



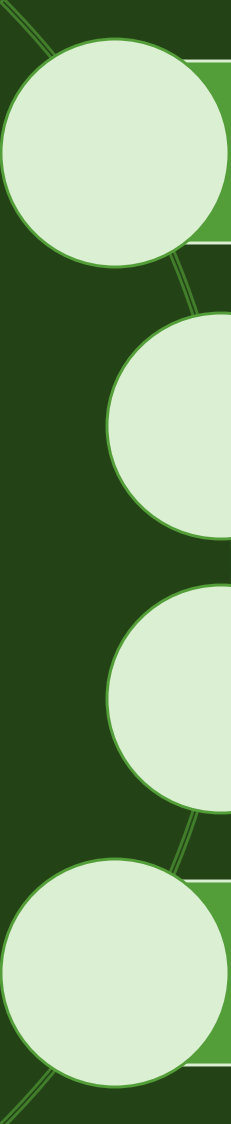
Chesapeake Healthy Watersheds Assessment (CHWA) 2.0

Sarah McDonald (she/her), Renee Thompson, Innovate Inc.

U.S. Geological Survey: Lower Mississippi Gulf Water Science Center

Healthy Watersheds GIT Meeting
August 14, 2023

What are the Goals of the CHWA 2.0?



Support the Chesapeake Bay Program and its jurisdiction partners in detecting signals of change in the state-identified healthy watersheds, providing information useful to support strategies to protect and maintain watershed health.

Provide vulnerability metrics that may help to provide an “early warning” to identify factors that could cause future degradation, allowing managers to take actions to head off these potential negative effects.

Support cross-connections to other CBP efforts, including stream health, fish habitat assessment, water quality, climate change, and local engagement.

Provide web-based visualization tools that make CHWA data available to a broad group of data users with an application and code that makes it easy to update based on new data.

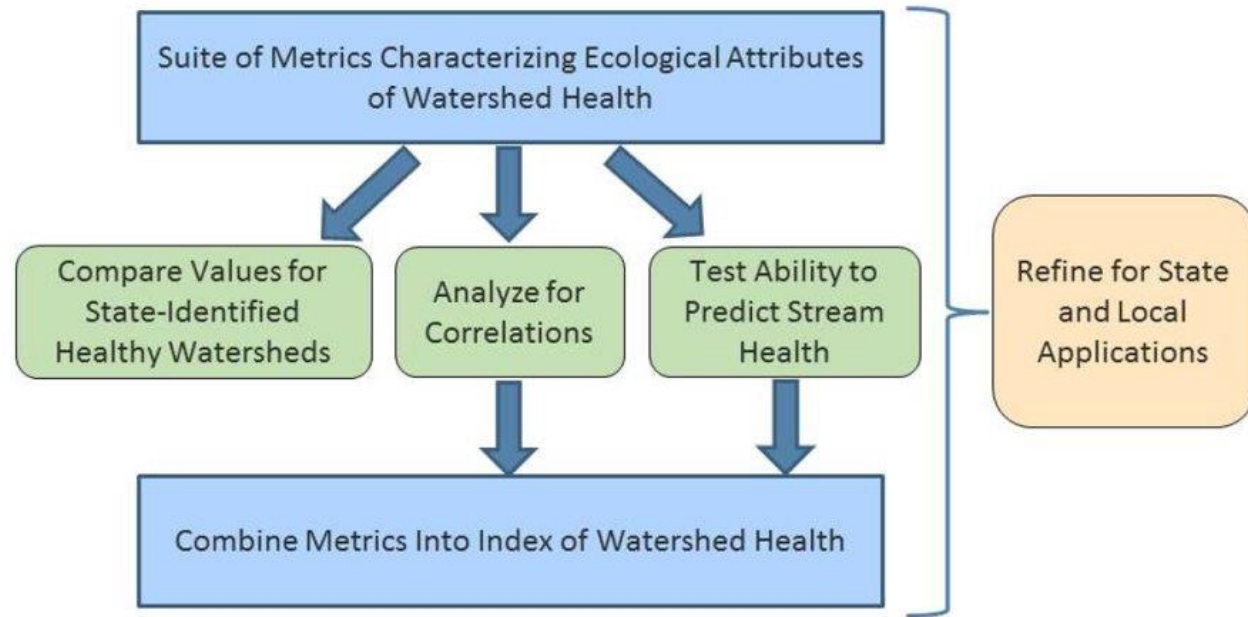


Figure 10: Exploration and refinement of metrics of watershed health. While initial analyses have been completed, additional investigations and refinement are proposed as future steps for the CHWA.

How is
CHWA 2.0
Different than
the Original
Assessment?

Source: [Chesapeake Healthy Watersheds Assessment](#),
May 2020, P. 20

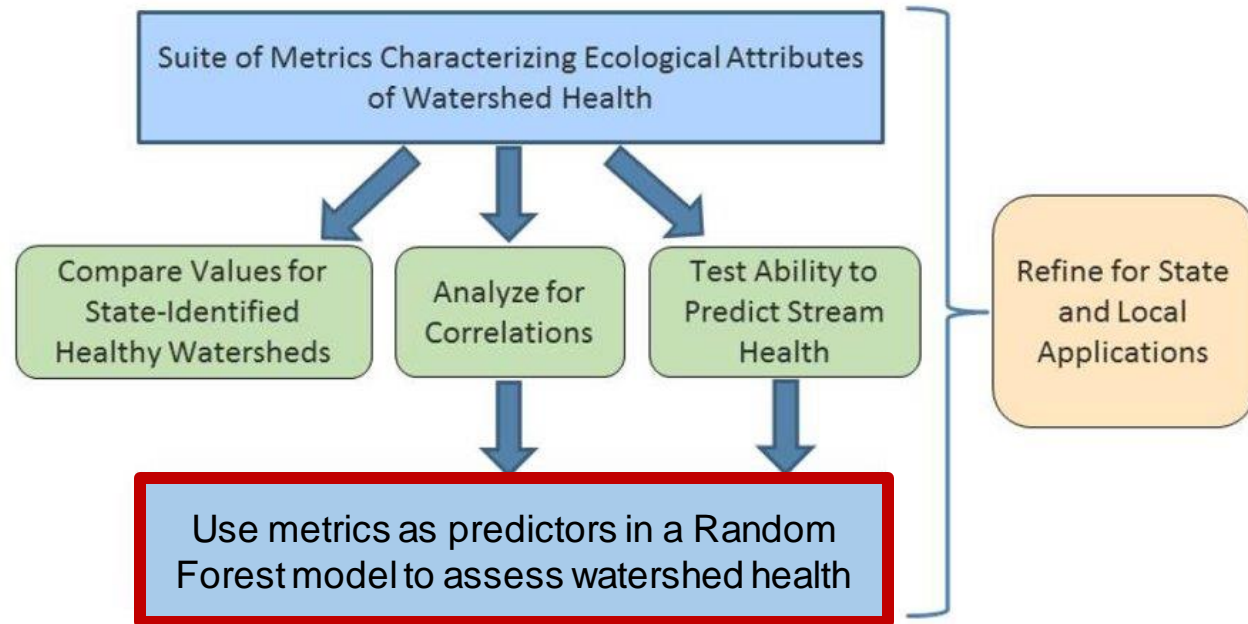


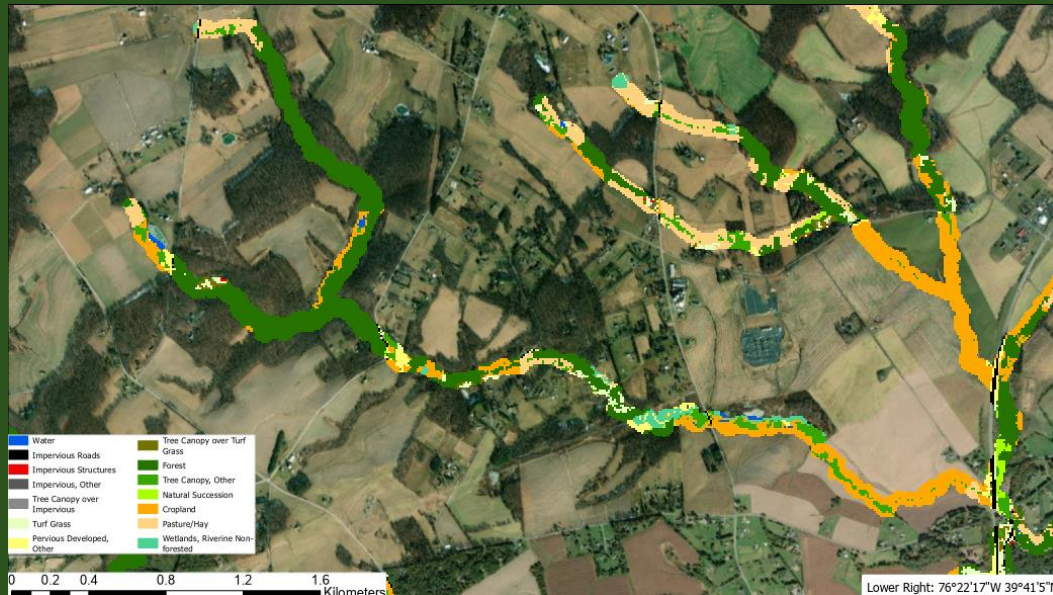
Figure 10: Exploration and refinement of metrics of watershed health. While initial analyses have been completed, additional investigations and refinement are proposed as future steps for the CHWA.

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Edited from Source: [Chesapeake Healthy Watersheds Assessment](#), May 2020, P. 20

Predictive Metrics

- CHWA 1.0 : An index was produced for each category, which were then used to create an overall index of watershed health.
- CHWA 2:0: The unique metrics within each category are used as predictors in the random forest model to assess watershed health.
 - New metrics were calculated for 2.0, including 1:24k landscape and landscape change riparian metrics.



Landscape
Condition



Hydrology



Geomorphology



Habitat



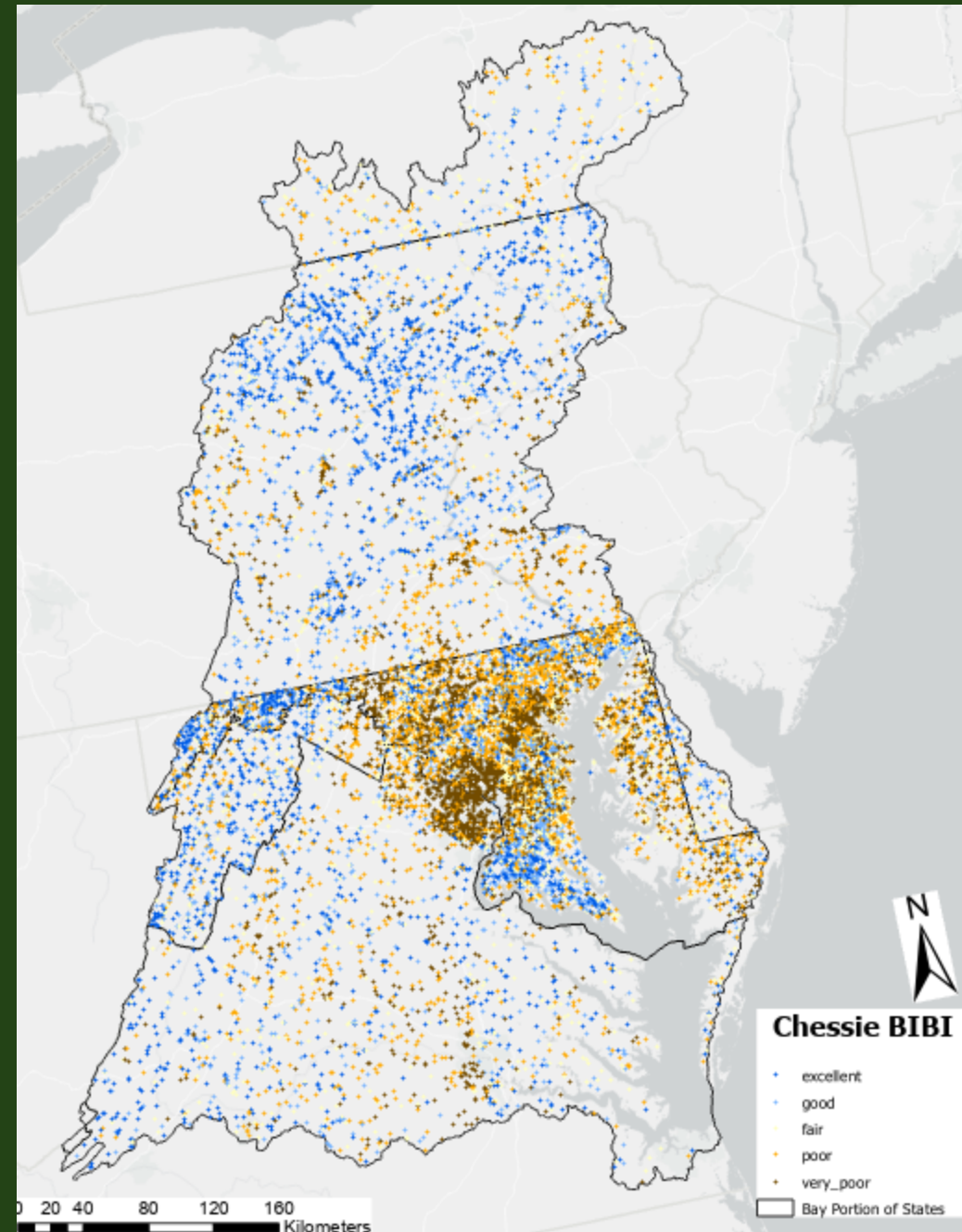
Biological
Condition



Water Quality

Chessie BIBI

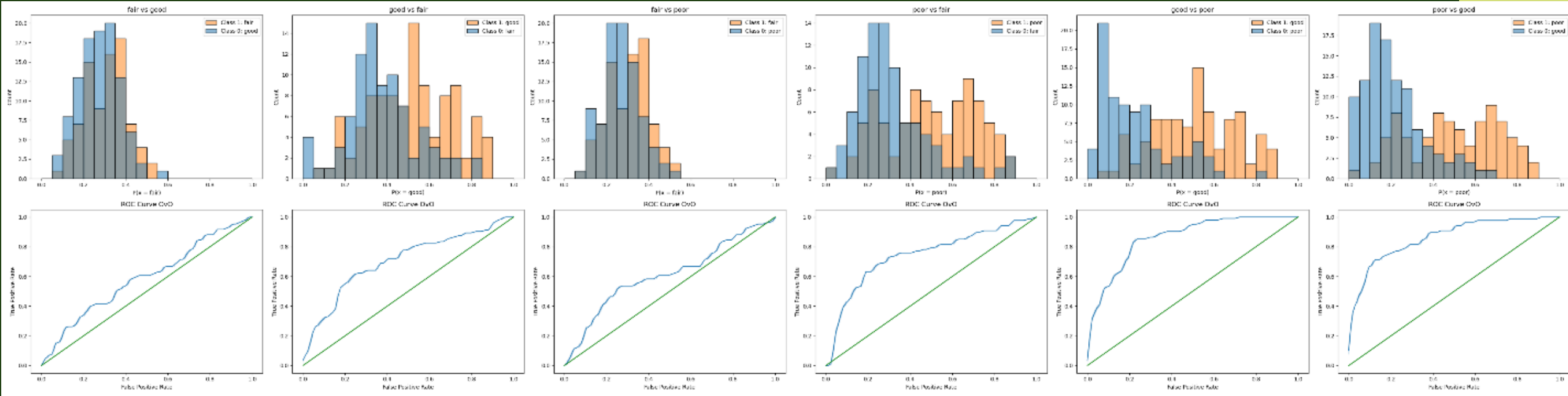
- Developed by Smith et al. (2017)
- Standardized, continuous biological index score from 0 to 100 and a categorical score, ranging from very poor to excellent
- Based on resampled diversity and species richness metrics driven by the sampled data for 1st-4th order streams at the 1:100k scale
- CHWA 2.0 Assessment uses the median categorical score



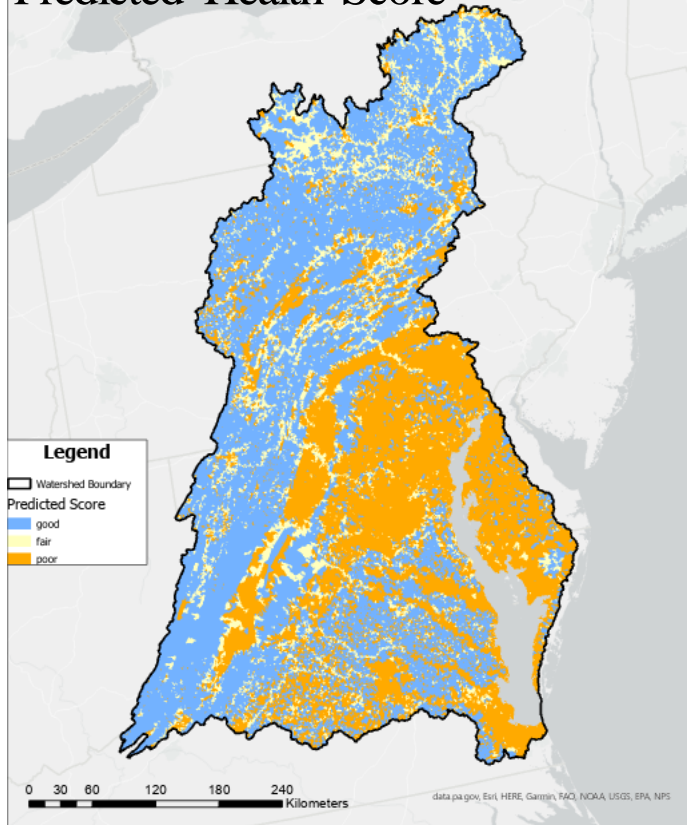
Model Accuracy

BIBI / predicted	good	fair	poor
good	79	10	14
fair	36	22	26
poor	18	8	61

- Overall model accuracy is 0.59 with a Cohen's Kappa of 0.38 (fair agreement).
- Confusion matrix and ROC curves to assess which classes are confused with one another.
 - The largest confusion is the fair class being predicted as good. Followed by fair being predicted as poor.



Predicted Health Score



Predicted Score (watershed)

Predicted Score (watershed)	% Area
good	52%
fair	13%
poor	35%

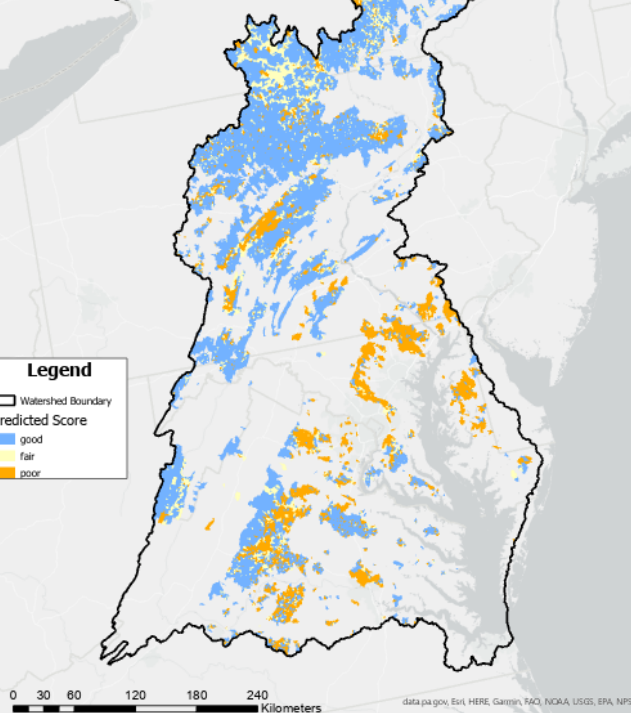
Results: Predicting Watershed Health

- The watershed is predicted to be 65% good and fair.
- Within state-identified healthy watersheds, the model predicted 80% good and fair.

Predicted Score (within State Identified Healthy watersheds)

Predicted Score (within State Identified Healthy watersheds)	% Area
good	67%
fair	13%
poor	19%

Predicted Health Score Within State-identified healthy watersheds



Metric Importance

- The random forest model measures metric importance by calculating how effective the metric has at reducing uncertainty when creating decision trees within the random forest.
- Over 100 metrics have been compiled into CHWA 2.0, 60 of which were included in the model as predictors.
- The top 7 metrics represent conditions in the upstream watershed.

Top 5 Most Important Metrics



% Tree Cover with Unmanaged Understory 2017/18 Watershed (% forest in the upstream watershed)



% Natural Land in Riparian 2017/18 Watershed (% forest, wetlands, and succession in the upstream watershed)



% Impervious Cover 2017/18 Watershed (% roads, structures, parking lots, etc. in the upstream watershed)



Housing Unit Density 2020 Watershed (housing units per area in the upstream watershed)



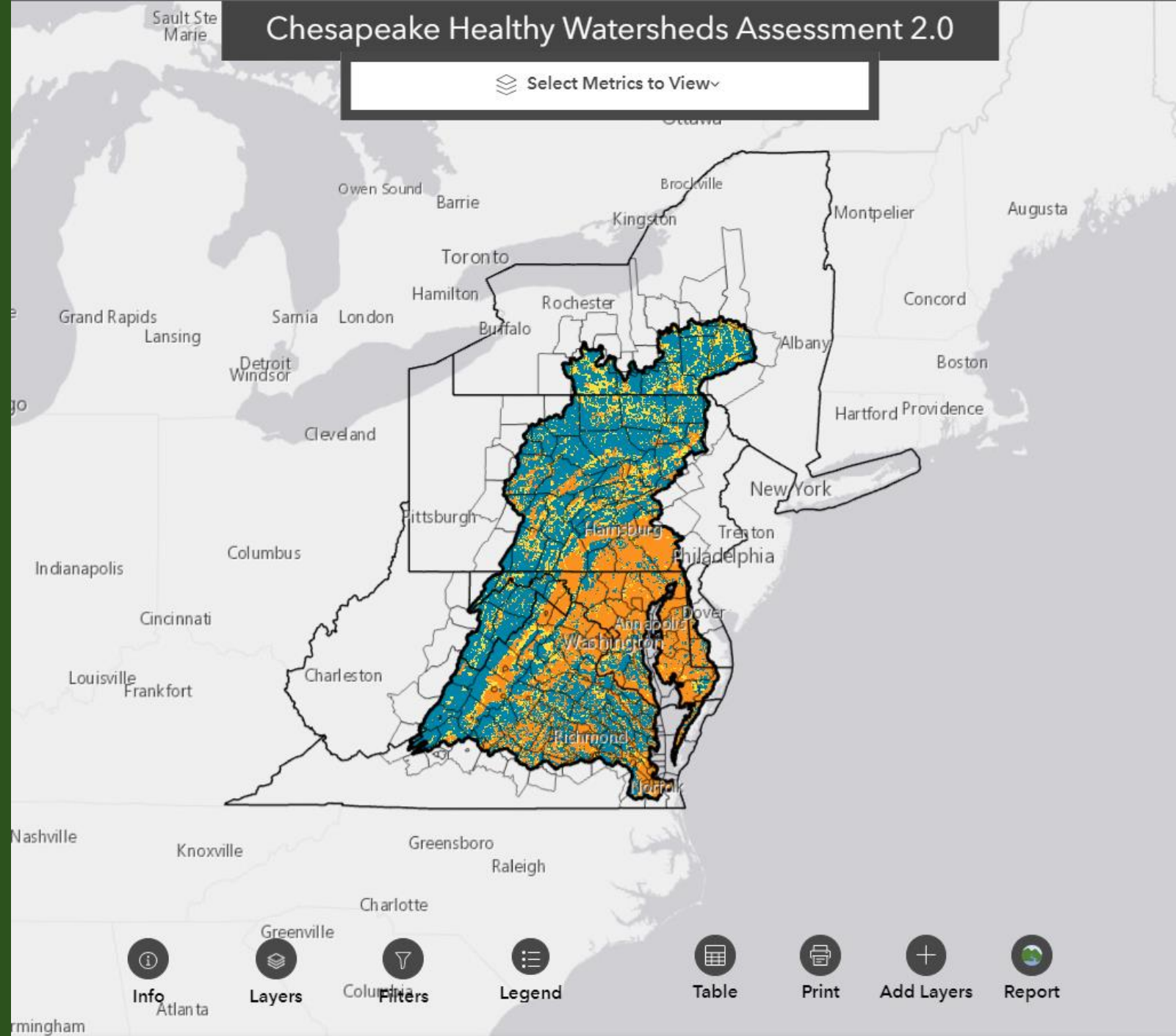
Road Density Watershed (road area per total area in the upstream watershed)



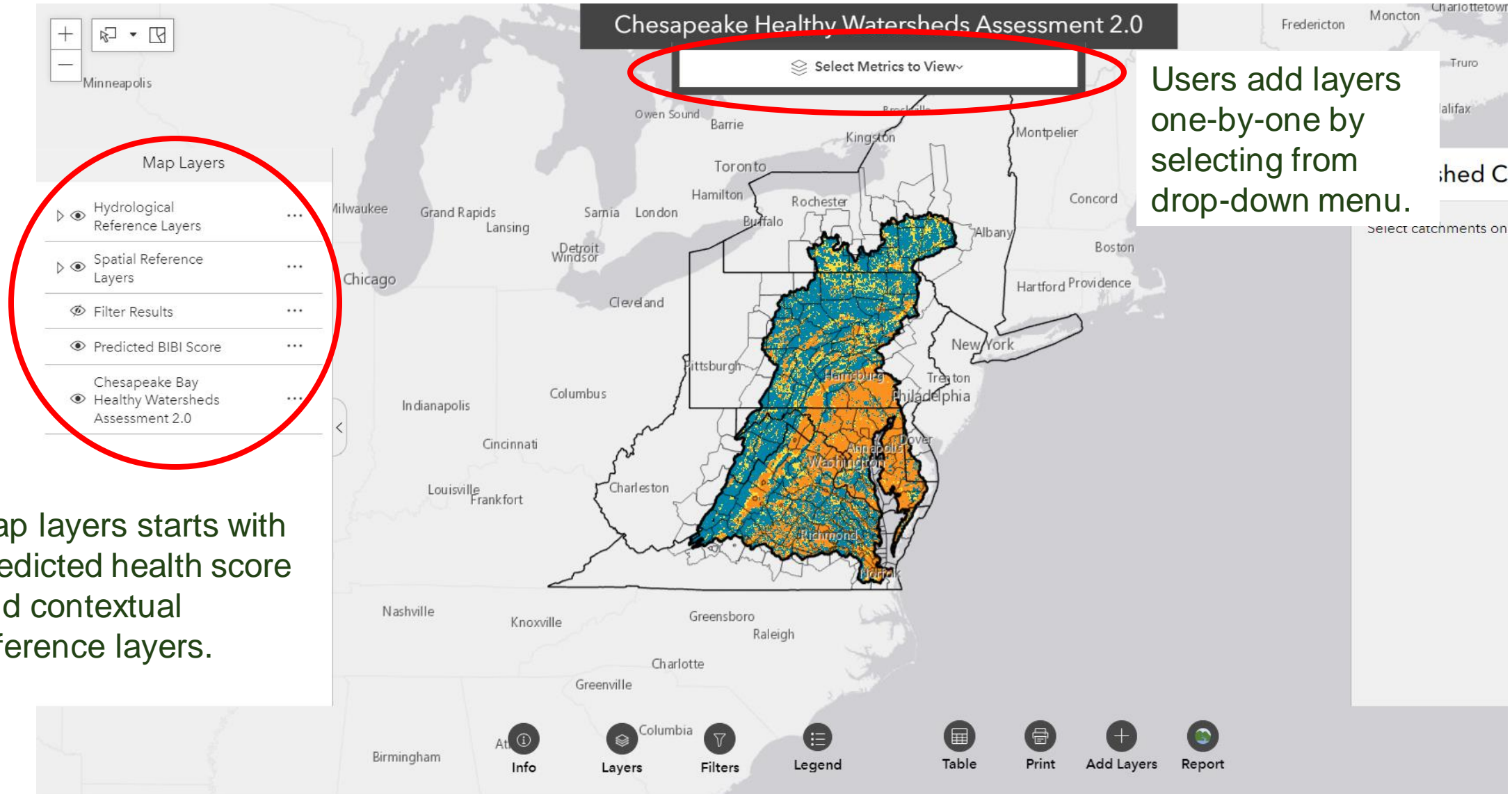
Visualization Tool

<https://gis.chesapeakebay.net/chwa2.0>

- A web-based visualization tool is to be complete this summer!
- This tool allows users and stakeholders to visualize and interact with over 100 metrics, predicted health scores, and numerous contextual overlay layers.



How to: Add metrics to the map



How to: Add metrics to the map

Chesapeake Healthy Watersheds Assessment 2.0

Select Metrics to View

You can add layers to the map by clicking on a category, subcategory, and metric layer.

Some metrics are provided at the catchment-level (meaning they were calculated within the boundaries of the catchment shown), while other metrics are provided at the watershed-level (meaning they were calculated across all catchments upstream of the catchment shown).

Note: Hovering over each metric in the catchment report provides additional information about each metric.

Most Important Metrics

- People >>
- Sediment >>
- Land Use Land Cover >>

Select By Metric Group

- Landscape Condition >>
- Hydrology >>
- Water Quality >>
- Habitat >>
- Geomorphology >>
- Vulnerability: Climate Change >>
- Vulnerability: Land Use Change >>
- Vulnerability: Water Use >>
- Vulnerability: Wildfire Risk >>

Additional Views

Map Layers

- Hydrological Reference Layers ...
- Spatial Reference Layers ...
- Filter Results ...
- Predicted BIBI Score ...
- Chesapeake Bay Healthy Watersheds Assessment 2.0 ...

Watershed

Select catchments

Metrics found as important in predicting watershed health.

Info **Layers** **Watershed** **Report**

How to: Add metrics to the map

Chesapeake Healthy Watersheds Assessment 2.0

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Most Important Metrics

People	>>
Sediment	>>
Land Use Land Cover	>>

Select By Metric Group

Landscape Condition	>>
Hydrology	>>
Water Quality	>>
Habitat	>>
Geomorphology	>>
Vulnerability: Climate Change	>>
Vulnerability: Land Use Change	>>
Vulnerability: Water Use	>>
Vulnerability: Wildfire Risk	>>

Additional Views

Watershed

Select catchments

Map Layers

- Hydrological Reference Layers ...
- Spatial Reference Layers ...
- Filter Results ...
- Predicted BIBI Score ...
- Chesapeake Bay Healthy Watersheds Assessment 2.0 ...

All metrics sorted by same categories as 1.0

Watershed-Level Metrics >>

Catchment-Level Metrics >>

Map navigation controls: +, -, Full Screen, Print, Home, Info, Layers, Add Layers, Report.

How to: Add metrics to the map

Chesapeake Healthy Watersheds Assessment 2.0

Map Layers

- Hydrological Reference Layers
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Most Important Metrics

- People
- Sediment
- Land Use Land Cover

Select By Metric Group

- Landscape Condition
- Hydrology
- Water Quality
- Habitat
- Geomorphology
- Vulnerability: Climate Change
- Vulnerability: Land Use Change
- Vulnerability: Water Use
- Vulnerability: Wildfire Risk

Watershed

- Watershed-Level Metrics
- Catchment-Level Metrics

Separate metrics by local catchment level and upstream watershed metrics.

Info **Layers** **Add Layers** **Report**

How to: Add metrics to the map

Chesapeake Healthy Watersheds Assessment 2.0

Map Layers

- Hydrological Reference Layers ...
- Spatial Reference Layers ...
- Filter Results ...
- Predicted BIBI Score ...
- Chesapeake Bay Healthy Watersheds Assessment 2.0 ...

Select Metrics to View

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- Geomorphology >>
- Vulnerability: Climate Change >>
- Vulnerability: Land Use Change >>
- Vulnerability: Water Use >>
- Vulnerability: Wildfire Risk >>

Watershed-Level Metrics

- % Tree Cover in Riparian 2017/18 Watershed
- Population Density 2020 Watershed (people/sq. km)
- Housing Unit Density 2020 Watershed (units/sq. km)
- % Extractive 2017/18 Watershed
- % Forested Extent Loss to Development 2001-2018 Watershed
- % Natural Land in Riparian 2017/18 Watershed**
- % Protected Lands Watershed
- % Impervious Cover 2017/18 Watershed
- % Agriculture 2017/2018 Watershed

Watershed C

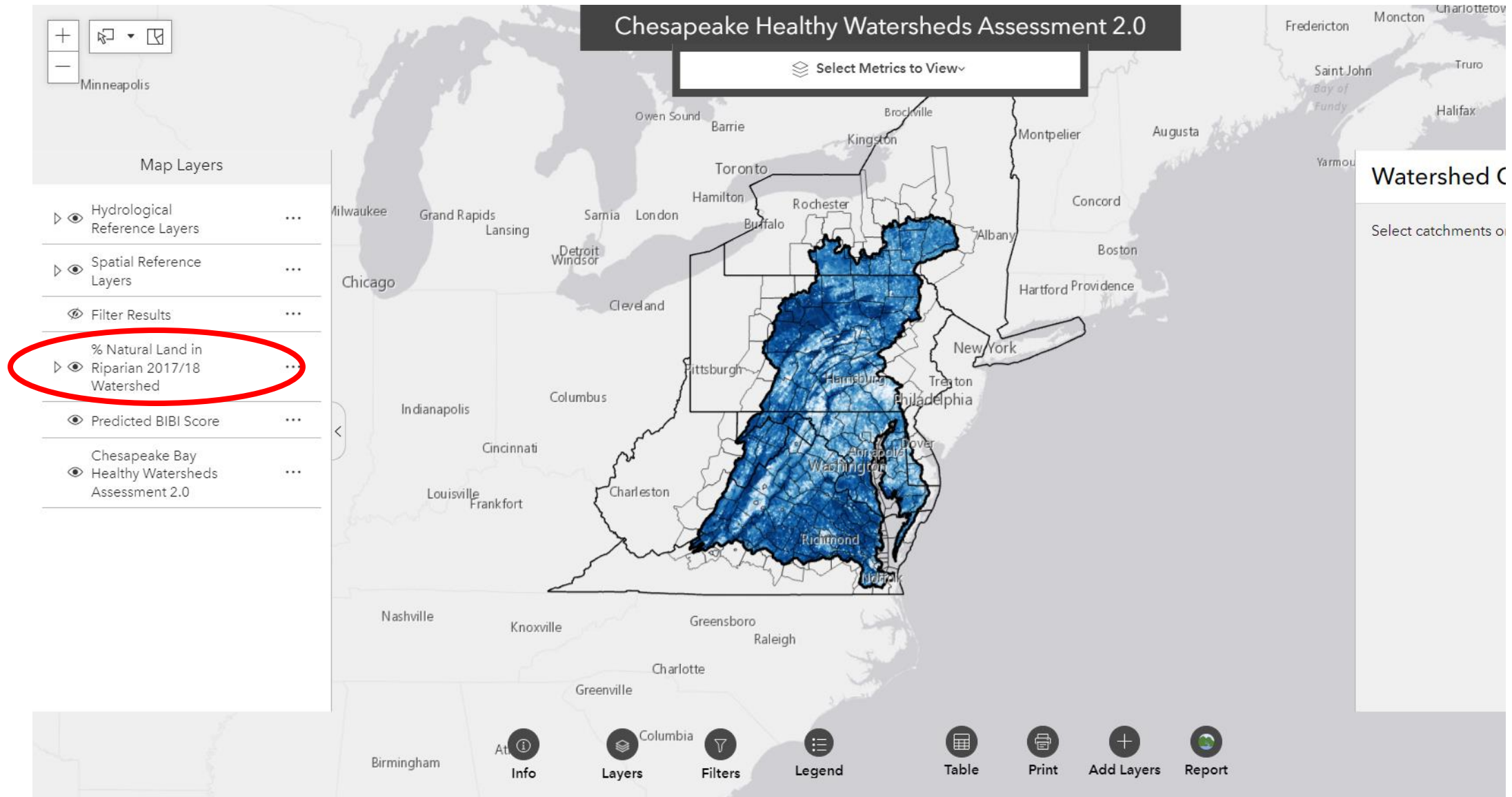
Select catchments on

Pick a metric from the list to add to "Map Layers"

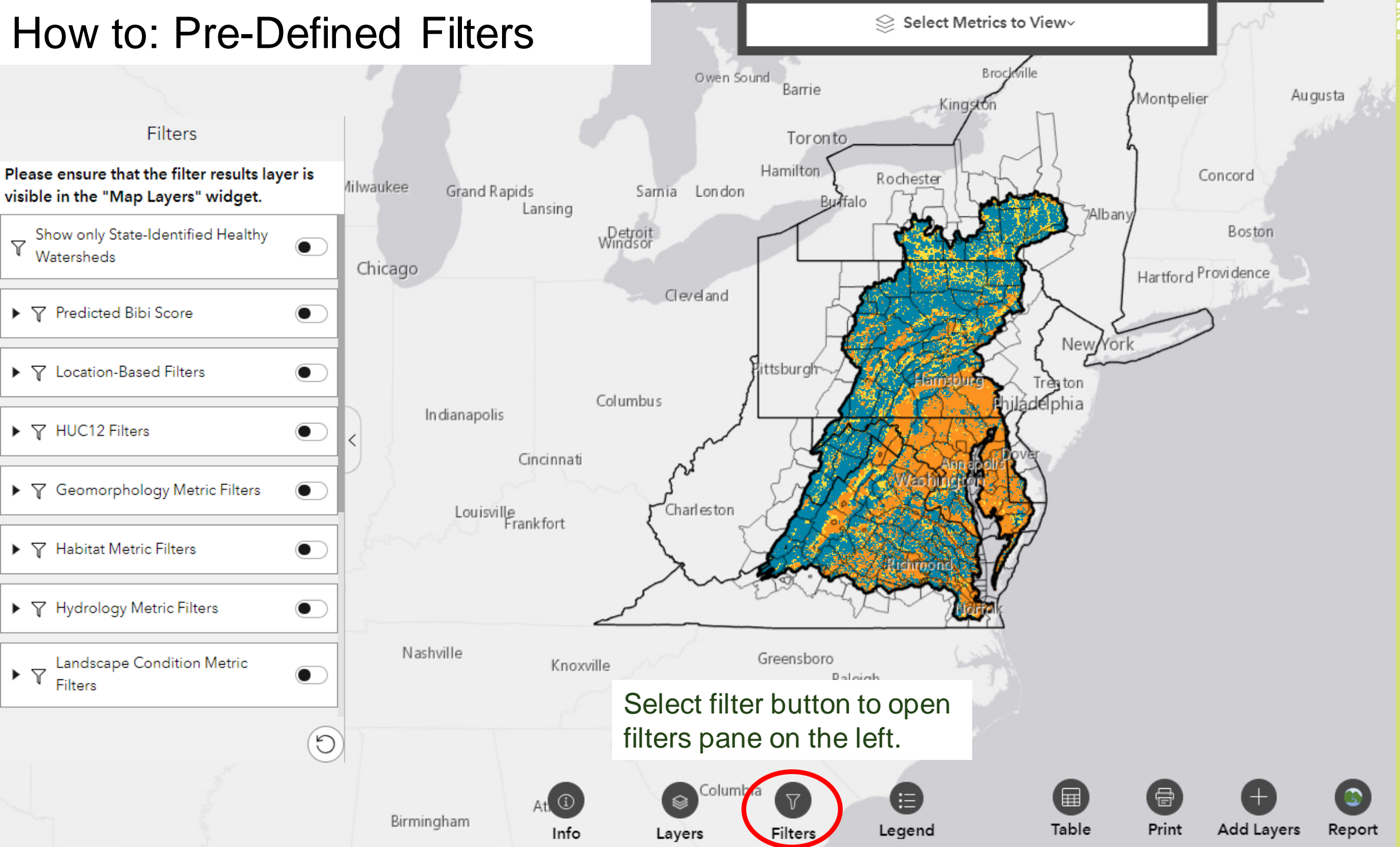
Info Layers

Esri | HERE | Garmin | USGS | EPA | NPS | Esri | HERE | NPS

How to: Add metrics to the map



How to: Pre-Defined Filters



How to: Pre-Defined Filters

Filters

Please ensure that the filter results layer is visible in the "Map Layers" widget.

☒ Show only State-Identified Healthy Watersheds

☐ Predicted Bibi Score

☐ Location-Based Filters

☐ HUC12 Filters

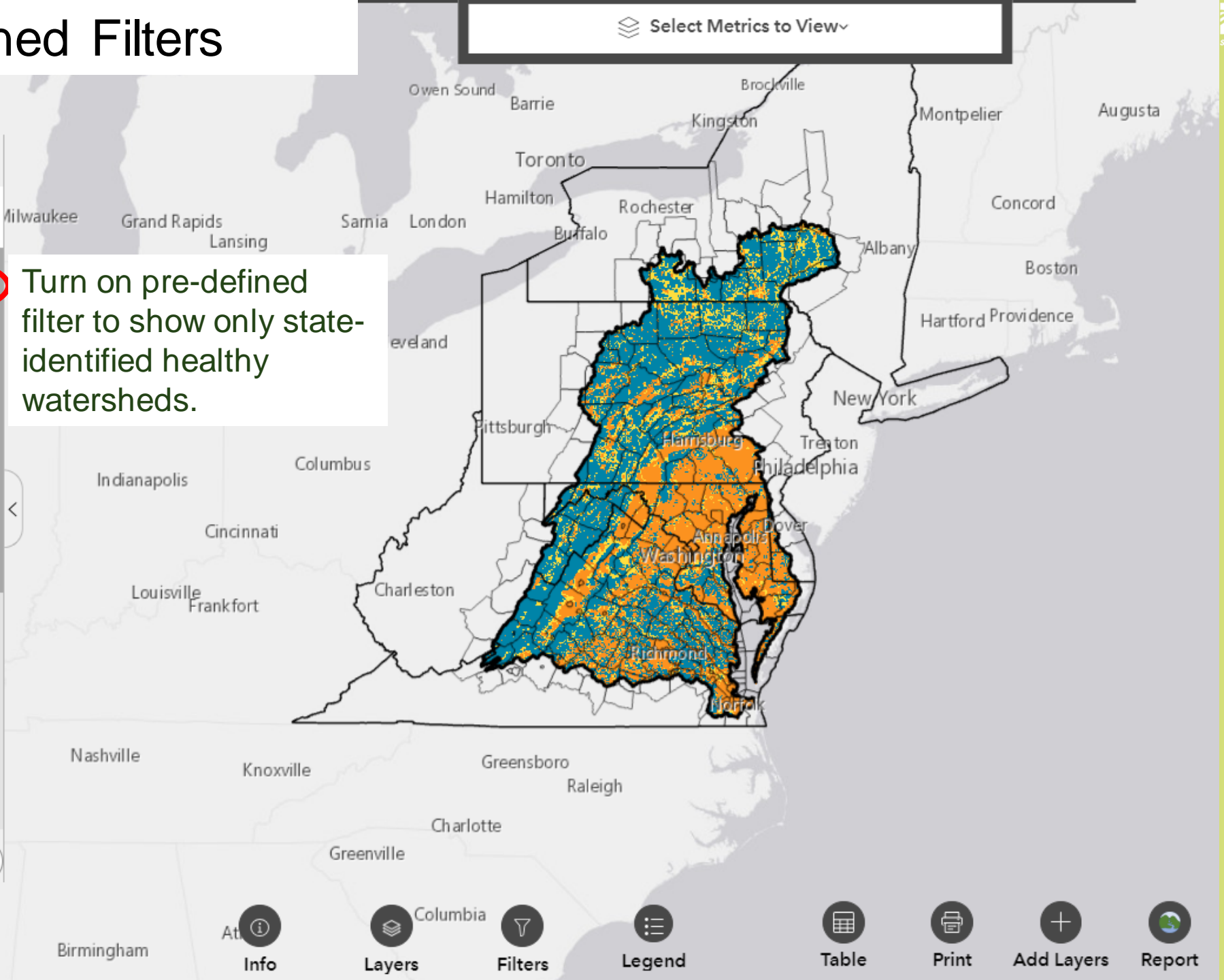
☐ Geomorphology Metric Filters

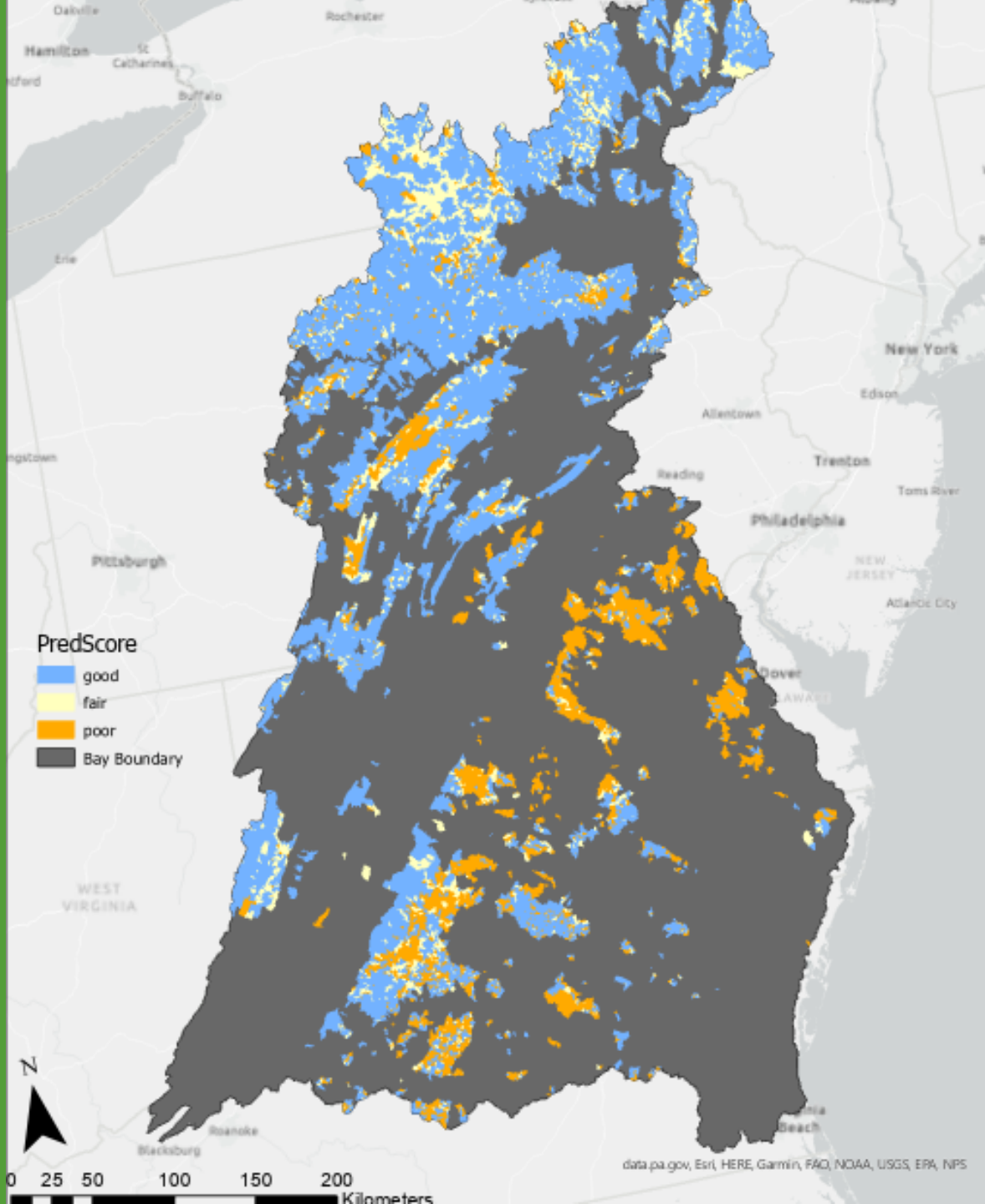
☐ Habitat Metric Filters

☐ Hydrology Metric Filters

☐ Landscape Condition Metric Filters

Turn on pre-defined filter to show only state-identified healthy watersheds.





Pre-Defined Filters: Example

What is the predicted health score within state-identified healthy watersheds?

How to: User-Defined Filters

Filters

Please ensure that the filter results layer is visible in the "Map Layers" widget.

▶ ☒ Hydrology Metric Filters ☐

▶ ☒ **Landscape Condition Metric Filters** ☐

% Extractive 2017/18 is between and

% Extractive 2017/18 Watershed is between and

% Forested Extent Loss to Development 2001-2013 is between and

% Forested Extent Loss to Development 2001-2013 Watershed is between and

% Impervious Cover 2017/18 is between and

% Impervious Cover 2017/18 Watershed is between and

Expand a category on filter pane. Add a min and/or max value to a metric to filter by.

Select Metrics to View

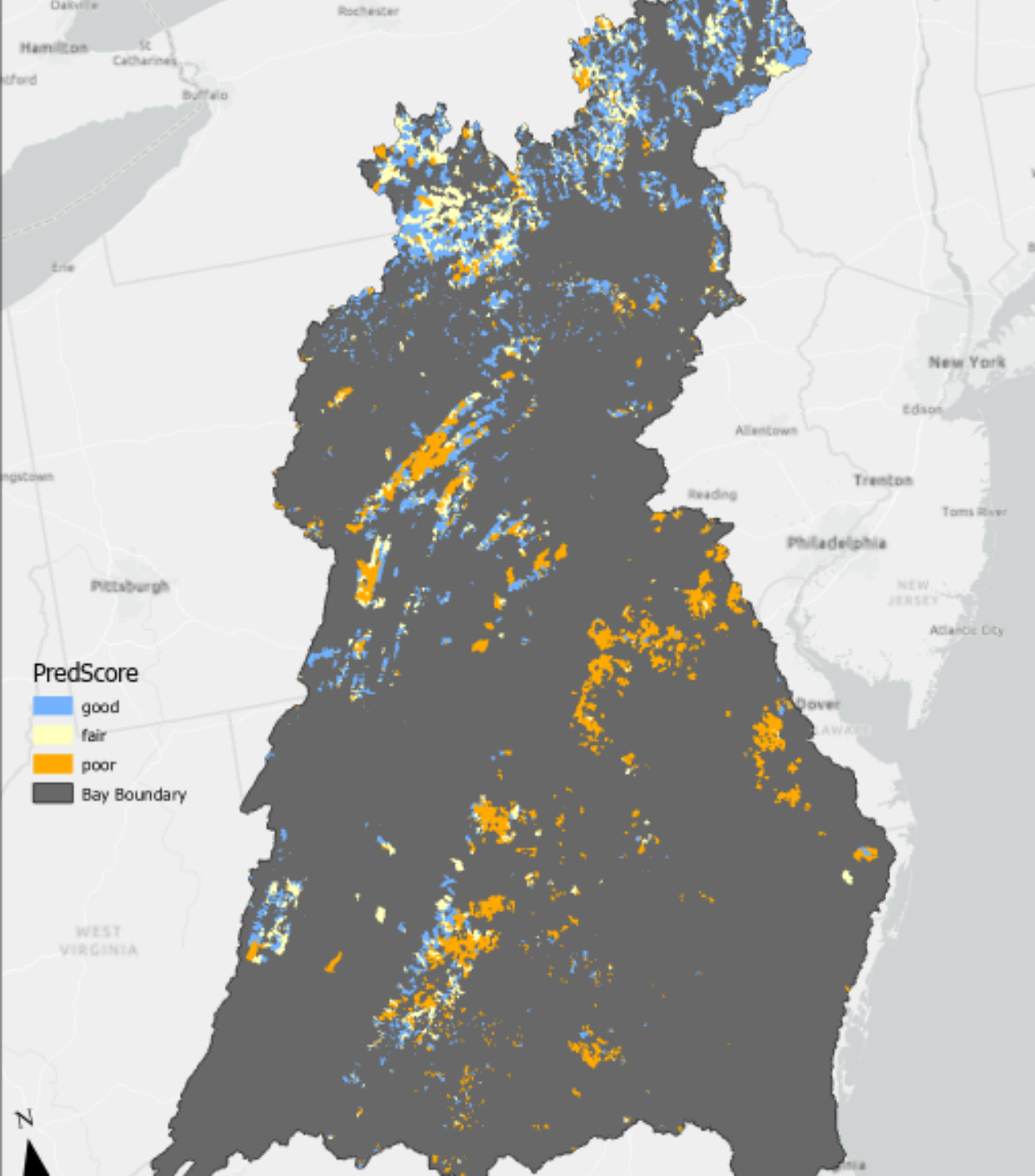
Watershed C

Select catchments on

InfoAtlas Layers Columbia Filters Legend Table Print Add Layers Report

How to: Answer Science Questions with User-Defined Filters

- What is the predicted health scores in state-identified healthy watersheds that have less than 70% riparian forest buffers?



How to: Navigate the Watershed Catchment Report

Chesapeake Healthy Watersheds Assessment 2.0

Select Metrics to View

Map Layers

- Hydrological Reference Layers
- Spatial Reference Layers
- Filter Results
- Predicted BIBI Score
- Chesapeake Bay Healthy Watersheds Assessment 2.0

Zoom in and select a catchment

Watershed Catchment Report

< 1 of 1 > Clear Selected

Watershed Health Metrics

- Landscape Condition
- Hydrology
- Geomorphology

Hover over each metric in the report for more information. Click the icon to view the original data source.

Icons Credit: Tracey Saxby, Catherine Collier, Dieter Tracey, Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/imagelibrary/)

Generate Report Zoom To

Selected features: 1

Info Layers Filters Legend Table Print Add Layers Report

Powered by Esri

How to: Navigate the Watershed Catchment Report

The screenshot displays the 'Chesapeake Healthy Watersheds Assessment 2.0' application. The main map area shows a watershed with a color-coded health score, ranging from blue (higher health) to orange (lower health). A text box overlaid on the map reads: 'Scroll through Watershed Catchment Report widget to view metrics in the application.'

On the left, a 'Map Layers' panel lists several layers: 'Hydrological Reference Layers', 'Spatial Reference Layers', 'Filter Results', 'Predicted BIBI Score', and 'Chesapeake Bay Healthy Watersheds Assessment 2.0'. Each layer has an eye icon and a dropdown menu.

On the right, the 'Watershed Catchment Report' widget is visible. It includes a 'Clear Selected' button and a 'Watershed Health Metrics' section. This section lists three metrics: 'Landscape Condition', 'Hydrology', and 'Geomorphology', each with a right-pointing arrow. A red circle highlights a vertical scrollbar on the right side of this metrics list, indicating that the list can be scrolled. Below the metrics, there is a note: 'Hover over each metric in the report for more information. Click the icon to view the original data source.' At the bottom of the widget are 'Generate Report' and 'Zoom To' buttons. A status bar at the bottom right shows 'Selected features: 1'.

The bottom of the application features a toolbar with icons for 'Info', 'Layers', 'Filters', 'Legend', 'Table', 'Print', 'Add Layers', and 'Report'. The bottom left corner shows the map data sources: 'Esri, HERE, Garmin, USGS, EPA, NPS | Esri, HERE, NPS'. The bottom right corner says 'Powered by Esri'.

How to: Navigate the Watershed Catchment Report

The screenshot displays the 'Chesapeake Healthy Watersheds Assessment 2.0' web application. The main map area shows a watershed with a color-coded health assessment, ranging from blue (healthy) to orange (degraded). A white text box with the instruction 'Click a category to expand.' is overlaid on the map. On the left, a 'Map Layers' panel lists several layers, including 'Hydrological Reference Layers', 'Spatial Reference Layers', 'Filter Results', 'Predicted BIBI Score', and 'Chesapeake Bay Healthy Watersheds Assessment 2.0'. On the right, a 'Watershed Catchment Report' panel is visible, showing 'Watershed Health Metrics' with three categories: 'Landscape Condition' (circled in red), 'Hydrology', and 'Geomorphology'. Below the metrics, there is a note about hovering over metrics for more information and a link to view the original data source. At the bottom of the report panel are buttons for 'Generate Report' and 'Zoom To'. The bottom of the map interface features a toolbar with icons for 'Info', 'Layers', 'Filters', 'Legend', 'Table', 'Print', 'Add Layers', and 'Report'. A status bar at the bottom right indicates 'Selected features: 1'.

Chesapeake Healthy Watersheds Assessment 2.0

Select Metrics to View

Map Layers

- Hydrological Reference Layers
- Spatial Reference Layers
- Filter Results
- Predicted BIBI Score
- Chesapeake Bay Healthy Watersheds Assessment 2.0

Click a category to expand.

Watershed Catchment Report

< 1 of 1 > Clear Selected

Watershed Health Metrics

- Landscape Condition
- Hydrology
- Geomorphology

Hover over each metric in the report for more information. Click the icon to view the original data source.

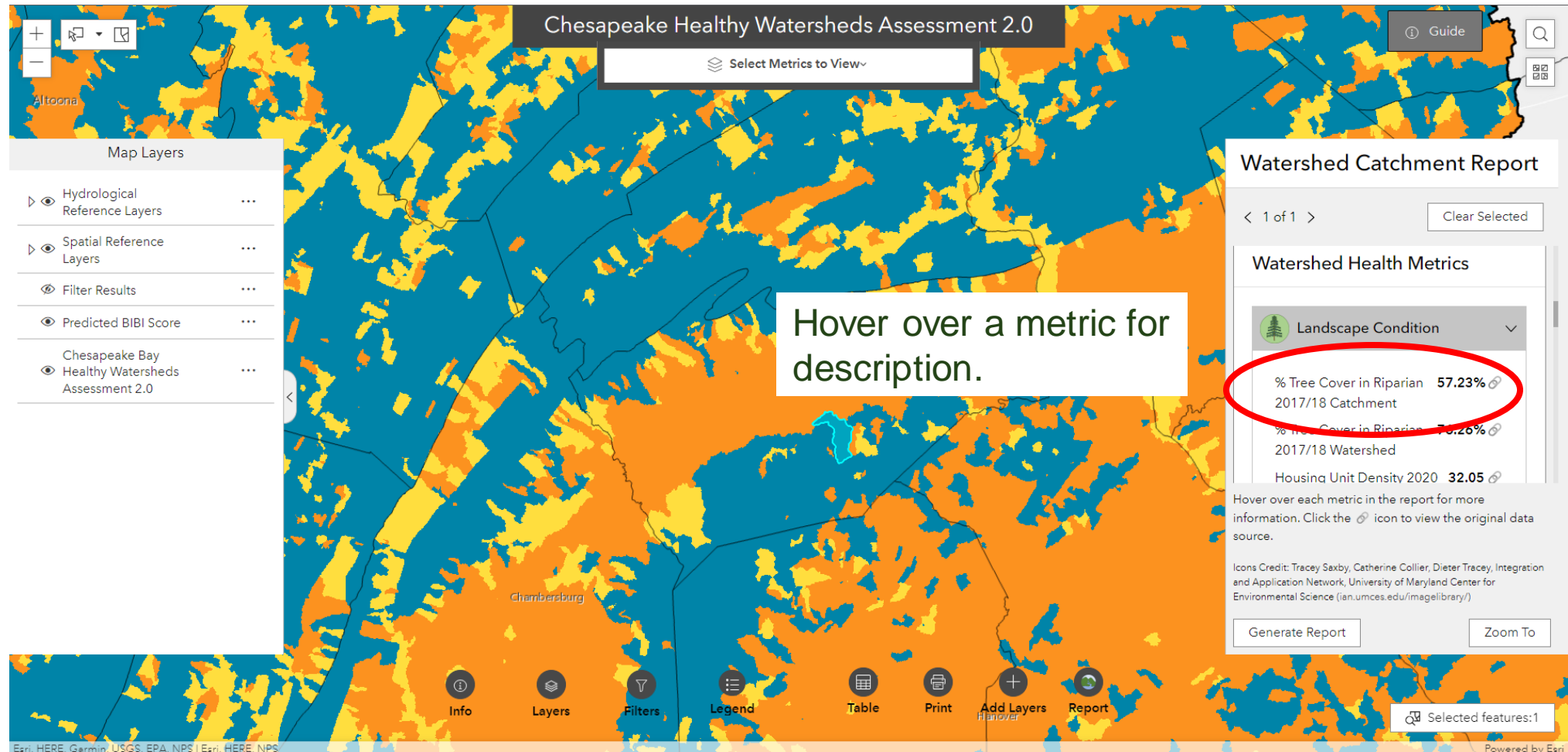
Icons Credit: Tracey Saxby, Catherine Collier, Dieter Tracey, Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/imagelibrary/)

Generate Report Zoom To

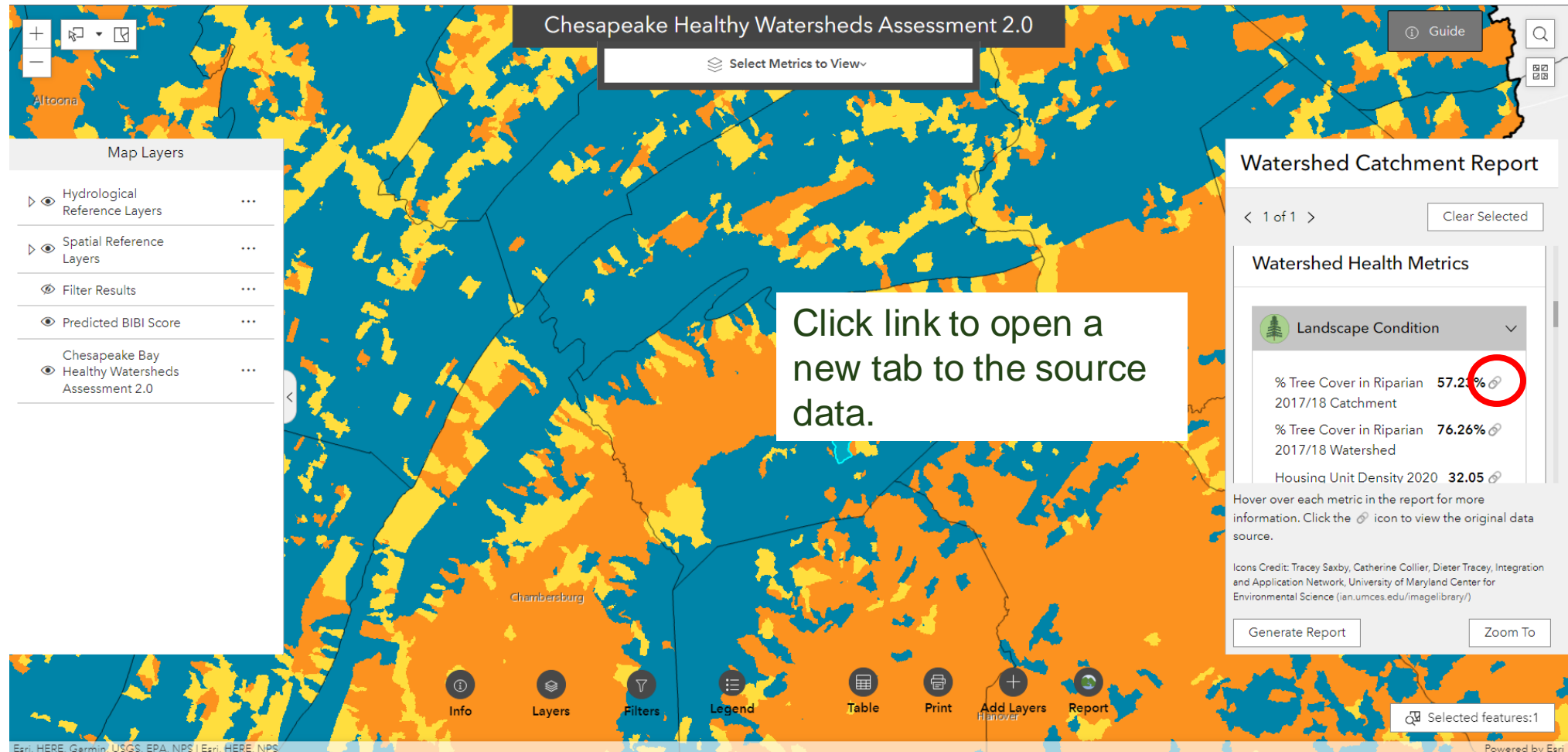
Selected features: 1

Powered by Esri

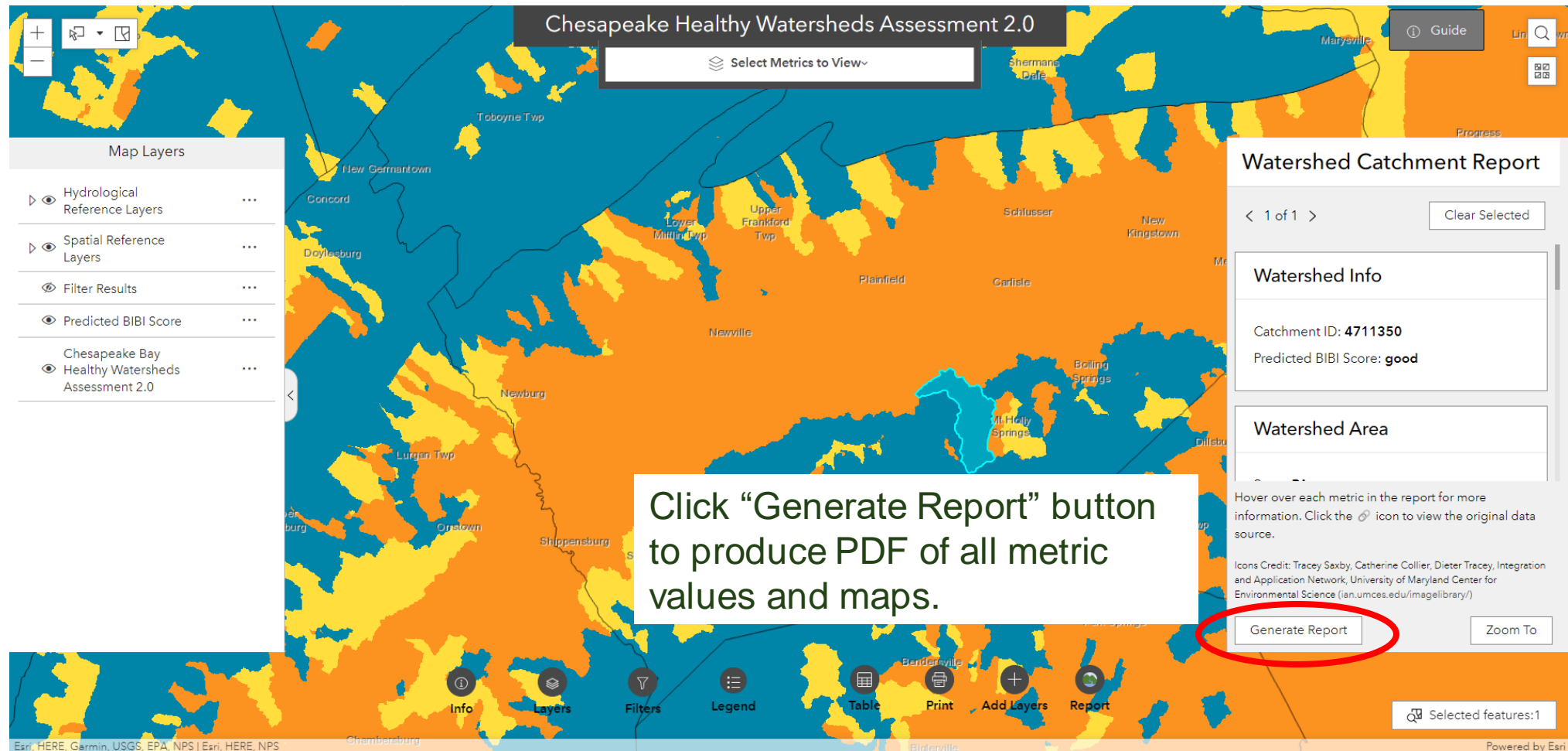
How to: Navigate the Watershed Catchment Report



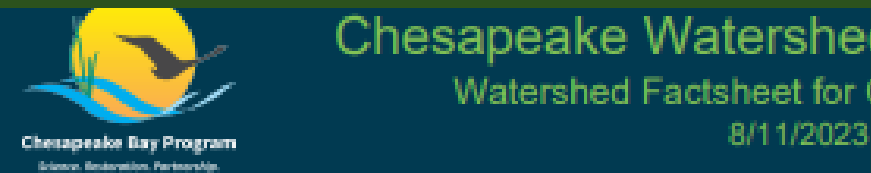
How to: Navigate the Watershed Catchment Report



How to: Generate a Watershed Catchment Report



How to: Generate a Watershed Catchment Report




Watershed Vulnerability

Land Use Change

Housing Unit Density Change Catchment*	11.98
Housing Unit Density Change Watershed*	4.61
% Non-forested Wetland Conversion to Development 2013-18 Catchment*	0.00%
% Non-forested Wetland Conversion to Development 2013-18 Watershed*	0.00%
% Forest Harvesting 2013-18 Catchment*	0.22%
% Forest Harvesting 2013-18 Watershed*	0.72%
% Change in Impervious Cover 2013-18 Catchment*	0.00%
% Change in Impervious Cover 2013-18 Watershed*	0.00%
% Change in Forested Extent 2013-18 Catchment*	-0.01%
% Change in Forested Extent 2013-18 Watershed*	-0.01%
% Impervious Projected to 2058 Catchment*	0.07%

Climate Change

Probability of Brook Trout (current)*	0.22
Probability of Brook Trout (2-degree Celsius increase)*	0.15
Probability of Brook Trout (4-degree Celsius increase)*	0.09
Probability of Brook Trout (6-degree Celsius increase)*	0.06
Climate Stress Catchment*	0.17



Chesapeake Watersheds Assessment -
Watershed Factsheet for COMID: 4711350
8/11/2023

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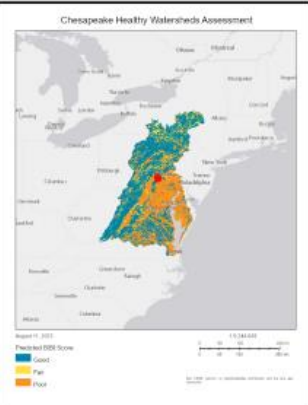
The Chesapeake Bay Program (CBP), through its Maintain Healthy Watersheds Goal Implementation Team, has a goal of maintaining the long-term health of watersheds identified as healthy by its partner jurisdictions.
[Maintain Healthy Watersheds Goal Implementation Team](#)

Watershed Info


Catchment ID	4711350
Predicted BIBI Score	good

Watershed Area

State	PA
County	Cumberland, PA
HUC12 Acres	15553
HUC12 Headwater	No
HUC12 ID	020503050502
HUC12 Name	Upper Yellow Breeches Creek




Chesapeake Healthy Watersheds Assessment



Watershed Area

Watershed Info

Predicted BIBI Score	good
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Chesapeake Watersheds Assessment -
Watershed Factsheet for COMID: 4711350
8/11/2023

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Watershed Health Metrics

Landscape Condition

% Tree Cover in Riparian 2017/18 Catchment	57.23%
% Tree Cover in Riparian 2017/18 Watershed	76.26%
Housing Unit Density 2020 Catchment (units/sq. km)	32.05
Housing Unit Density 2020 Watershed (units/sq. km)	15.03
Population Density 2020 Catchment (people/sq. km)	80.07
Population Density 2020 Watershed (people/sq. km)	31.94
% Extractive 2017/18 Catchment	2.36%
% Extractive 2017/18 Watershed	0.39%
% Forested Extent Loss to Development 2001-2013 Catchment*	0.01%
% Forested Extent Loss to Development 2001-2013 Watershed*	0.03%
% Impervious Cover 2017/18 Catchment*	4.55%
% Impervious Cover 2017/18 Watershed*	3.17%
% Natural Land in Riparian 2017/18 Catchment*	53.17%
% Natural Land in Riparian 2017/18 Watershed*	75.94%
% Protected Lands Catchment*	18.33%
% Protected Lands Watershed*	44.28%
% Agriculture 2017/18 Catchment*	45.21%
% Agriculture 2017/18 Watershed*	28.66%

Habitat

Nature's Network Connectivity Catchment*	0.08%
Fish Habitat Condition Index (Catchment)	4
Fish Habitat Condition Index Cumulative (Watershed)	3.75
% Tree Cover with Unmanaged Understory 2017/18 Catchment	32.22%
% Tree Cover with Unmanaged Understory 2017/18 Watershed	58.46%

Hydrology

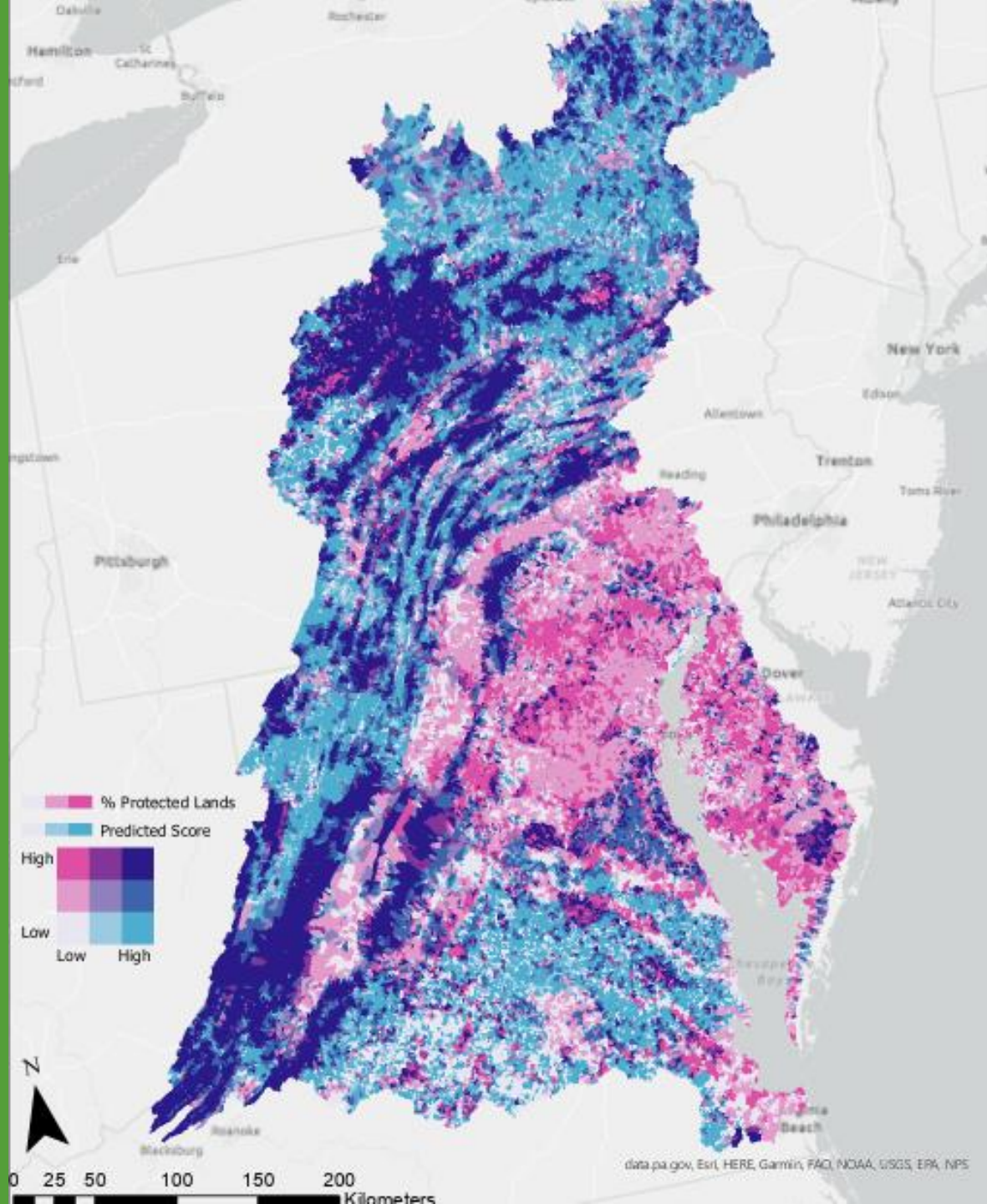
% Tree Canopy with Managed Understory 2017/18 Catchment*	4.23%
% Tree Canopy with Managed Understory 2017/18 Watershed*	2.02%
% Non-forested Wetlands 2017/18 Catchment*	0.27%
% Non-forested Wetlands 2017/18 Watershed*	0.26%
Road Stream Crossing Density Catchment (km/sq. km)	0.02
Road Stream Crossing Density Watershed (km/sq. km)	0.02
Flow Alteration	1

Geomorphology

Streambed Fine Sediment and Sand Cover Catchment	10
Streambed Particle Size D50 Catchment	7.30
Streambank Sediment Flux Catchment (kg-sed m-1 yr-1)	<0.01
Streambank Lateral Erosion Catchment (kg-finesed m-1 yr-1)	<0.01
Streambank Fine Sediment Flux Catchment (kg-finesed m-1 yr-1)	<0.01
Streambank Erosional Change Catchment	<0.01
Road Density Catchment (km/sq. km)	3.78
Road Density Riparian Catchment (km/sq. km)	4.27
Road Density Watershed (km/sq. km)	2.53

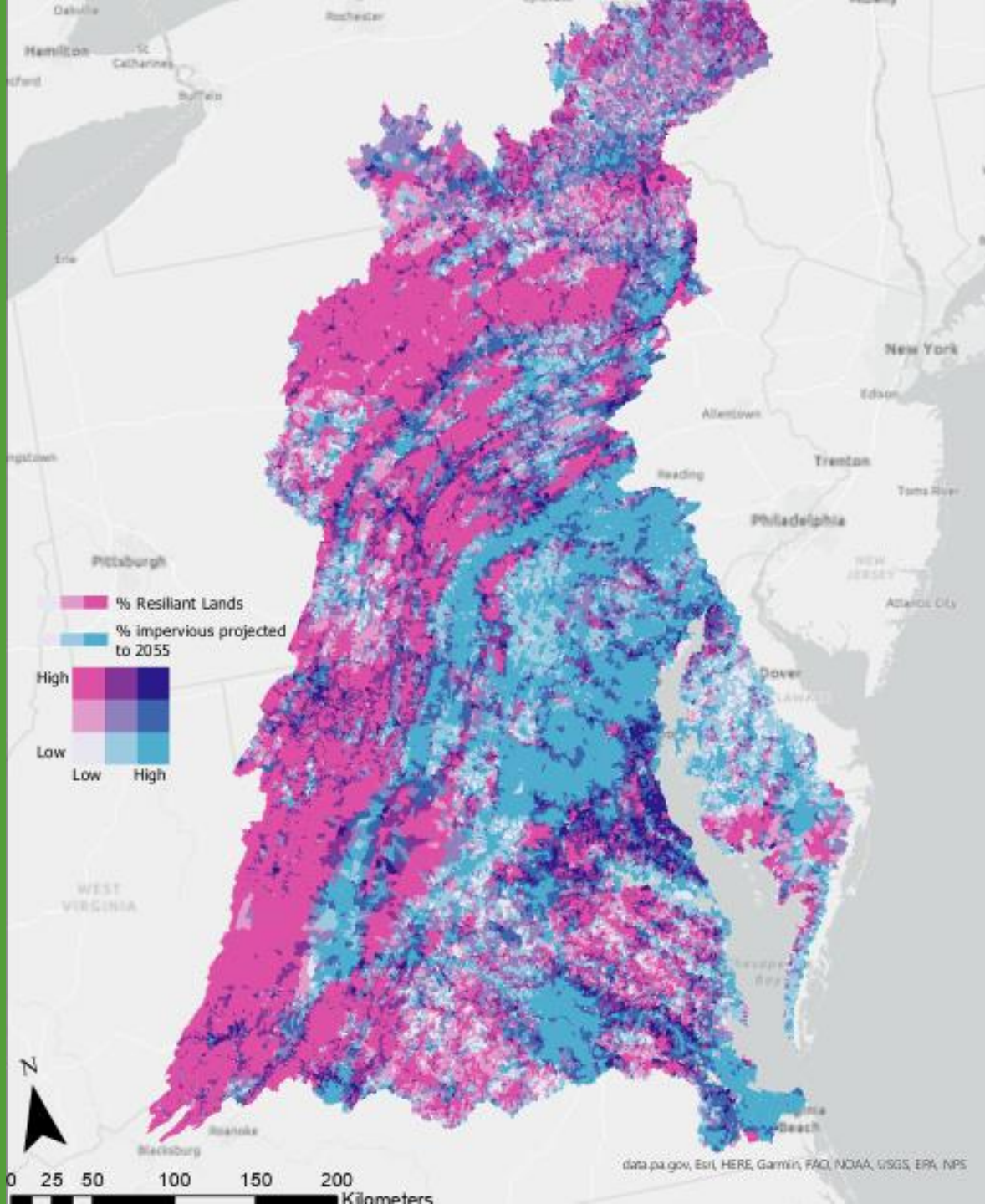
Water Quality

% Impaired Stream Catchment*	0.00%
Incremental suspended-sediment load from streambank erosion (lbs/acre/yr)*	222.03
Incremental total nitrogen load from manure applications (kg/yr)*	5977.24
Incremental total nitrogen load from fertilizer applications (kg/yr)*	5688.20
Incremental total nitrogen load from septic system effluent (kg/yr)*	1487.52
Incremental total nitrogen load from wastewater treatment facility point sources (kg/yr)*	0
Incremental total phosphorus load from manure applications (kg/yr)*	322.19



How to: Answer Science Questions using CHWA 2.0 Bivariate Maps

How protected are resilient lands?



How to: Answer Science Questions using CHWA 2.0 Bivariate Maps

Where are resilient lands vulnerable to future development?

How to: Access Table of Metrics

The screenshot shows the 'Chesapeake Healthy Watersheds Assessment 2.0' interface. A map of the Chesapeake Bay region is displayed, with various cities and landmarks labeled. A 'Table' window is open, showing a list of features and their metrics. The table has columns for 'FEATUREID', '% Natural Land in ...', and '% Protected Lands'. The 'Table' button in the bottom navigation bar is circled in red.

Table

Landscape Condition

FEATUREID	% Natural Land in ...	% Natural Land in ...	% Protected Lands
2598583	95.12000274658203	95.12000274658203	0
2598585	97.16000366210938	87.80000305175781	0
2598587	82.97000122070312	89.44000244140625	0
2598589	45.130001068115234	74.08000183105469	0
2598591	95.5999984741211	96.79000091552734	0
2598593	67.02999877929688	71.04000091552734	0

Selected features: 1

Click "Table" button to open a tabular version of the data.

How to: Access Table of Metrics

The screenshot displays the 'Chesapeake Healthy Watersheds Assessment 2.0' web application. The interface includes a map of the Chesapeake Bay region, a 'Map Layers' panel on the left, and a 'Table' view in the foreground. A red circle highlights the 'Landscape Condition' dropdown menu, which is open, showing options: 'Geomorphology', 'Landscape Condition' (selected), 'Hydrology', 'Water Quality', 'Habitat', and 'Vulnerability'. A text box with the instruction 'Click drop-down to subset table by category of metrics.' points to the dropdown. The table shows data for various watersheds, including '2598589', '2598591', and '2598593'. The bottom navigation bar includes icons for 'InfoAtlanta', 'Layers', 'Columbia Filters', 'Legend', 'Table', 'Print', 'Add Layers', and 'Report'. The bottom right corner shows 'Selected features: 1' and 'Powered by Esri'.

Chesapeake Healthy Watersheds Assessment 2.0

Select Metrics to View

Map Layers

- Hydrological Reference Layers
- Spatial Reference Layers
- Filter Results
- Predicted BIBI Score
- Chesapeake Bay Healthy Watersheds Assessment 2.0

Watershed Catchment Report

Select catchments on the map

Click drop-down to subset table by category of metrics.

Table

Landscape Condition

- Geomorphology
- ✓ Landscape Condition
- Hydrology
- Water Quality
- Habitat
- Vulnerability

	Natural Land in ...	% Natural Land in ...	% Protected Lands
2598589	45.130001068115234	74.08000183105469	0
2598591	95.5999984741211	96.79000091552734	0
2598593	67.02999877929688	71.04000091552734	0

InfoAtlanta Layers Columbia Filters Legend Table Print Add Layers Report

Selected features: 1

Powered by Esri

How to: Access Table of Metrics

The screenshot displays the 'Chesapeake Healthy Watersheds Assessment 2.0' web application. A map of the Chesapeake Bay region is shown with various watersheds highlighted. A 'Table' window is open, displaying a list of features with their IDs and associated metrics. The 'Actions' button, represented by a grid icon, is circled in red. A callout box points to this button with the text: 'Click “Actions” button to export tabular data.' The callout also lists the export options: 'Export to JSON', 'Export to CSV', and 'Export to GeoJSON'.

Chesapeake Healthy Watersheds Assessment 2.0

Select Metrics to View

Map Layers

- Hydrological Reference Layers
- Spatial Reference Layers
- Filter Results
- Predicted BIBI Score
- Chesapeake Bay Healthy Watersheds Assessment 2.0

Table

Landscape Condition

FEATUREID	% Natural Land in ...	% Natural Land in ...	% Protected Lands
2598583	95.12000274658203	95.12000274658203	0
2598585	97.16000366210938	87.80000305175781	0
2598587	82.97000122070312	89.44000244140625	0
2598589	45.130001068115234	74.08000183105469	0
2598591	95.5999984741211	96.79000091552734	0
2598593	67.02999877929688	71.04000091552734	0

Export all

- Export to JSON
- Export to CSV
- Export to GeoJSON

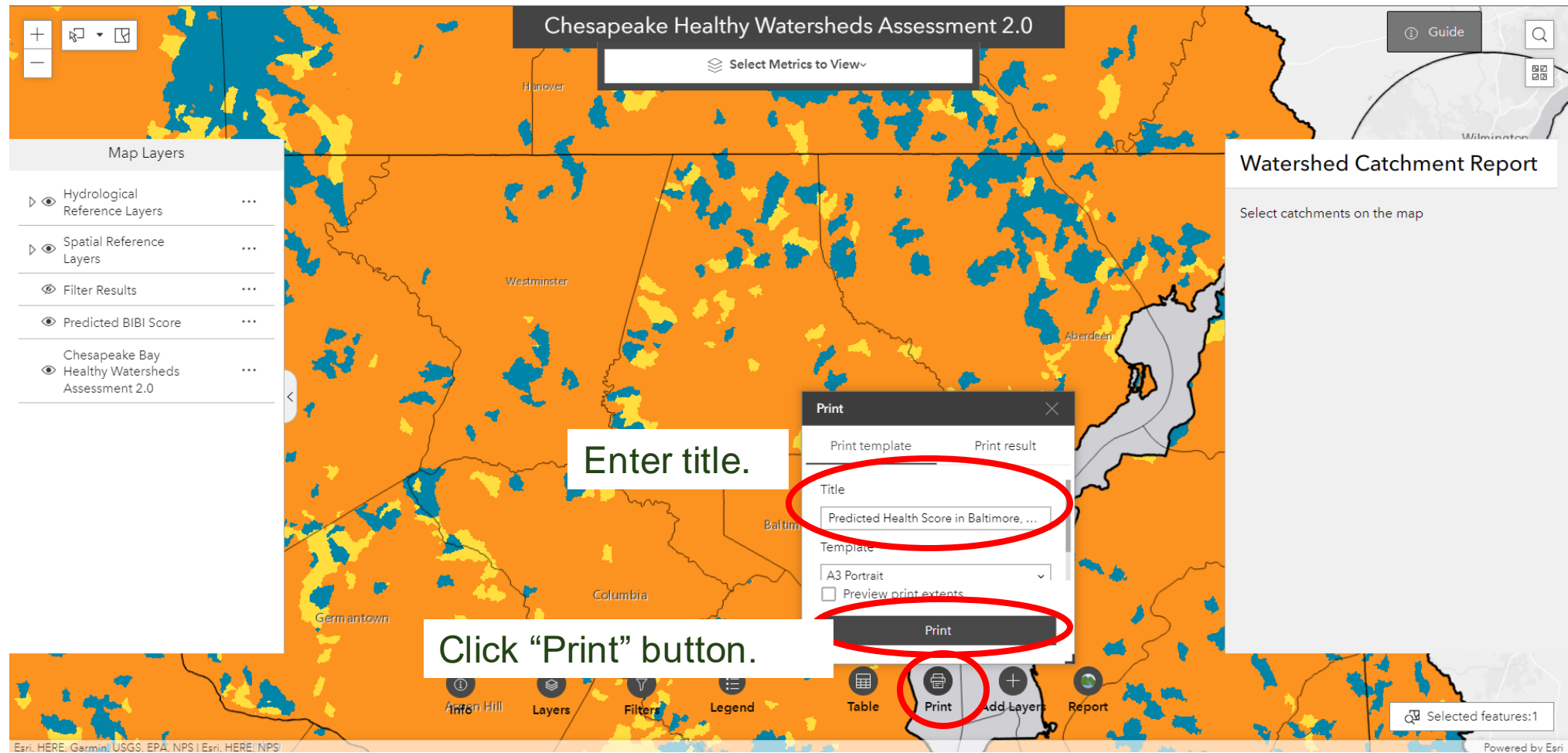
Click “Actions” button to export tabular data.

InfoAtlanta Layers Columbia Filters Legend Table Print Add Layers Report

Selected features:1

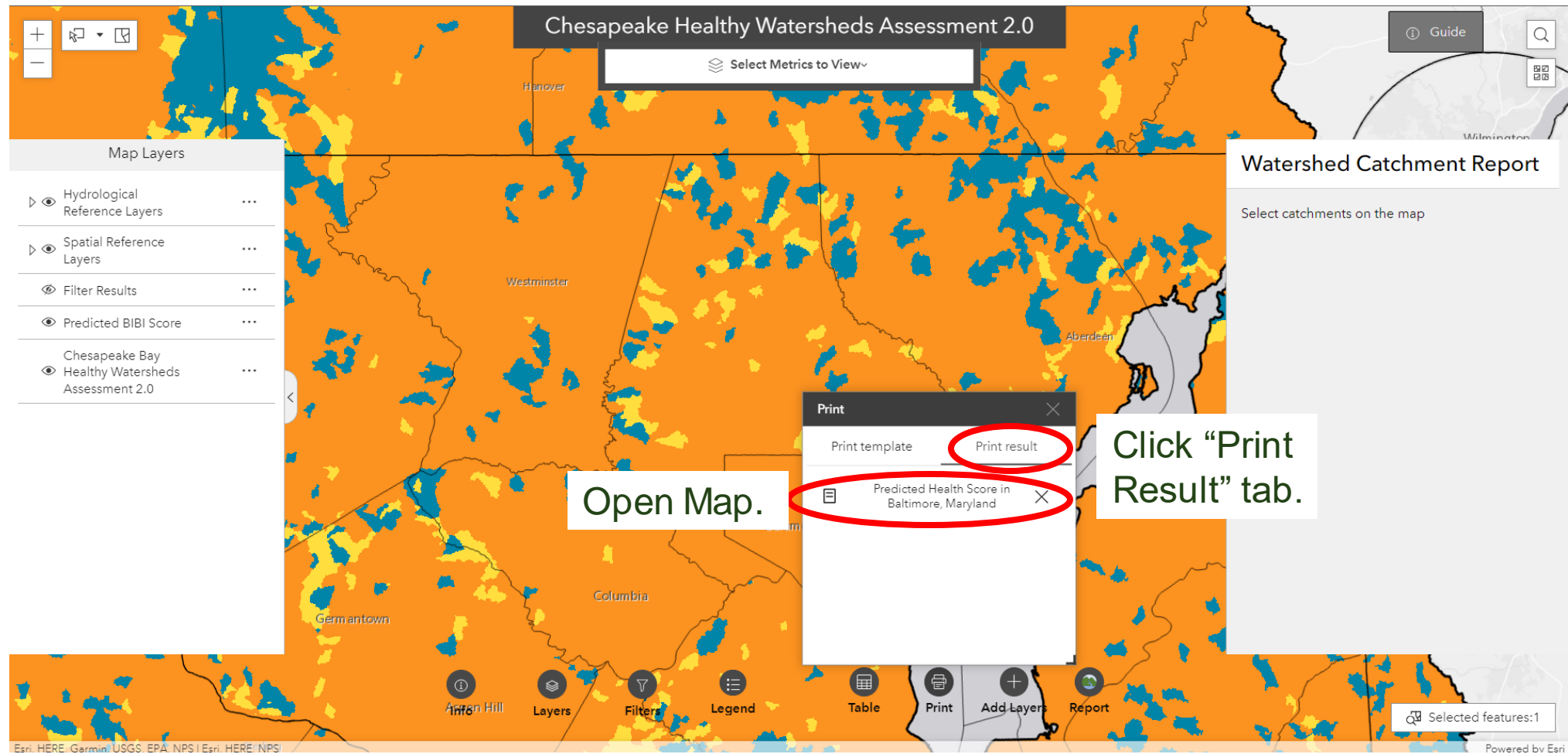
Powered by Esri

How to: Print Maps

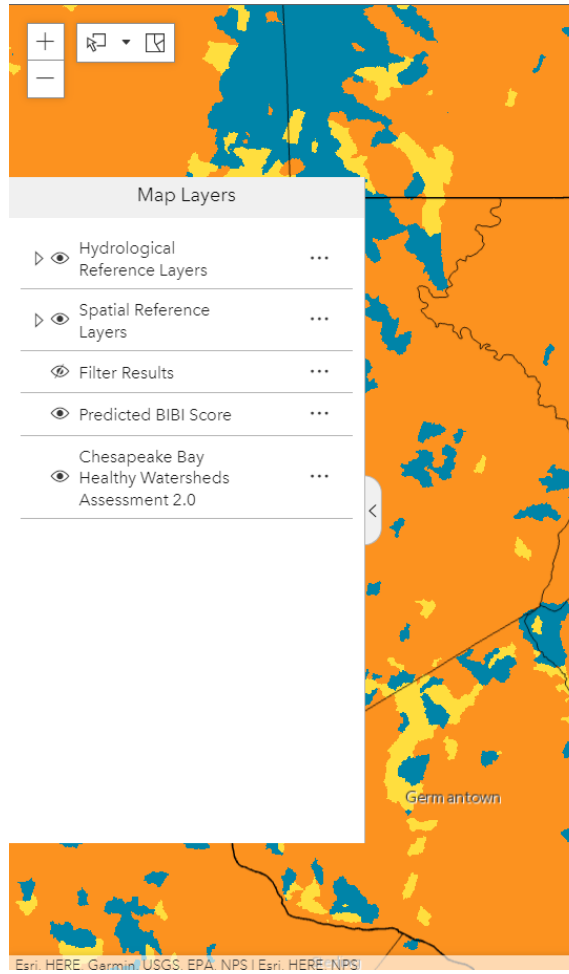


Click "Print" button to open the print prompt.

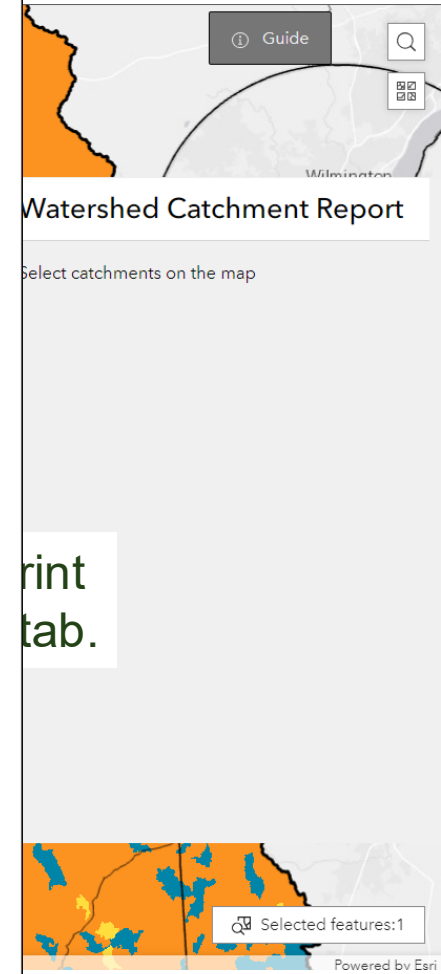
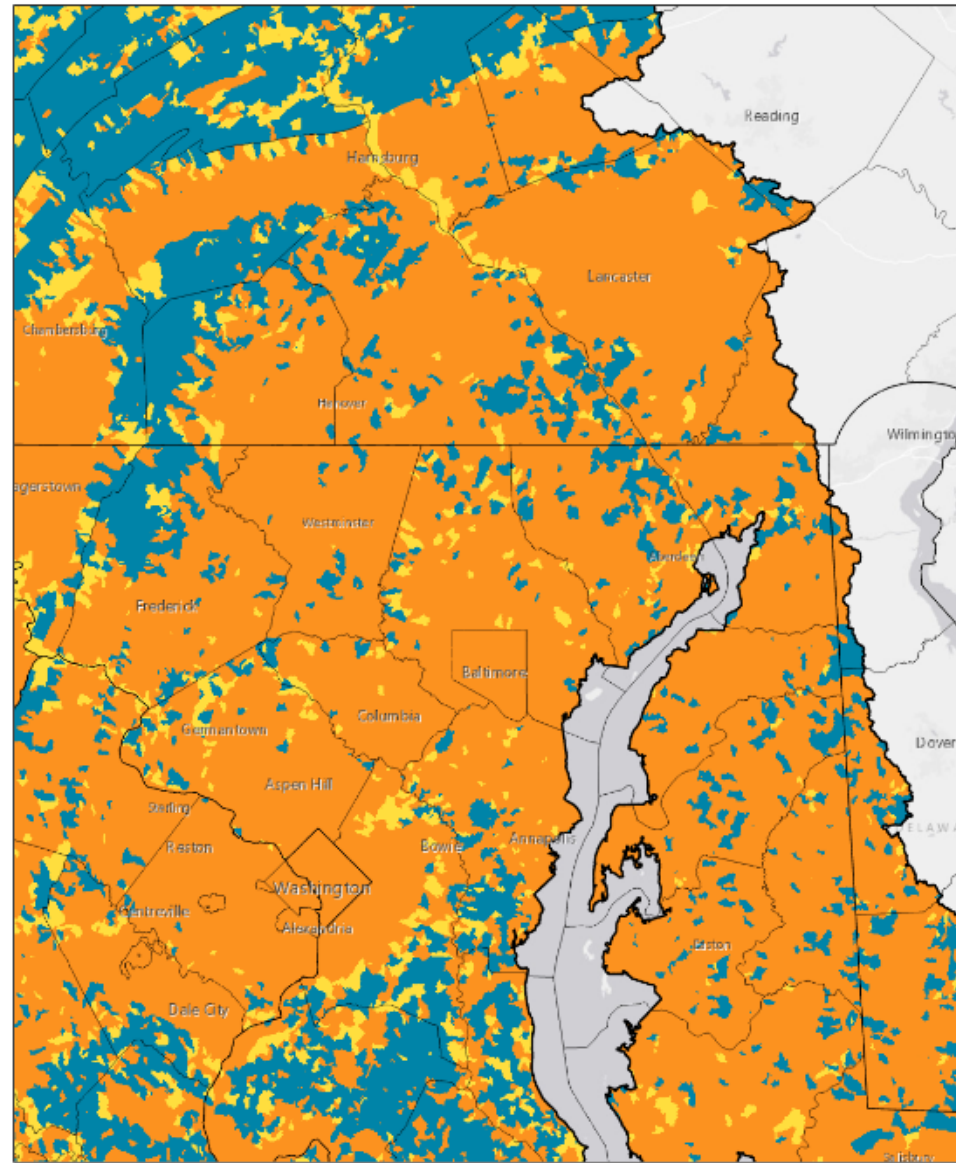
How to: Print Maps



How to: Print Maps



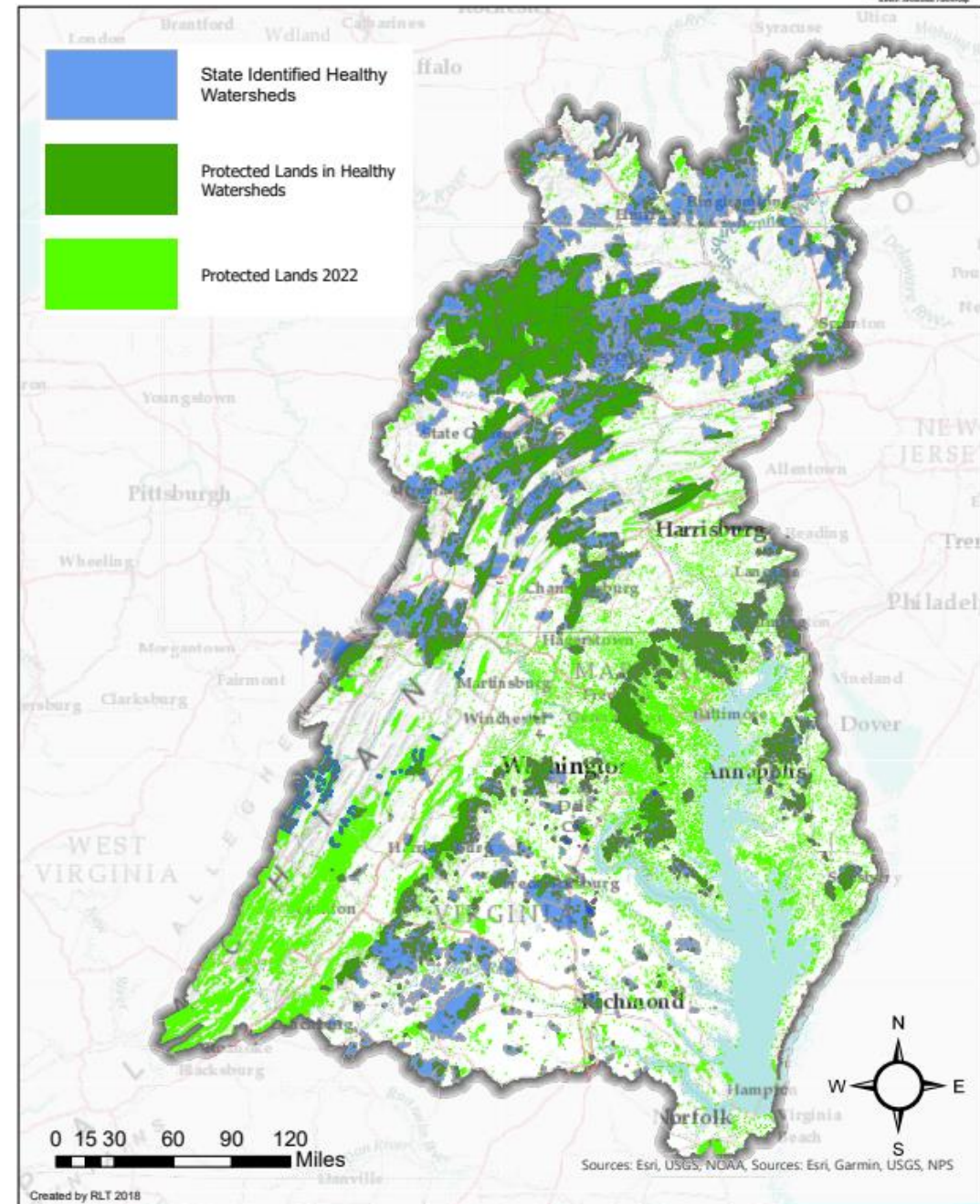
Predicted Health Score in Baltimore, Maryland



Print
tab.

Next Steps

- FY' 23: Release visualization tool and report.
- FY' 23: Incorporate new metrics, including conductivity, “effective”/connected impervious cover.
- FY '24: Author journal article to better understand:
 - Which metrics are most important in predicting watershed health.
 - the difference in local catchment versus upstream watershed conditions in predicting watershed health.
- FY '24: Incorporate feedback on improvements on the visualization tool.



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