIS Approach to Scale Issue: Small Watersheds

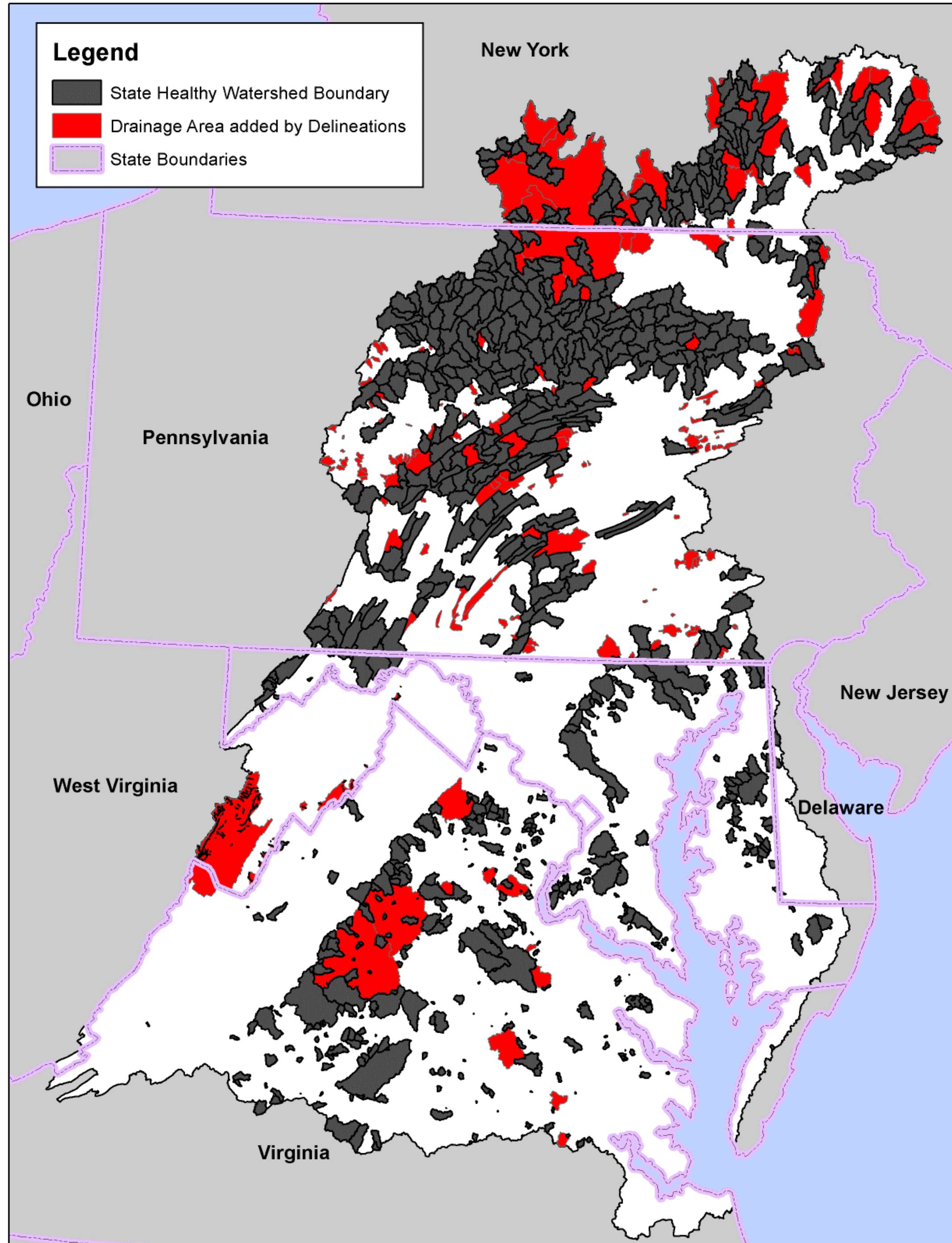
State	State-Identified Healthy Watersheds	Update for PHWA-Based Analyses
All	Some healthy watersheds smaller than a single NHDPlus Catchment	Use actual watershed boundary as provided by state-identified healthy watershed designation Conduct visual check

TETRA TECH

- Delineation of Total Upstream Drainage Areas for NY, PA, and WV healthy water **streamlines**
  - includes 2017 lines for NY and PA

- **Adds significant areas**

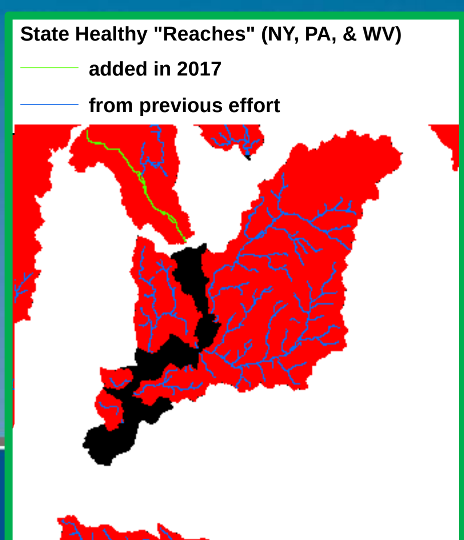
- Removes some areas
  - see next map/slide

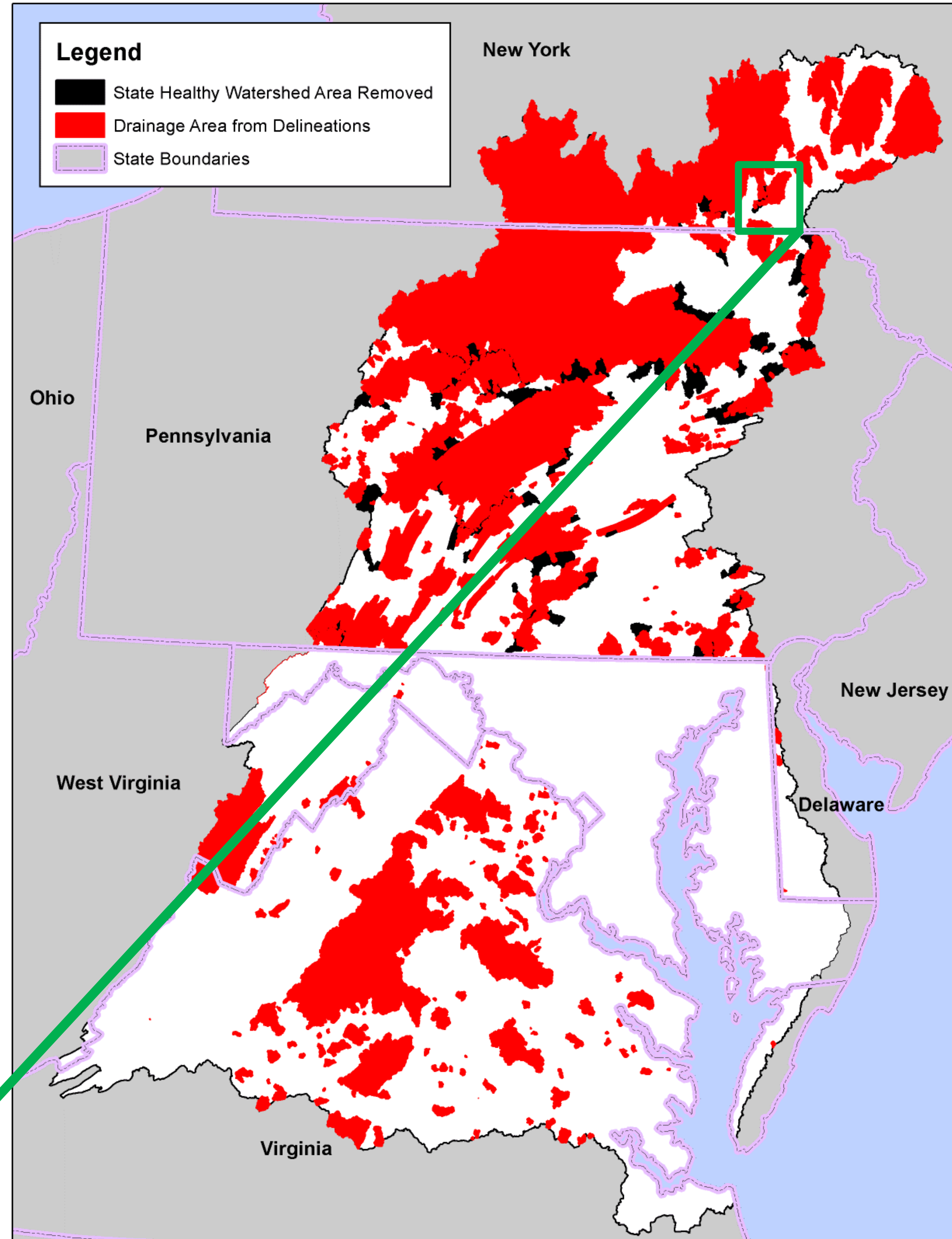


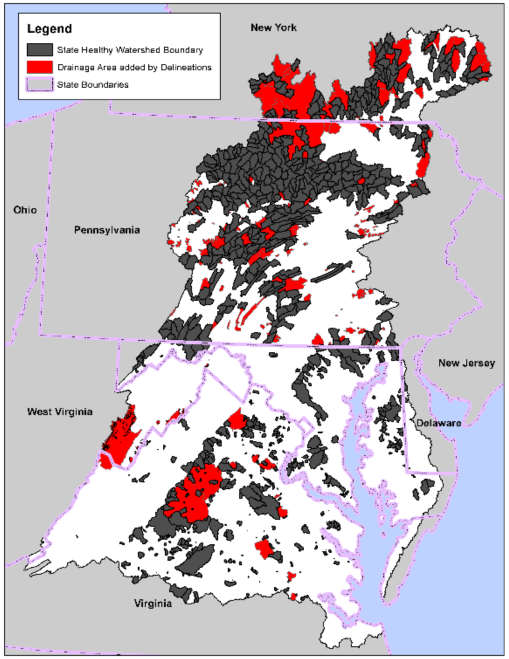
TETRA TECH

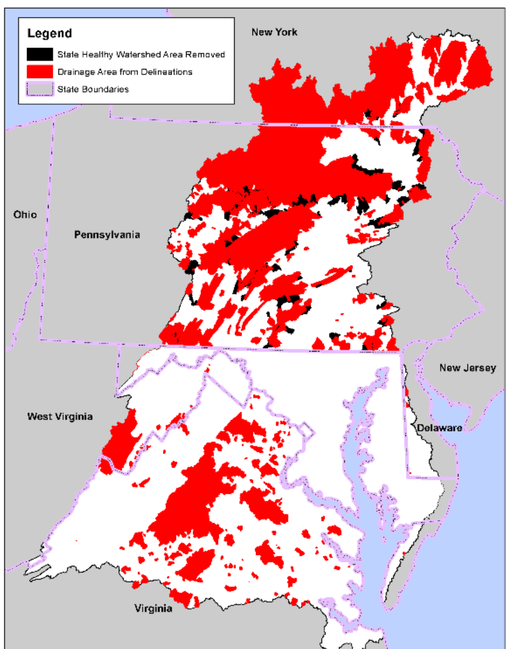
- Delineation of Total Upstream Drainage Areas for NY, PA, and WV healthy water **streamlines**

- Adds significant areas
- **Removes some areas**









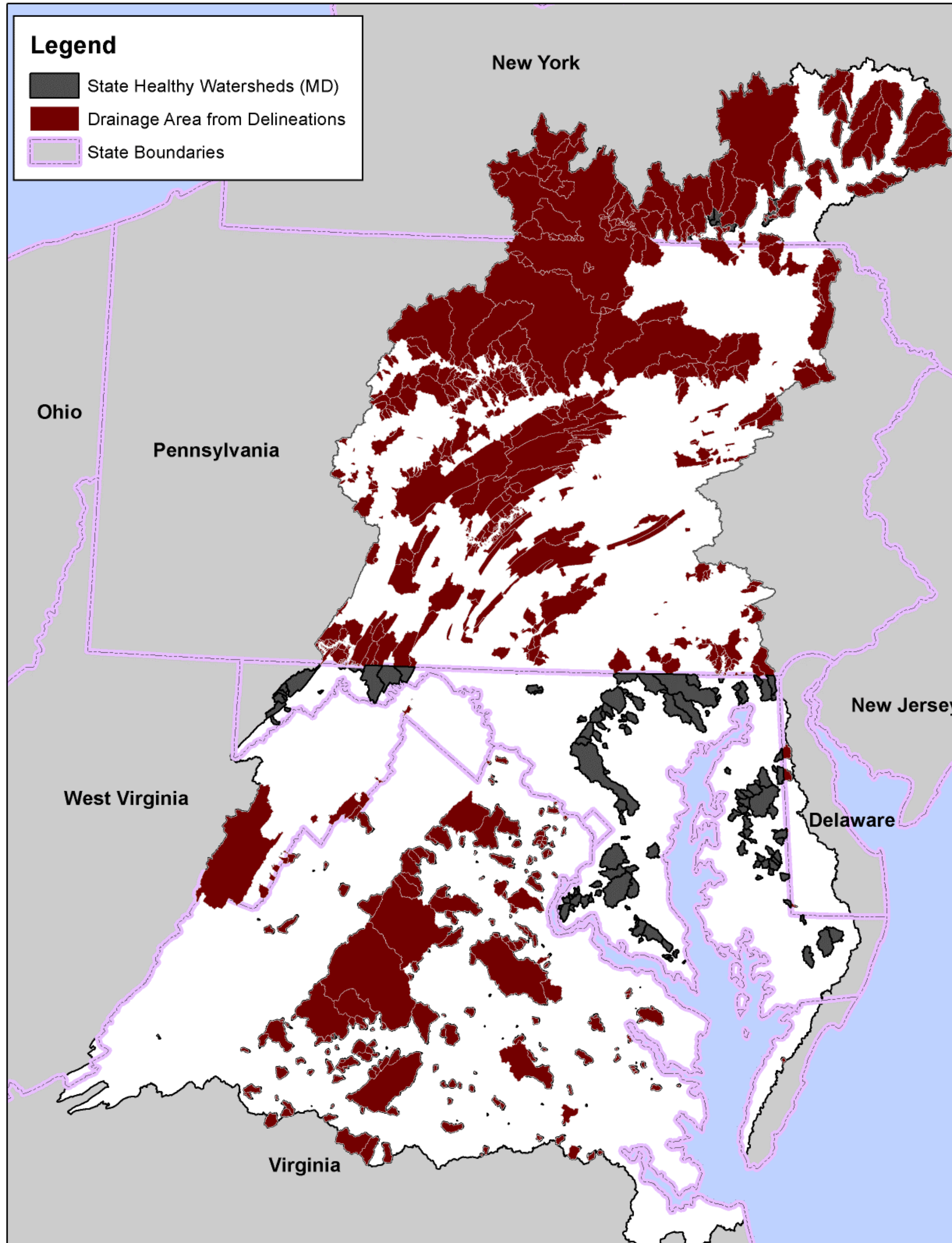
State	Within State-Identified Watershed Boundaries			
	Length of State Identified Healthy Waterways (miles)	Length of Other Waterways, NHDPlus-based (miles)	Total Length of Waterways (miles)	Watershed Area (sq mi)
NY	4,263	359	4,623	2,537
PA	13,474	2,864	16,338	9,777
WV[1]	144	n/a	144	n/a
MD	n/a	2,228	2,228	1,776
VA	n/a	4,265	4,265	3,333
DE[2]	n/a	34	34	27
CBW Total	17,881	9,750	27,632	17,450

1 – Lengths were calculated using NHDPlus Flowlines; 2 – Areas are from MD-provided HW polygons

State	Within Delineated (Total Upstream) Watershed Boundaries			
	Length of State Identified Healthy Waterways (miles)	Length of Other Waterways, NHDPlus-based (miles)	Total Length of Waterways (miles)	Watershed Area (sq mi)
NY	5,670	2,332	8,002	4,336 (+939; Chemung)
PA	14,253	2,697	16,950	9,291
WV[1]	139	555	694	731
MD	n/a	2,228	2,228	1,776
VA	n/a	5,099	5,099	4,087
DE[2]	n/a	34	34	27
CBW Total	20,062	12,945	33,007	20,248 (21,187 with Chemung)

TETRA TECH

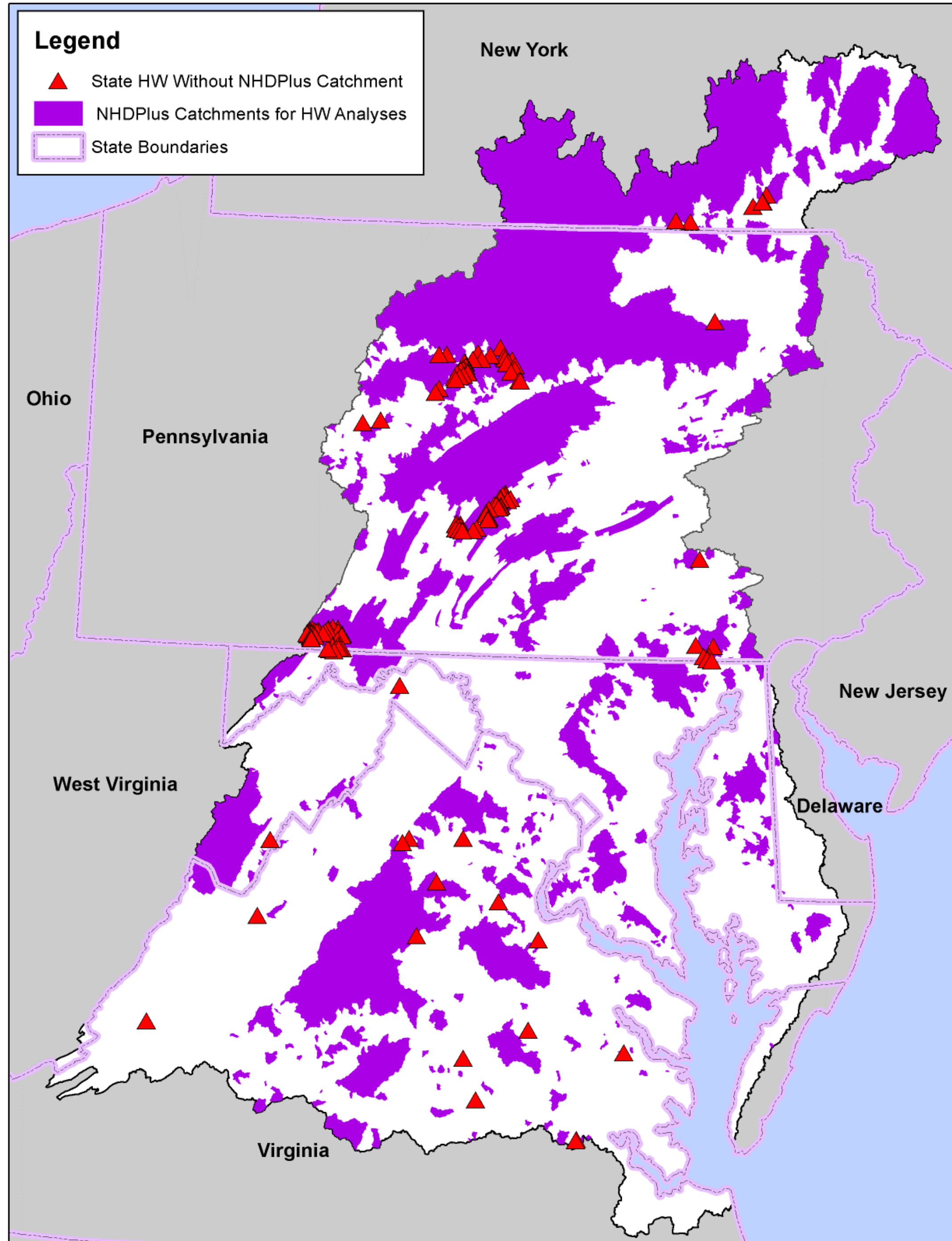
- For moving forward…
- Delineation of Total Upstream Drainage Areas for NY, PA, and WV healthy water **streamlines**
- Delineation of Total Upstream Drainage Areas for certain VA healthy **watersheds** as provided.
- MD and many VA Watersheds used "as-is"
    - MD includes some areas coming from DE



TETRA TECH

- Selection of NHDPlus Catchment Boundaries for subsequent PHWA-based Analyses
- Red Triangles mark those areas where State HW (watershed or watershed-derived from a State's identified HW "streamline") are smaller than NHDPlus Catchment – direct zonal stats should be used for these, not NHDPlus boundaries, StreamCat, etc.
- Review of Selected NHDPlus Catchments is requested

(GIS layers provided)



PHWA Core Group Meeting
October 22, 2018

<u>Attendees</u>
Renee Thompson, USGS
Nancy Roth, Tetra Tech
Chris Wharton, Tetra Tech
Katherine Wares, CRC
Bill Jenkins, EPA
Emily Trentacoste, EPA
Kristen Saunders, UMCES
Angie Wei, UMCES
Chad Thompson, WV DEP
Angel Valdez, MDE
Deborah Herr Cornwell, MD DEP
Todd Janeski, VA
Cassandra Davis, NYSDEC
Lauren Townley, NYSDEC
Steve Epting, EPA
John Wolf, USGS
Kelly Maloney, USGS
Peter Tango, USGS
Gregory Steyer, USGS
Peter Cada, Tetra Tech

Tetra Tech ran through the draft Chesapeake Bay Watershed Health Index. The Index has the same six sub-indices as the National Preliminary Healthy Watersheds Assessment (PHWA) Index. The list of metrics uses some of the same metrics in the National PHWA Index and some new metrics using CBP and federal agency data. Work still needs to be done to see if there is overlap of some of these metrics. The Chesapeake Bay Watershed Health Index metrics and their source are listed in the presentation. In the Biological Condition sub-index, the metric Outlet Aquatic Condition Score, 2016 (catchment) can be replaced by the Chessie BIBI when it is complete.

- <u>Discussion</u>
    - Tetra Tech used previously made mask to define spatial areas such as the riparian buffer or hydrologically active zone; Steve Epting/EPA HW used a 100meter buffer around NHD Plus
    - There are several landscape condition metrics that go into the Aquatic Condition Index (as previously calculated). Similarly, the National Fish Habitat Partnership indicator incorporates other data. We need to make sure when we use these model-based indicatorsthat we aren't double weighing the metrics that go into them. We need to think about this as we develop weightings for an overall indicator.

Tetra Tech ran through the draft Chesapeake Bay Watershed Vulnerability Indicators. There were three sub-indices in the National PHWA Index; a fourth sub-index, Climate Change, has been added. ***Renee will send Nancy and Chris the updated Protected Lands layers***.

- <u>Discussion</u>

- CBP Climate Change Indicators can be added when they are developed. Some of these are developed, but it would be difficult to translate them to NHDPlus catchments.
- Peter Tango suggested an additional groundwater dataset (from National Water-Quality Assessment, NAWQA) that could be helpful.

Tetra Tech ran through some examples of metric data within the healthy watershed segment, other catchments upstream of the healthy watershed outlet, and non-healthy watershed catchments. For the graphs, the dark green is the healthy watershed segment/catchments at outlet of healthy watersheds. The light green is other catchments within the healthy watershed/the full watershed that includes the upstream area. The yellow is catchments outside of healthy watersheds/areas without healthy watersheds.

- Discussion
    - These graphs are interesting in that they are showing potential thresholds for healthy watersheds.
    - There's a correlation between vulnerable geology and agriculture, so it's possible healthy watersheds aren't typically in areas with vulnerable geology since agricultural activities and land use also tend to be in that area.
    - ***Nancy will check to see if nutrient loads were normalized to watershed size.***
    - Another way to look at brook trout metric could be change in probability.

Next will be to normalize metric score to 0 and 1 and calculate mean score for each of the six sub-indices. The application for this assessment is to assess condition and vulnerability of state-identified healthy watersheds and to track state-identified healthy watersheds in the future.

- Discussion
    - We can brainstorm additional uses and could present this to coordinator-staffers down the road to see if this can be helpful to other outcomes and indicators, but we're also still determining how to inform the Healthy Watersheds outcome.
    - Angel Valdez has the idea of creating a dashboard of county specific tier II watershed information.
    - Todd wants to look at the data closer before making any decisions. ***Renee will work with Todd on how to best package it for Virginia.***
    - John Wolf hopes this data would be available and accessible to the CBP Partners and GIS Team. ***Renee will work with Angie to make the data is the appropriate format for open data.***
    - Can we see what percent of upstream area is also a healthy watershed? It could be "% Upstream Watershed Area that is State-Designated Healthy Watershed".
    - Can we visualize healthy watersheds across state lines?
        - This assessment calculates on a watershed scale, including watershed area across state links. Data users should be able to view and sort by political boundaries, which would be useful for state and local partners.
    - Can we see connectivity? Was there discussion about including landscape connectivity data/indicators (habitat fragmentation) in in the assessment?
        - Data could come from Maryland green print, North Atlantic LCC data, CCP priority layers, Peter Claggett's wetland migration data. We should also keep track of the data that wasn't included in the end product. ***Bill Jenkins and Renee will consider and recommend which summary data may be most useful to characterize habitat value and connectivity. Nancy will look into adding this information.***

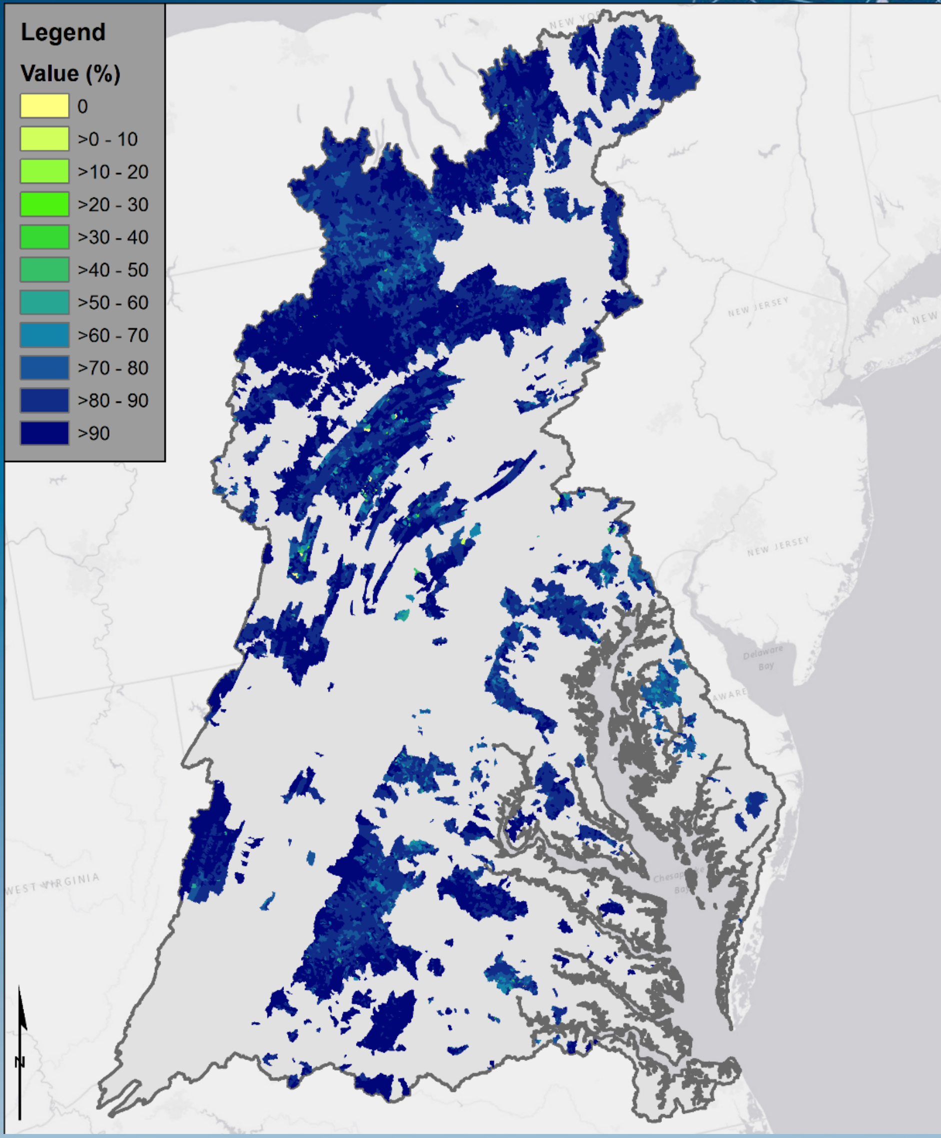
    - Will it be possible to see what metrics are on the edge for areas to see which are close to meeting that metric in order to try and improve that metric?
        - Data will be useable for this purpose.

<u>Next Steps</u>

- ***Renee would like to have a demo/tutorial with Chris Wharton and state leads in December on how the data is organized and how to use it.***
- ***Katherine will set up a phone call between Emily, Renee, Nancy, and Chris to discuss weighing the indices and aggregating to find correlations off line***.

Preliminary State-Identified Healthy Watersheds Vulnerability Assessment for the Chesapeake Bay Watershed

Project Update
October 2018



Project Overview

- **Apply the Preliminary Healthy Watersheds Assessment (PHWA) framework to**
  - (1) assess current condition of State-Identified Healthy Watersheds,
  - (2) develop an approach for future tracking of condition, and
  - (3) assess vulnerabilities of these watersheds.

Today's Update

- Review PHWA approach and scale of analysis
- Overview of candidate metrics
  - Indicators of watershed condition
  - Indicators of watershed vulnerability
- Evaluating metric performance for catchments in Chesapeake Bay watershed
- Approach for combining metrics into index of Watershed Health

Assessing Watershed Health

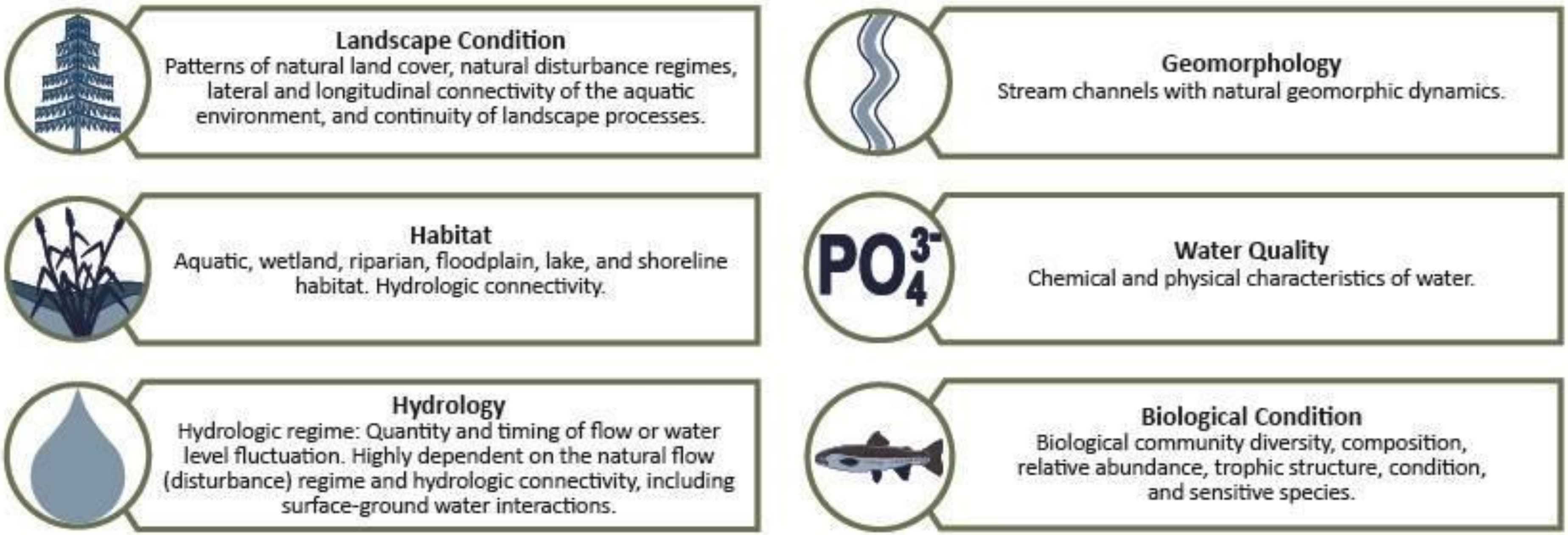
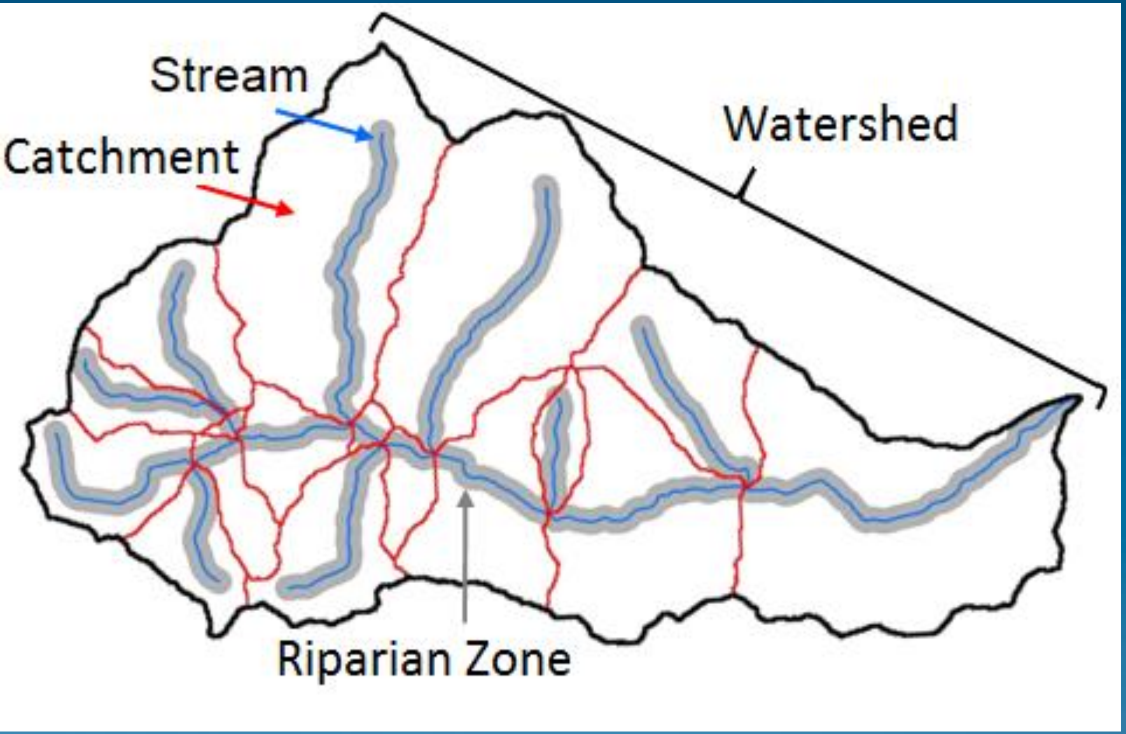


Figure 1. Six attributes of watershed health described in *Identifying and Protecting Healthy Watersheds: Concepts, Assessments, and Management Approaches* (USEPA 2012). Measurement of watershed indicators related to each attribute (i.e., "sub-index") provides the basis for the Watershed Health Index score.

EPA Office of Water Healthy Watersheds Program, March 2017

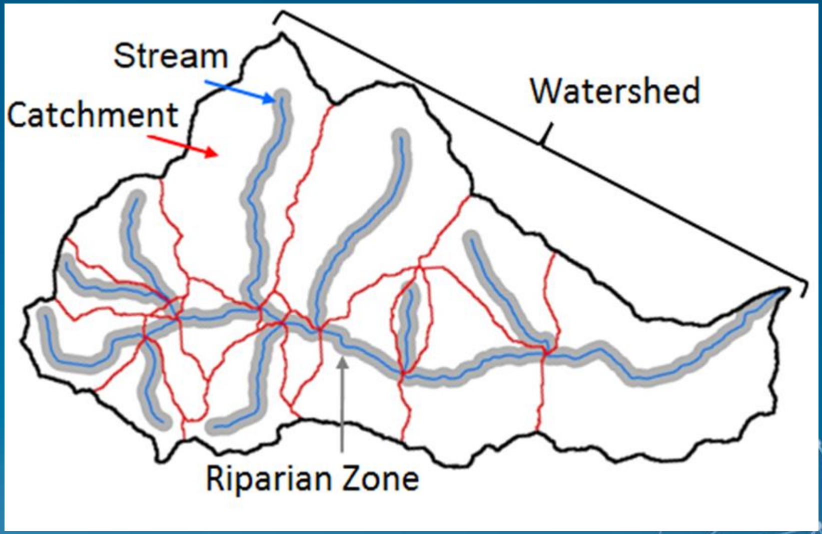
Healthy Watersheds – Naming Conventions



Modified from EPA StreamCat

Catchment- and Watershed-Scale Metrics

- "Catchment" - Local catchment condition
- "Watershed" - Cumulative condition over entire watershed upstream of outlet



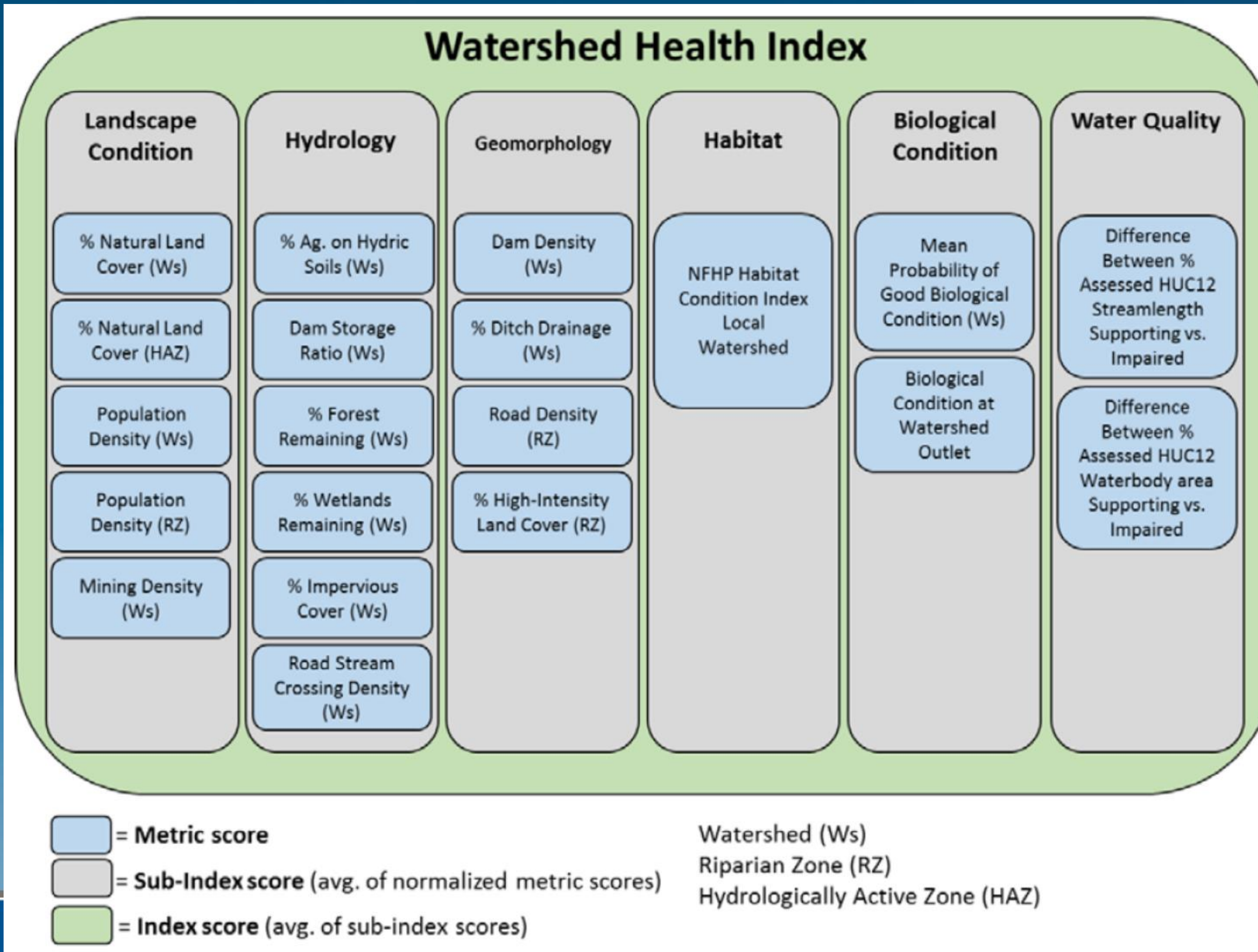
- Most Chesapeake Bay candidate metrics were calculated as watershed-scale metrics, reflecting influence of entire upstream watershed
  - Ex: Percent Impervious Cover in Watershed
- A few at catchment scale only
  - Ex: Aquatic Biological Condition at Outlet

Spatial Zones

The PHWA utilized watershed indicators measured in three different spatial zones (EPA PHWA overview and metadata, Feb. 2017)

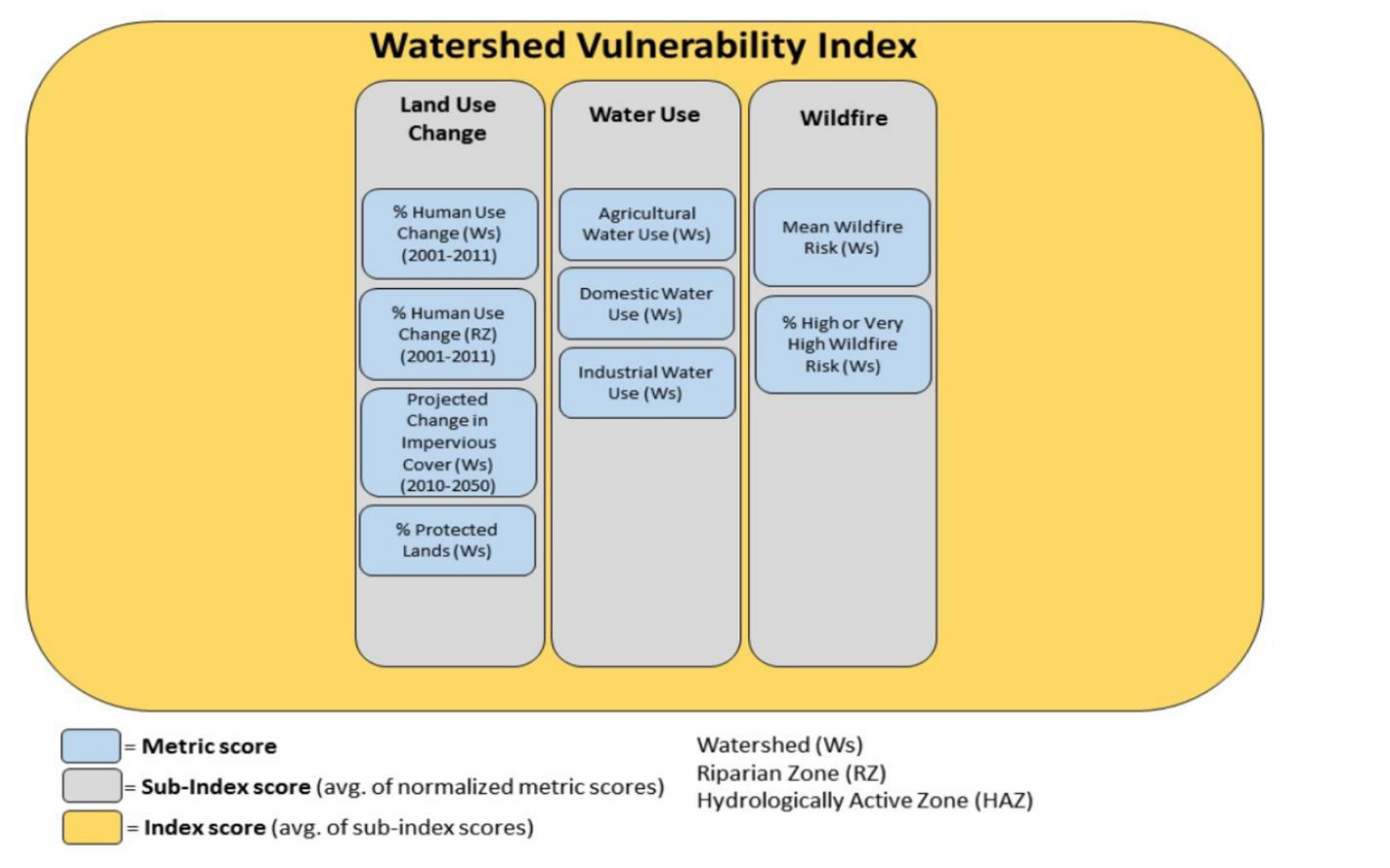
1. The watershed
2. The riparian zone (RZ), the corridor of land adjacent to surface waters, within a 100-meter buffer of the stream
3. The hydrologically active zone (HAZ), defined by the riparian corridor adjacent to surface waters combined with areas of high topographic wetness potential that are contiguous to surface waters (the hydrologically connected zone, HCZ).

PHWA Metrics – Watershed Health



TETRA TECH

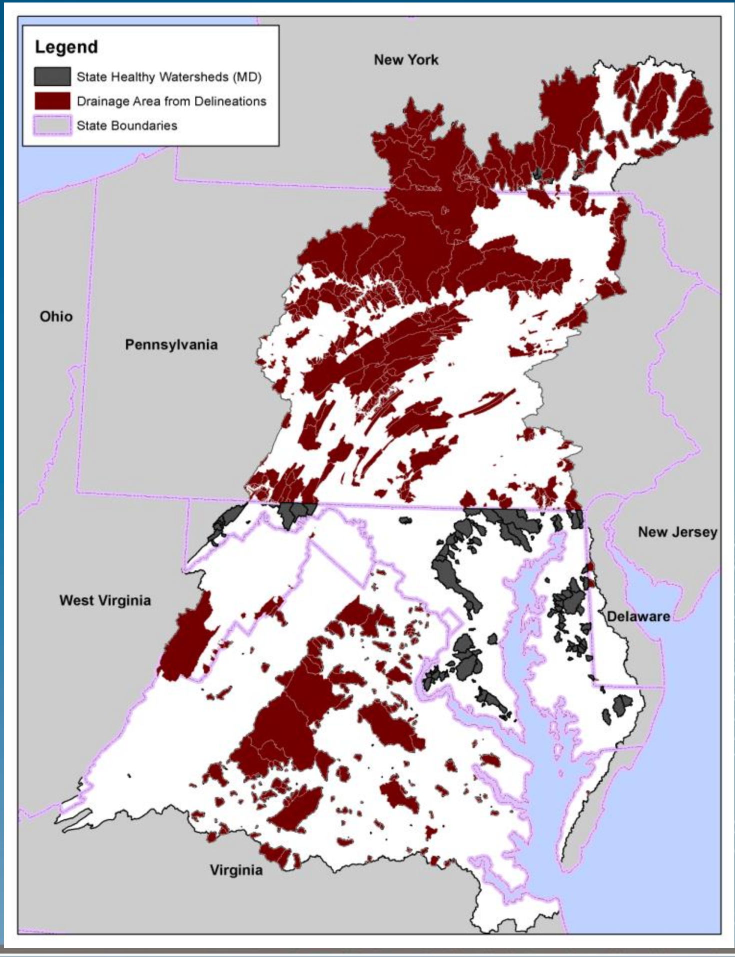
PHWA Metrics – Watershed Vulnerability

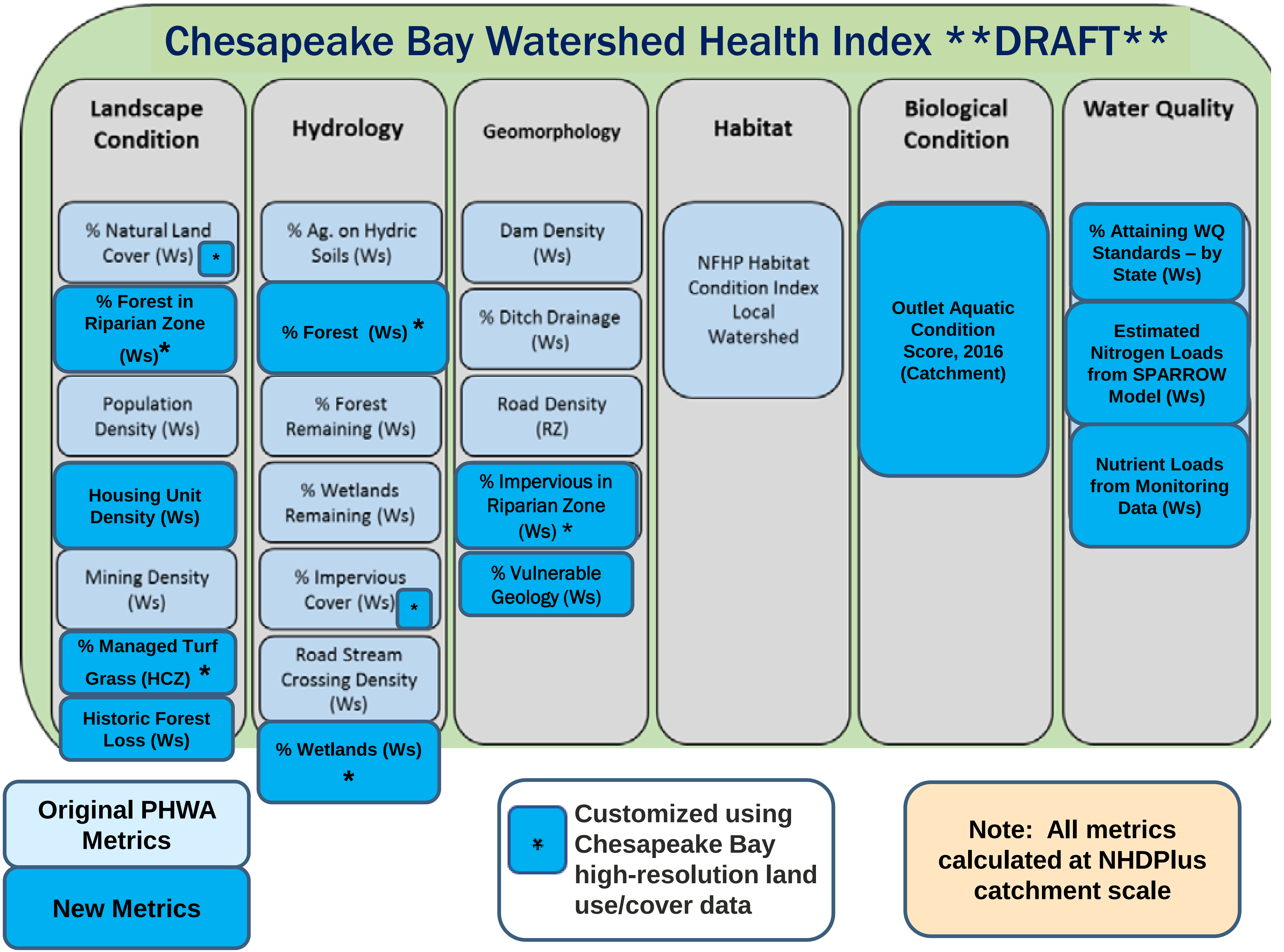


TETRA TECH

Addressing Watershed Scale

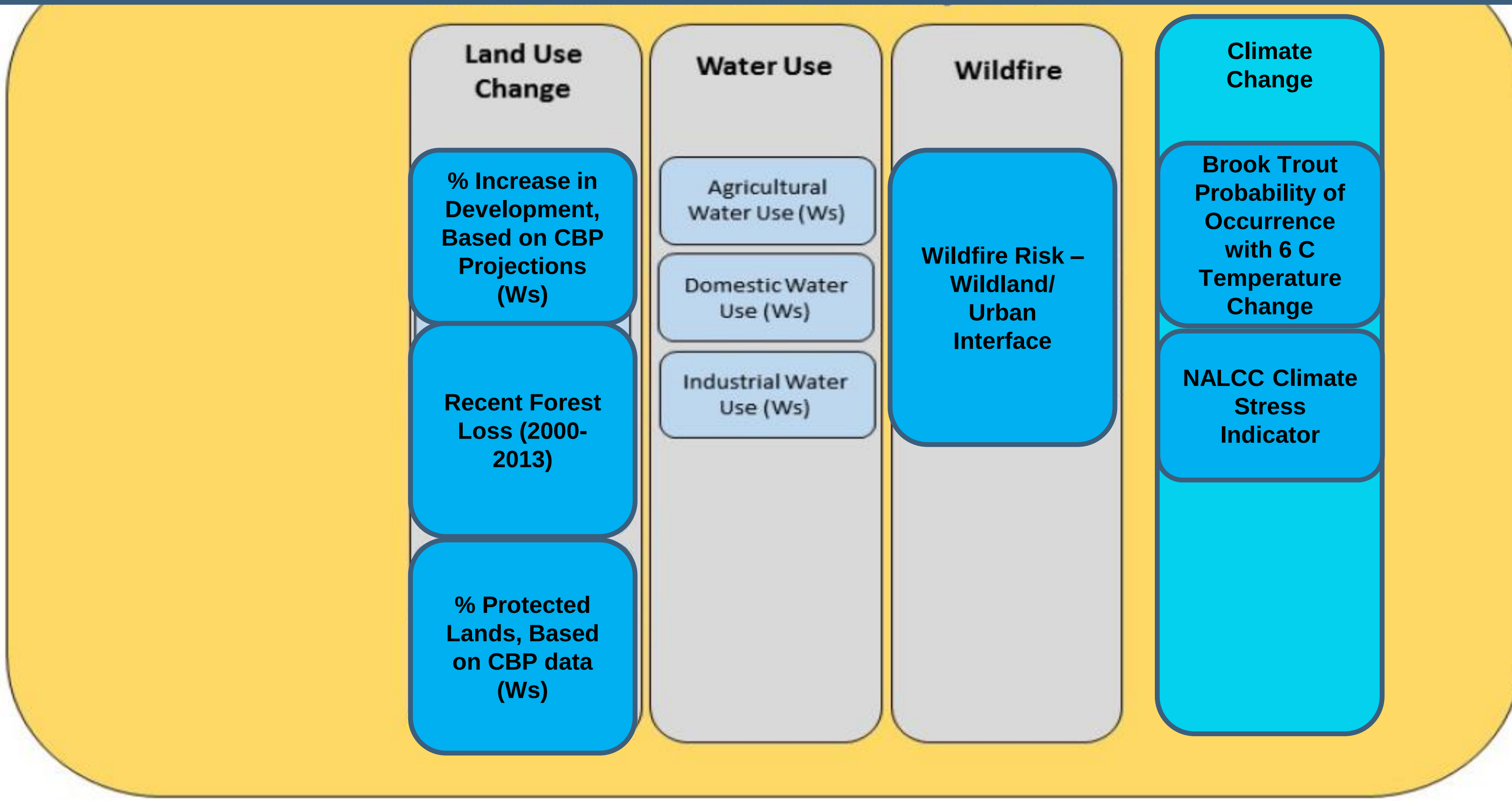
- **PHWA developed nationally to provide data at HUC12 scale**
- **Healthy watersheds identified by Chesapeake Bay states**
  - Differing Approaches/Scales
    - Streamlines only (WV)
    - Custom (total) watersheds upstream of reaches designated as healthy waters (VA/MD)
    - HUC12 selections containing healthy reaches (PA/NY)
- **This project: Provide assessments of state-identified Healthy Watersheds, at scale finer than national PHWA**
- **Primarily NHDPlus catchment scale**





Chesapeake Bay Watershed Health Index **DRAFT**
Landscape Condition
% Natural Land Cover (Ws) *
% Forest in Riparian Zone (Ws)*
Population Density (Ws)
Housing Unit Density (Ws)
Mining Density (Ws)
% Managed Turf Grass (HCZ) *
Historic Forest Loss (Ws)
Hydrology
% Ag. on Hydric Soils (Ws)
% Forest (Ws) *
% Forest Remaining (Ws)
% Wetlands Remaining (Ws)
% Impervious Cover (Ws) *
Road Stream Crossing Density (Ws)
% Wetlands (Ws) *
Geomorphology
Dam Density (Ws)
% Ditch Drainage (Ws)
Road Density (RZ)
% Impervious in Riparian Zone (Ws) *
% Vulnerable Geology (Ws)
Habitat
NFHP Habitat Condition Index Local Watershed
Biological Condition
Outlet Aquatic Condition Score, 2016 (Catchment)
Water Quality
% Attaining WQ Standards – by State (Ws)
Estimated Nitrogen Loads from SPARROW Model (Ws)
Nutrient Loads from Monitoring Data (Ws)
Original PHWA Metrics
New Metrics
* Customized using Chesapeake Bay high-resolution land use/cover data
Note: All metrics calculated at NHDPlus catchment scale

Chesapeake Bay Watershed Vulnerability Indicators **DRAFT**



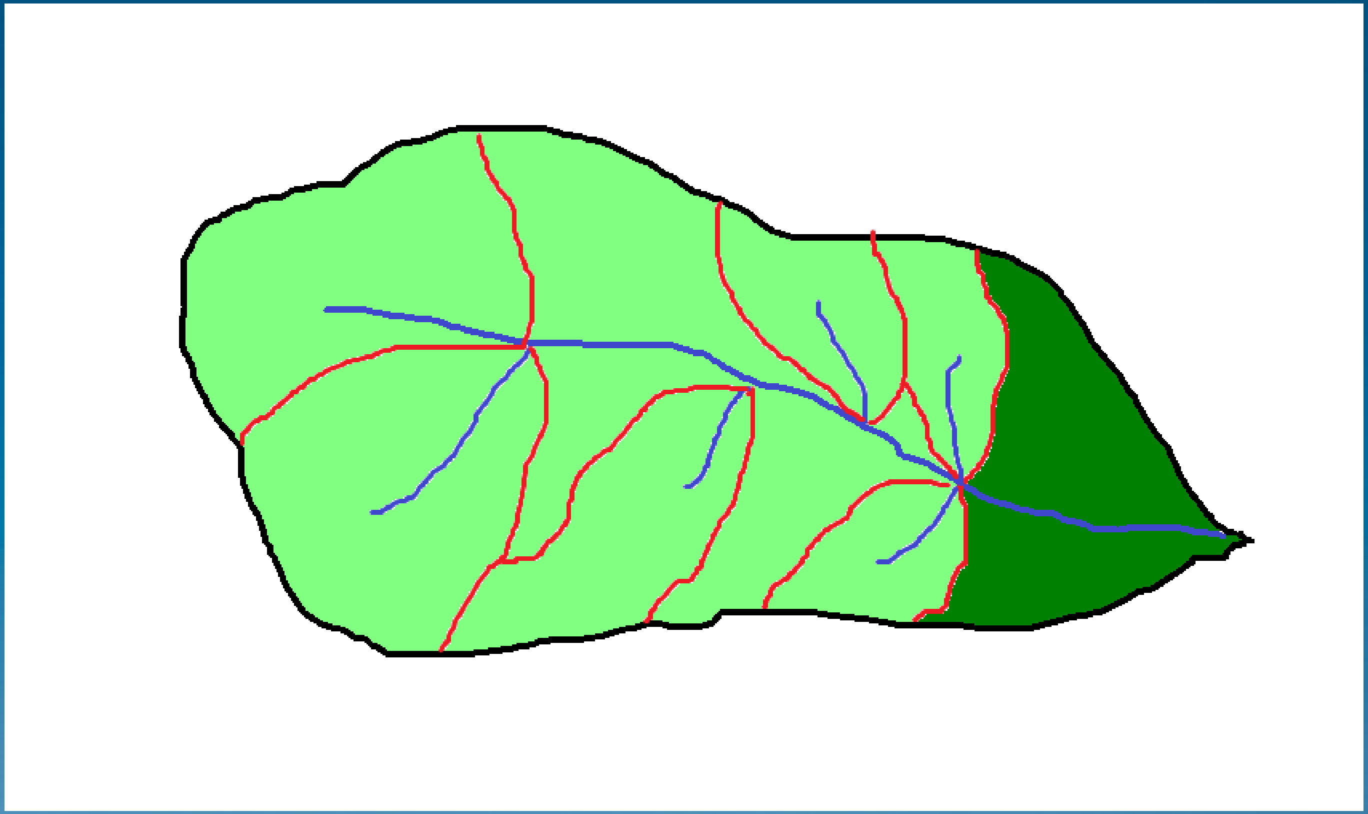
Original PHWA Metrics

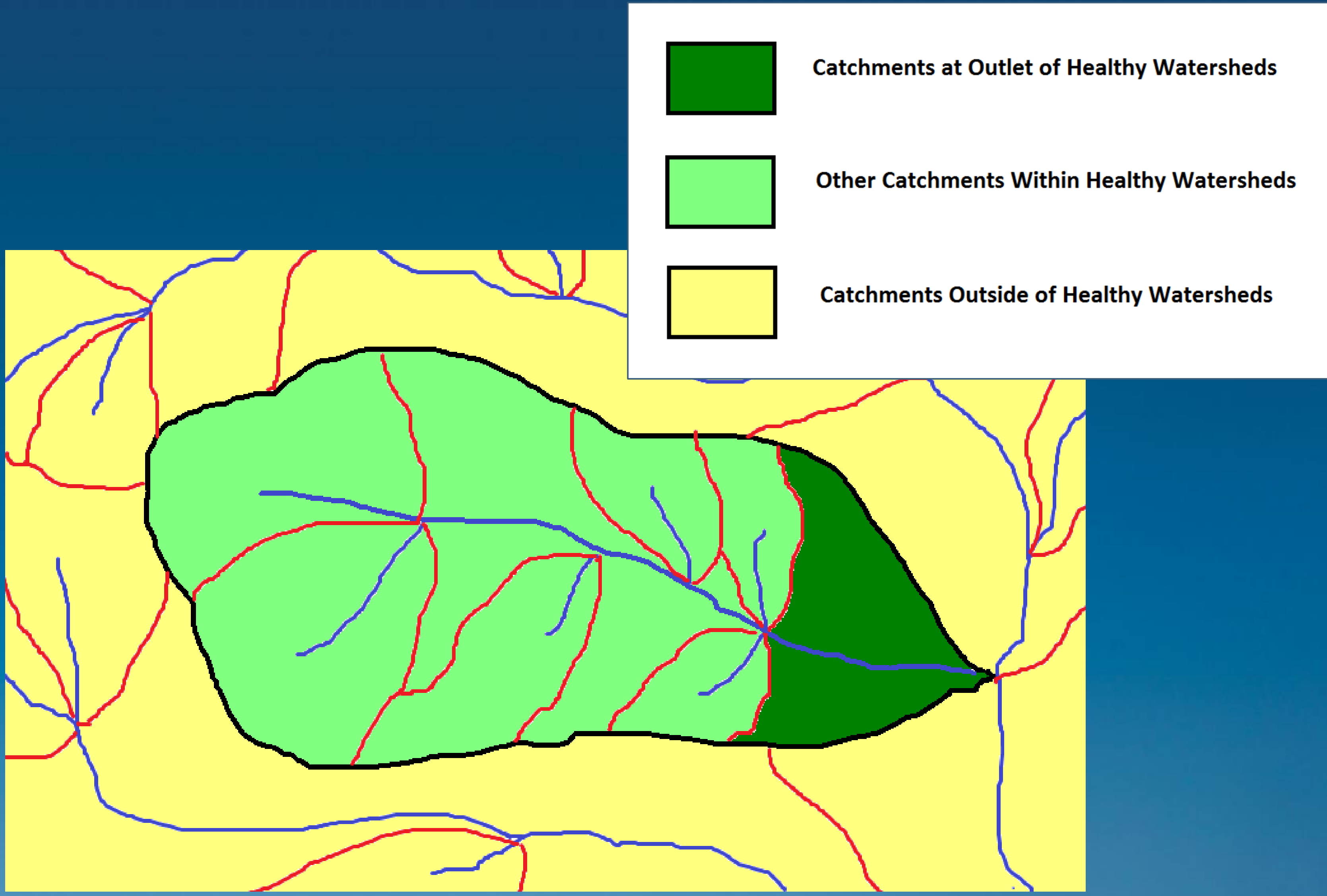
New Metrics

Note: All metrics calculated at NHDPlus catchment scale

Evaluating Metric Performance

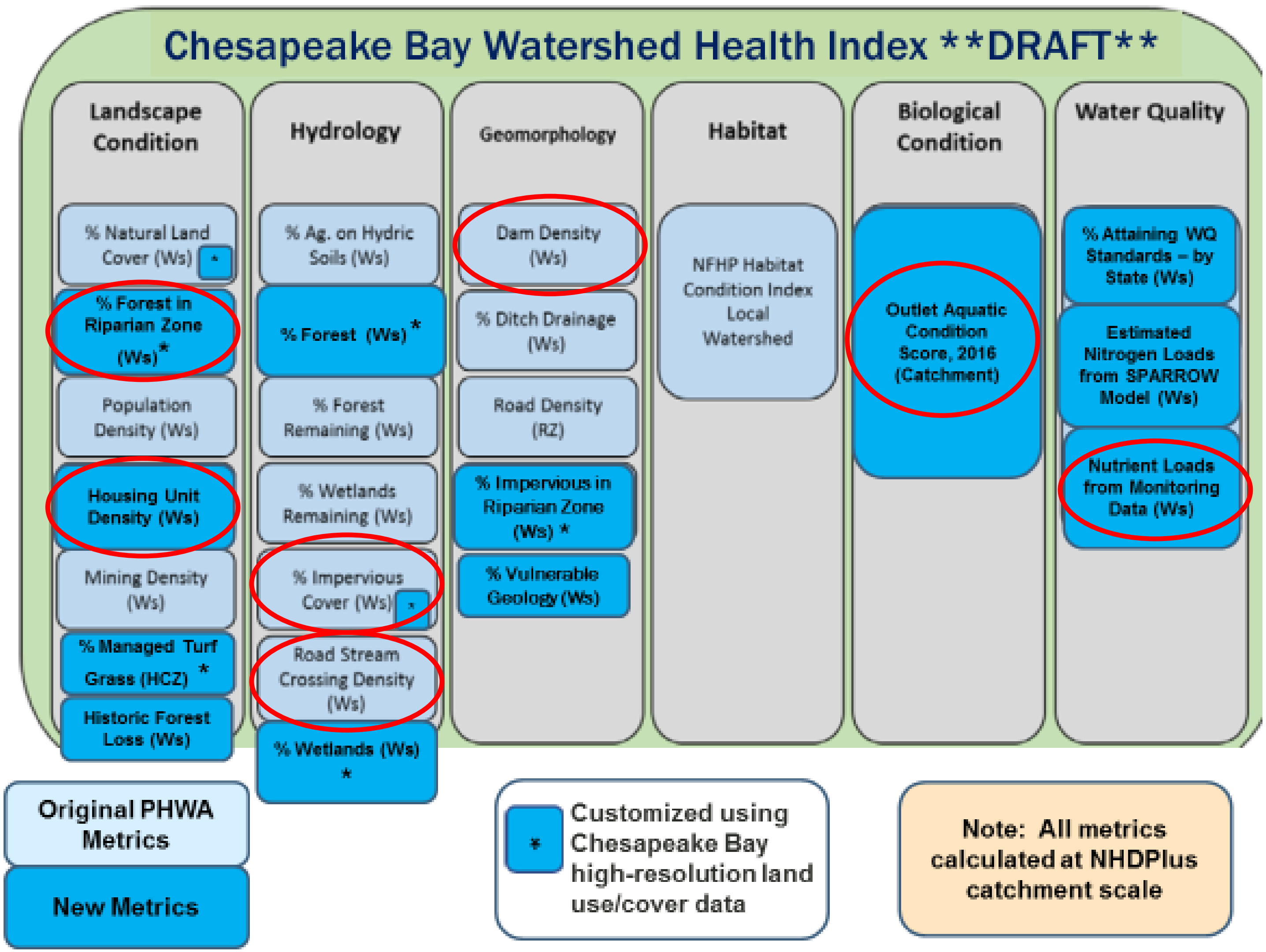
- Distributions of scores for healthy watersheds
- Comparison with distribution of scores for areas outside of healthy watersheds
- Appropriateness of scale




Catchments at Outlet of Healthy Watersheds
Other Catchments Within Healthy Watersheds
Catchments Outside of Healthy Watersheds

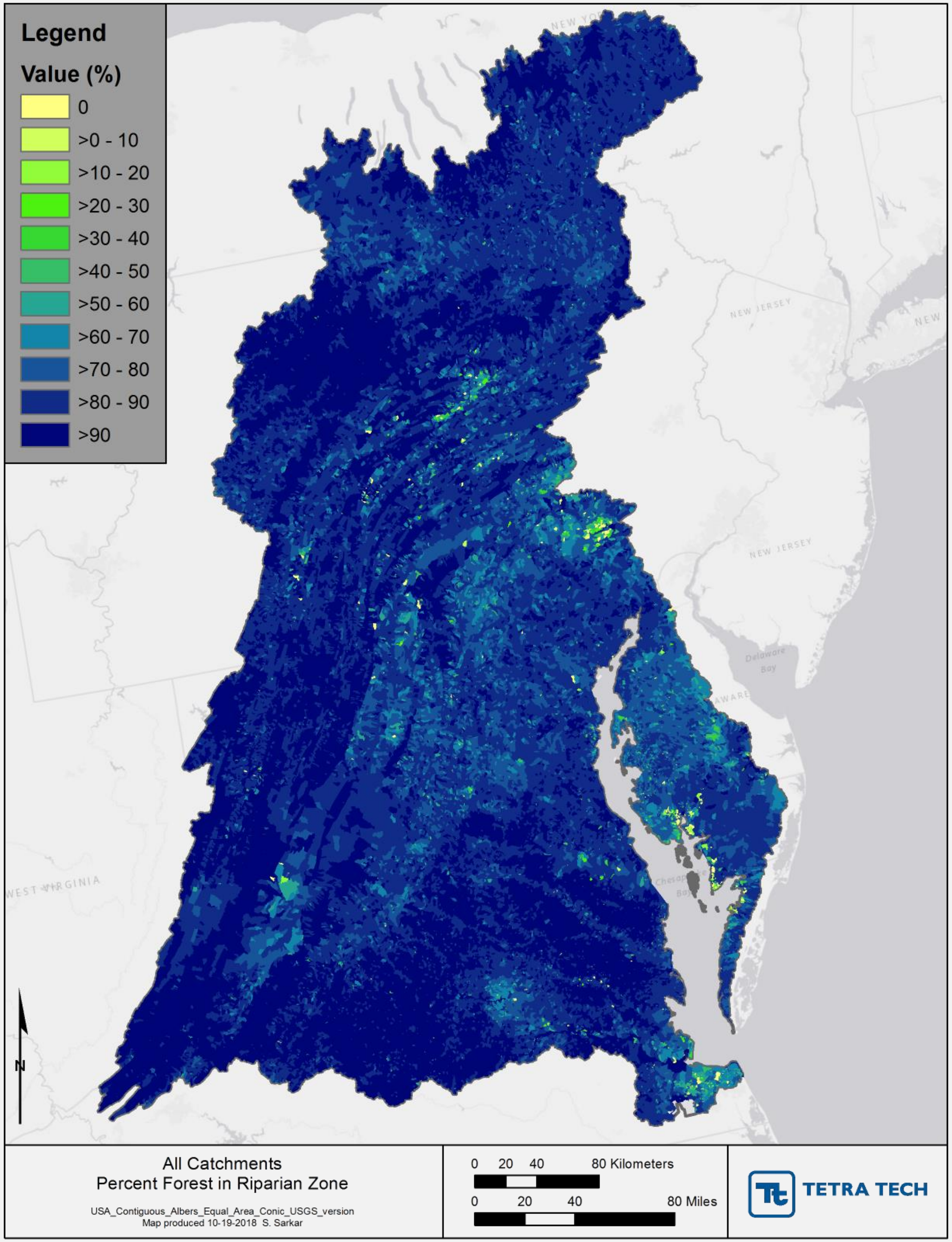
Metric Performance

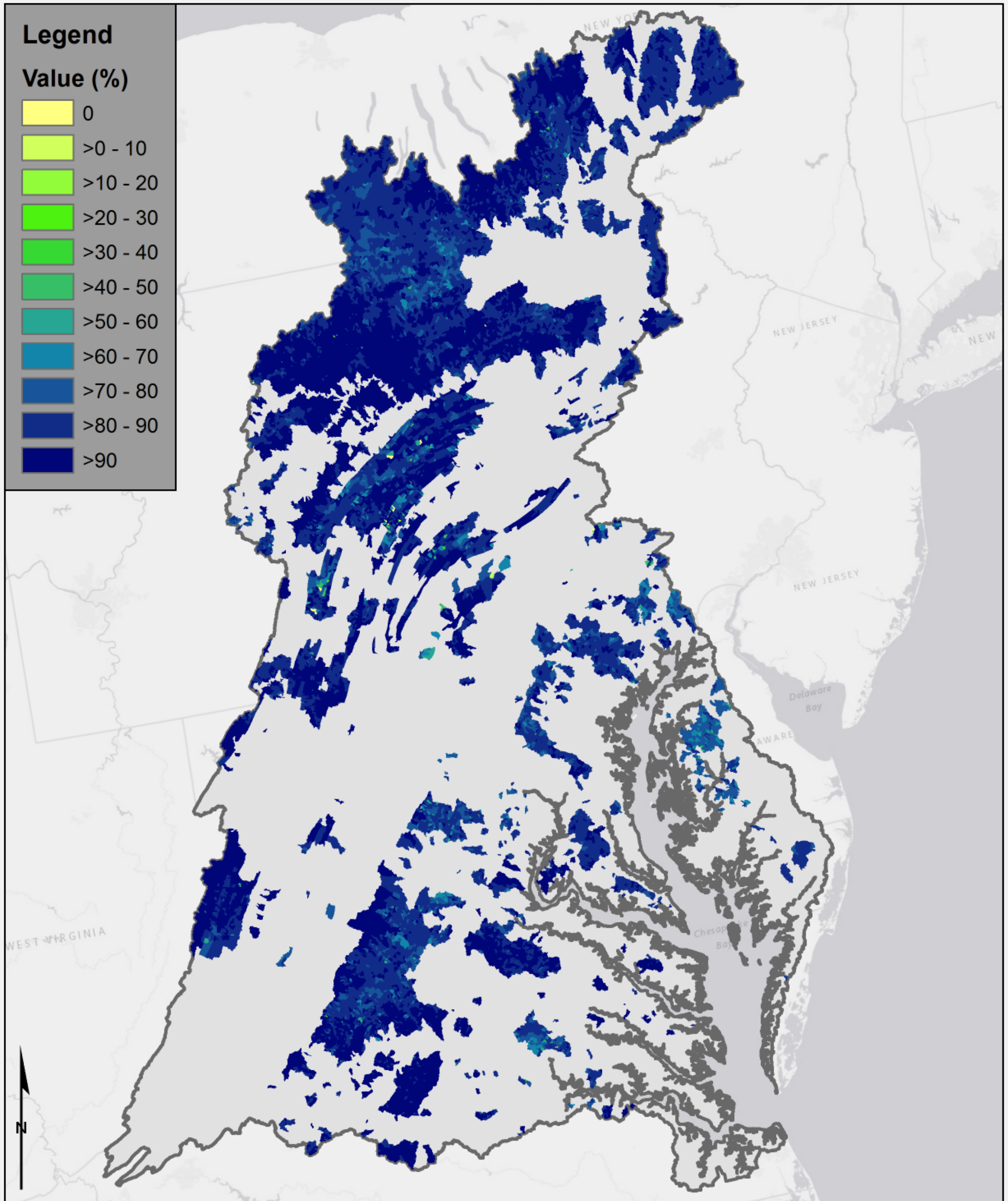
- Examples:



Metric Performance

- Example: Percent Forest in Riparian Zone
- Indicative of: Landscape condition
- Value calculated for entire upstream riparian zone
- Metric expected to be high in healthy watersheds


Legend
Value (%)
0
>0 - 10
>10 - 20
>20 - 30
>30 - 40
>40 - 50
>50 - 60
>60 - 70
>70 - 80
>80 - 90
>90
NEW JERSEY
NEW JERSEY
WEST VIRGINIA
Delaware Bay
N
All Catchments
Percent Forest in Riparian Zone
USA_Contiguous_Albers_Equal_Area_Conic_USGS_version
Map produced 10-19-2018 S. Sarkar
0 20 40 80 Kilometers
0 20 40 80 Miles
TETRA TECH



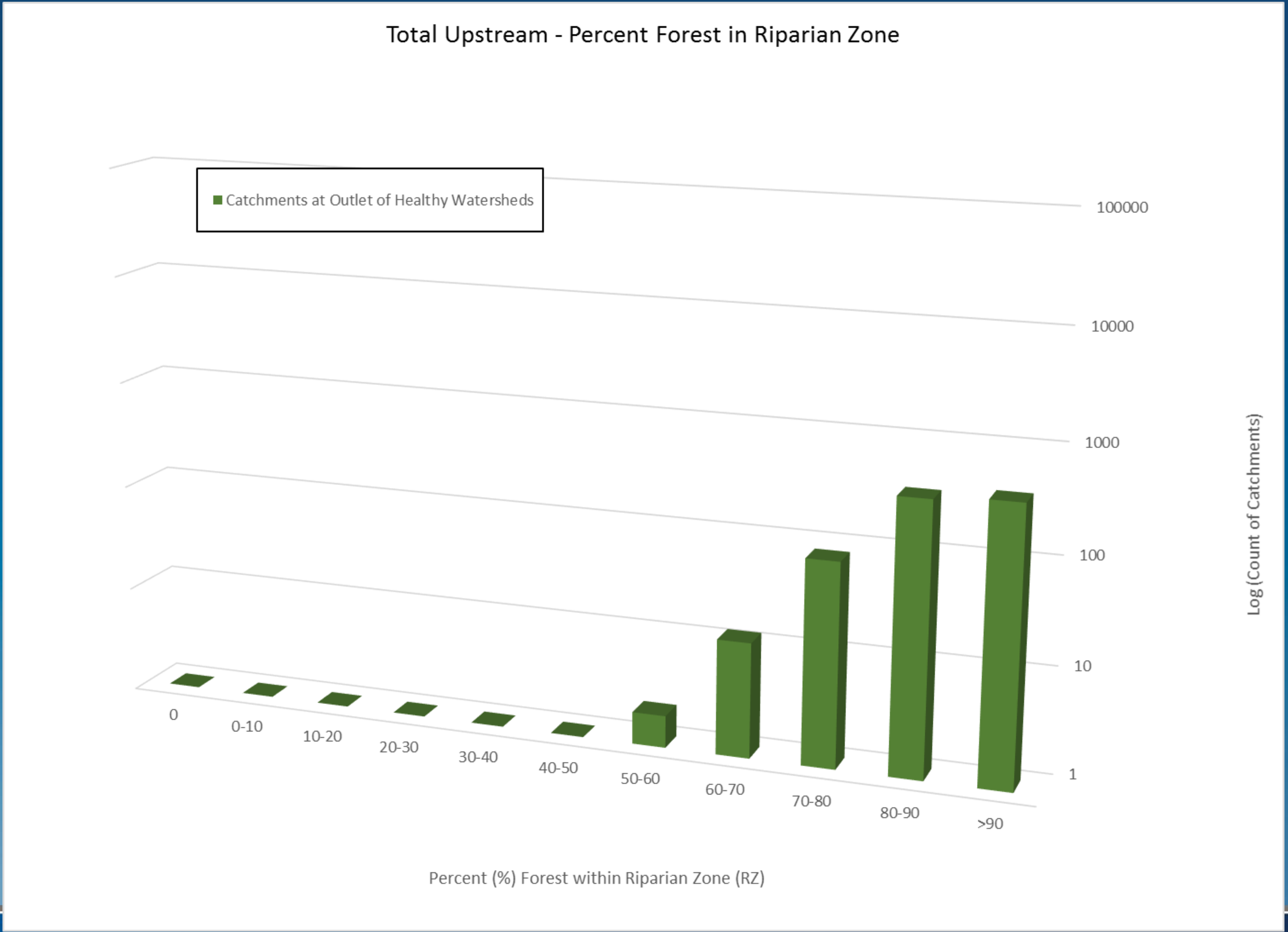
Catchments Upstream of Healthy Watersheds
Percent Forest in Riparian Zone

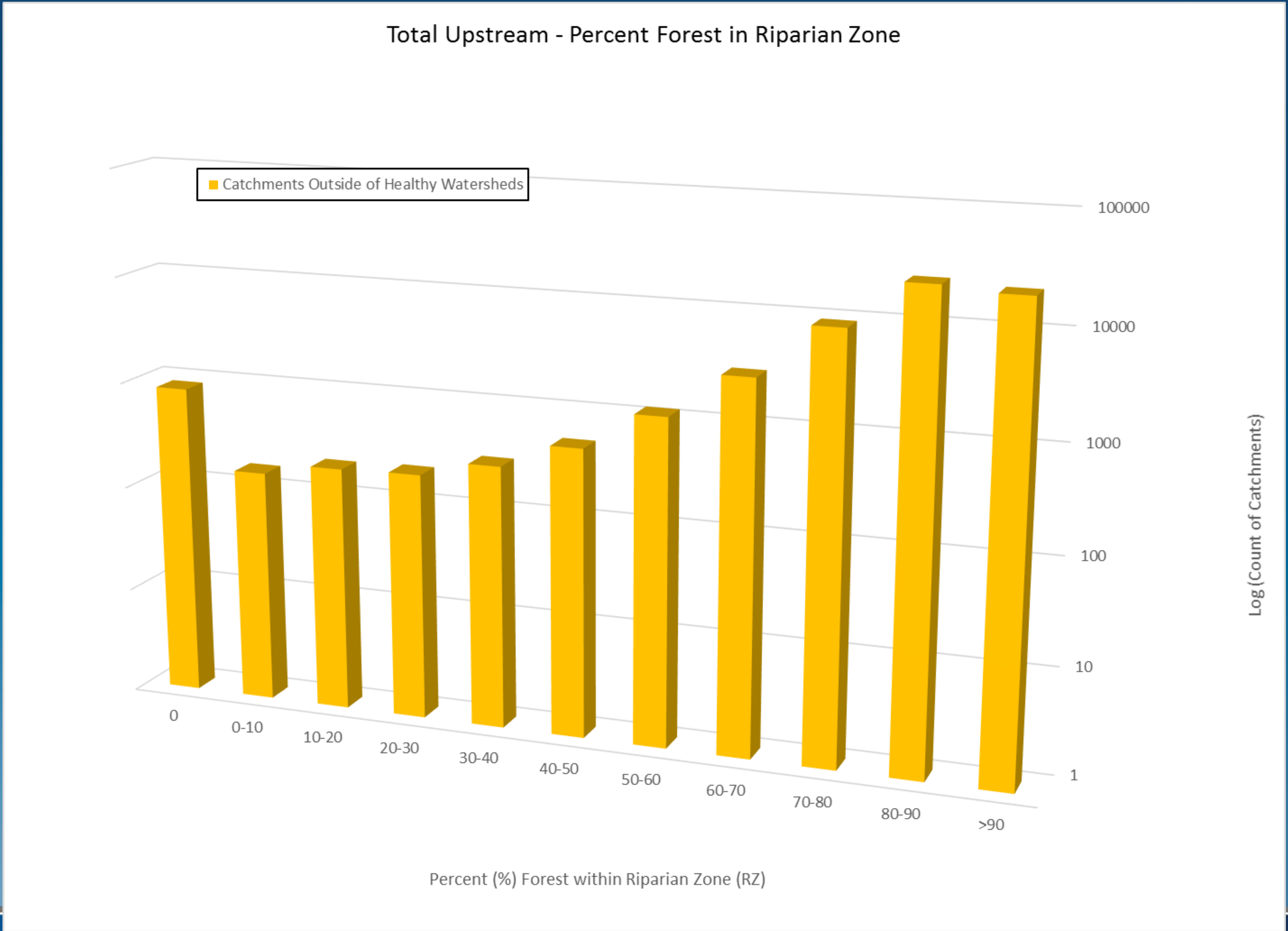
USA_Contiguous_Albers_Equal_Area_Conic_USGS_version
Map produced 10-19-2018 S. Sarkar

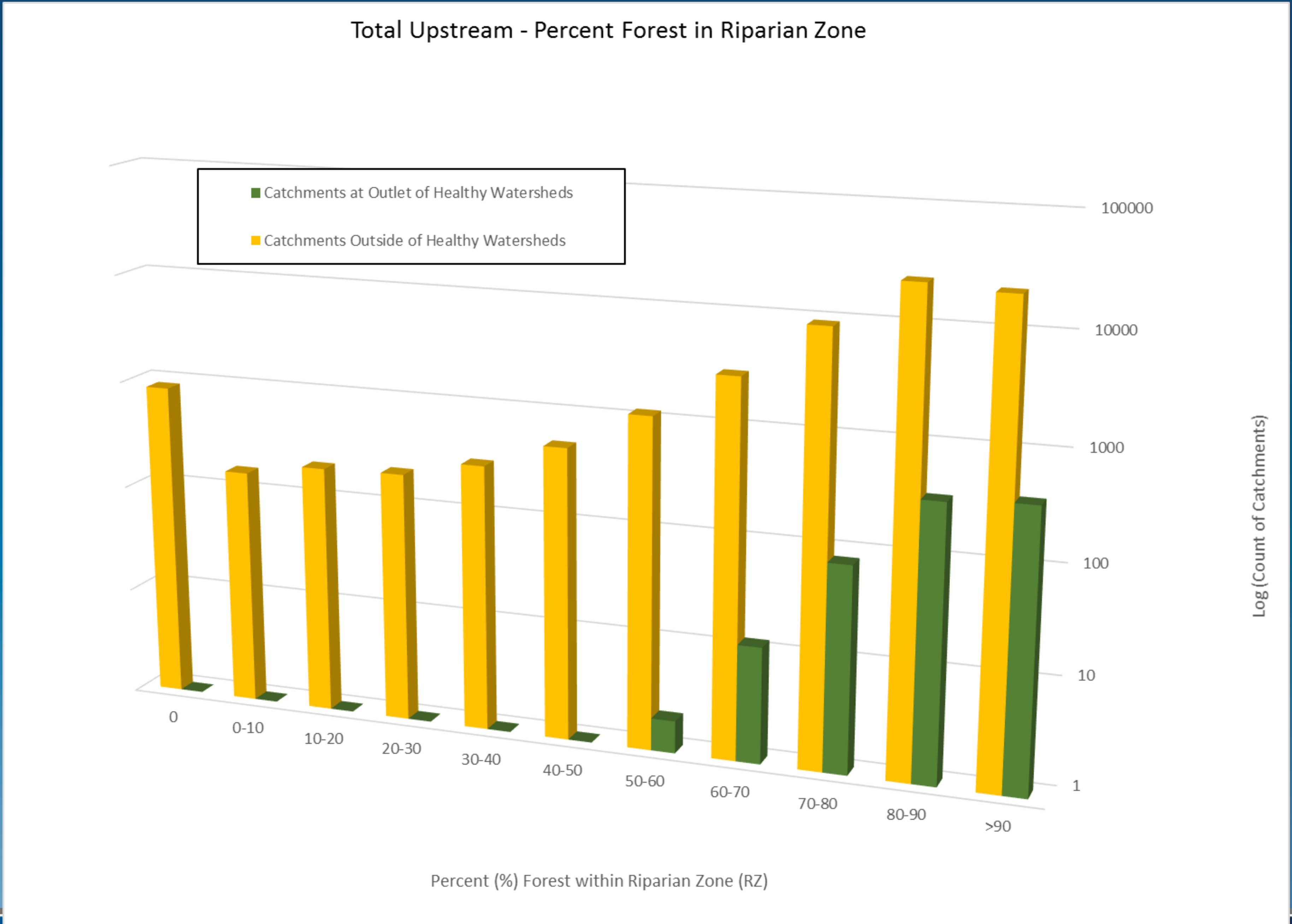
0 20 40 80 Kilometers

0 20 40 80 Miles

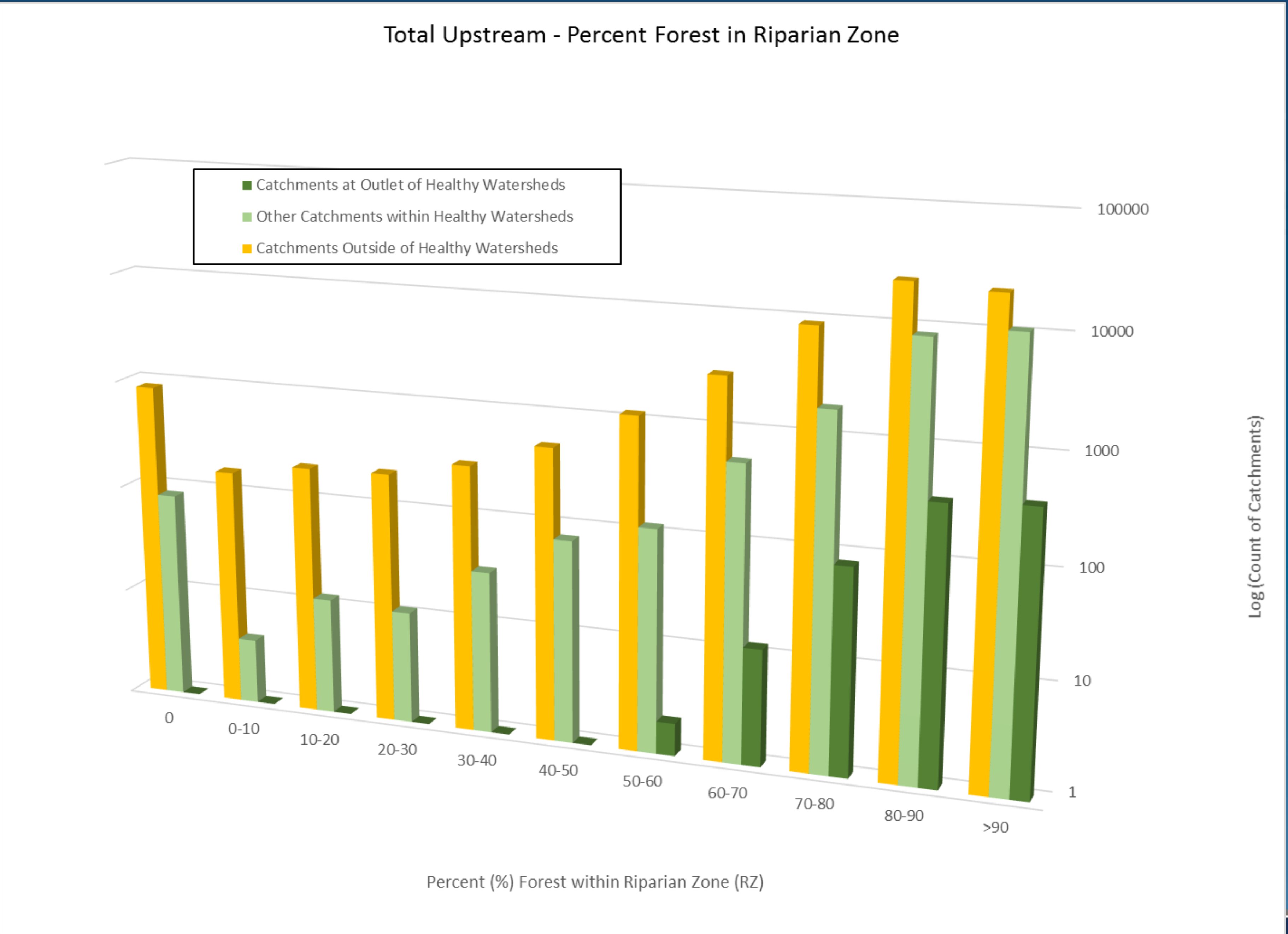
TETRA TECH


Total Upstream - Percent Forest in Riparian Zone
Catchments at Outlet of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
>90
Percent (%) Forest within Riparian Zone (RZ)


Total Upstream - Percent Forest in Riparian Zone
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
>90
Percent (%) Forest within Riparian Zone (RZ)



Total Upstream - Percent Forest in Riparian Zone
Catchments at Outlet of Healthy Watersheds
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
>90
Percent (%) Forest within Riparian Zone (RZ)


Total Upstream - Percent Forest in Riparian Zone
Catchments at Outlet of Healthy Watersheds
Other Catchments within Healthy Watersheds
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
>90
Percent (%) Forest within Riparian Zone (RZ)

Metric Performance

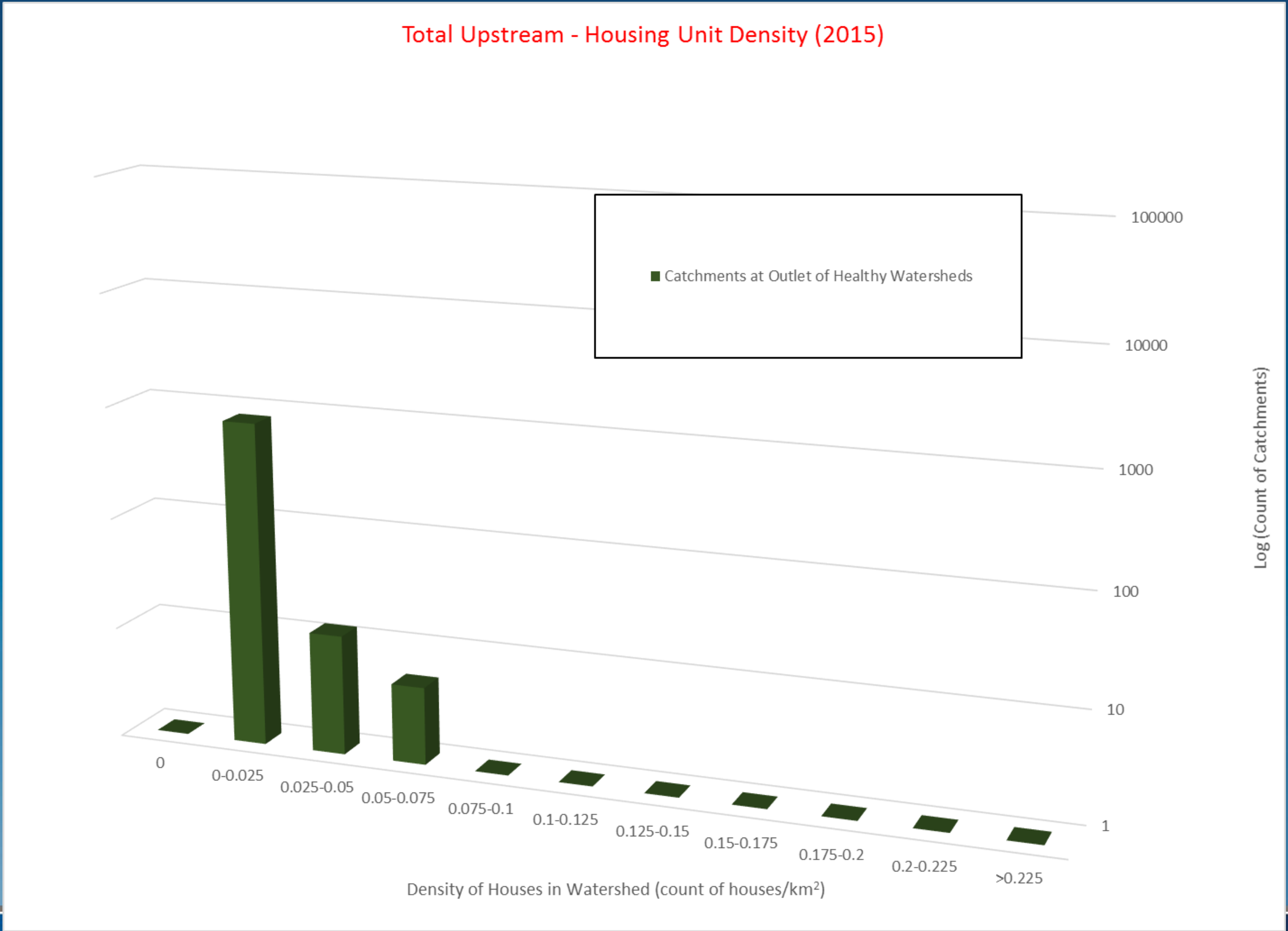
- Example: <u>Percent Forest in Riparian Zone</u>
- Indicative of: <u>Landscape</u> condition
- Value calculated for entire upstream riparian zone
- Metric expected to be <u>high</u> in healthy watersheds

Findings:

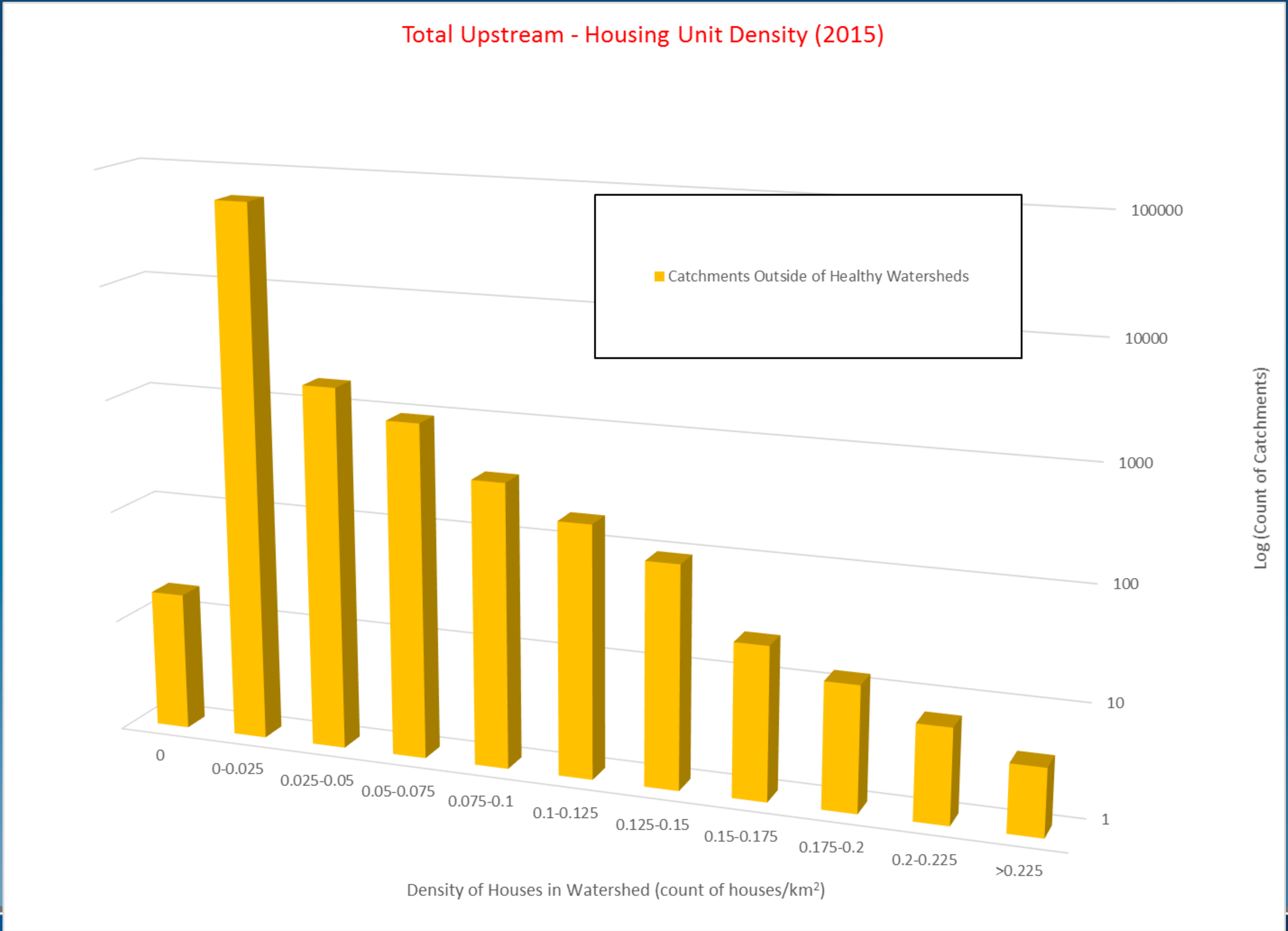
- As expected, values for percent riparian forest are high in the Chesapeake Bay (CB) Healthy Watersheds, all with >50% forest in riparian zone

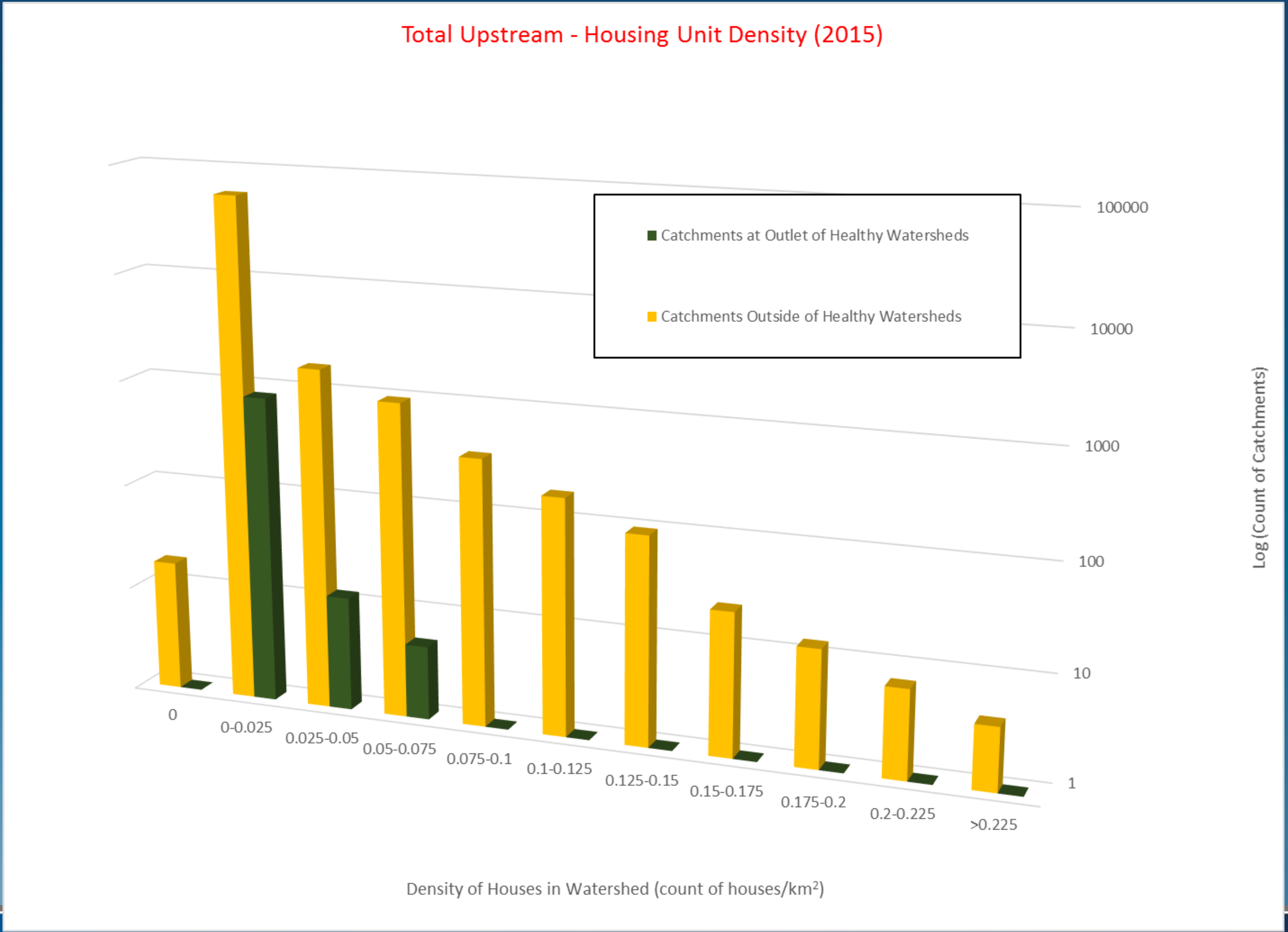
Metric Performance

- Example: Housing Unit Density
- Indicative of: Landscape condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

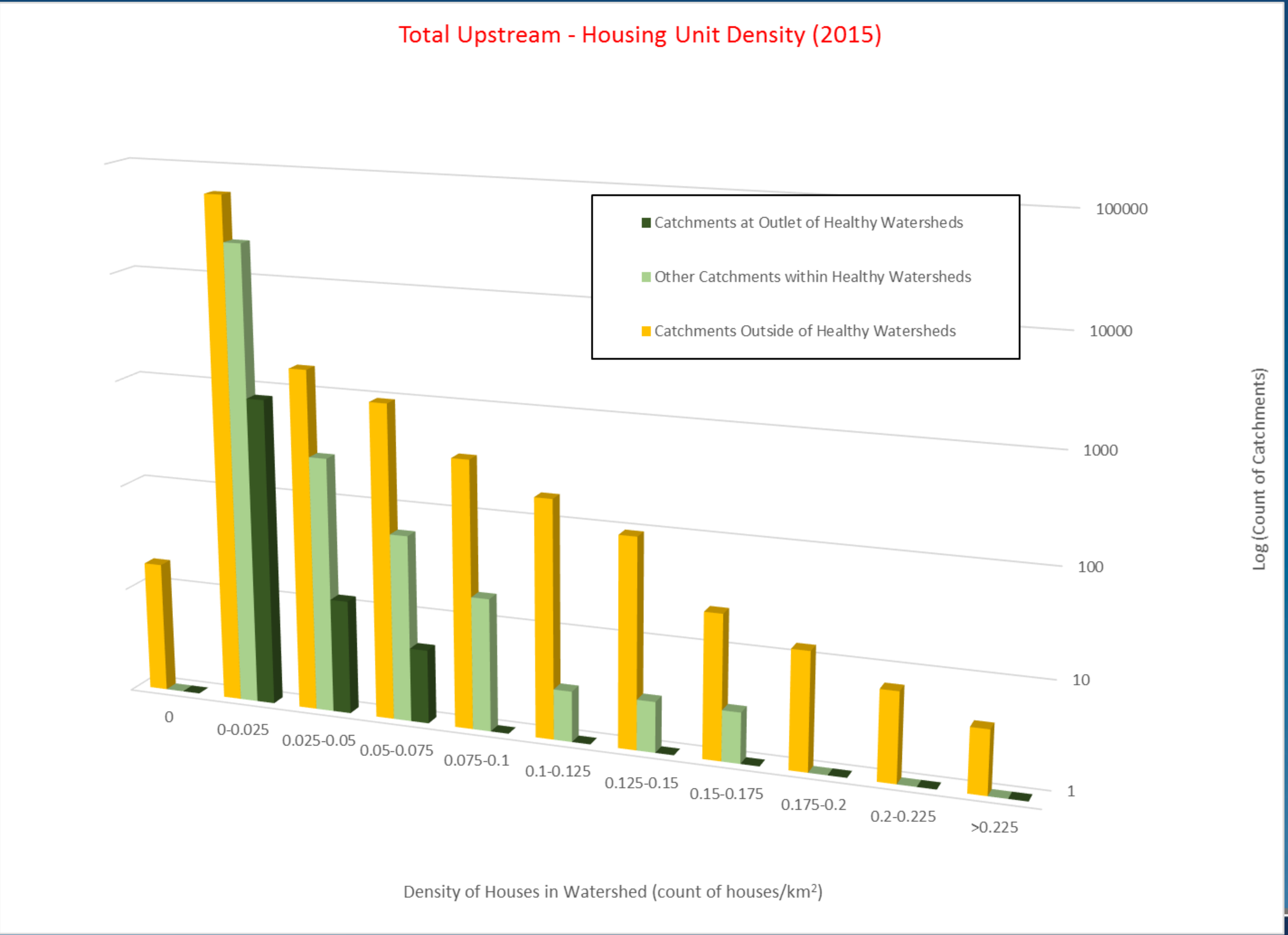


Total Upstream - Housing Unit Density (2015)
Catchments at Outlet of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-0.025
0.025-0.05
0.05-0.075
0.075-0.1
0.1-0.125
0.125-0.15
0.15-0.175
0.175-0.2
0.2-0.225
>0.225
Density of Houses in Watershed (count of houses/km2)


Total Upstream - Housing Unit Density (2015)
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-0.025
0.025-0.05
0.05-0.075
0.075-0.1
0.1-0.125
0.125-0.15
0.15-0.175
0.175-0.2
0.2-0.225
>0.225
Density of Houses in Watershed (count of houses/km2)



Total Upstream - Housing Unit Density (2015)
Catchments at Outlet of Healthy Watersheds
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-0.025
0.025-0.05
0.05-0.075
0.075-0.1
0.1-0.125
0.125-0.15
0.15-0.175
0.175-0.2
0.2-0.225
>0.225
Density of Houses in Watershed (count of houses/km2)

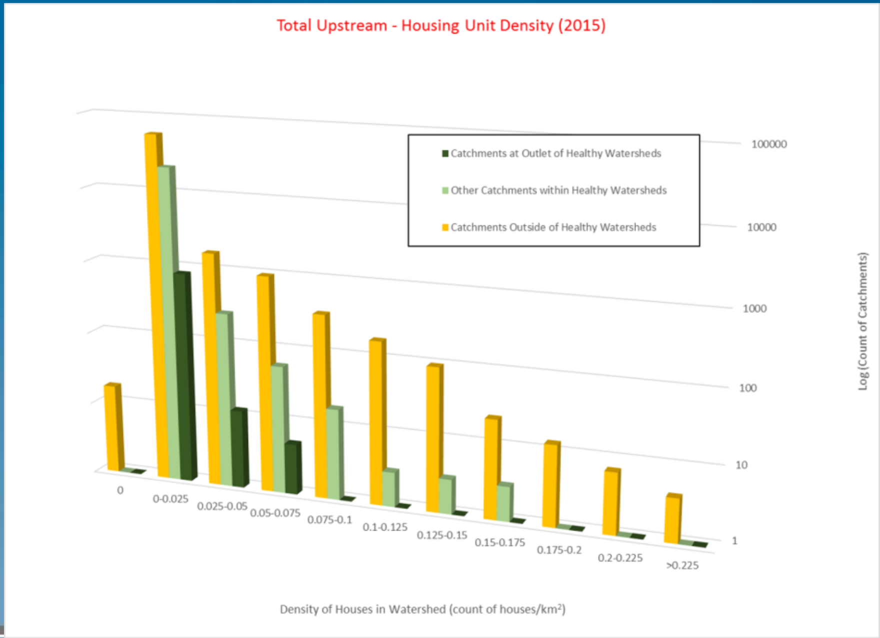

Total Upstream - Housing Unit Density (2015)
Catchments at Outlet of Healthy Watersheds
Other Catchments within Healthy Watersheds
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-0.025
0.025-0.05
0.05-0.075
0.075-0.1
0.1-0.125
0.125-0.15
0.15-0.175
0.175-0.2
0.2-0.225
>0.225
Density of Houses in Watershed (count of houses/km2)

Metric Performance

- Example: Housing Unit Density
- Indicative of: Landscape condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

Findings:

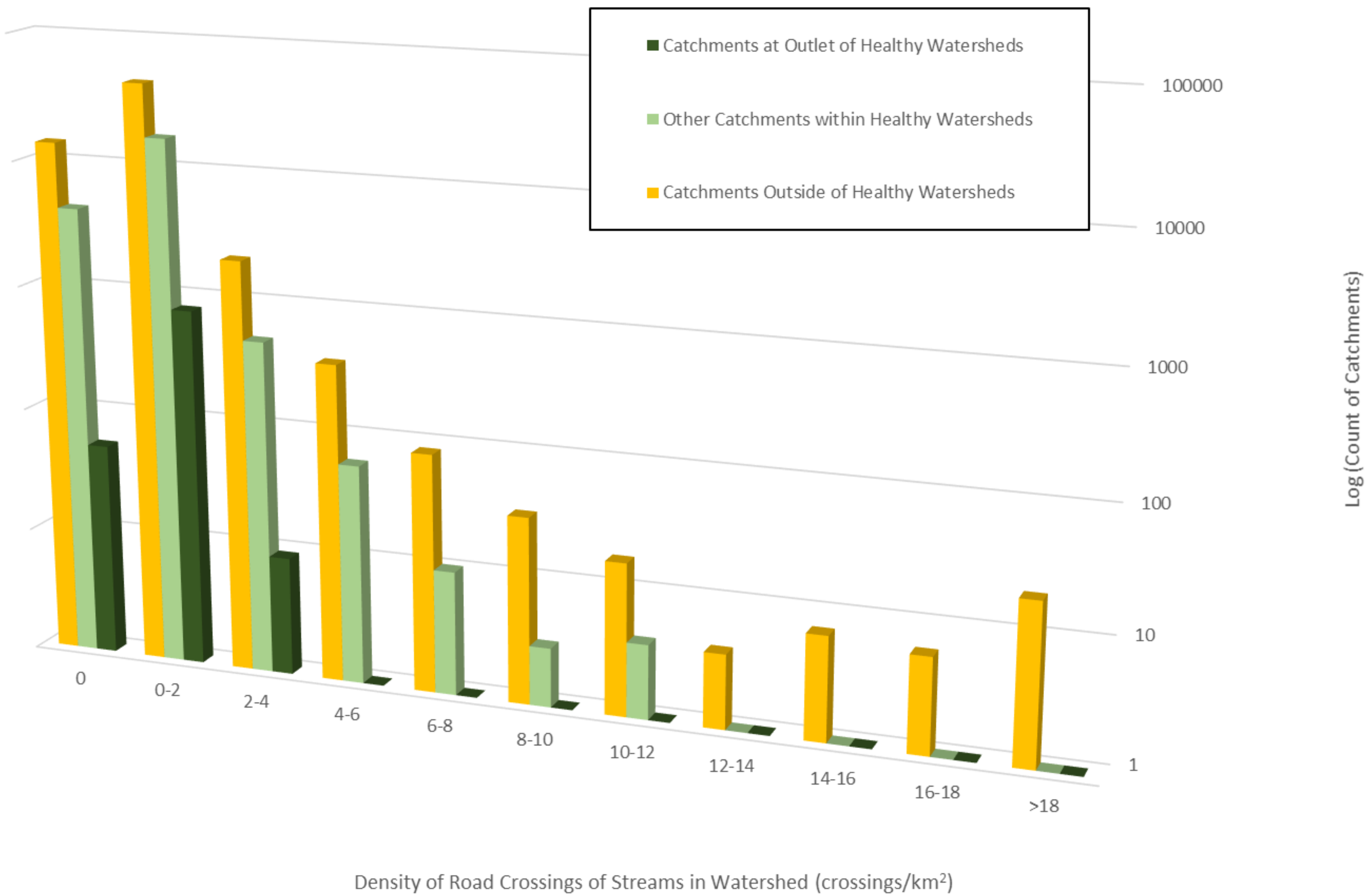
- As expected, housing unit densities are low in CB Healthy Watersheds



Metric Performance

- Example: Density of Road-Stream Crossings in Watershed
- Indicative of: Hydrologic condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

Density of Road-Stream Crossings (2010)



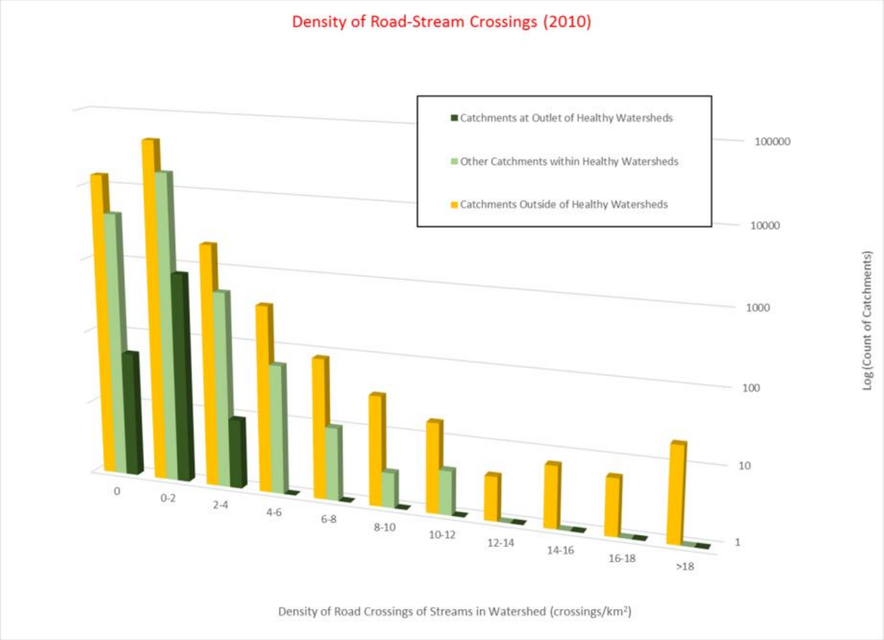
TETRA TECH

Metric Performance

- Example: Density of Road-Stream Crossings in Watershed
- Indicative of: Hydrologic condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

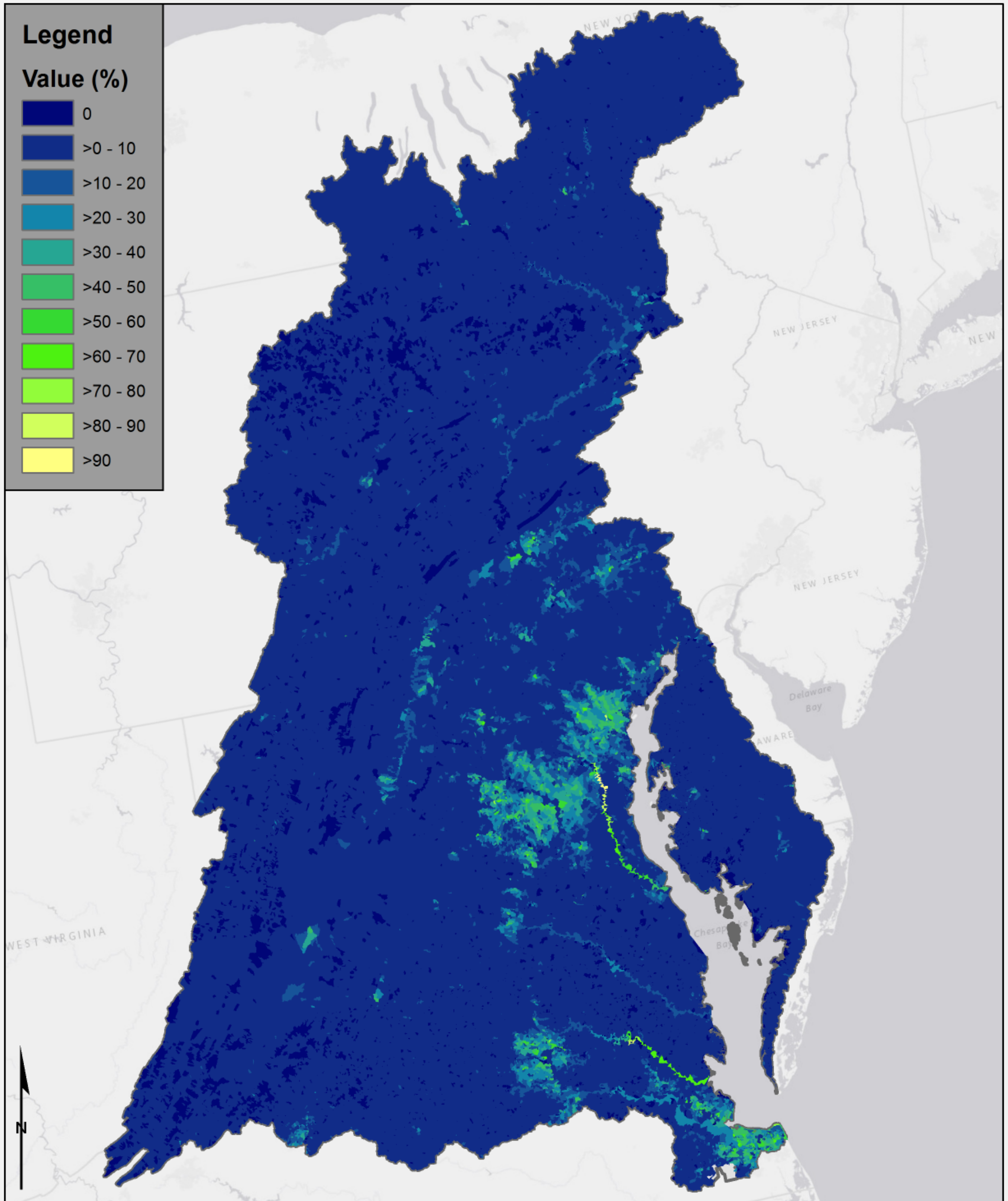
Findings:

- In CB Healthy Watershed, values for density of road-stream crossings are at low end of scale, as expected
- Many zero values



Metric Performance

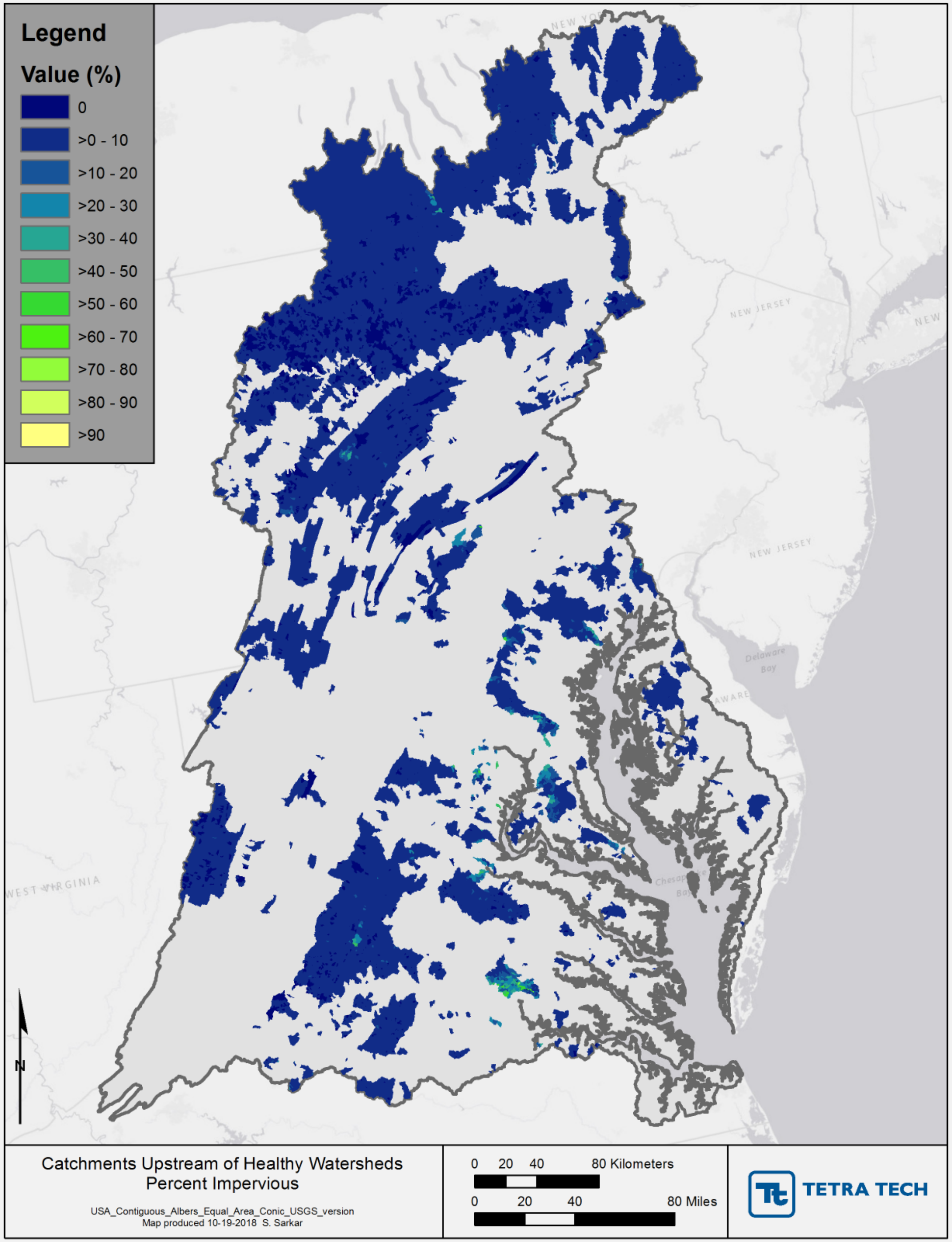
- Example: Percent Impervious Surface Cover in Watershed
- Indicative of: Hydrologic condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

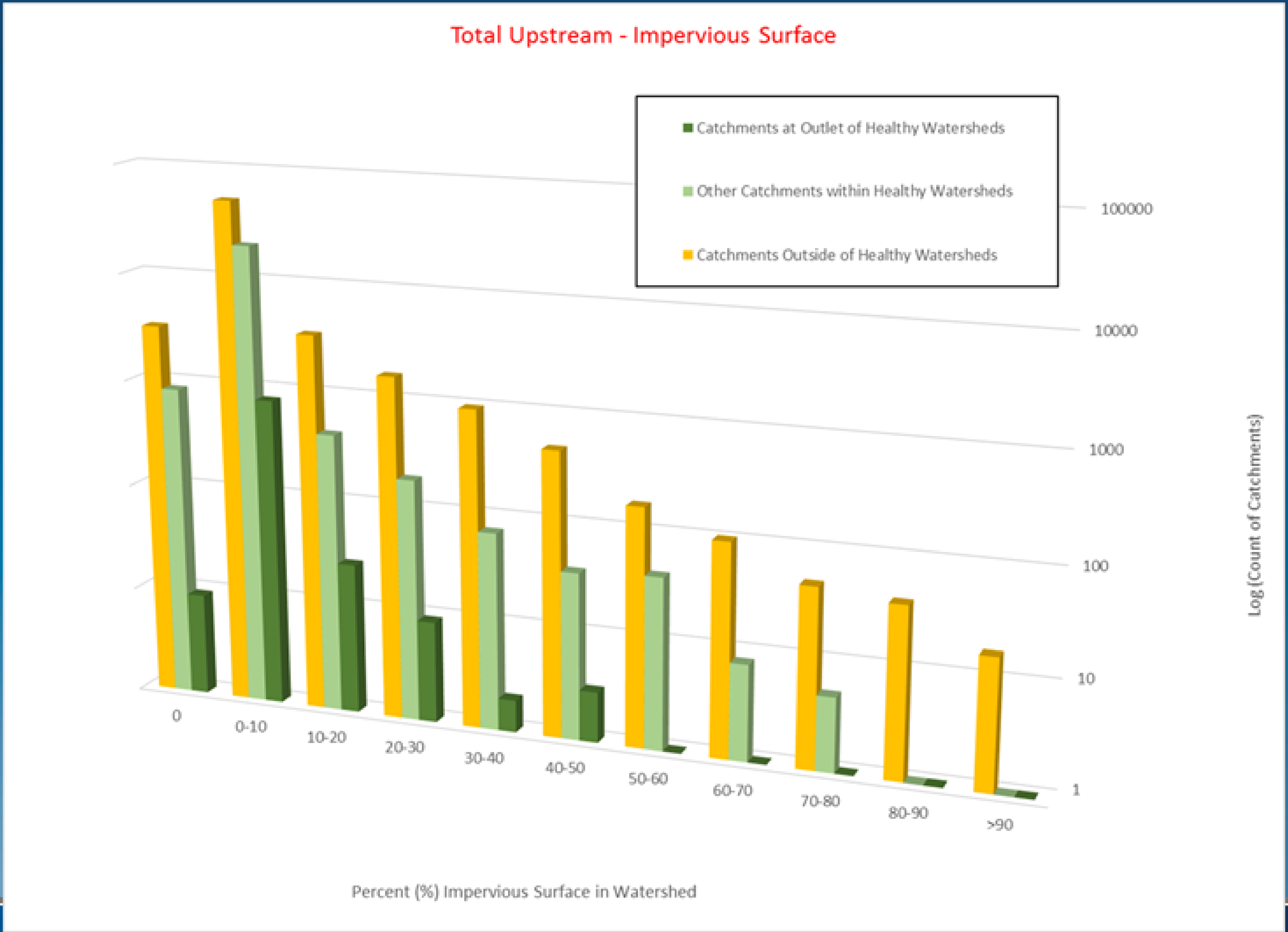


All Catchments
Percent Impervious

USA_Contiguous_Albers_Equal_Area_Conic_USGS_version
Map produced 10-19-2018 S. Sarkar

TETRA TECH


Legend
Value (%)
0
>0 - 10
>10 - 20
>20 - 30
>30 - 40
>40 - 50
>50 - 60
>60 - 70
>70 - 80
>80 - 90
>90
NEW JERSEY
NEW JERSEY
WEST VIRGINIA
Delaware Bay
N
Catchments Upstream of Healthy Watersheds
Percent Impervious
USA_Contiguous_Albers_Equal_Area_Conic_USGS_version
Map produced 10-19-2018 S. Sarkar
0 20 40 80 Kilometers
0 20 40 80 Miles
TETRA TECH

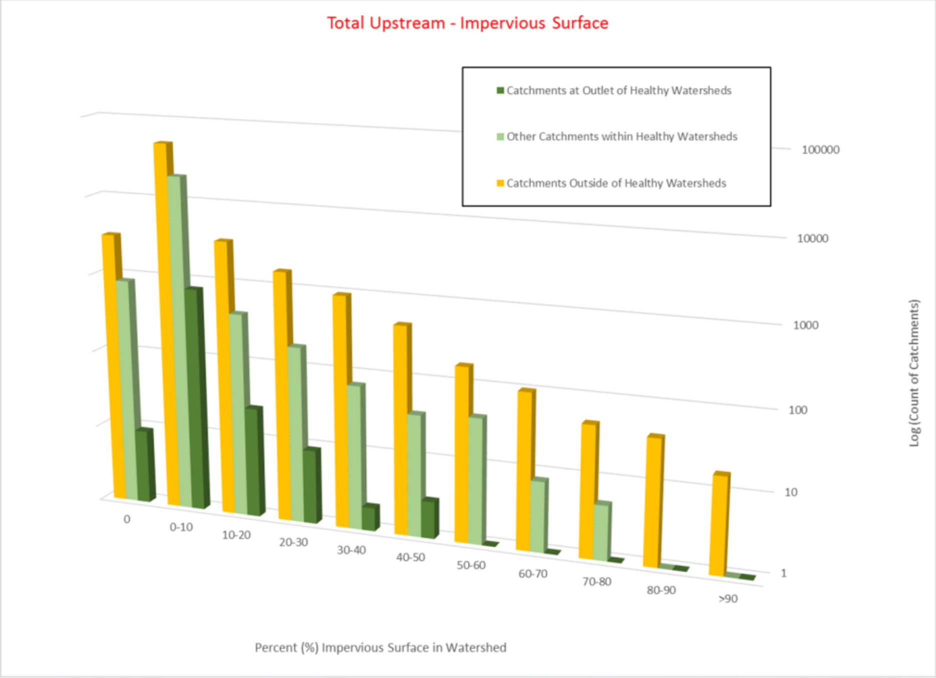


Total Upstream - Impervious Surface
Catchments at Outlet of Healthy Watersheds
Other Catchments within Healthy Watersheds
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
>90
Percent (%) Impervious Surface in Watershed

Metric Performance

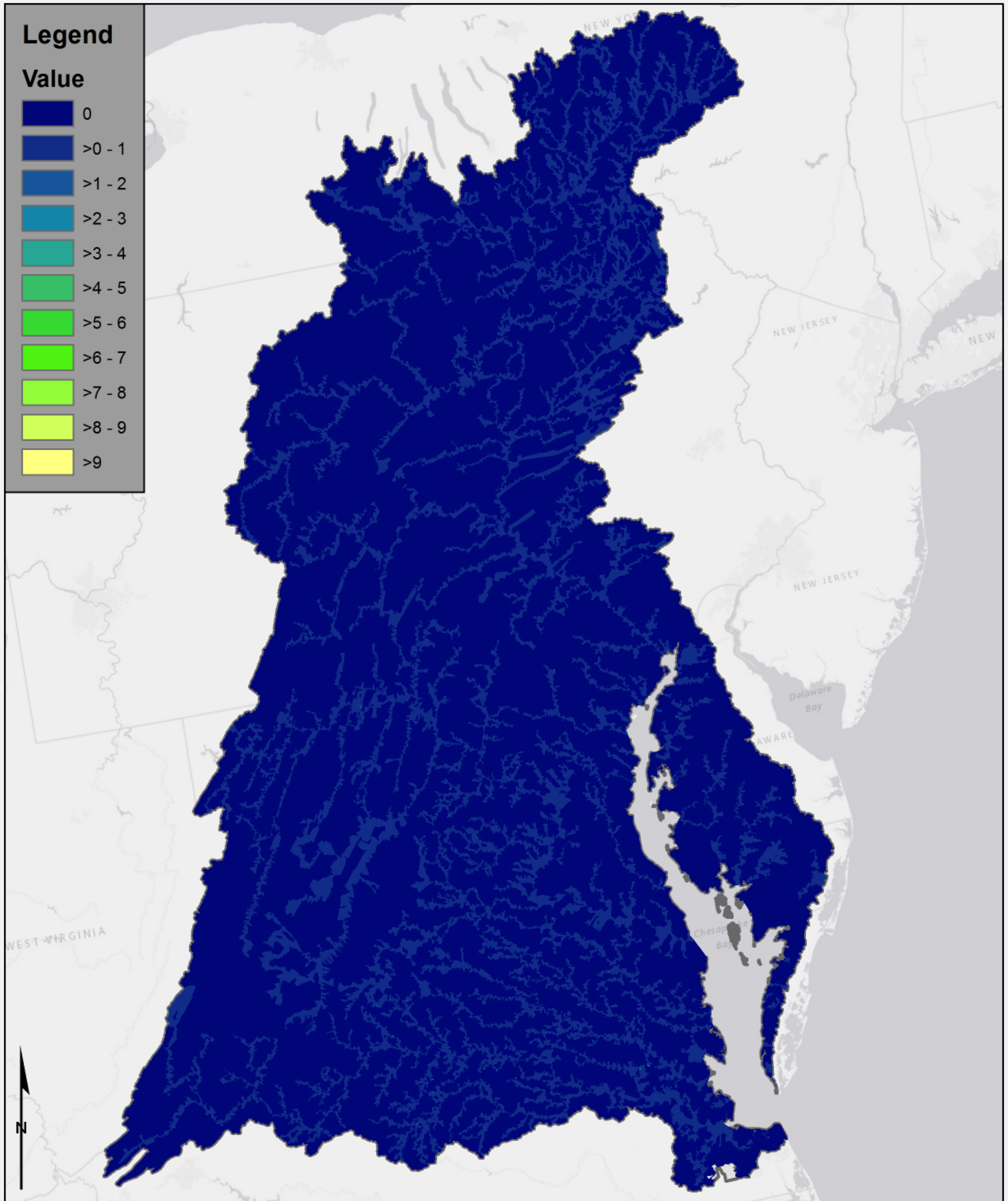
- Example: Percent Impervious Surface Cover in Watershed
- Indicative of: Hydrologic condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

- Findings:
- Impervious cover is generally low in CB Healthy Watersheds, many with <10% or <20% impervious cover
- Some with 20-50% impervious cover, levels that may lead to degradation



Metric Performance

- Example: Dam Density in Watershed
- Indicative of: Geomorphic condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

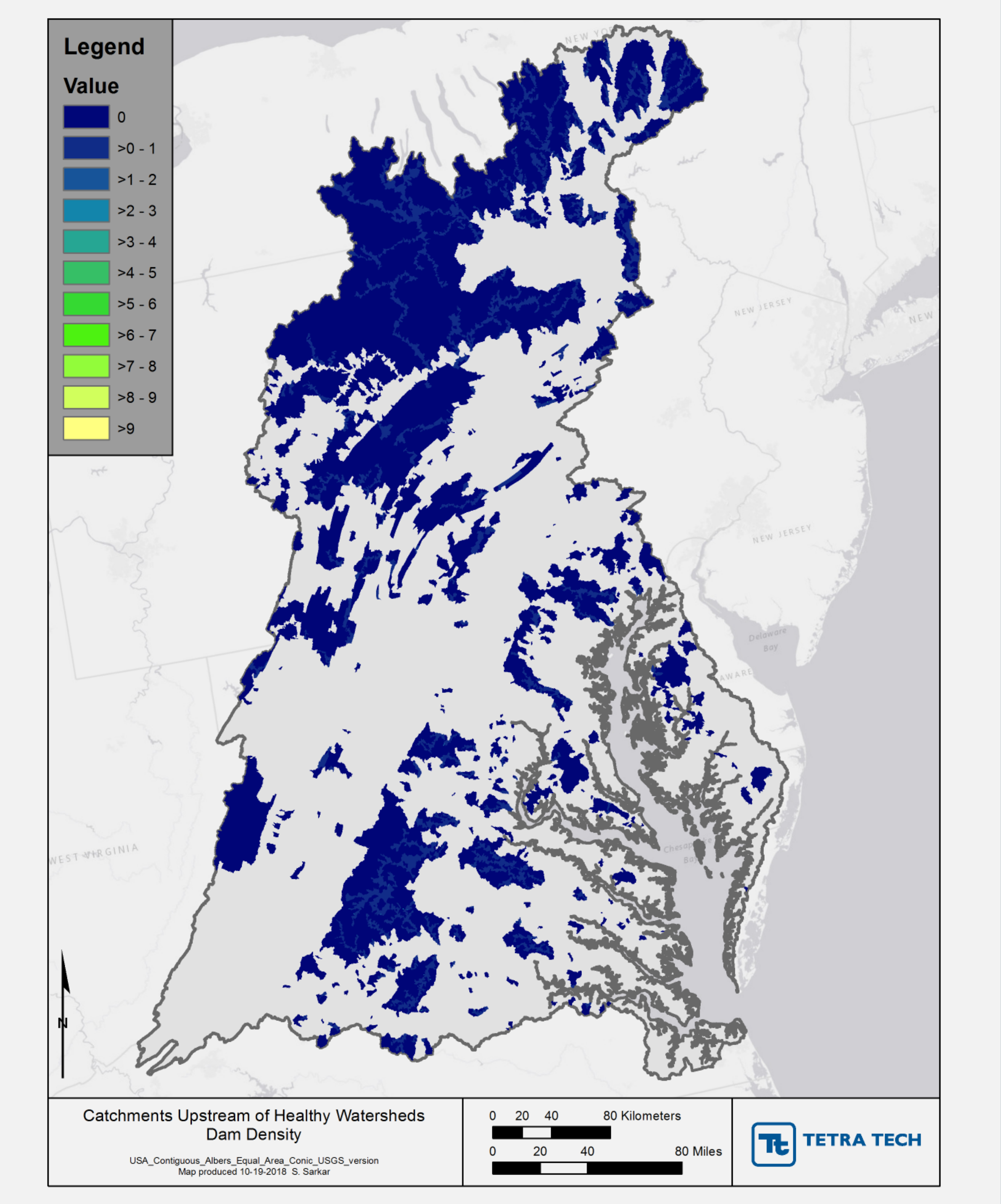


All Catchments
Dam Density

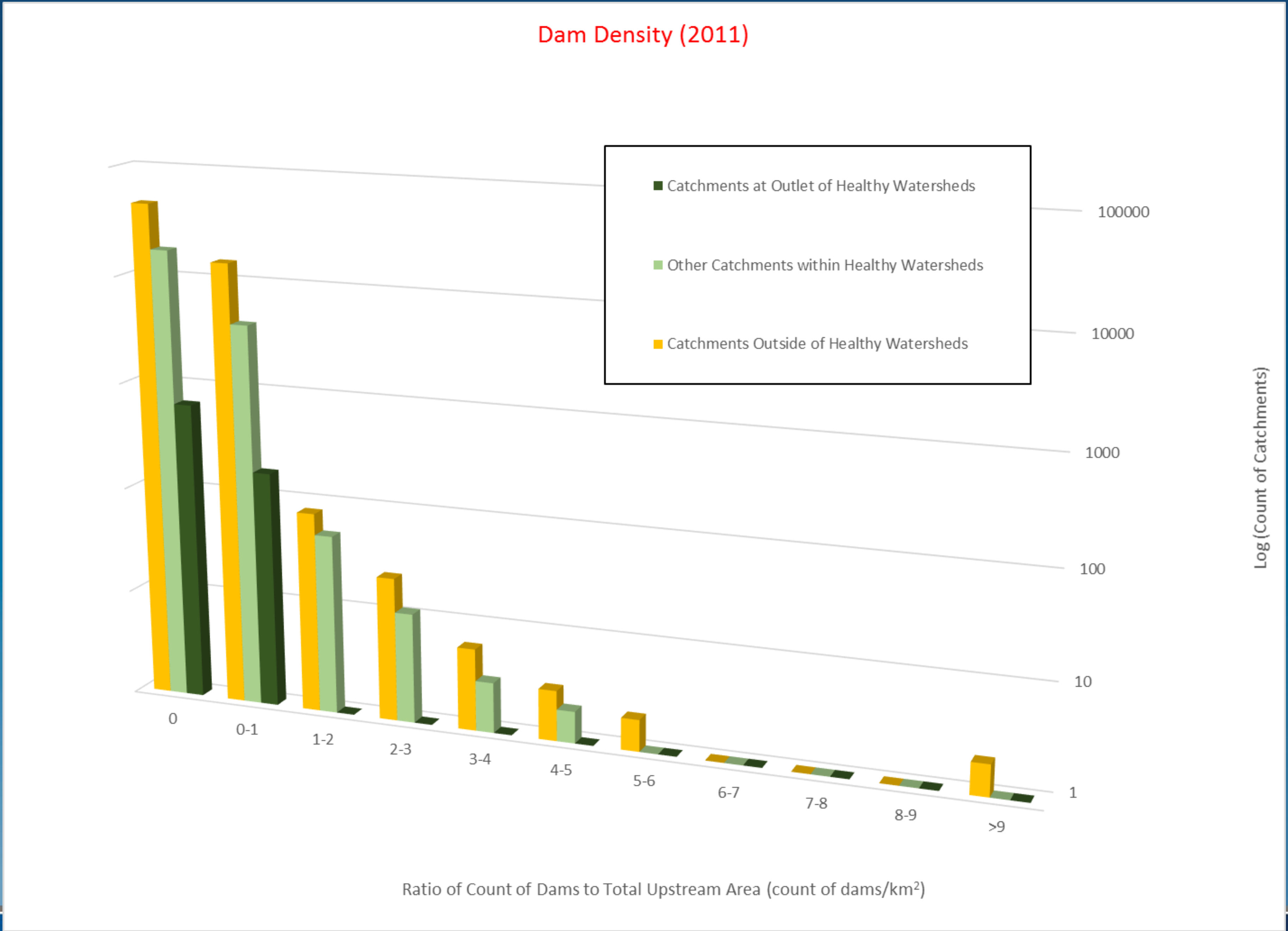
USA_Contiguous_Albers_Equal_Area_Conic_USGS_version
Map produced 10-19-2018 S. Sarkar

0 20 40 80 Kilometers
0 20 40 80 Miles

TETRA TECH



Legend
Value
0
>0 - 1
>1 - 2
>2 - 3
>3 - 4
>4 - 5
>5 - 6
>6 - 7
>7 - 8
>8 - 9
>9
NEW JERSEY
NEW JERSEY
WEST VIRGINIA
Delaware Bay
N
Catchments Upstream of Healthy Watersheds
Dam Density
USA_Contiguous_Albers_Equal_Area_Conic_USGS_version
Map produced 10-19-2018 S. Sarkar
0 20 40 80 Kilometers
0 20 40 80 Miles
TETRA TECH



Dam Density (2011)
Catchments at Outlet of Healthy Watersheds
Other Catchments within Healthy Watersheds
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-1
1-2
2-3
3-4
4-5
5-6
6-7
7-8
8-9
>9
Ratio of Count of Dams to Total Upstream Area (count of dams/km2)

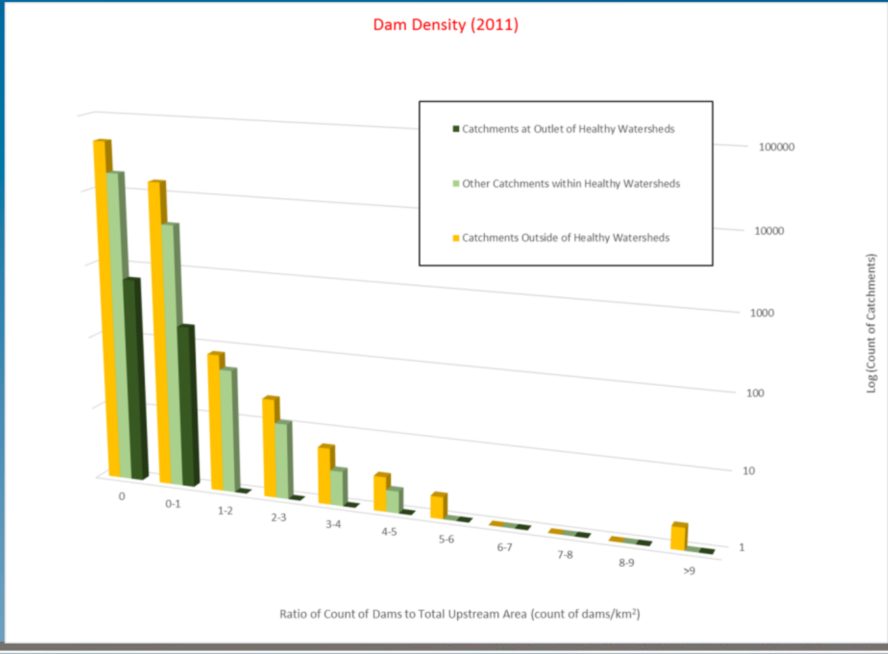
TETRA TECH

Metric Performance

- Example: Dam Density in Watershed
- Indicative of: Geomorphic condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

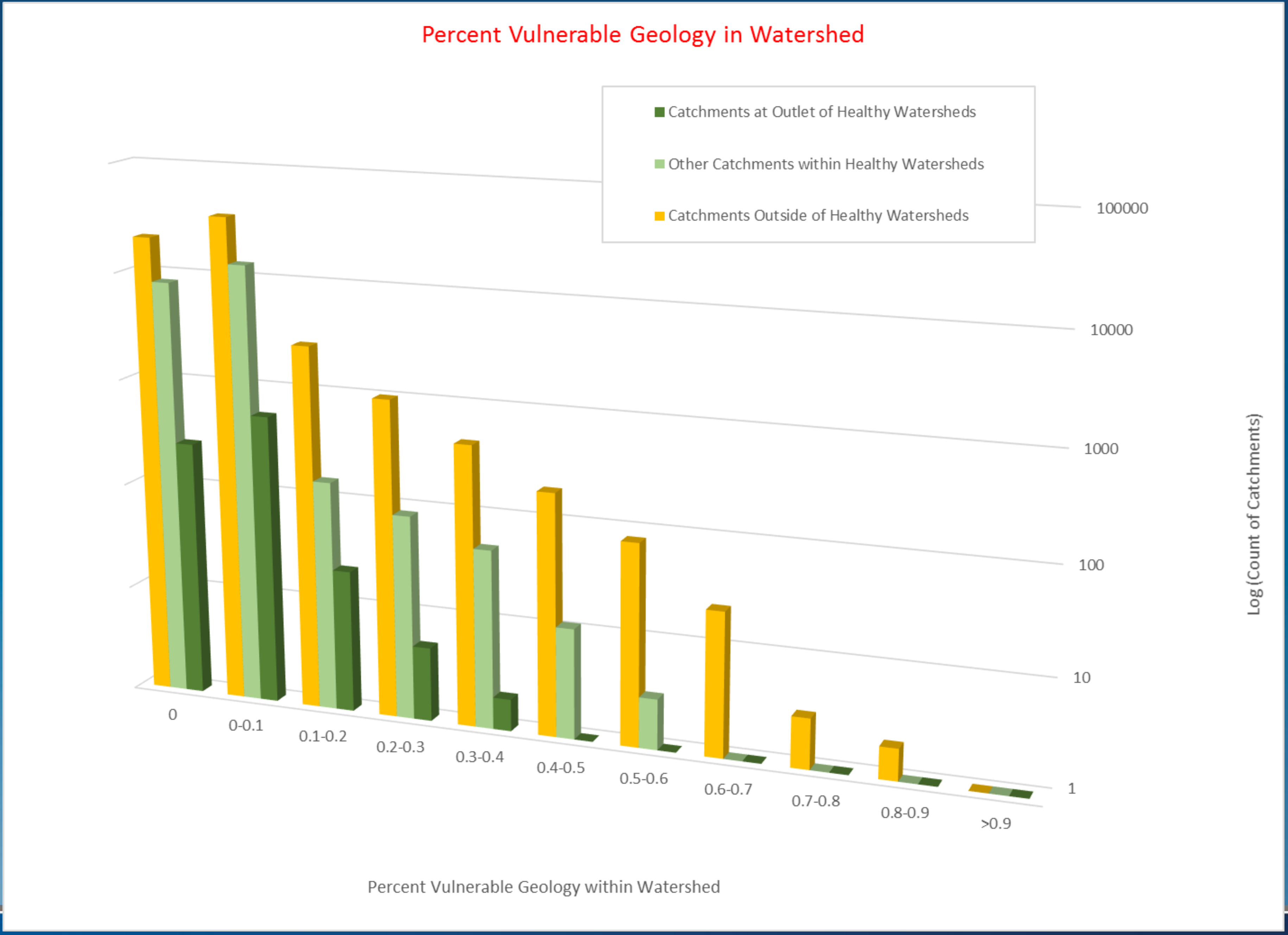
Findings:

- Dam density low in CB Healthy Watersheds; 0 to 1 dam per km^2
- Many zero values



Metric Performance

- Example: Percent Vulnerable Geology in Watershed
- Indicative of: Geomorphic condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds


Percent Vulnerable Geology in Watershed
Catchments at Outlet of Healthy Watersheds
Other Catchments within Healthy Watersheds
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
0.6-0.7
0.7-0.8
0.8-0.9
>0.9
Percent Vulnerable Geology within Watershed

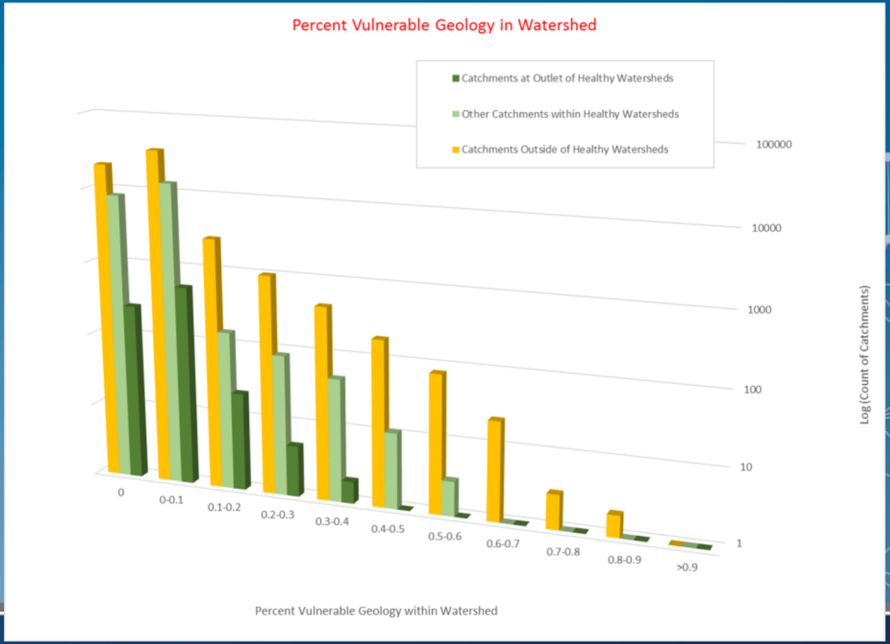
TETRA TECH

Metric Performance

- Example: Percent Vulnerable Geology in Watershed
- Indicative of: Geomorphic condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

Findings:

- Vulnerable geology tends to be low in CB Healthy Watersheds

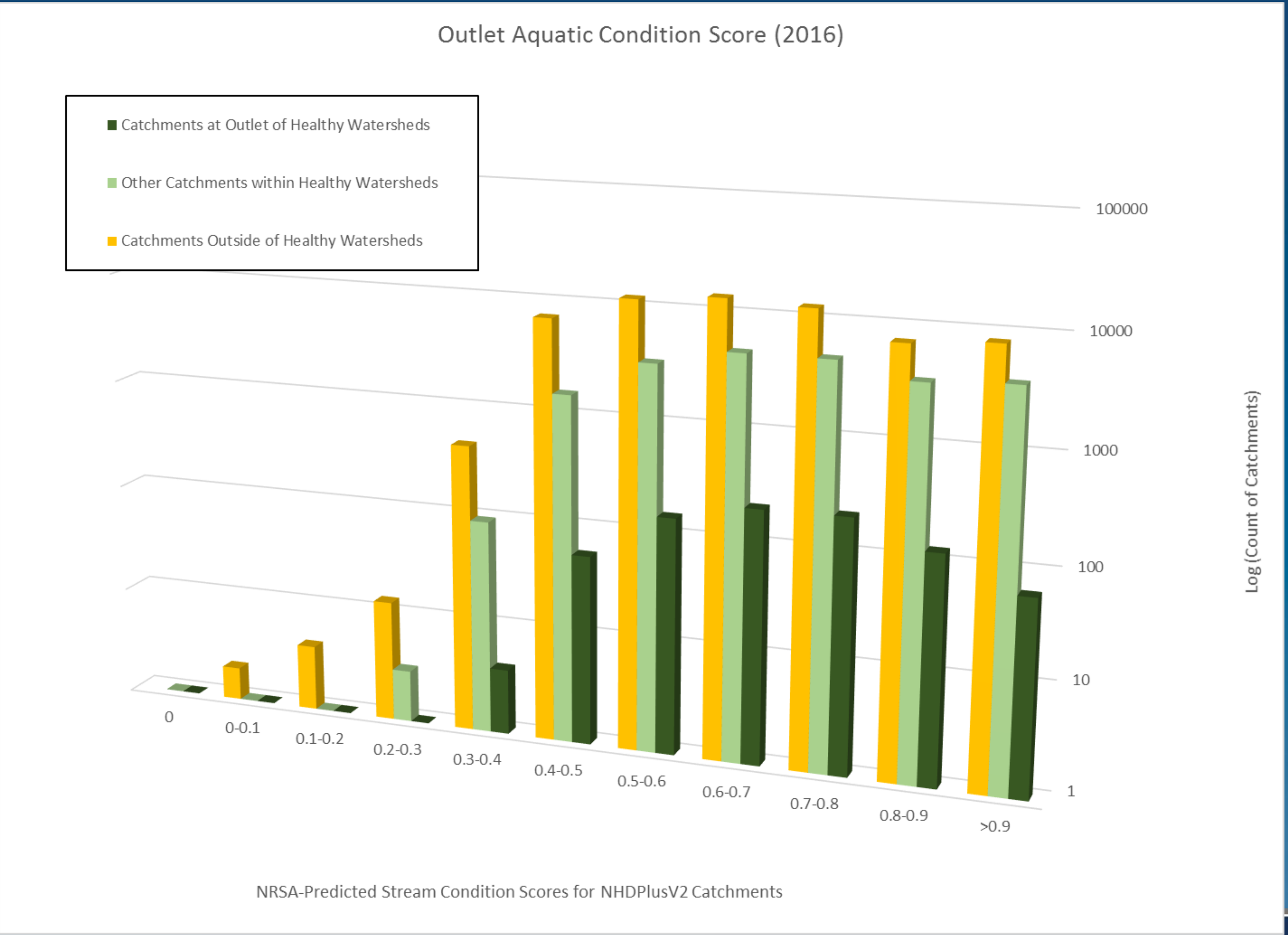


Metric Performance

- Example: National Fish Habitat Condition Index in Catchment
- Indicative of: Habitat condition
- Value calculated for catchment at healthy watershed outlet only
- Metric expected to be high in healthy watersheds

Metric Performance

- Example: Aquatic Condition Score
- Indicative of: Biological condition
- Value calculated for catchment at healthy watershed outlet only
- Metric expected to be high in healthy watersheds



Outlet Aquatic Condition Score (2016)
Catchments at Outlet of Healthy Watersheds
Other Catchments within Healthy Watersheds
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
0.6-0.7
0.7-0.8
0.8-0.9
>0.9
NRSA-Predicted Stream Condition Scores for NHDPlusV2 Catchments

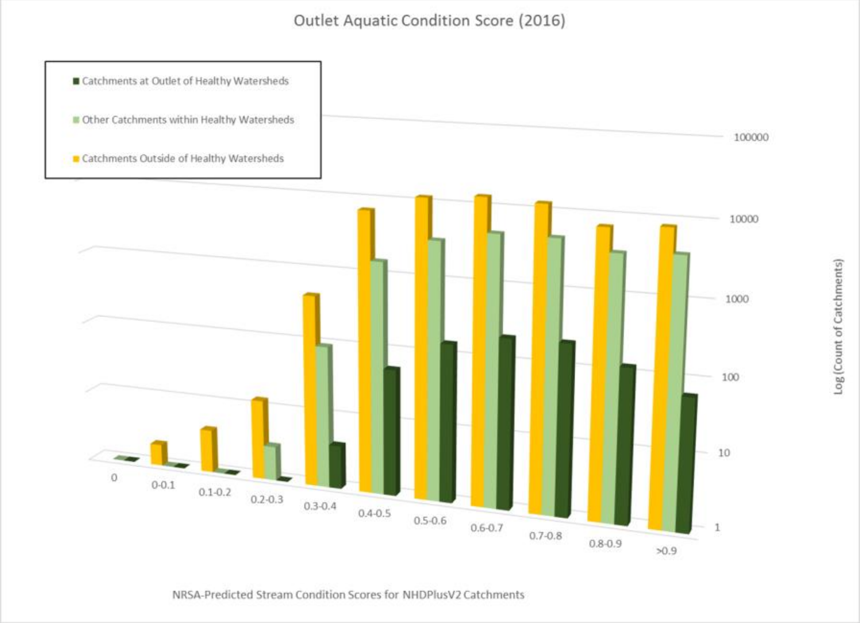
TETRA TECH

Metric Performance

- Example: Aquatic Condition Score
- Indicative of: Biological condition
- Value calculated for catchment at healthy watershed outlet only
- Metric expected to be high in healthy watersheds

Findings:

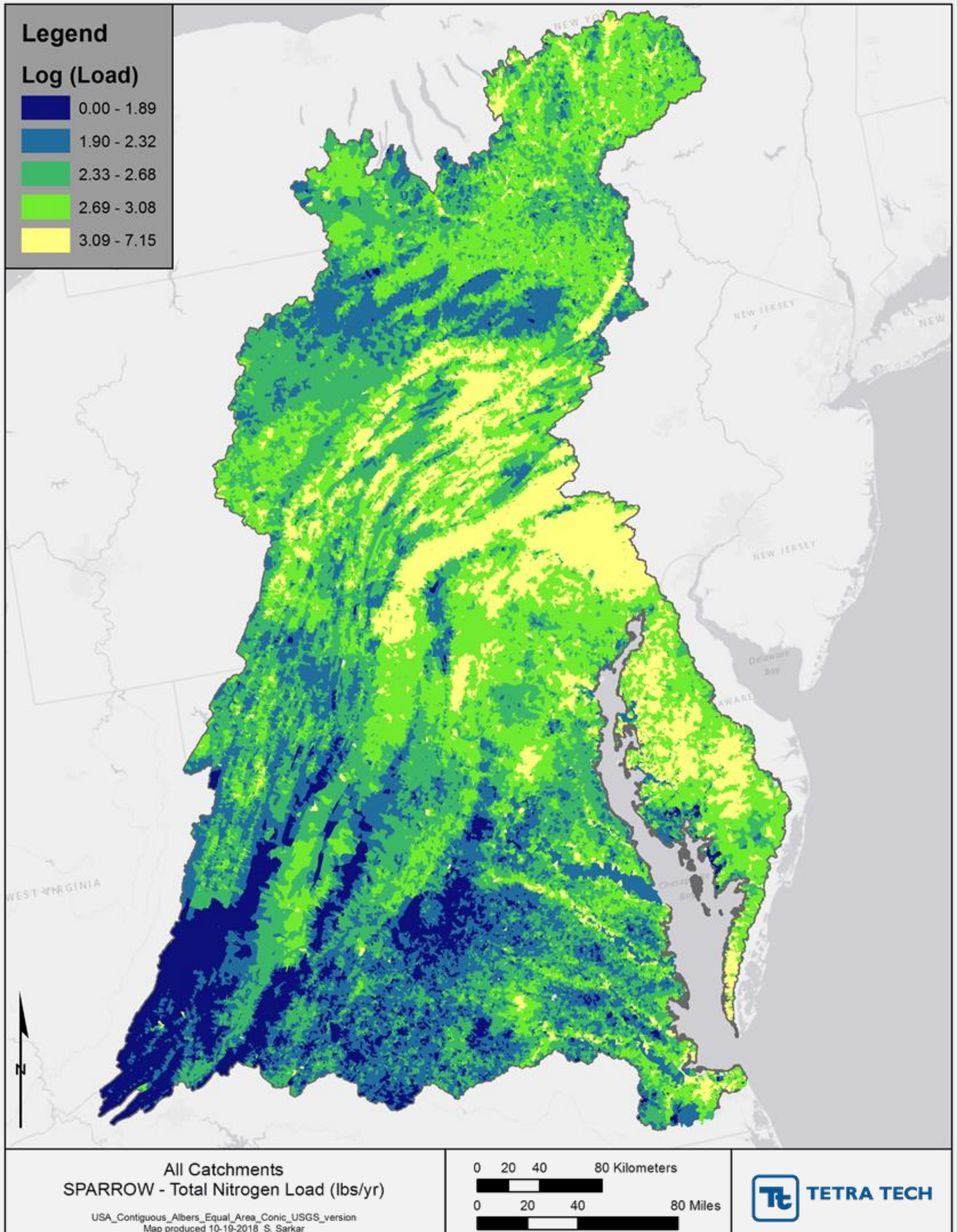
- Aquatic condition scores tend to be higher in CB Healthy Watersheds
- Current indicator provides estimates across all watersheds using national model; Stream Health modeling may provide CB region-specific estimates to apply in future



Metric Performance

- **Example: Nutrient Loading**
- **Indicative of: Water Quality condition**
- **Values calculated for entire upstream watershed area**
- **Metric expected to be low in healthy watersheds**

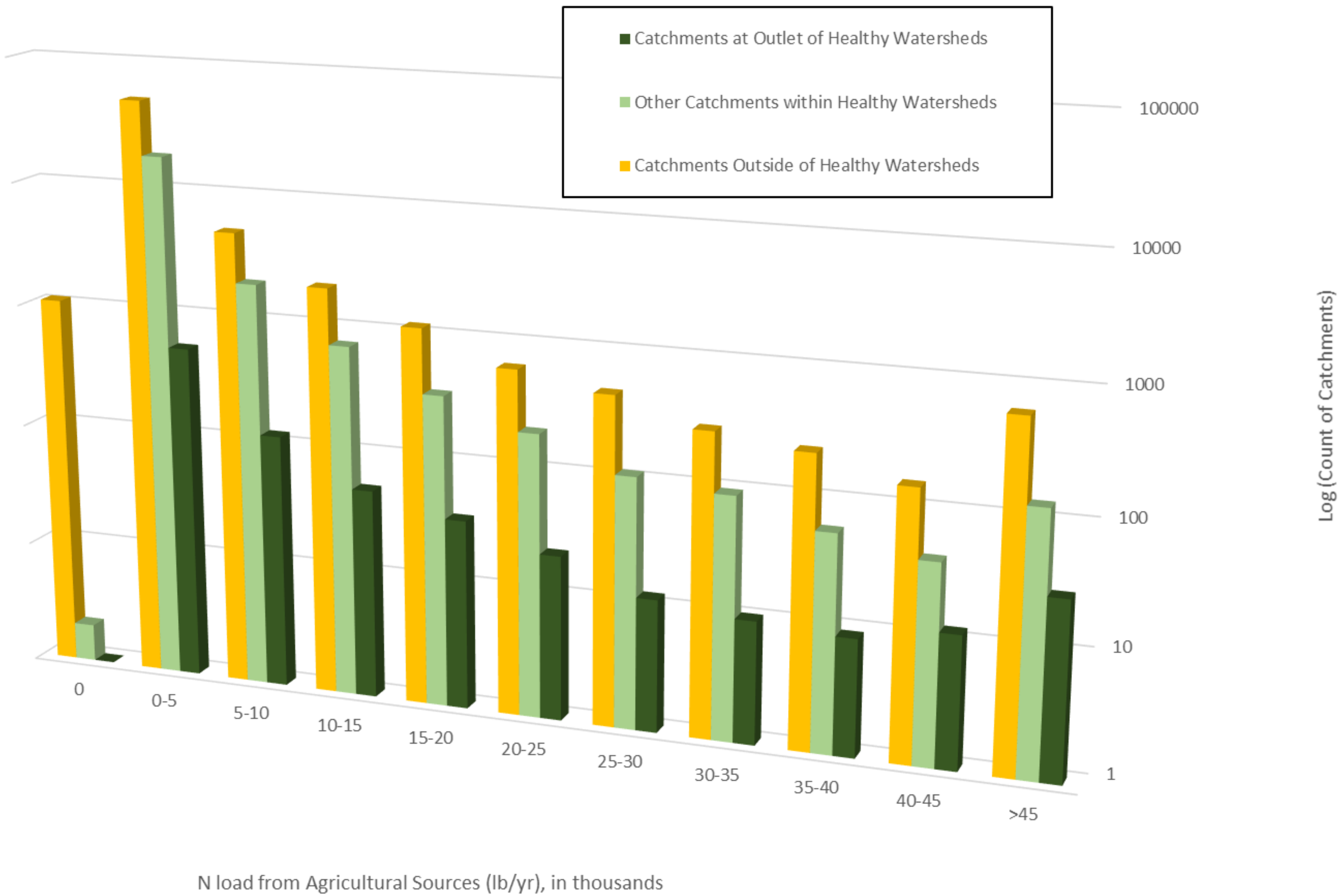
- **Data sources:**
  - SPARROW model of total N loads
  - CB Model of nutrient loading for N, P, and sediment, by sector (developed, agricultural, wastewater, combined sewer overflow, septic) – 15 individual metrics

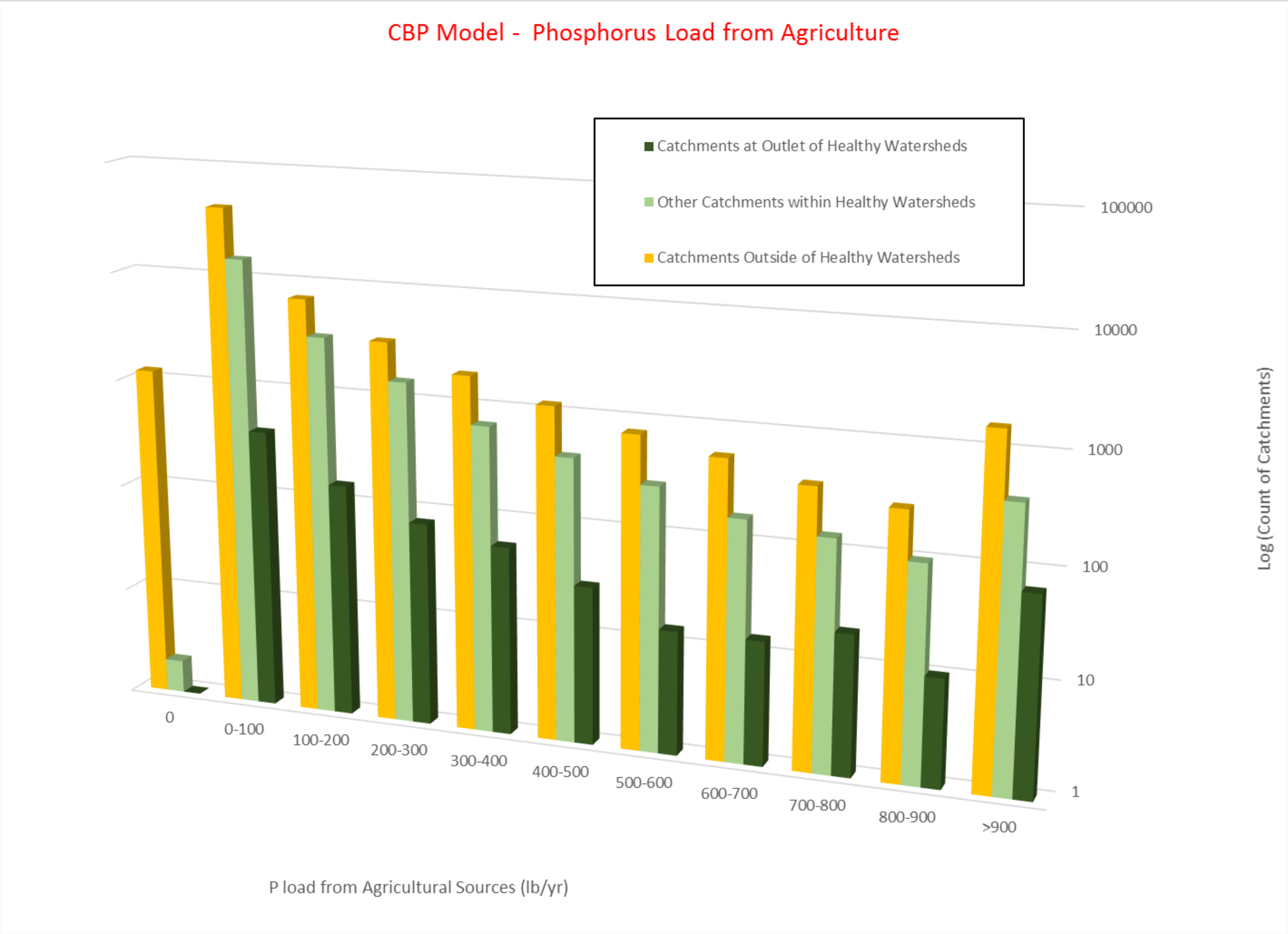


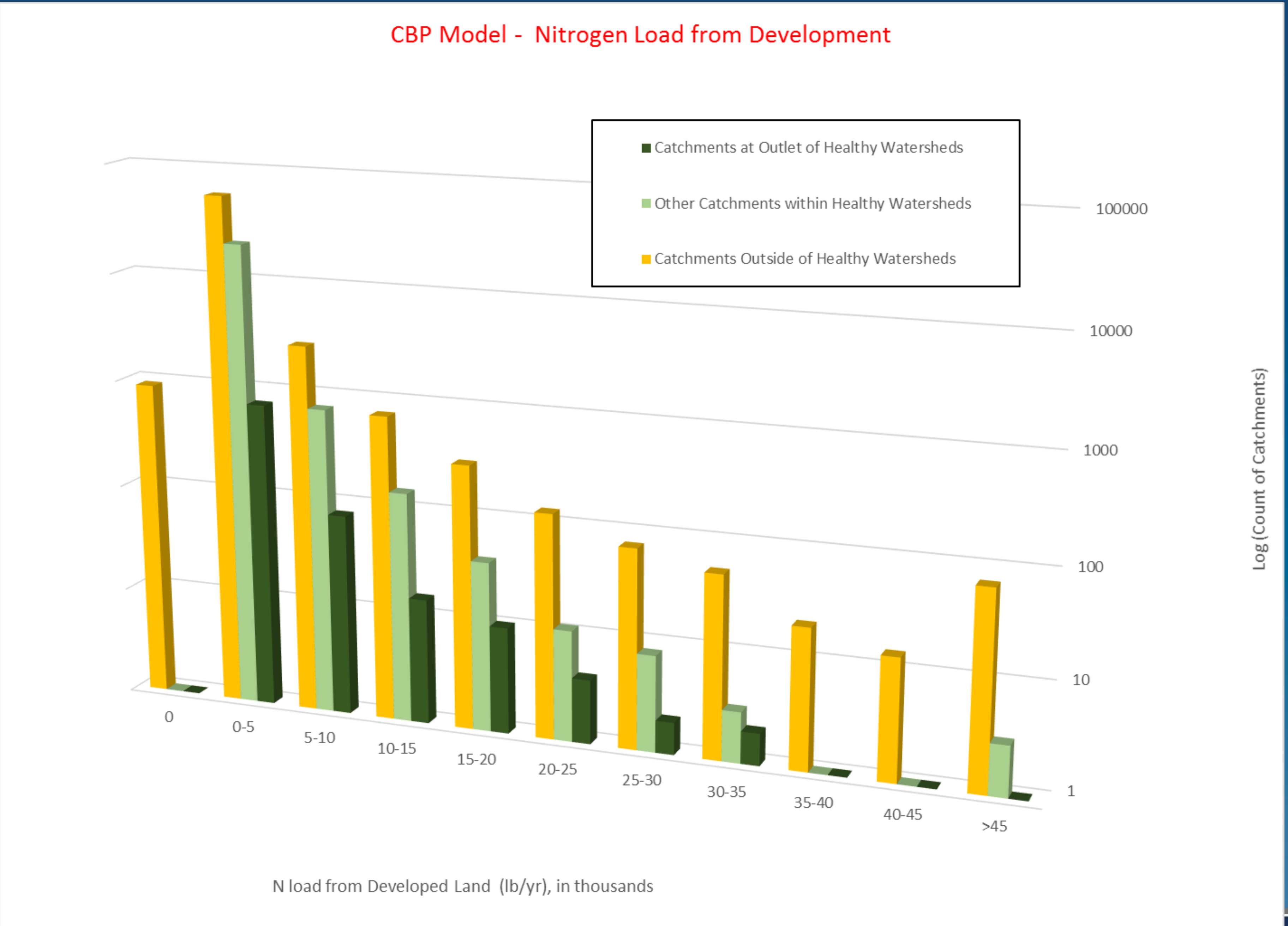
All Catchments
SPARROW - Total Nitrogen Load (lbs/yr)

USA_Contiguous_Albers_Equal_Area_Conic_USGS_version
Map produced 10-19-2018 S. Sarkar

CBP Model - Nitrogen Load from Agriculture




CBP Model - Phosphorus Load from Agriculture
Catchments at Outlet of Healthy Watersheds
Other Catchments within Healthy Watersheds
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-100
100-200
200-300
300-400
400-500
500-600
600-700
700-800
800-900
>900
P load from Agricultural Sources (lb/yr)

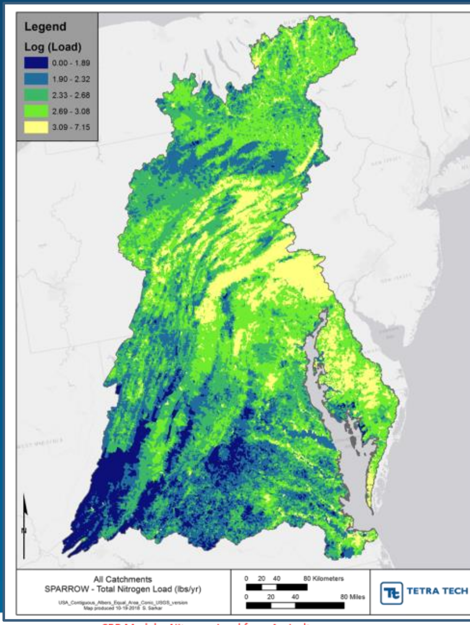


CBP Model - Nitrogen Load from Development
Catchments at Outlet of Healthy Watersheds
Other Catchments within Healthy Watersheds
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
>45
N load from Developed Land (lb/yr), in thousands

TETRA TECH

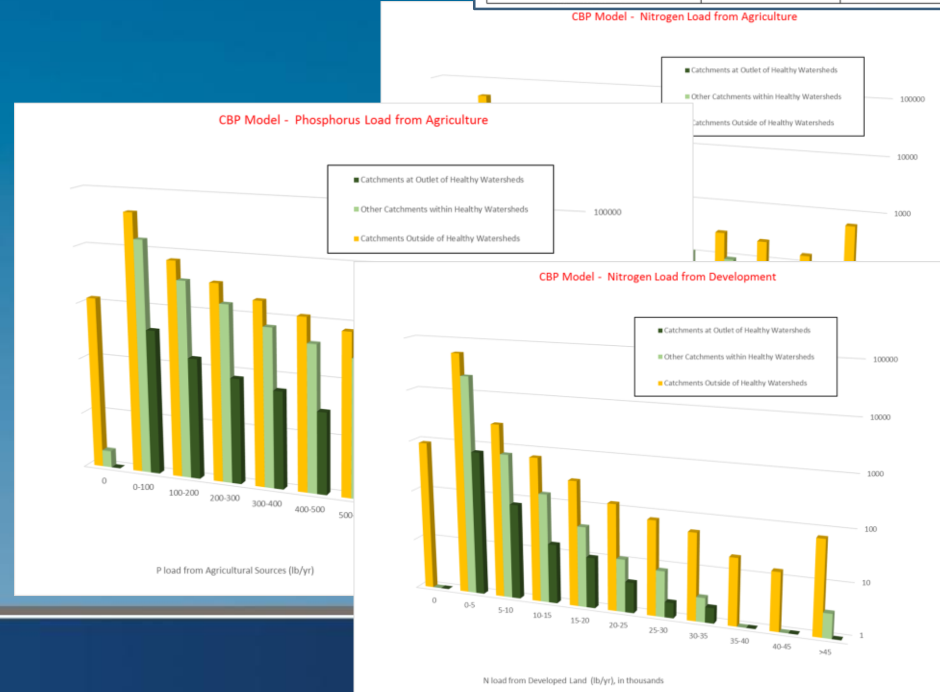
Metric Performance

- Example: Nutrient Loading
- Indicative of: Water Quality condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds



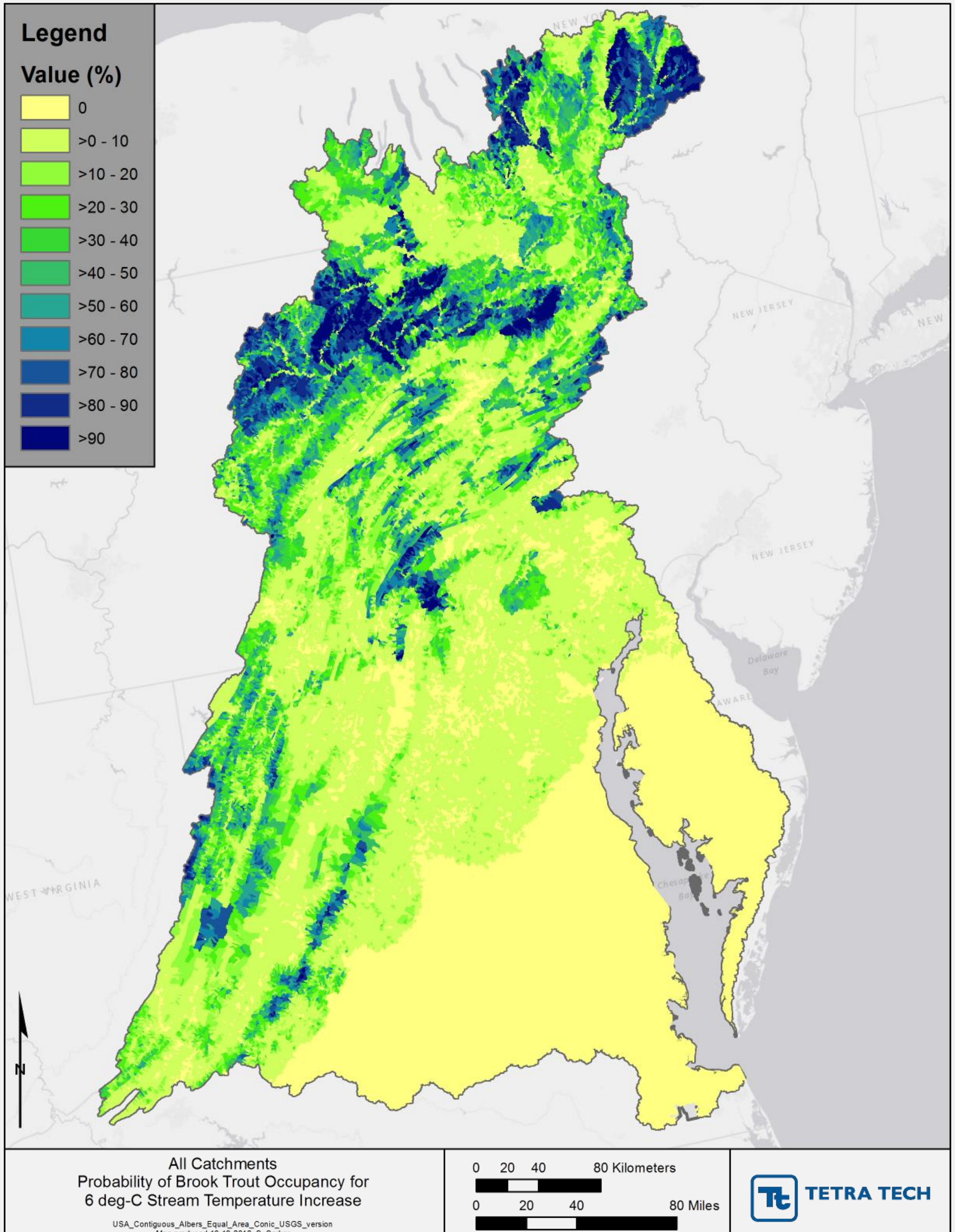
Findings:

- SPARROW provides good single metric describing N loads across the Bay watershed
- Individual source- and parameter-specific metrics from Bay Model may serve as diagnostic tools



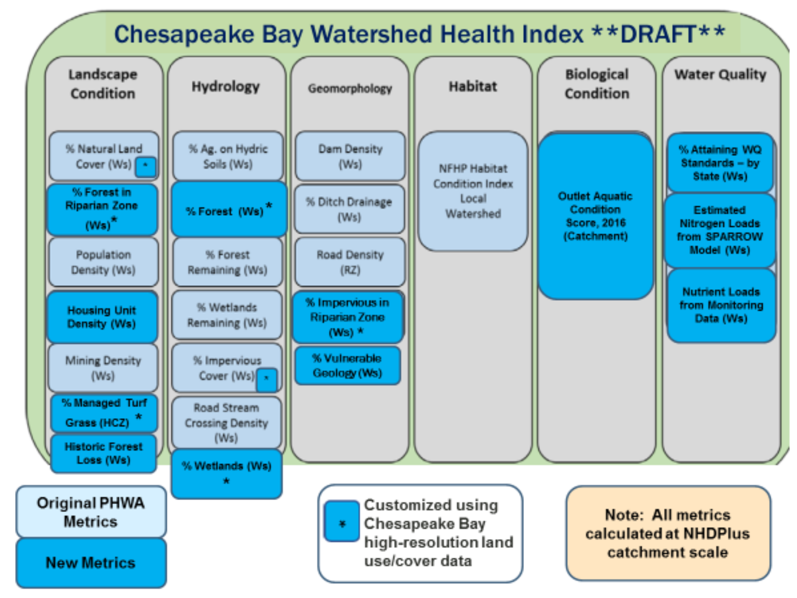
Metric Performance (Example of Vulnerability)

- Example: Brook Trout Occurrence with 6 degree C Temperature Change
- Indicative of: Climate Change
- Values calculated for entire upstream watershed area
- Metric expected to be high in healthy watersheds


Legend
Value (%)
0
>0 - 10
>10 - 20
>20 - 30
>30 - 40
>40 - 50
>50 - 60
>60 - 70
>70 - 80
>80 - 90
>90
NEW JERSEY
NEW JERSEY
Delaware Bay
WEST VIRGINIA
N
All Catchments
Probability of Brook Trout Occupancy for
6 deg-C Stream Temperature Increase
USA_Contiguous_Albers_Equal_Area_Conic_USGS_version
Map produced 10-19-2018 S. Sarkar
0 20 40 80 Kilometers
0 20 40 80 Miles
TETRA TECH

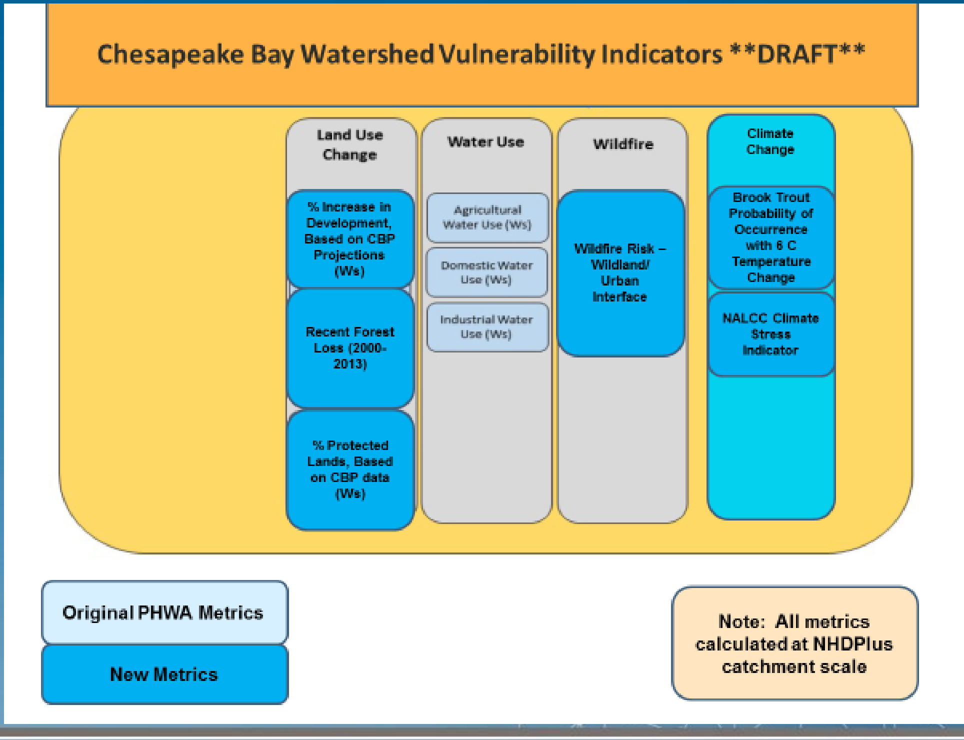
Combining Metrics into Sub-indices and Index of Watershed Health

- Normalize metric scores to 0 to 1
- Calculate mean score for each of six sub-indices (landscape condition, hydrology, geomorphology, habitat, biological condition, water quality)
- Calculate mean score – scaled from 0 to 1 – to obtain overall Index of Watershed Health



Combining Metrics into Sub-indices for Watershed Vulnerability

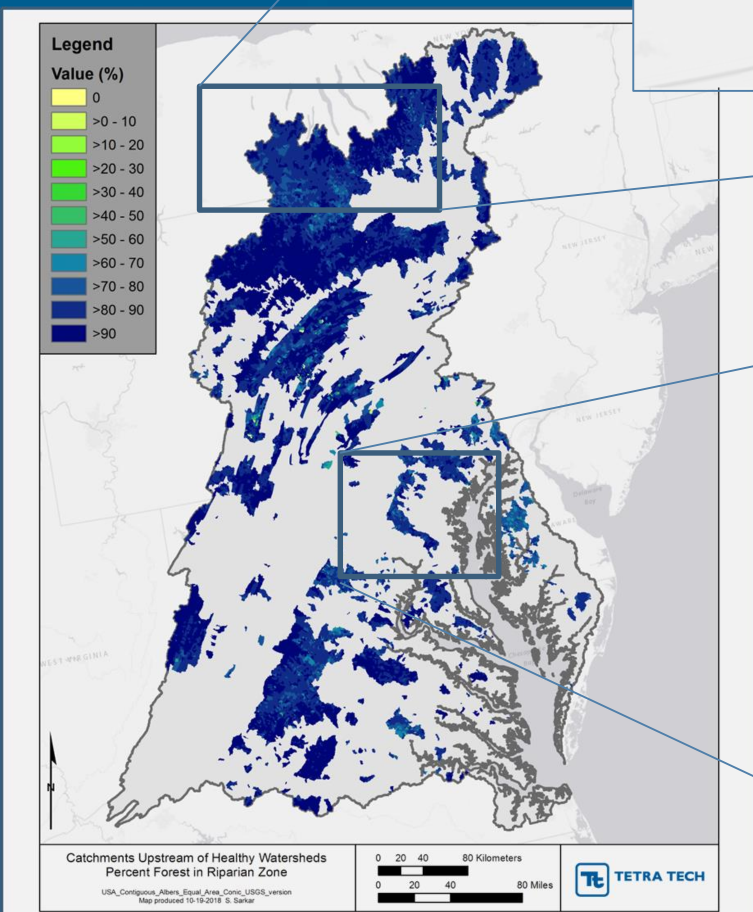
- Normalize metric scores to 0 to 1
- Calculate mean score for each of four sub-indices (land use change, water use, wildfire risk, climate change)

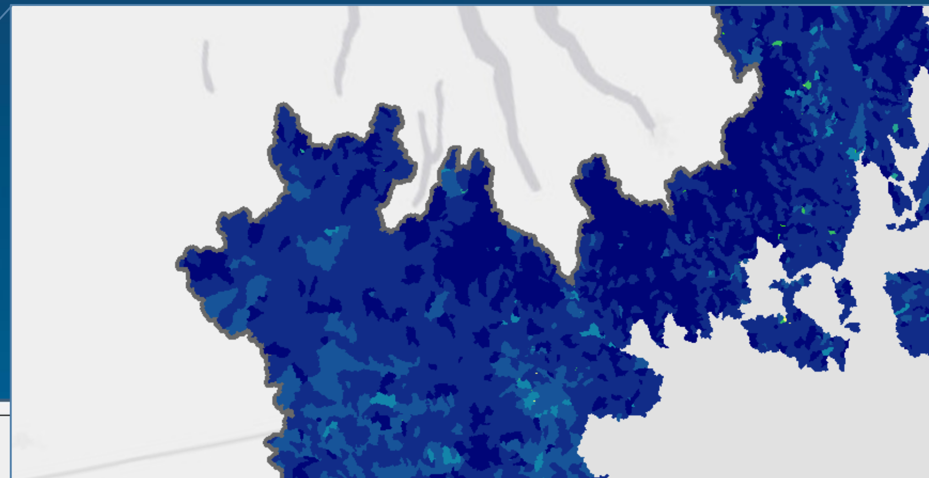


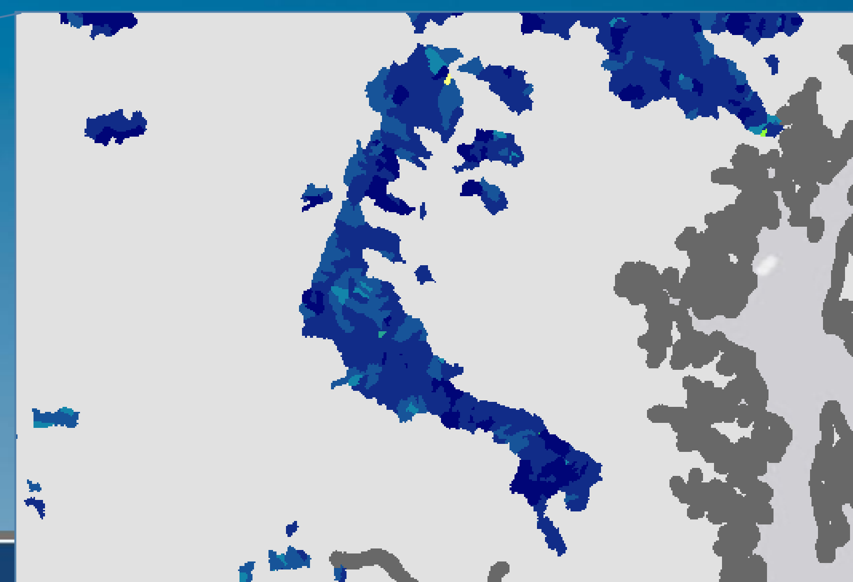
Applications of Chesapeake Bay Healthy Watershed Assessment

- Bay-wide and state-specific assessments of the condition of CB Healthy Watersheds
- Understand vulnerability of the CB Healthy Watersheds
- Assess conditions to inform watershed management efforts for particular CB Healthy Watersheds
- Future tracking

Assess Conditions to Inform Watershed Management Efforts







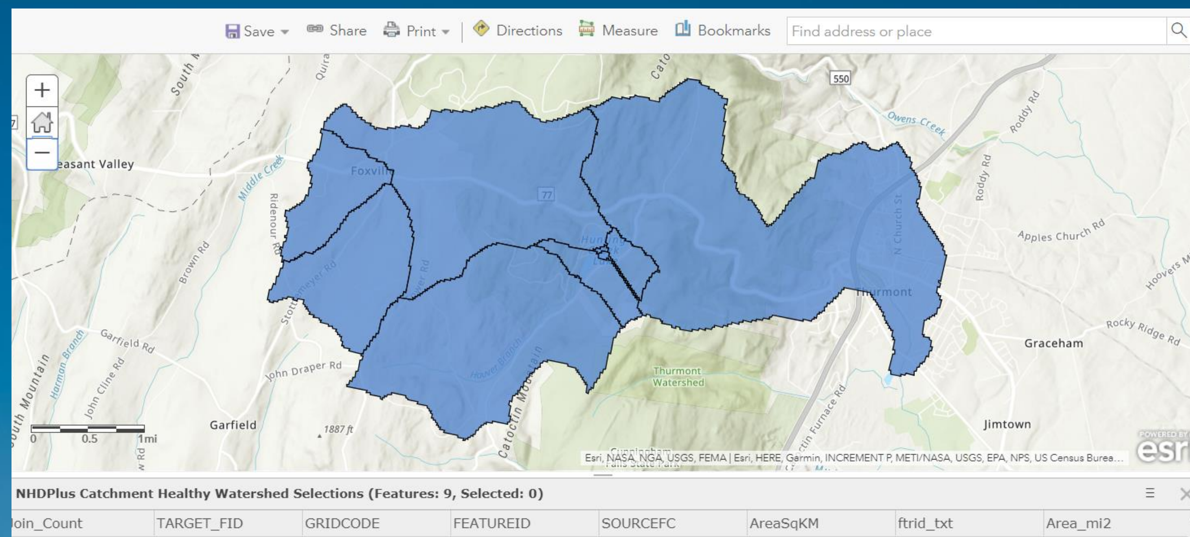
TETRA TECH

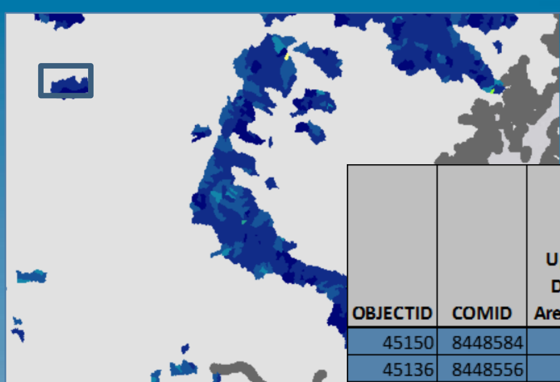
Assess Conditions to Inform Watershed Management Efforts

Provide suite of Healthy Watershed metrics and indicators for future data visualization and analysis

Example: Hunting Creek near Thurmont, MD

- 1 CB Healthy Watershed, containing 9 NHDPlus catchments





OBJECTID	COMID	Total Upstream Drainage Area (sq km)	Aquatic Condition Index	Road Density (Cs)	Road Density (Ws)	Road/Stream Crossings (Ws)	Housing Unit Density 2010 (Ws)	Population Density 2010 (Ws)	Impervious (Cs)	Impervious (Ws)	Impervious RZ (Cs)	Impervi RZ (W
45150	8448584	29.5938	0.6538	5.3470	3.5362	0.4731	0.0041	0.0045	0.0891	0.0111	0.4883	0.
45136	8448556	10.4337	0.7589	3.2747	2.8520	0.4792	0.0011	0.0012	0.0280	0.0141	0.3968	0.
45139	8448562	6.9849	0.8106	4.5346	1.7741	0.2863	0.0011	0.0012	0.0023	0.0235	0.1700	0.
45149	8448582	6.3117	0.8198	1.5082	1.5082	0.3169	0.0011	0.0012	0.0220	0.0220	0.2945	0.
45388	8449076	1.4373	0.6660	2.2839	2.2839	0.6957	0.0011	0.0012	0.0415	0.0415	0.4069	0.
45389	8449078	2.6784	0.7116	2.6806	2.6806	0.7467	0.0011	0.0012	0.0326	0.0326	0.3932	0.
45419	8449144	17.7921	0.8604	2.3465	2.4658	0.3934	0.0011	0.0012	0.0108	0.0182	0.3303	0.
45420	8449146	10.4481	0.8853	4.5346	2.8538	0.4786	0.0011	0.0012	0.0118	0.0310	0.2125	0.
45421	8449150	6.9516	0.7945	4.1690	1.7659	0.2877	0.0011	0.0012	0.0391	0.0036	0.5096	0.

Tracking Conditions in Healthy Watersheds in the Future

TETRA TECH

- **Updates to Source Data**
  - CBP high-resolution land use/land cover data - future iterations
  - StreamCat – will be updated as new data become available (e.g.: 2020 census data and every 10 years beyond)
  - LANDFIRE - periodic updates - next version 2020
  - State data - updates available with 303(d) reports, every 2 years

Tracking Conditions in Healthy Watersheds in the Future

- **New metrics under development**
  - Chesapeake B-IBI (Chessie B-IBI) and current efforts to extrapolate from point data and apply areawide; model-based estimates for unsampled watersheds - CBP Stream Health Workgroup
  - Fish Habitat indicator development – CBP Sustainable Fisheries and Habitat Goal Implementation Teams
  - Climate Change indicator development – CBP Climate Resiliency

Questions/Discussion

TETRA TECH

TETRA TECH

Preliminary Healthy Watershed Assessment (PHWA) in the Chesapeake Bay Watershed

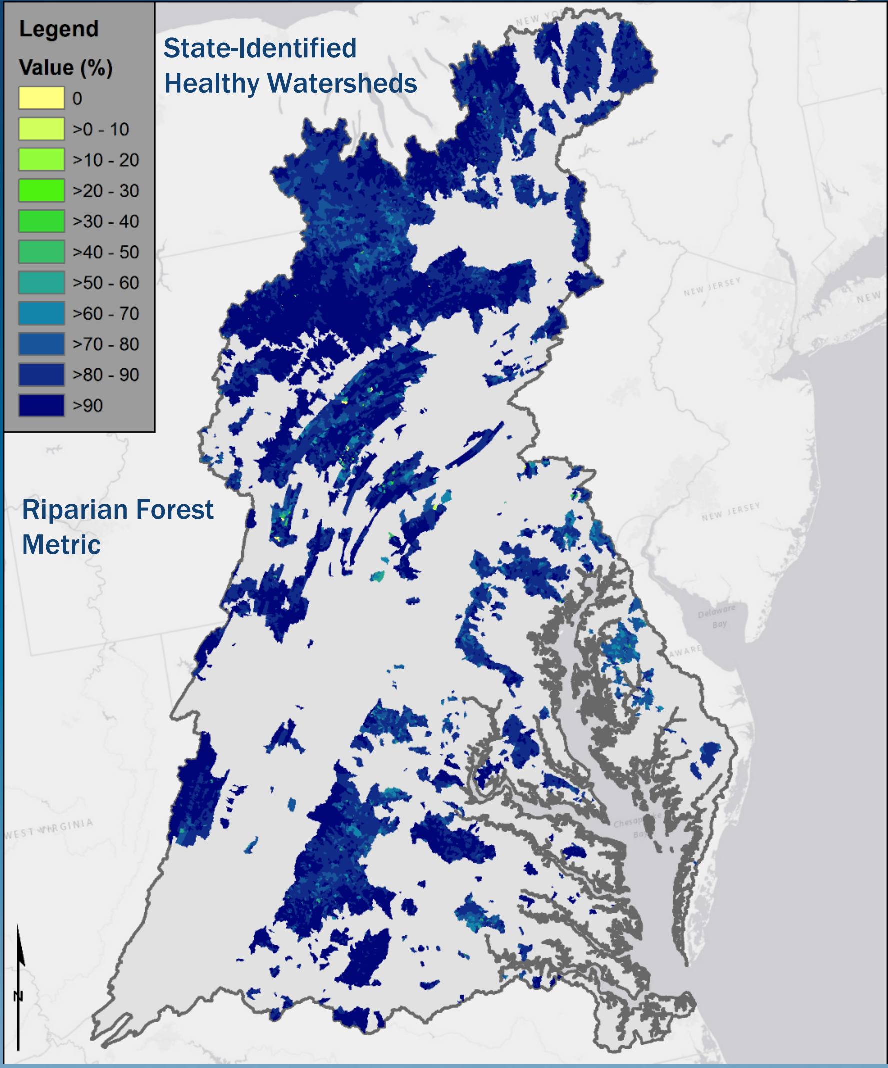
Tetra Tech Team:

Nancy Roth

Christopher Wharton

Sam Sarkar

Brian Pickard



Healthy Watersheds Goal Implementation Team Meeting

June 2019

Background

- Chesapeake Bay Program (CBP) Healthy Watersheds Goal Implementation Team identified need for quantitative indicators to support watershed assessment and management
- U.S. Environmental Protection Agency (EPA) Preliminary Healthy Watershed Assessment (PHWA) as framework

Project Overview

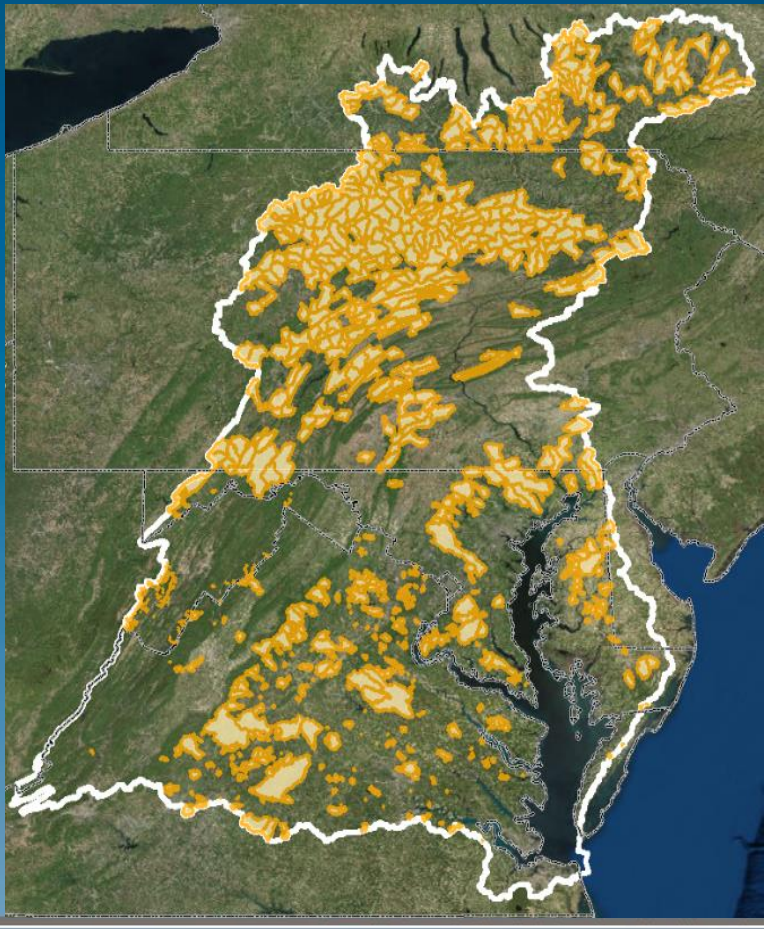
- **Apply and adapt EPA's Preliminary Healthy Watersheds Assessment framework to**
  - Assess current condition of state-identified Healthy Watersheds
  - Develop an approach for future tracking of condition
  - Assess vulnerabilities of these watersheds
- **Provide data that will help inform watershed management activities that best support the maintenance of watershed health**

Management Goals and Outcome

Goal: Sustain state-identified healthy waters and watersheds recognized for their high quality and/or high ecological value

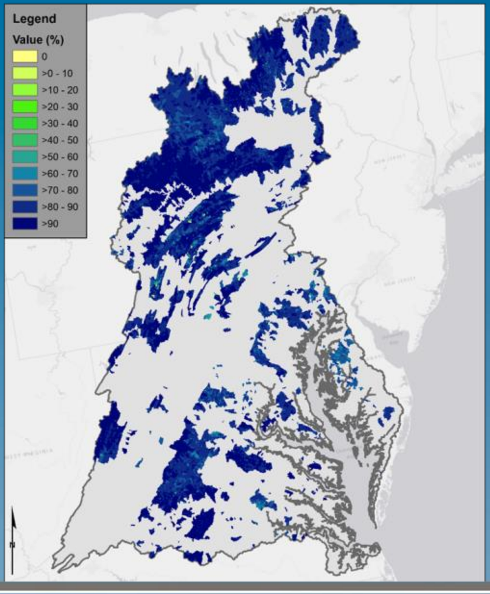
Target Outcome: 100 percent of state-identified currently healthy waters and watersheds remain healthy

- CBP Healthy Watersheds Outcome Management Strategy, 2018



Today's Presentation

- Adapting the PHWA approach and addressing scale
- Indicators of watershed condition
- Indicators of watershed vulnerability
- Data visualization and access to data



Today's Presentation

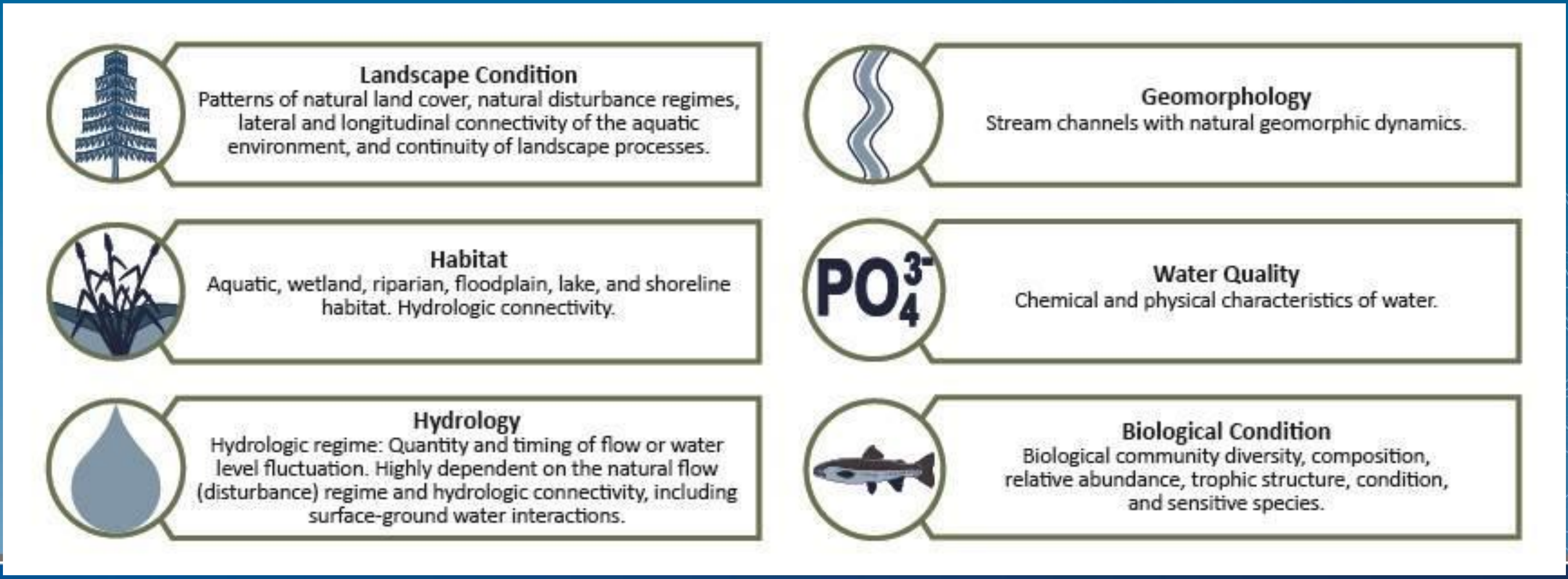
- Adapting the PHWA approach and addressing scale
- Indicators of watershed condition
- Indicators of watershed vulnerability
- Data visualization and access to data

TETRA TECH

Assessing Watershed Health

PHWA employs metrics in six categories:

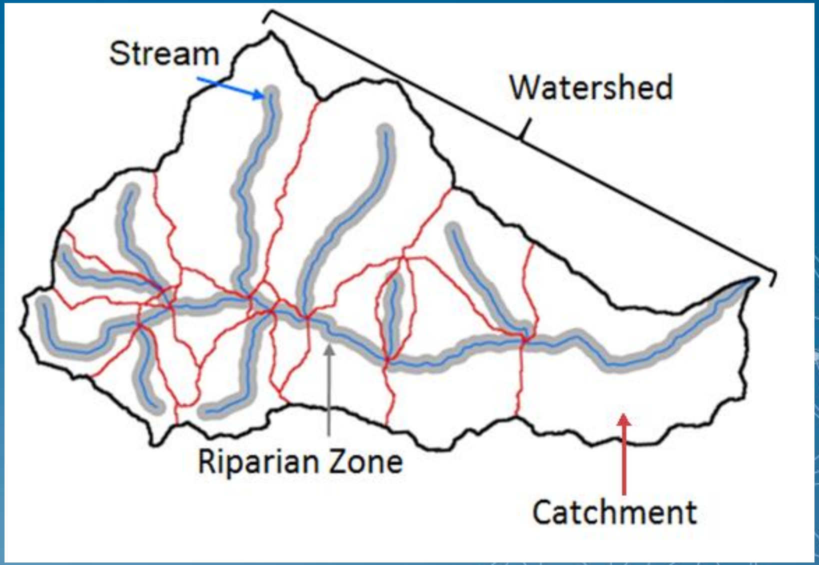
- Landscape condition
- Habitat
- Hydrology
- Geomorphology
- Water quality
- Biological condition



EPA Office of Water, Healthy Watersheds Program, March 2017

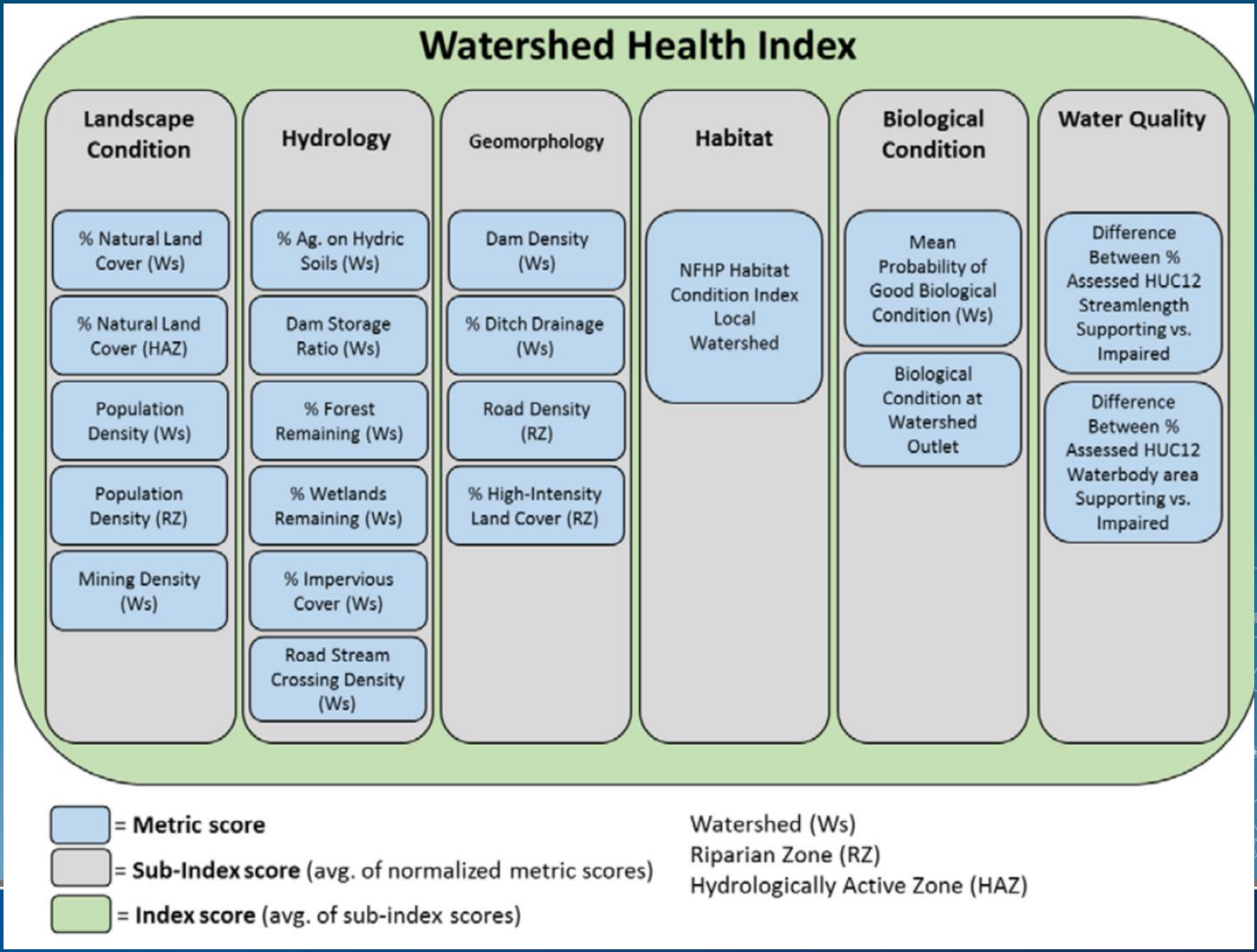
Healthy Watersheds: Catchment- and Watershed-Scale Metrics

- "Catchment" - Local catchment condition
- "Watershed" - Cumulative condition over entire watershed upstream of outlet
- Most Chesapeake Bay candidate metrics were calculated as watershed-scale metrics, reflecting influence of entire upstream watershed
  - Ex: Percent Impervious Cover in Watershed
- A few at catchment scale only
  - Ex: Aquatic Biological Condition at Outlet
- Some for riparian zone only: the corridor of land within 100 meters of stream



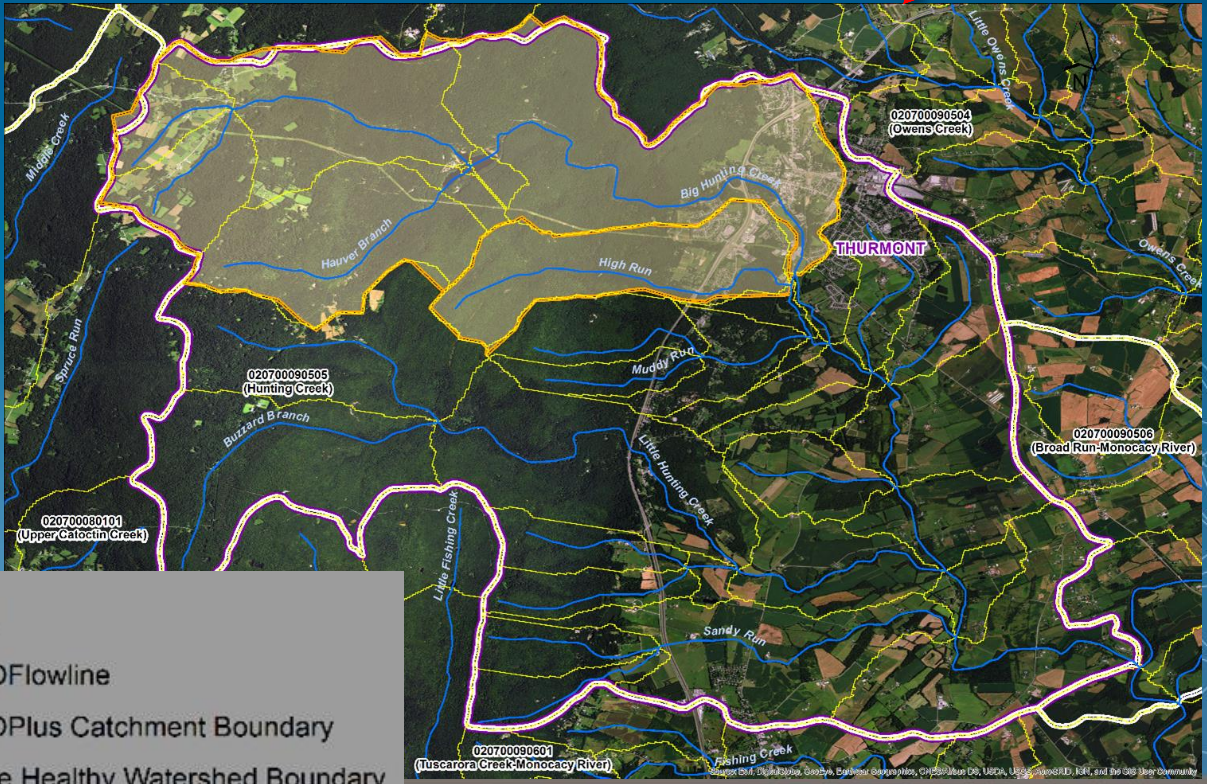
Modified from EPA StreamCat

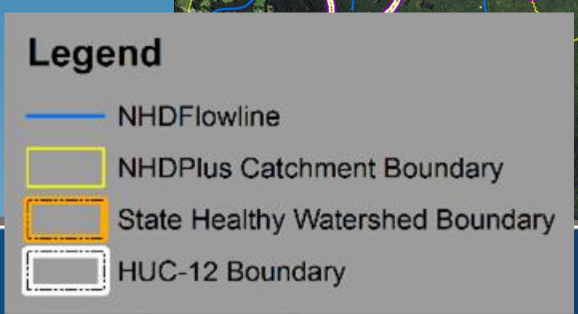
PHWA Metrics – Watershed Health



Addressing Watershed Scale

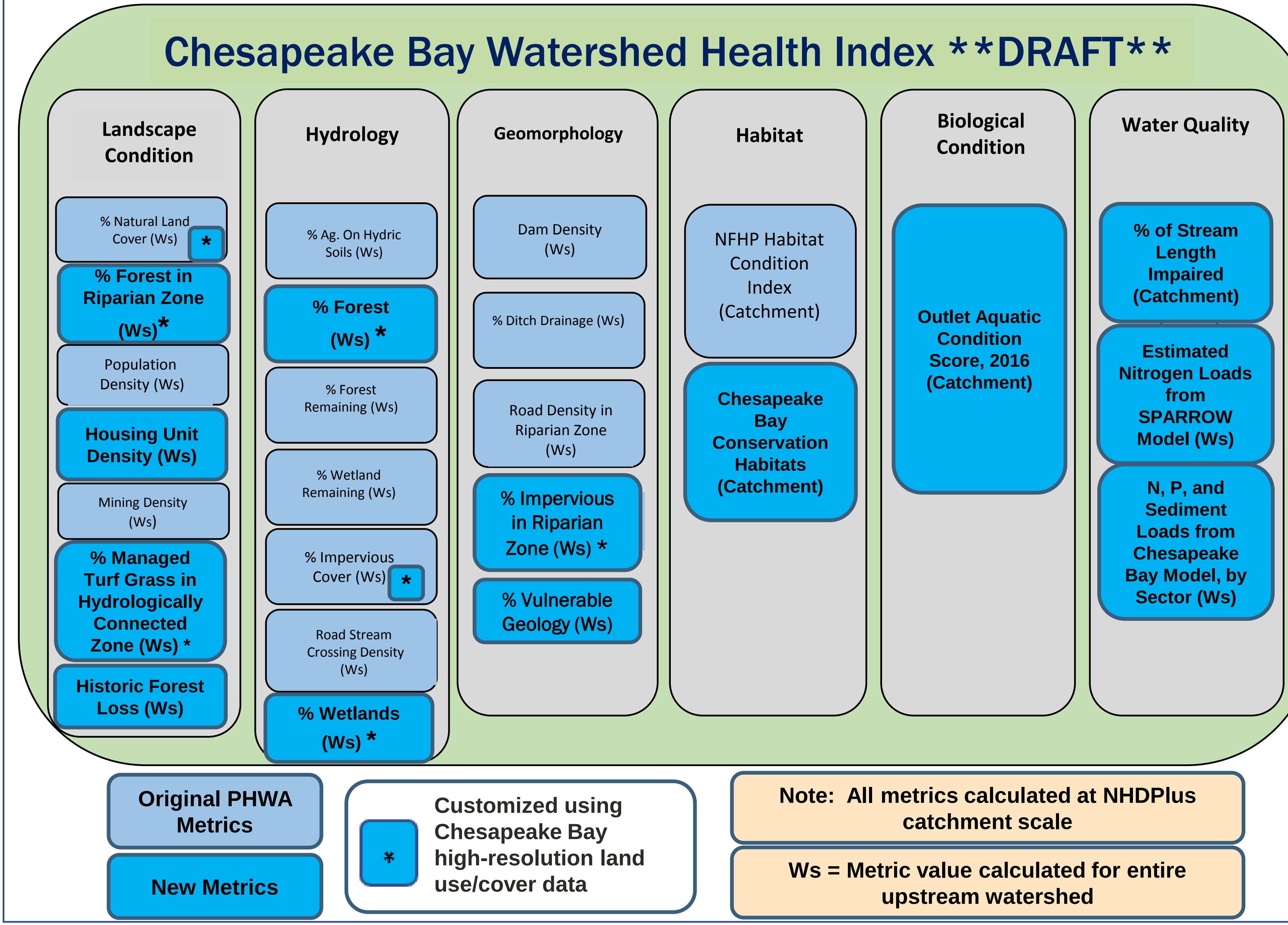
- PHWA developed nationally to provide data at HUC12 scale; this regional application required finer scale
- Developed metrics at NHDPlus catchment scale
- Calculated for all 83,623 catchments in Chesapeake watershed (average area ~2 km^2)





Today's Presentation

- Adapting the PHWA approach and addressing scale
- Indicators of watershed condition
- Indicators of watershed vulnerability
- Data visualization and access to data

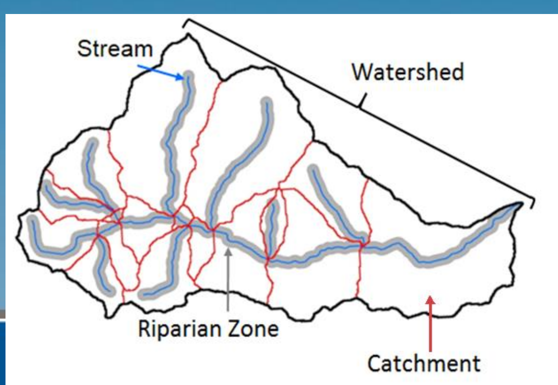

Chesapeake Bay Watershed Health Index **DRAFT**
Landscape Condition
% Natural Land Cover (Ws) *
% Forest in Riparian Zone (Ws)*
Population Density (Ws)
Housing Unit Density (Ws)
Mining Density (Ws)
% Managed Turf Grass in Hydrologically Connected Zone (Ws) *
Historic Forest Loss (Ws)
Hydrology
% Ag. On Hydric Soils (Ws)
% Forest (Ws) *
% Forest Remaining (Ws)
% Wetland Remaining (Ws)
% Impervious Cover (Ws) *
Road Stream Crossing Density (Ws)
% Wetlands (Ws) *
Geomorphology
Dam Density (Ws)
% Ditch Drainage (Ws)
Road Density in Riparian Zone (Ws)
% Impervious in Riparian Zone (Ws) *
% Vulnerable Geology (Ws)
Habitat
NFHP Habitat Condition Index (Catchment)
Chesapeake Bay Conservation Habitats (Catchment)
Biological Condition
Outlet Aquatic Condition Score, 2016 (Catchment)
Water Quality
% of Stream Length Impaired (Catchment)
Estimated Nitrogen Loads from SPARROW Model (Ws)
N, P, and Sediment Loads from Chesapeake Bay Model, by Sector (Ws)
Original PHWA Metrics
New Metrics
* Customized using Chesapeake Bay high-resolution land use/cover data
Note: All metrics calculated at NHDPlus catchment scale
Ws = Metric value calculated for entire upstream watershed

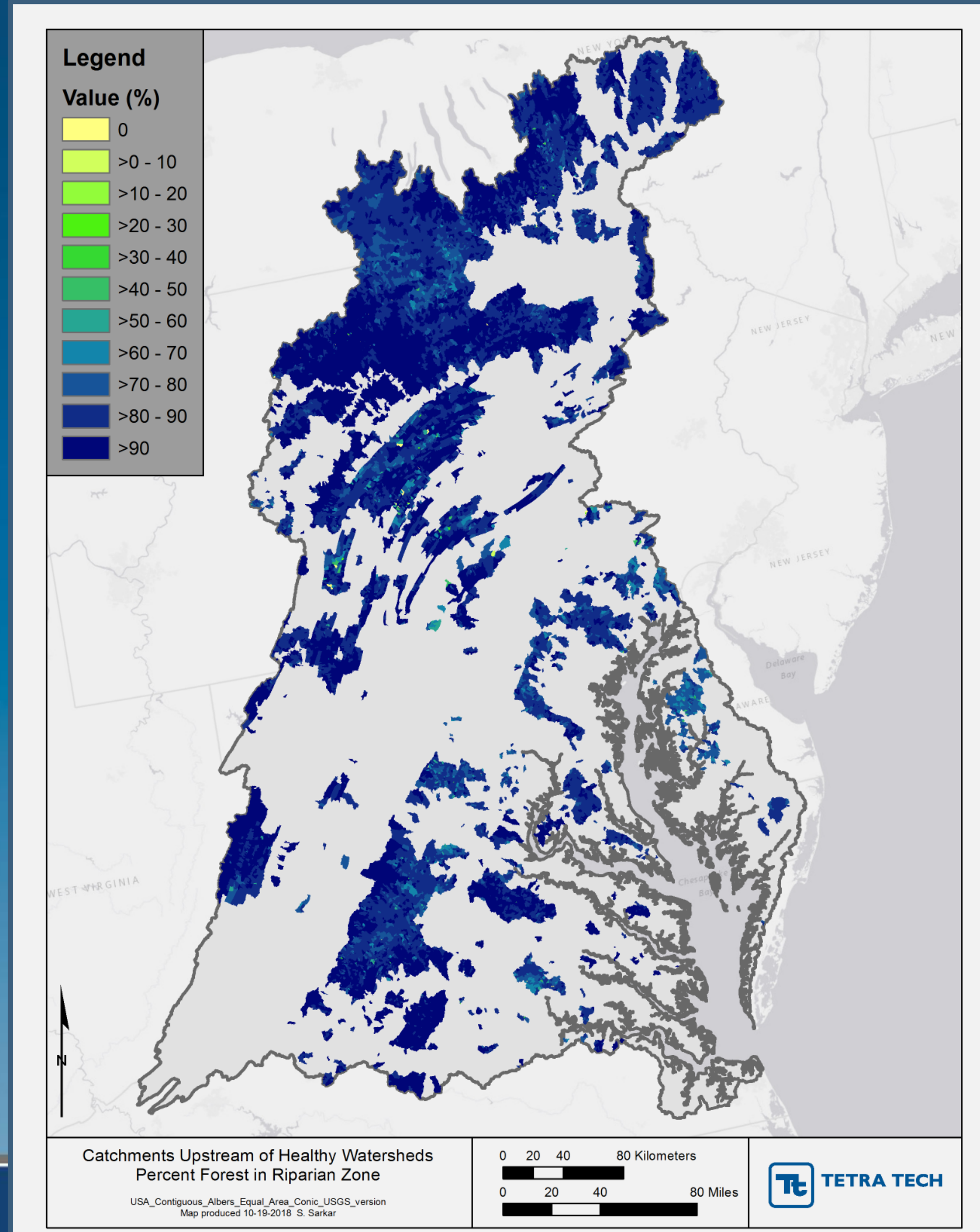
Data Sources

- For use Bay-wide, sought data that would provide consistent, wall-to-wall coverage
- Needed data at catchment or finer-scale resolution
- Derived several key indicators from recent high-resolution Chesapeake Bay land use/land cover data developed by CBP and partners
- Where possible, leveraged other geospatial data from regional sources, for example:
  - EPA StreamCat
  - National Fish Habitat Partnership
  - Chesapeake Bay model for nutrient loads
  - North Atlantic Landscape Conservation Cooperative
  - LandScope/Nature's Network

Metric Performance Example

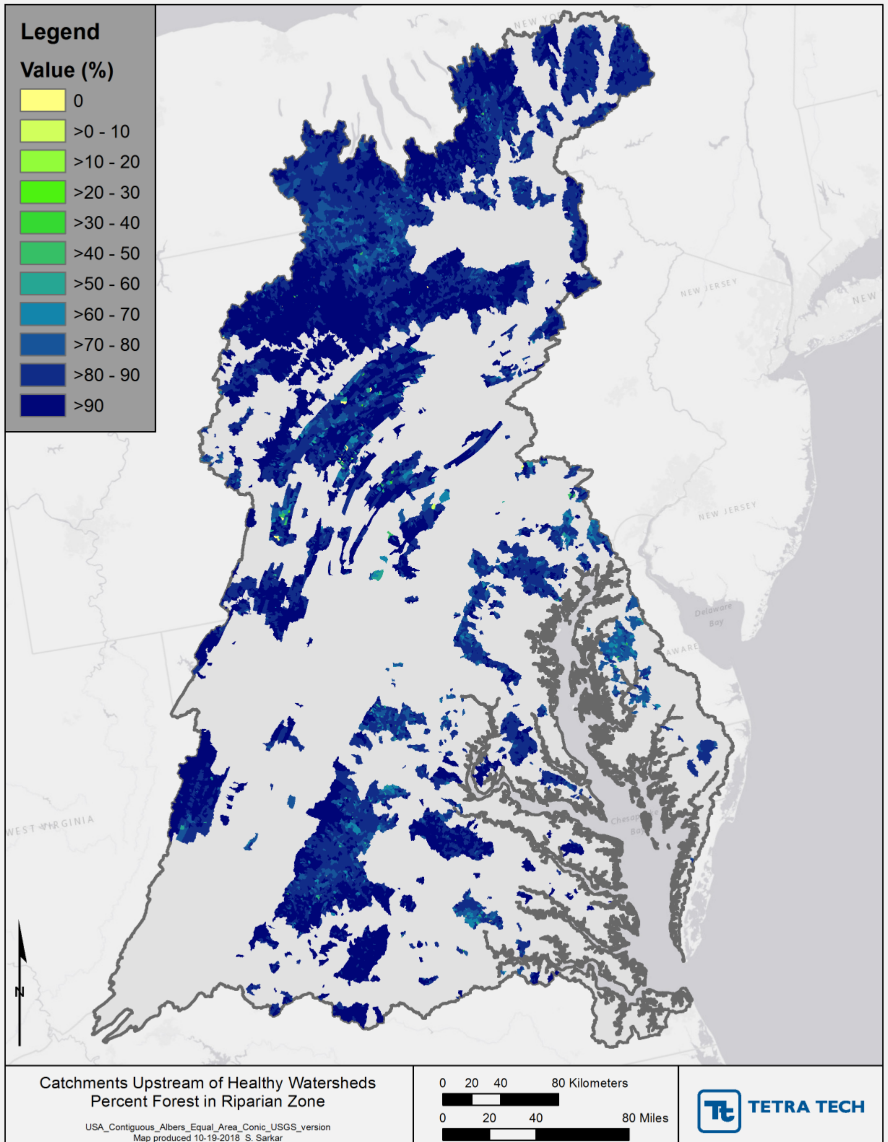
- Example: <u>Percent Forest in Riparian Zone</u>
- Indicative of: <u>Landscape</u> condition
- Value calculated for riparian zone in entire upstream watershed
- Metric expected to be <u>high</u> in healthy watersheds

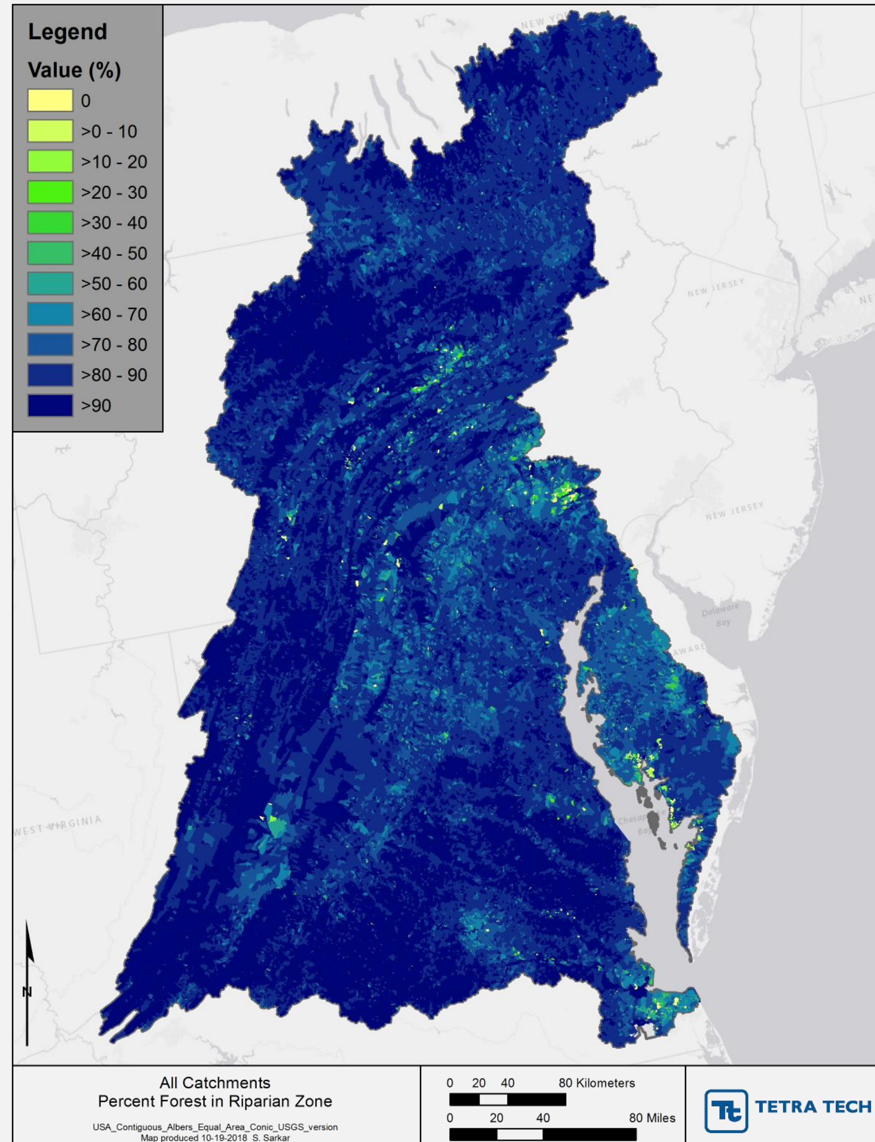




Metric Performance

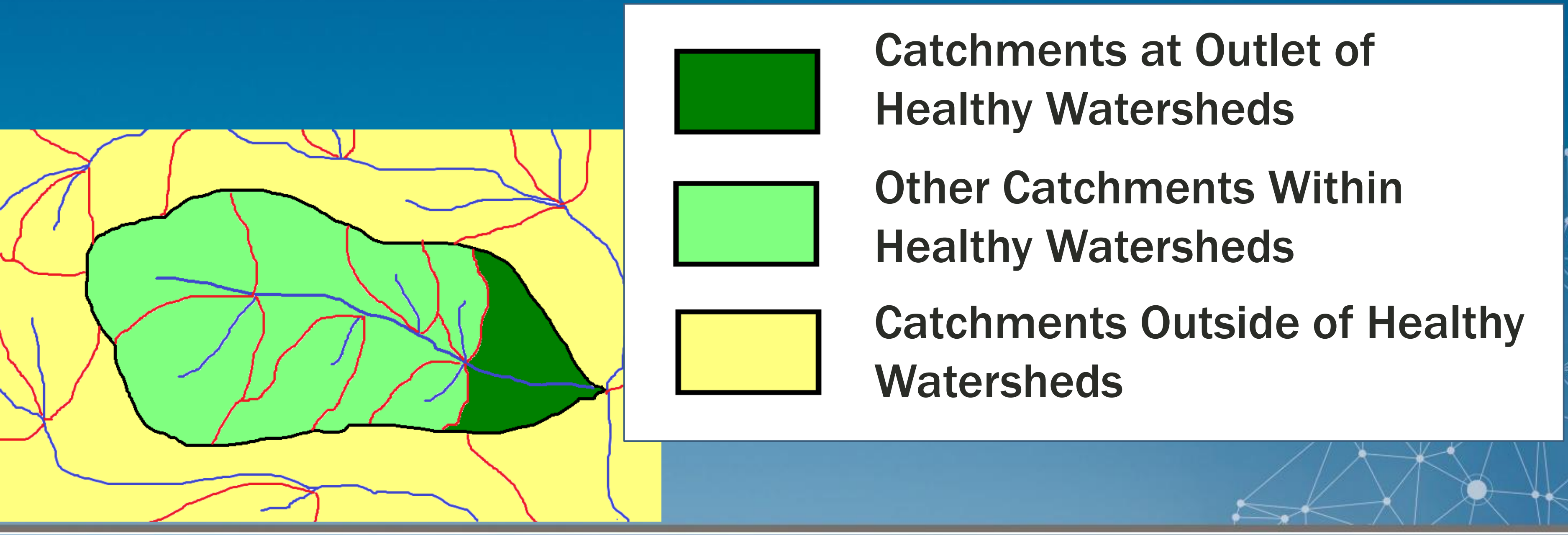
- Example: <u>Percent Forest in Riparian Zone</u>

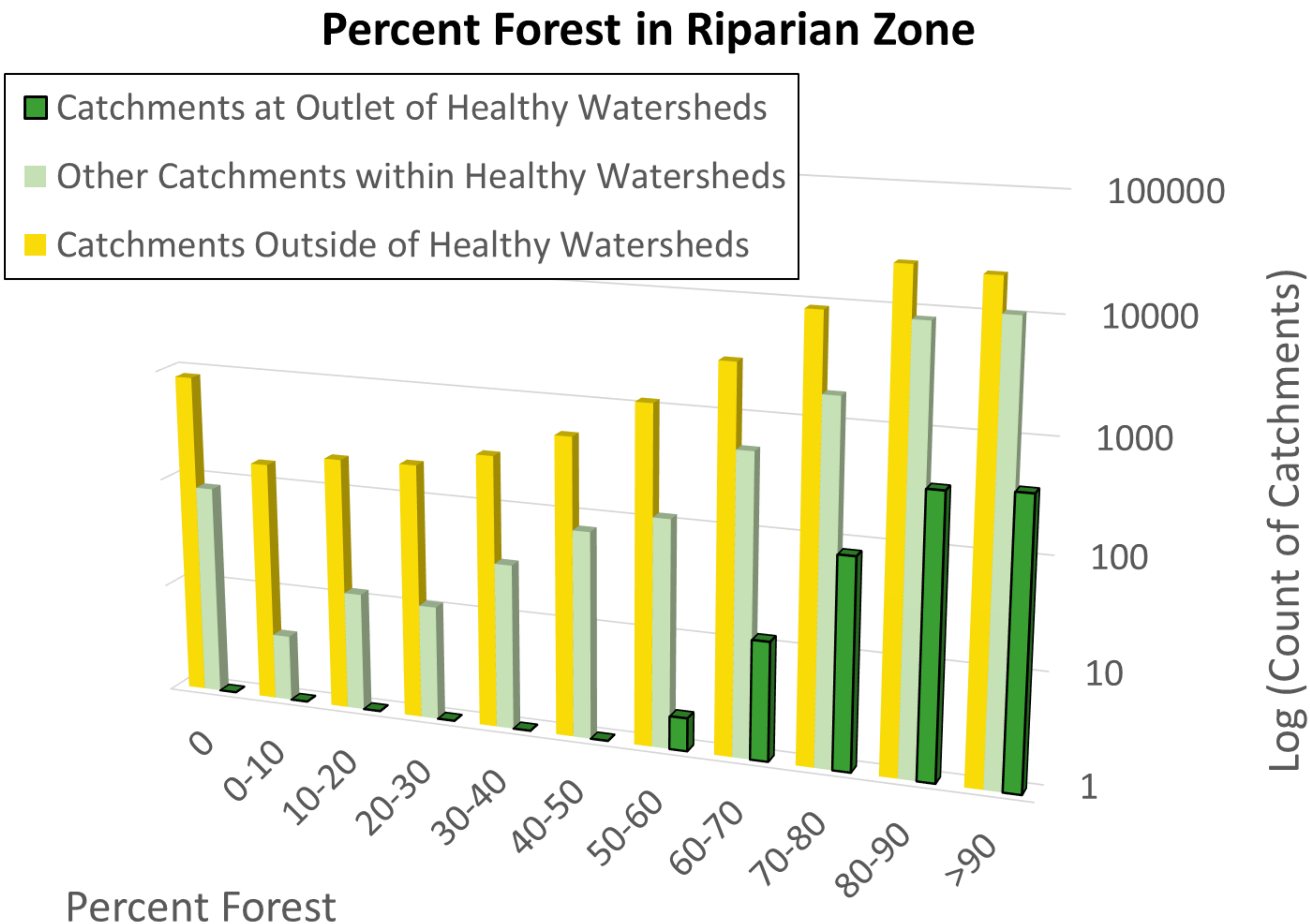




Evaluating Metric Performance

- Appropriateness of data scale and completeness
- Distributions of scores for healthy watersheds
- Comparison with distribution of scores for areas outside of healthy watersheds





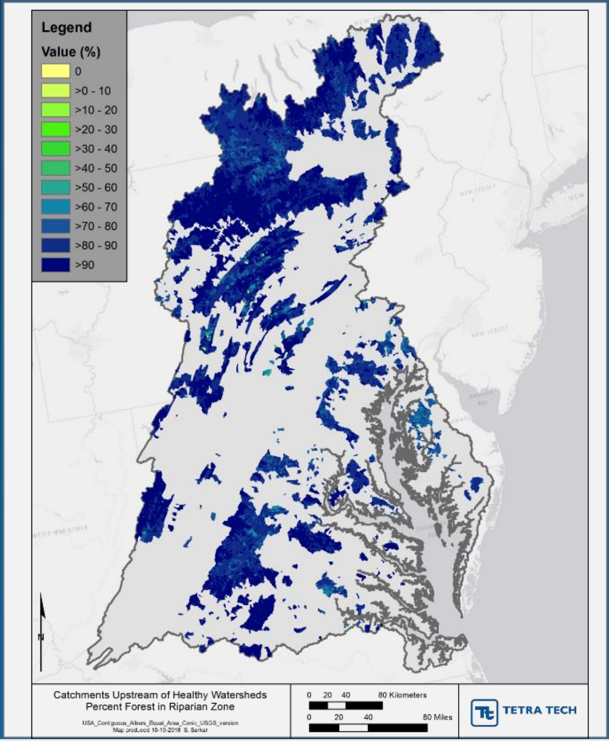
Percent Forest in Riparian Zone
Catchments at Outlet of Healthy Watersheds
Other Catchments within Healthy Watersheds
Catchments Outside of Healthy Watersheds
100000
10000
1000
100
10
1
Log (Count of Catchments)
0
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
>90
Percent Forest

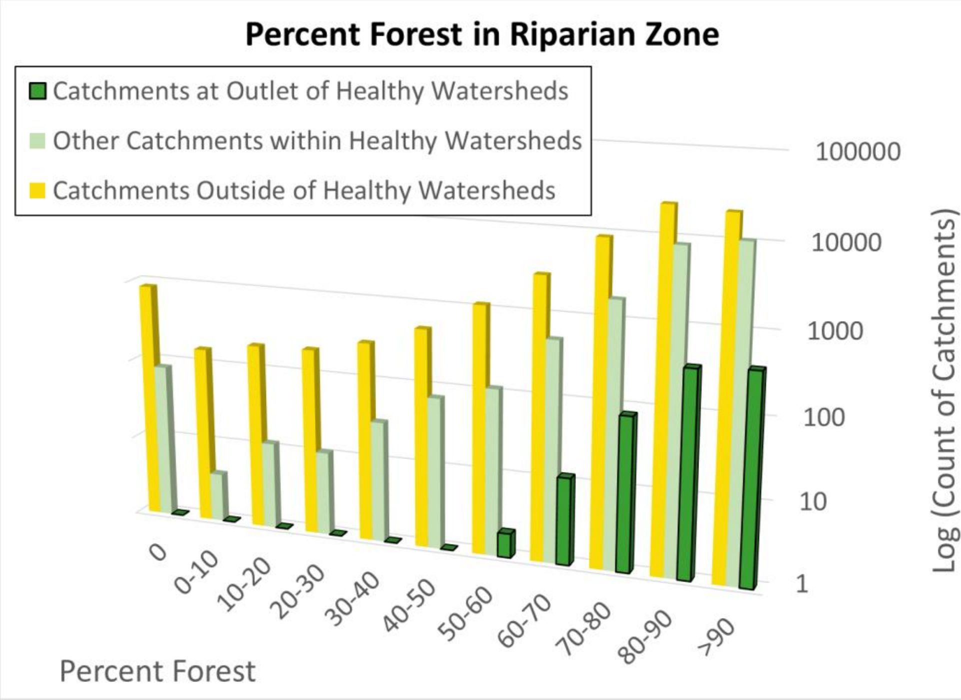
Metric Performance

- Example: Percent Forest in Riparian Zone
- Indicative of: Landscape condition
- Value calculated for entire upstream riparian zone
- Metric expected to be high in healthy watersheds

Findings:

- As expected, values for percent riparian forest are high in the Chesapeake Bay (CB) Healthy Watersheds, all with >50% forest in riparian zone



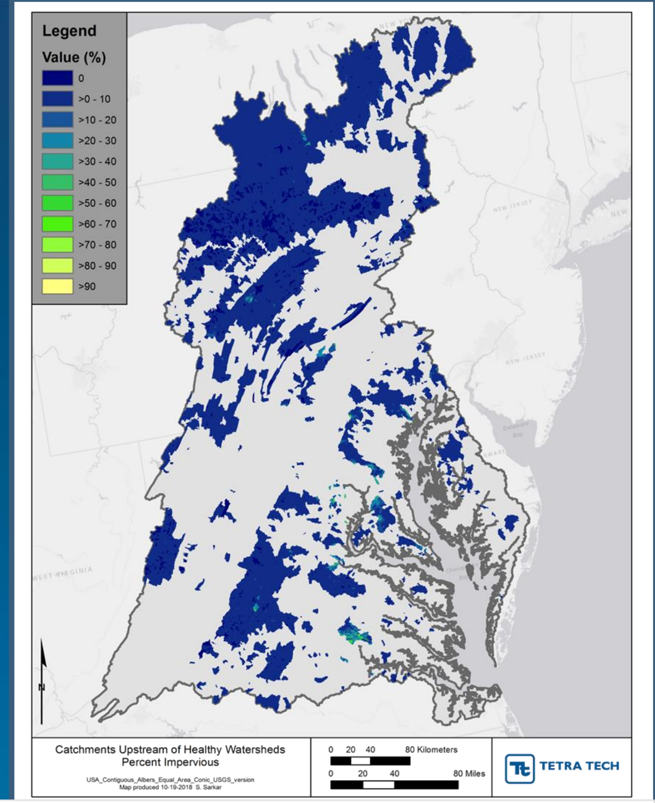


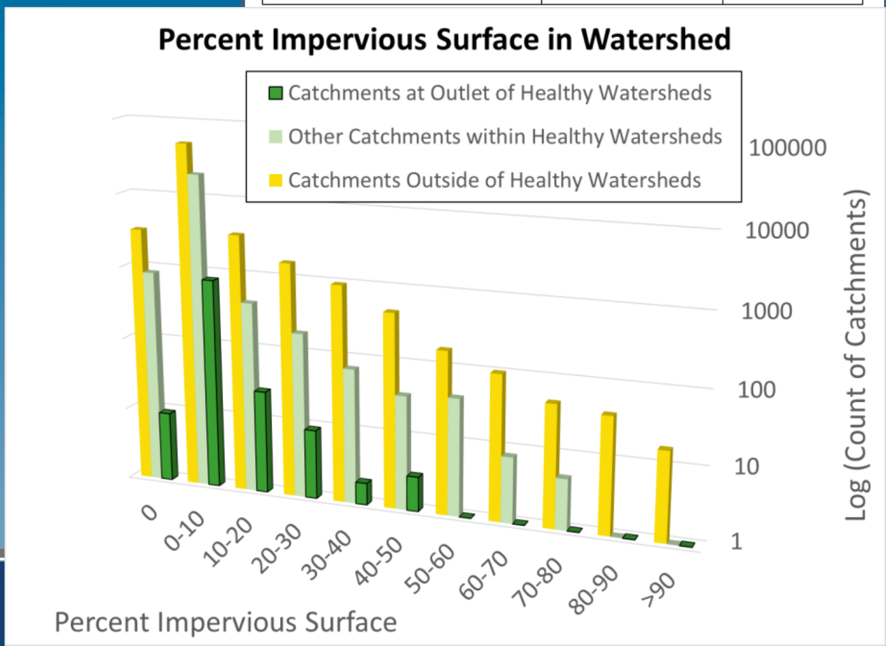
Metric Performance

- Example: Percent Impervious Surface Cover in Watershed
- Indicative of: Hydrologic condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

Findings:

- Impervious cover is generally low in CB Healthy Watersheds, many with <10% or <20% impervious cover
- Some with 20-50% impervious cover, levels that may lead to degradation



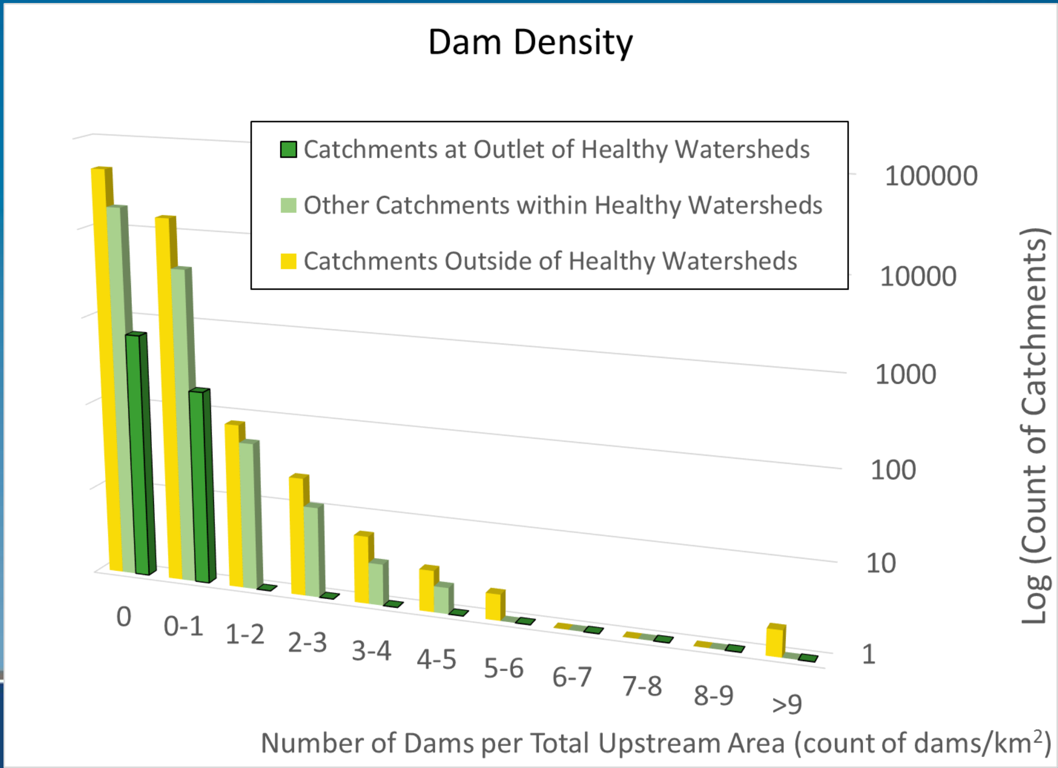


Metric Performance

- Example: Dam Density in Watershed
- Indicative of: Geomorphic condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

Findings:

- Dam density low in CB Healthy Watersheds; 0 to 1 dam per km^2
- Many zero values

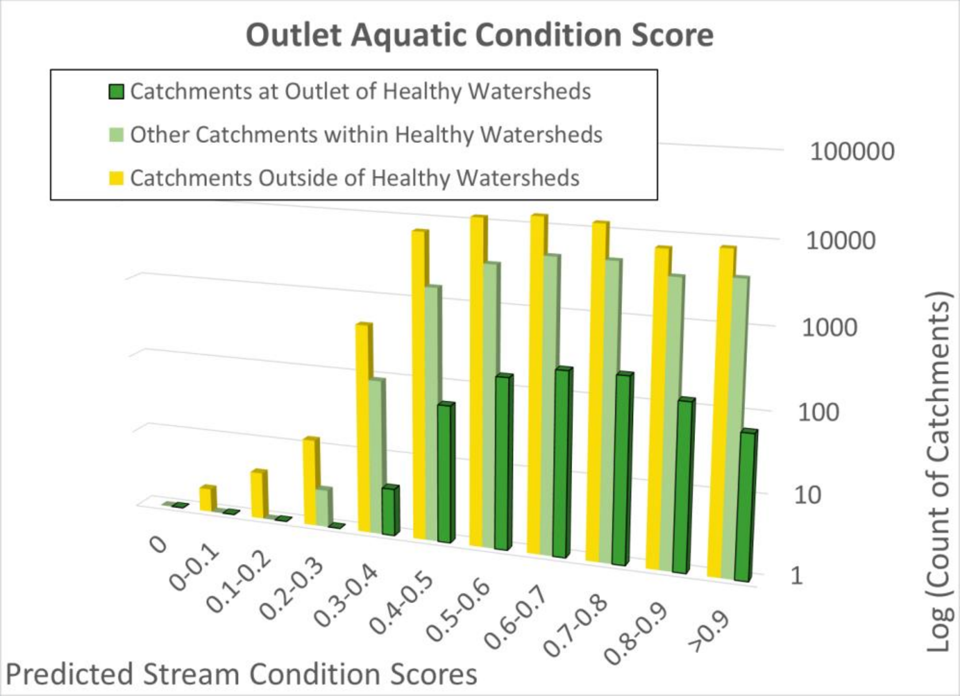


Metric Performance

- Example: Aquatic Condition Score
- Indicative of: Biological condition
- Value calculated for catchment at healthy watershed outlet only
- Metric expected to be high in healthy watersheds

Findings:

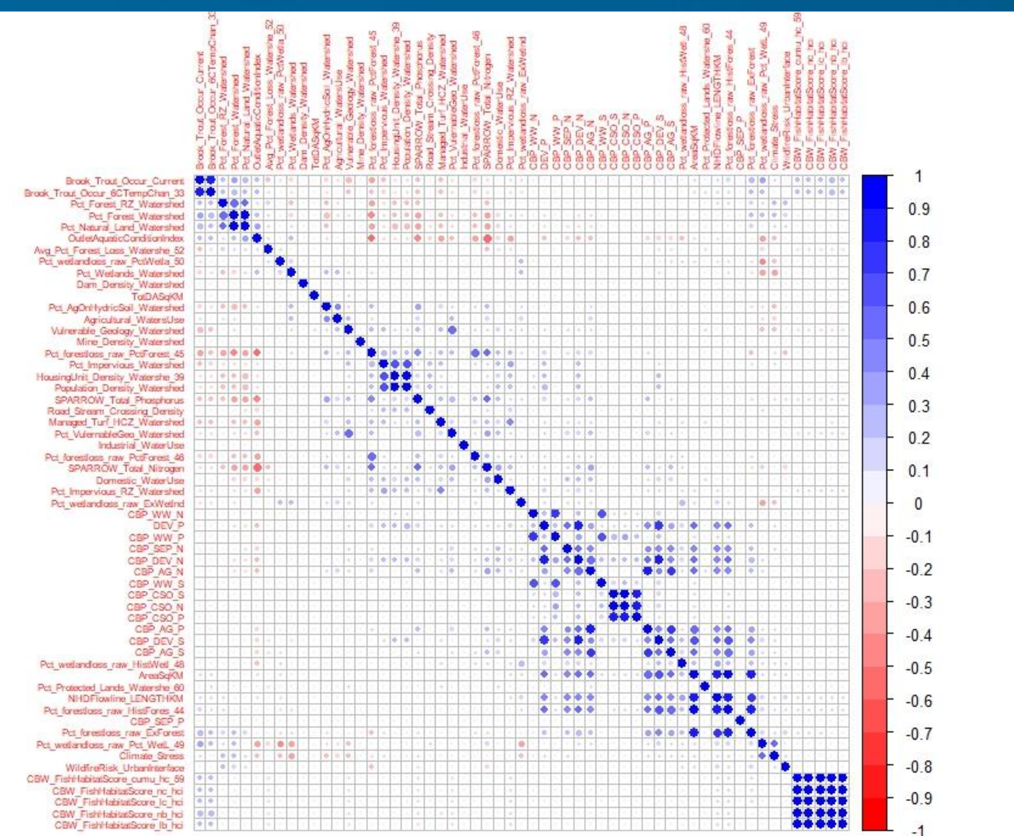
- Aquatic condition scores tend to be higher in CB Healthy Watersheds
- Current indicator provides estimates across all watersheds using national model



TETRA TECH

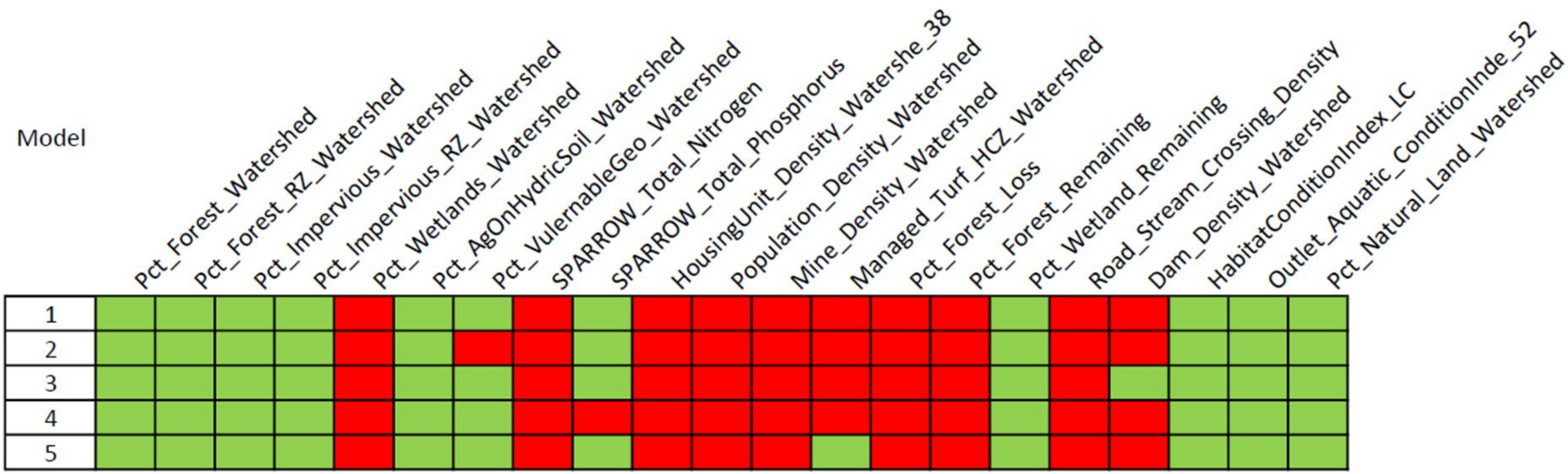
Developing an Overall Index of Watershed Health

- Assessed correlations among watershed condition metrics
- PHWA employed simple additive approach to build six subindices and one overall index
- Also testing random forest / stepwise regression approach to build index based on individual watershed condition metrics



```
Call:
glm(formula = ExistingHW ~ ., family = binomial, data = fishy)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.9625  -0.7985  -0.6189   0.8986   3.6844

Coefficients:
                                 Estimate Std. Error z value Pr(>|z|)
(Intercept)                     -2.361567   0.087448 -27.005  < 2e-16 ***
Pct_Forest_Watershed             2.847948   0.139195  20.460  < 2e-16 ***
Pct_Forest_RZ_Watershed          0.594413   0.085540   6.949 3.68e-12 ***
Pct_Impervious_Watershed        -4.232838   0.202585 -20.894  < 2e-16 ***
Pct_Impervious_RZ_Watershed     -0.506342   0.067466  -7.505 6.14e-14 ***
Pct_AgOnHydricSoil_Watershed    -4.499293   0.288726 -15.583  < 2e-16 ***
Pct_VulernableGeo_Watershed      0.119759   0.028768   4.163 3.14e-05 ***
SPARROW_Total_Phosphorus         1.003068   0.264111   3.798 0.000146 ***
Pct_Wetland_Remaining           -0.371099   0.036634 -10.130  < 2e-16 ***
HabitatConditionIndex_LC         0.404602   0.006549  61.777  < 2e-16 ***
Outlet_Aquatic_ConditionInde_52  1.074884   0.067844  15.843  < 2e-16 ***
Pct_Natural_Land_Watershed      -2.123635   0.134579 -15.780  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 97589  on 83622  degrees of freedom
Residual deviance: 87827  on 83611  degrees of freedom
AIC: 87851

Number of Fisher Scoring iterations: 5
```

Metric Contributions



Future Tracking of Watershed Health

- **Certain metrics able to be updated readily with new data**
  - Example: Land use/land cover metrics – future versions of Chesapeake Bay high-resolution data
  - Example: Metrics derived from StreamCat and EnviroAtlas – periodic updates of EPA datasets
- **New metrics under development**
  - Fish Habitat: new CBP regional fish habitat assessment under development
  - Biological condition: CBP freshwater benthic index ("Chessie BIBI"), with hybrid monitoring/modeling approach to develop baseline condition and periodic assessments to track stream health

2019…2025…2030…2040…2050…

Today's Presentation

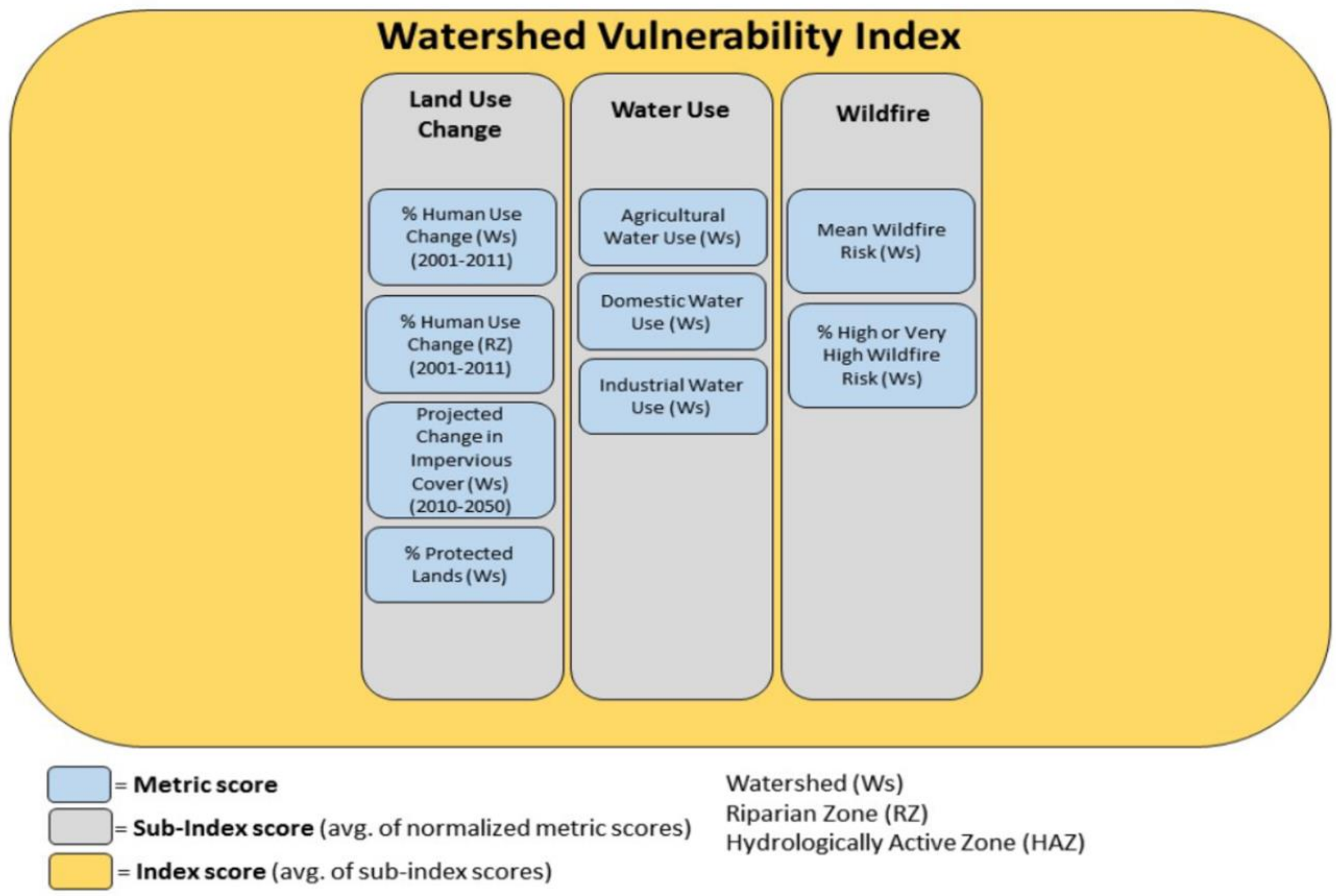
- Adapting the PHWA approach and addressing scale
- Indicators of watershed condition
- Indicators of watershed vulnerability
- Data visualization and access to data

Indicators of Watershed Vulnerability

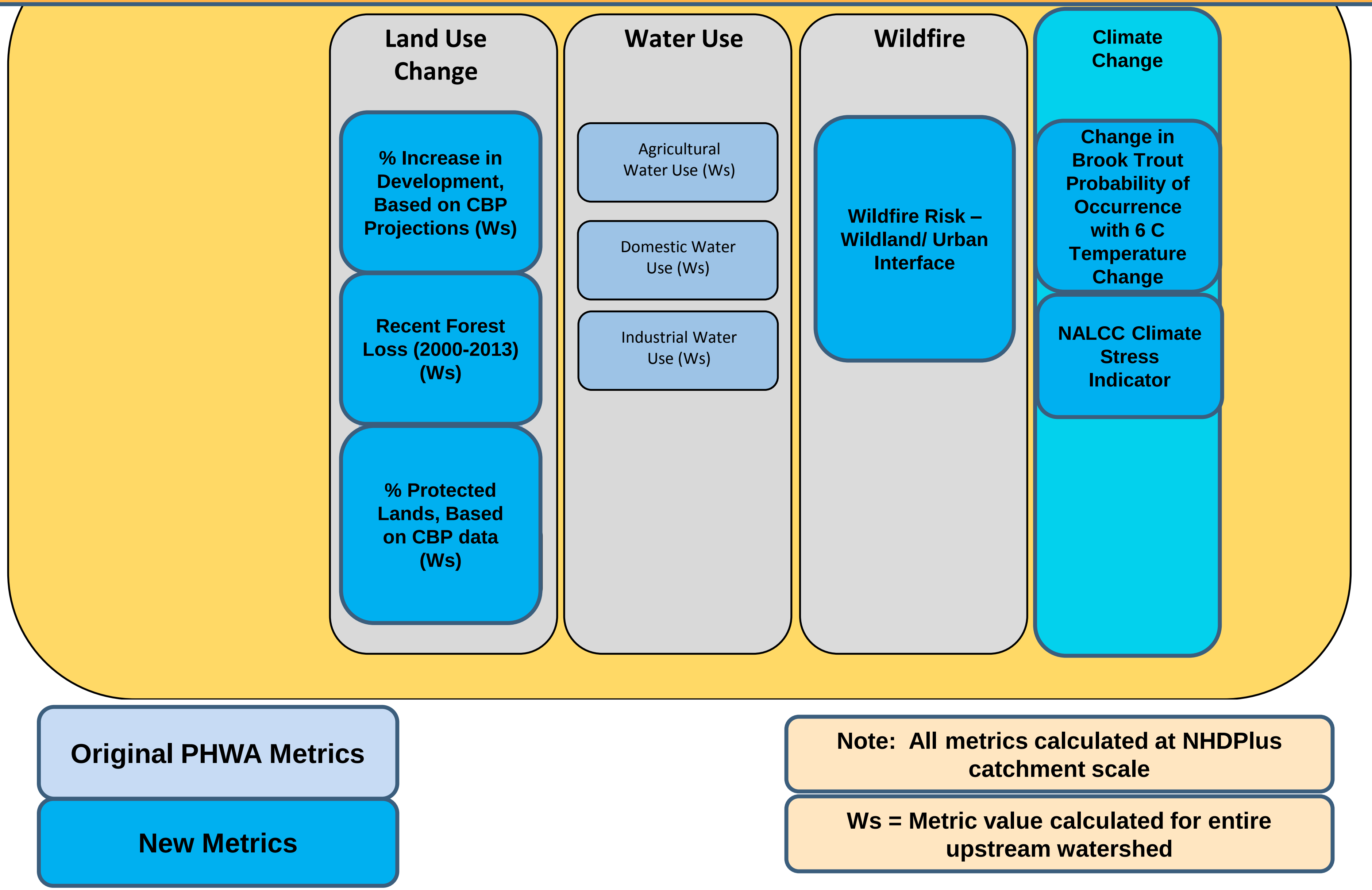
- **Important to consider stressors that affect healthy watersheds or result in future degradation, such as:**
  - Future development
  - Forest loss
  - Extent of land protection
  - Water use
  - Wildfire risk
  - Climate change

PHWA Metrics – Watershed Vulnerability

TETRA TECH



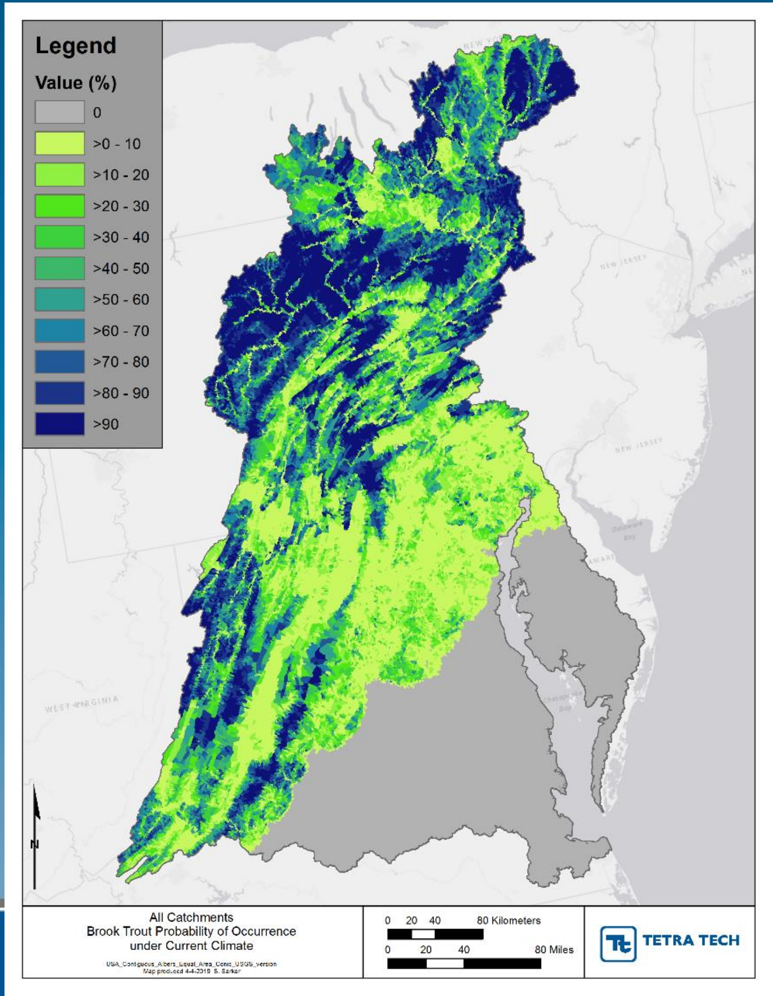
Chesapeake Bay Watershed Vulnerability Indicators **DRAFT**



Vulnerability to Climate Change

- Example: <u>Brook Trout Probability of Occurrence</u>

Current climate condition



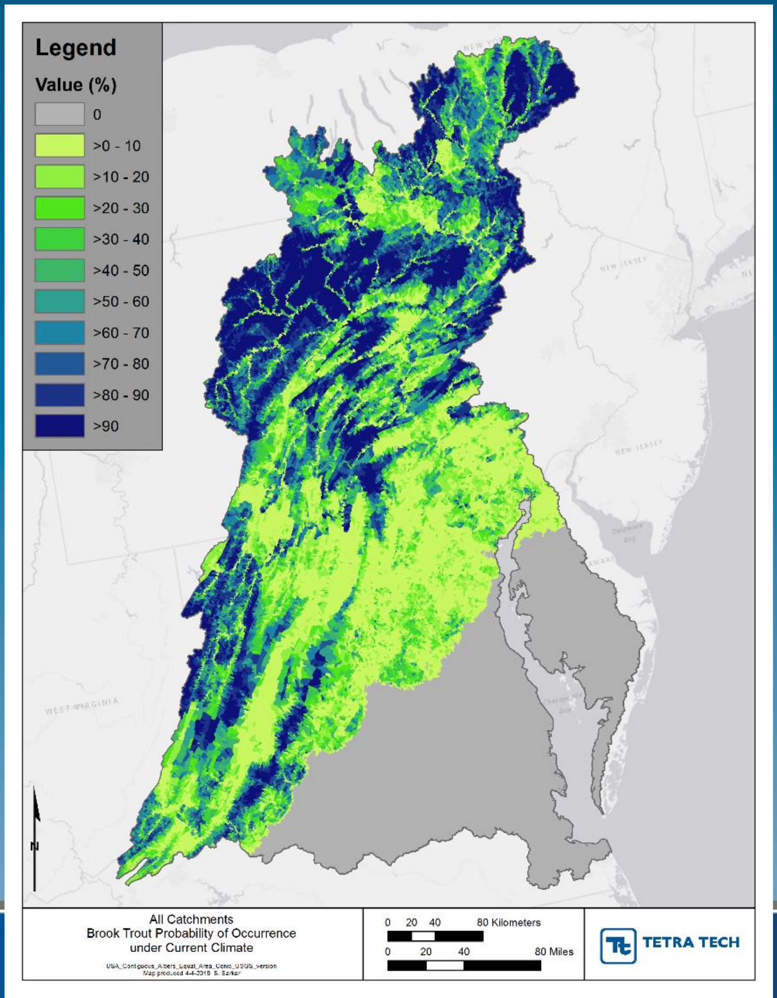
- Data source: Nature's Network, USGS Conte Lab
- Model included effects of landscape, land-use, and climate variables on the probability of brook trout occupancy in stream reaches
- Provides predictions under current environmental conditions and future increases in stream temperature.

TETRA TECH

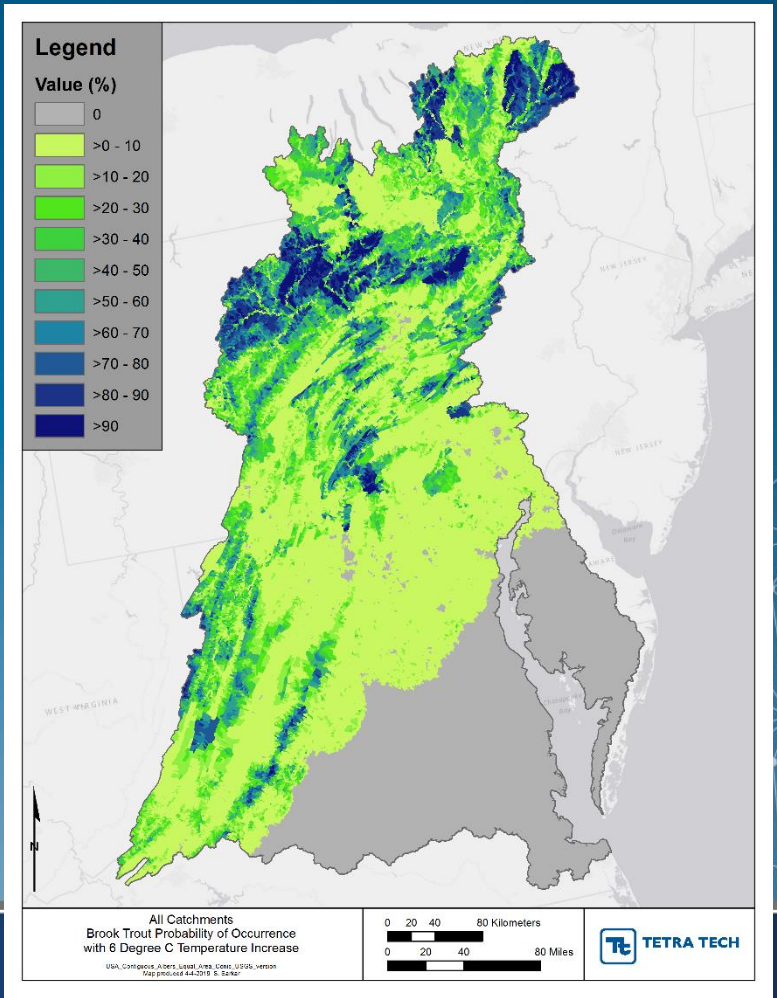
Vulnerability to Climate Change

- Example: <u>Brook Trout Probability of Occurrence</u>

Current climate condition



With 6 degree C increase

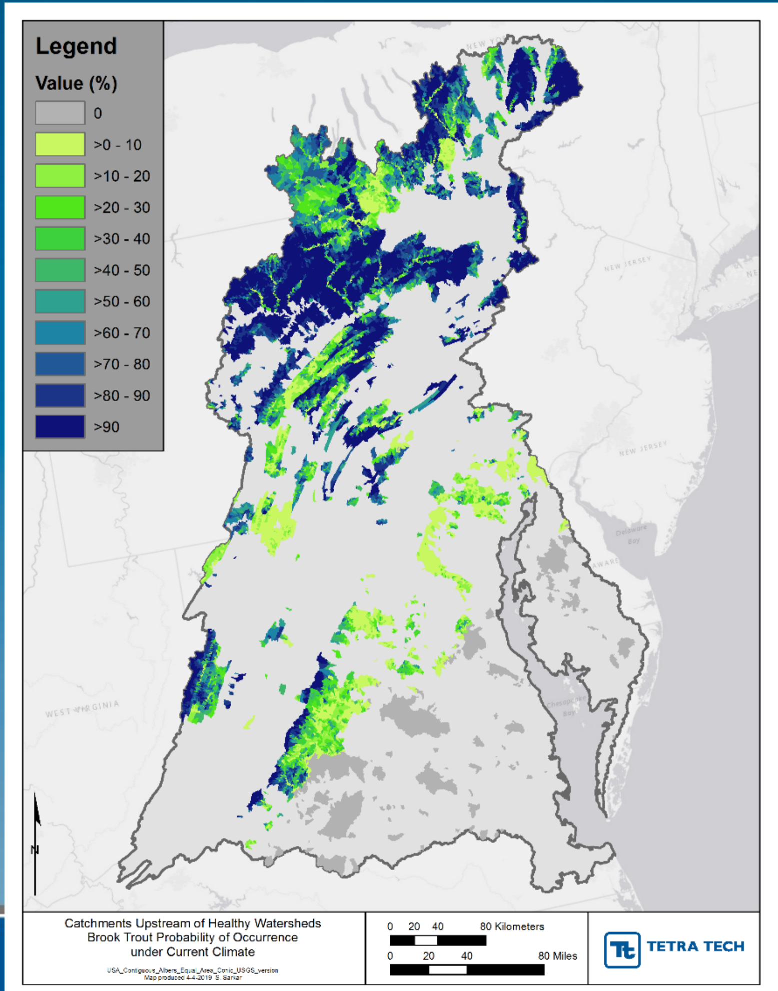


TETRA TECH

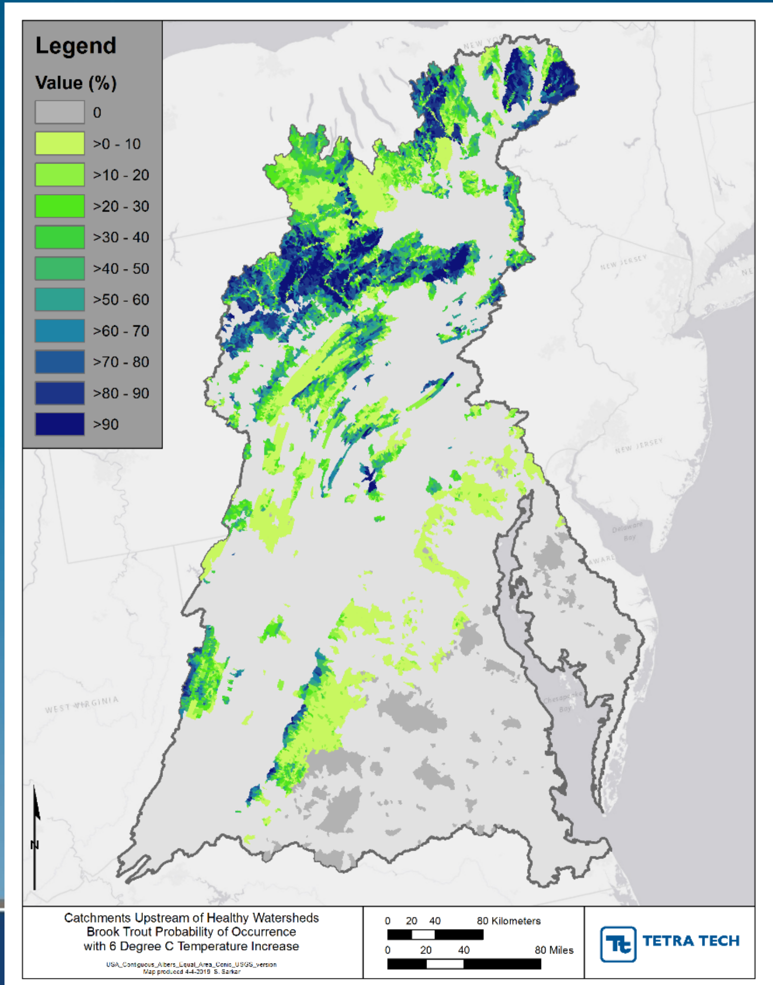
Vulnerability to Climate Change

- Example: Brook Trout Probability of Occurrence

Current climate condition



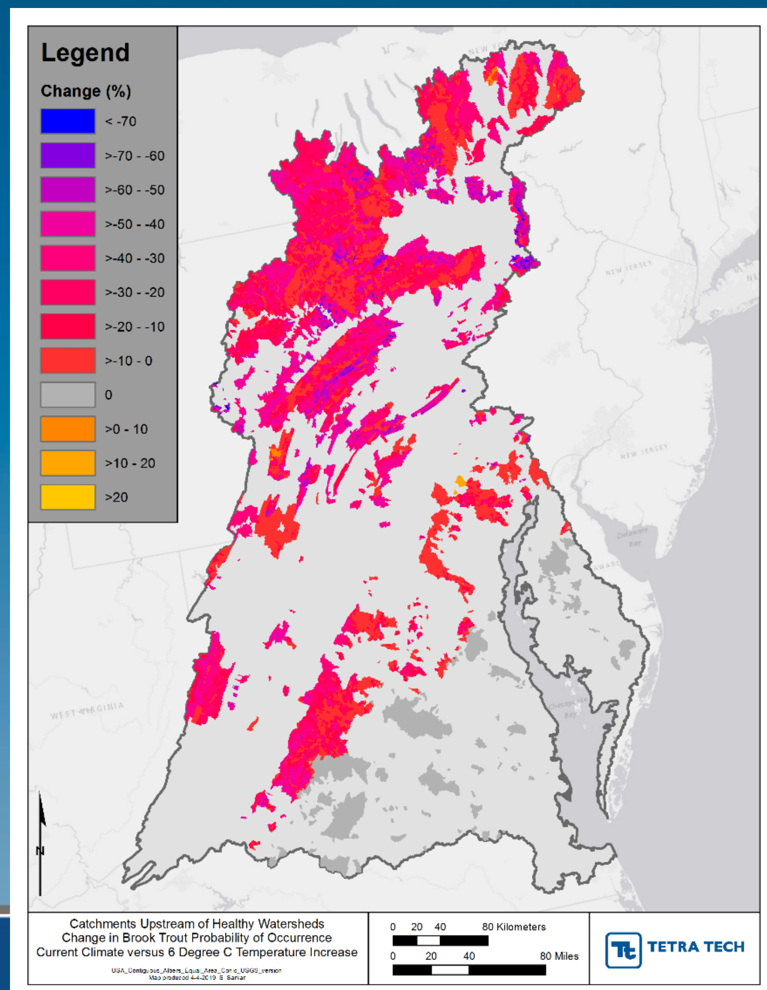
With 6 degree C increase



Vulnerability to Climate Change

- Example Metric: Change in Brook Trout Probability of Occurrence

In Healthy Watersheds



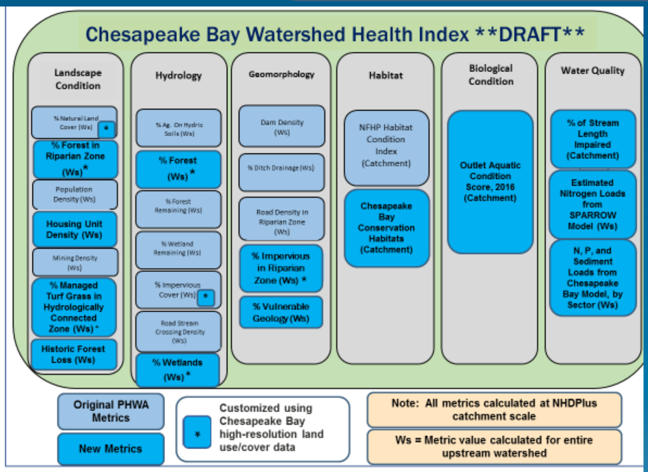
Today's Presentation

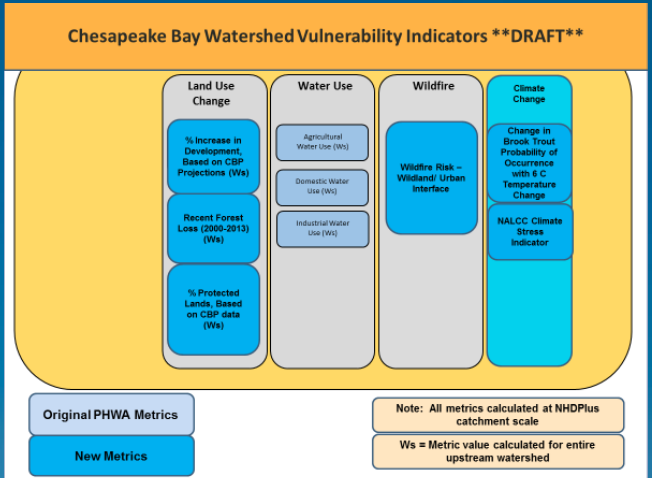
- Adapting the PHWA approach and addressing scale
- Indicators of watershed condition
- Indicators of watershed vulnerability
- Data visualization and access to data

TETRA TECH

Data Visualization and Access Tools

Watershed Health and Vulnerability Metrics





Geodatabase with suite of data, basic approach for analysis and visualization

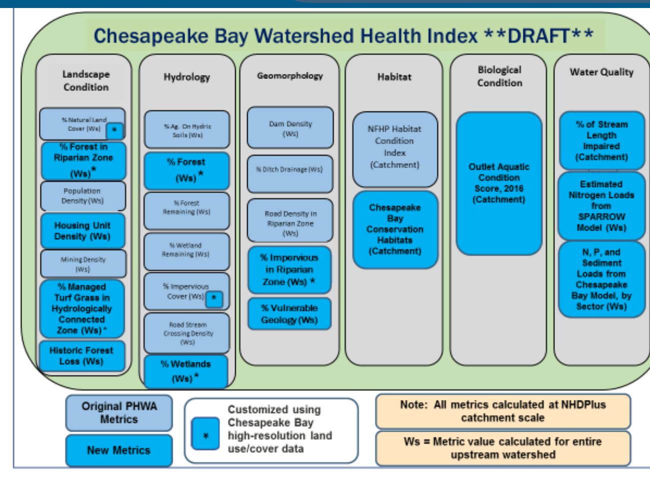
Combine Metrics for Tracking Watershed Health

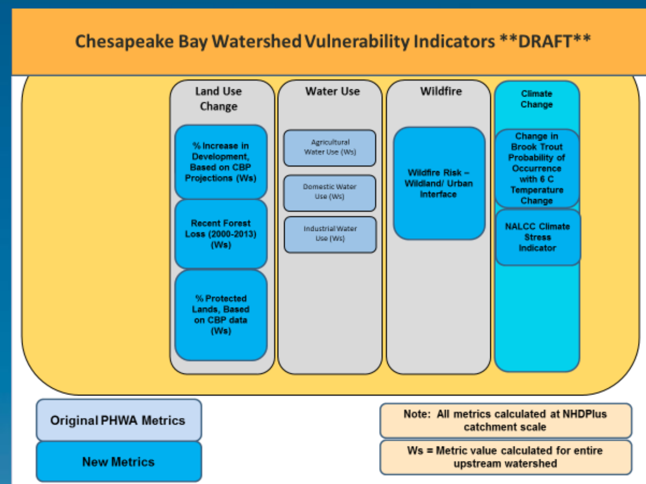
Identify Vulnerabilities

Data Visualization and Access Tools

TETRA TECH

Watershed Health and Vulnerability Metrics





Combine Metrics for Tracking Watershed Health

Identify Vulnerabilities

Geodatabase with suite of data, basic approach for analysis and visualization

Advanced Tools for Analysis and Visualization

Online Data Access

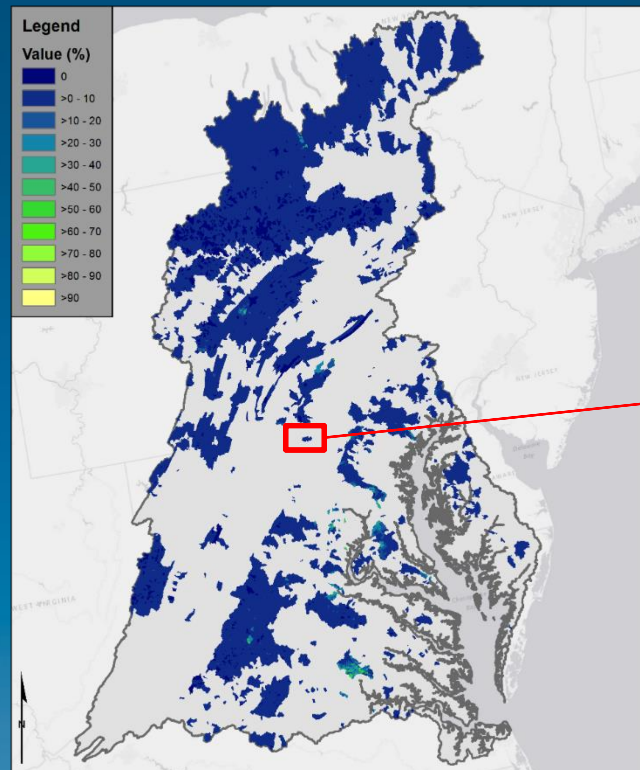
- Provide suite of Healthy Watershed metrics and indicators for data visualization and analysis
- Geodatabase structured by catchment (COMID)
- Ability to select areas of interest, compare values, visualize data…and more
- Accessible via ArcGIS Online or CBP Chesapeake Open Data portal

Example: Big Hunting Creek near Thurmont, MD

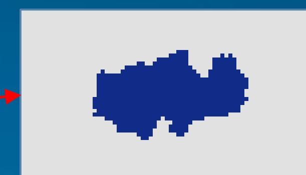
TETRA TECH

Example: Percent Impervious Cover

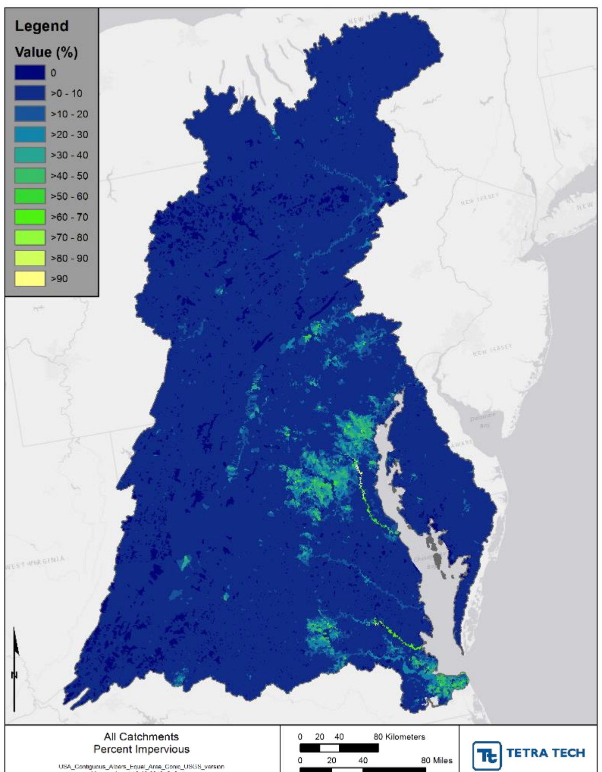
Healthy Watersheds



Big Hunting Creek



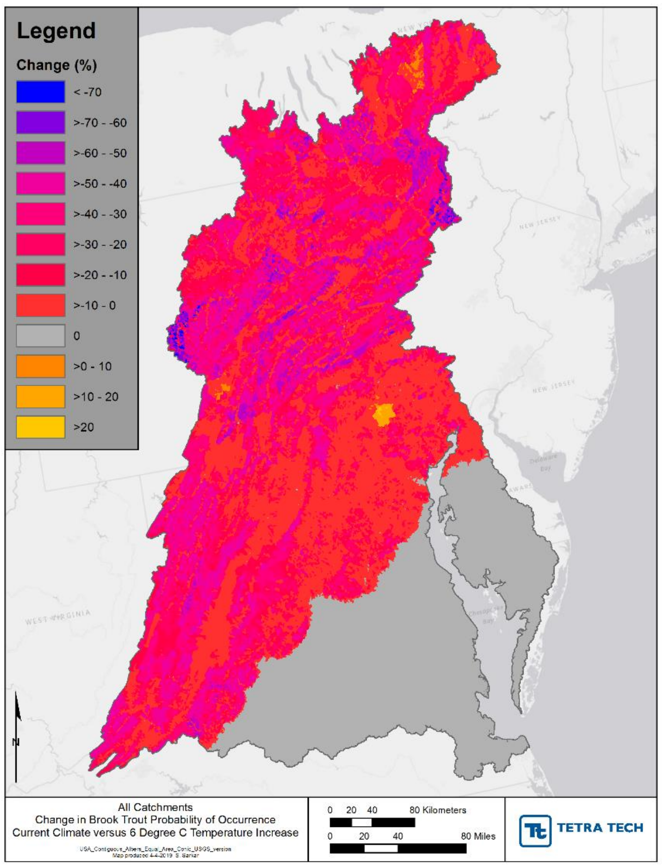
All Catchments



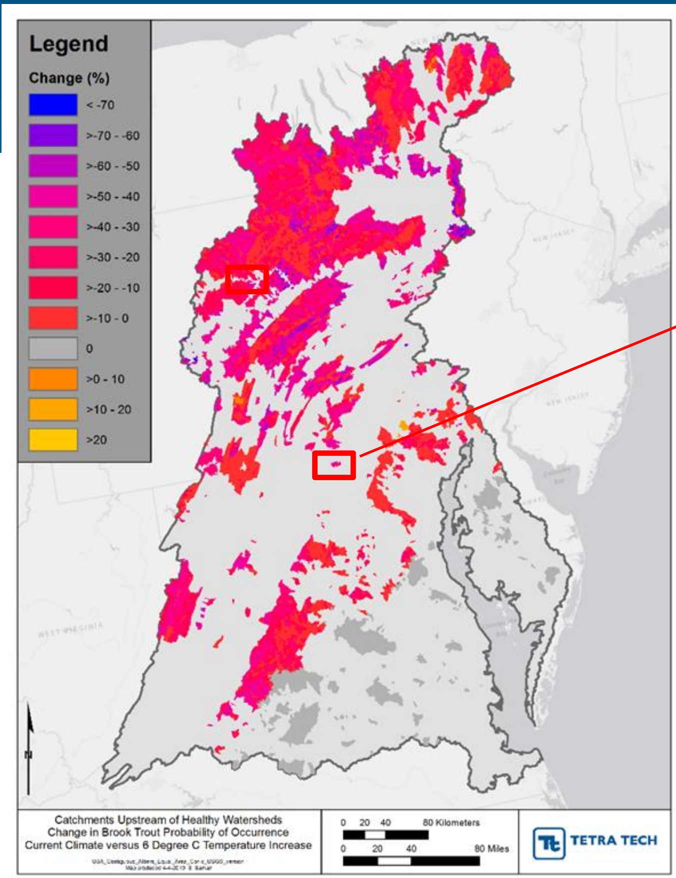
OBJECTID	COMID	Total Upstream Drainage Area (sq km)	Aquatic Condition Index	Road Density (Cs)	Road Density (Ws)	Road/Stream Crossings (Ws)	Housing Unit Density 2010 (Ws)	Population Density 2010 (Ws)	Impervious (Cs)	Impervious (Ws)
45150	8448584	29.5938	0.6538	5.3470	3.5362	0.4731	0.0041	0.0045	0.0891	0.0111
45136	8448556	10.4337	0.7589	3.2747	2.8520	0.4792	0.0011	0.0012	0.0280	0.0141
45139	8448562	6.9849	0.8106	4.5346	1.7741	0.2863	0.0011	0.0012	0.0023	0.0235
45149	8448582	6.3117	0.8198	1.5082	1.5082	0.3169	0.0011	0.0012	0.0220	0.0220
45388	8449076	1.4373	0.6660	2.2839	2.2839	0.6957	0.0011	0.0012	0.0415	0.0415
45389	8449078	2.6784	0.7116	2.6806	2.6806	0.7467	0.0011	0.0012	0.0326	0.0326
45419	8449144	17.7921	0.8604	2.3465	2.4658	0.3934	0.0011	0.0012	0.0108	0.0182
45420	8449146	10.4481	0.8853	4.5346	2.8538	0.4786	0.0011	0.0012	0.0118	0.0310
45421	8449150	6.9516	0.7945	4.1690	1.7659	0.2877	0.0011	0.0012	0.0391	0.0036

Example: Change in Brook Trout Probability of Occurrence

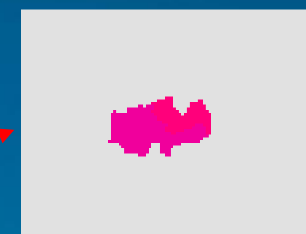
All Catchments



Healthy Watersheds



Big Hunting Creek



Demonstration

TETRA TECH

Management Applications

- Chesapeake Bay Program - assess/track conditions, support management strategies
- State agencies / healthy watershed program managers: track conditions in Tier II waters, identify and evaluate potential threats, adapt management strategies
- Data readily available through CBP online platform for variety of users and uses including local governments and watershed groups
- Flexible framework that can be updated periodically, augmented with new or more specific local data
- Potential to screen watersheds to identify healthy ecosystems not currently protected

TETRA TECH

Seeking Your Feedback

- How will you be able to use these data?
- How best to provide data for a variety of users?
- What should be added/updated in future?

TETRA TECH

Acknowledgements

- Chesapeake Bay Program
- EPA Healthy Watersheds Program
- Jurisdictional watershed managers and data contacts – NY, PA, WV, VA, DC, MD, DE
- Peter Cada, formerly Tetra Tech
- Chesapeake Bay Trust