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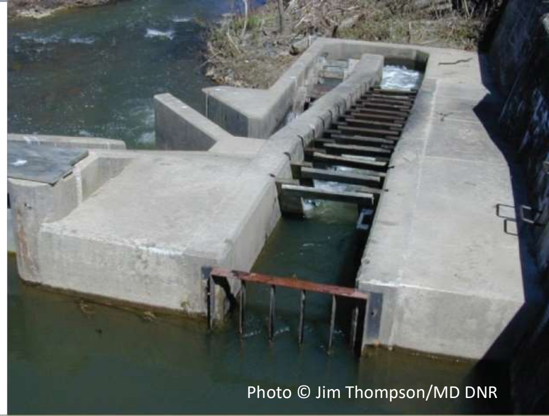
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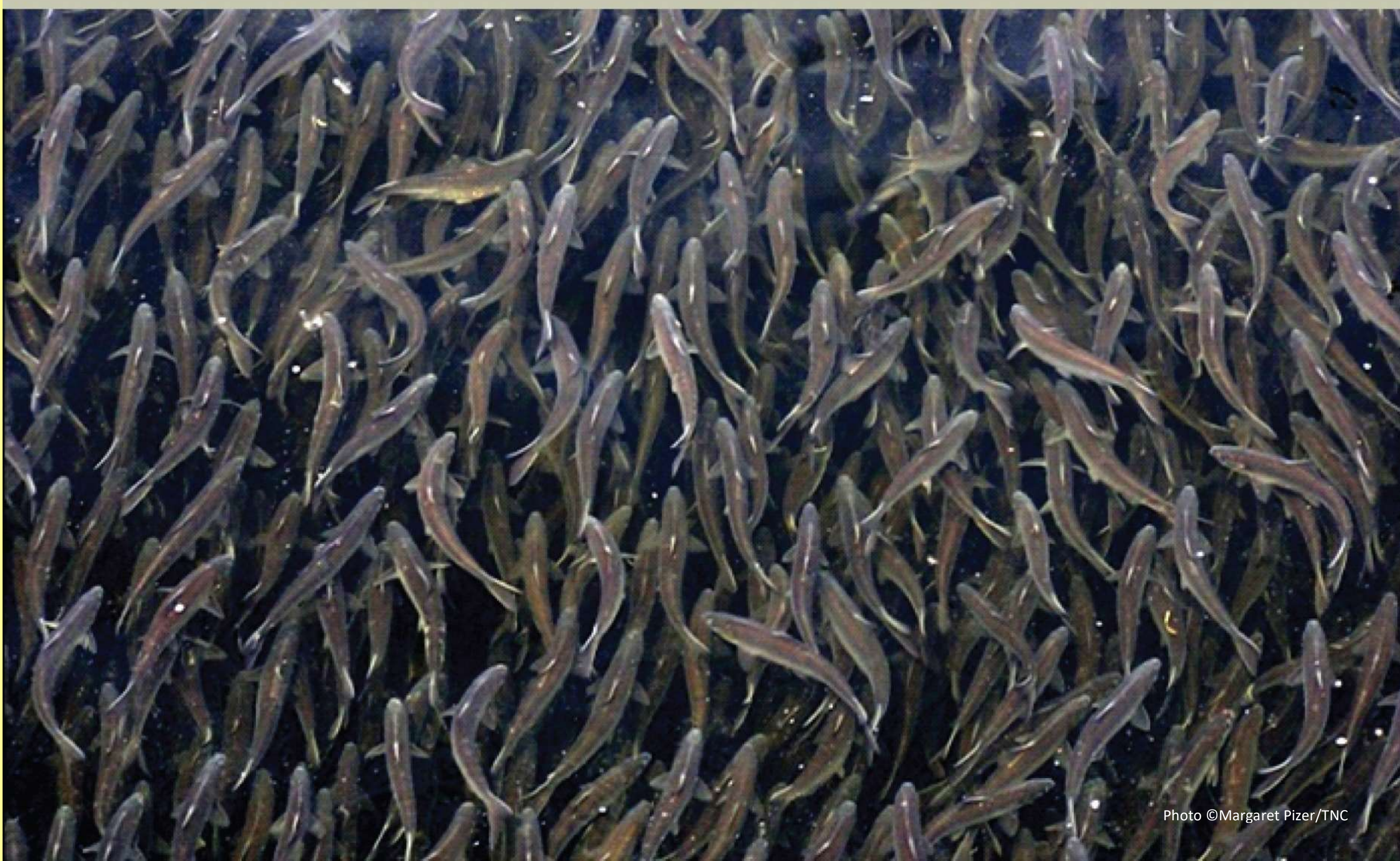
Photo © Jim Thompson/MD DNR

Chesapeake Fish Passage Prioritization

An Assessment of Dams in the Chesapeake Bay Watershed

2023 Revision
October, 2023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1 Foreword to the 2023 Revision

The Chesapeake Fish Passage Prioritization tool (hereafter the Tool or the Project) has been used since 2013 to help identify potential dam removals and fish passage projects, secure and allocate funds for these projects, and communicate the importance of aquatic connectivity in the Chesapeake Bay watershed. In 2017, The Nature Conservancy (TNC) revised the first version of the Tool and analysis to incorporate data updates and new functionality. This third iteration of the Tool again includes updates to data and functionality including:

1. Updates to the web map and Tool to use a modern, JavaScript-based, web mapping framework (Vue3) and the latest ArcGIS JavaScript API (4.27)
2. Incorporation of data updates compiled since the previous analysis. These primarily include updates to the dam data, but also other datasets including anadromous fish habitat, land cover, and other data.
3. Incorporation of road-stream crossings (i.e., culverts) which, like dams, can inhibit aquatic organism passage, into the analysis. For the first time, surveyed culverts that were rated as severe barriers by the North Atlantic Aquatic Connectivity Collaborative's (NAACC) scoring algorithm
4. Incorporation of Environmental Justice information from version 1 of the Climate & Economic Justice Screening Tool (CEJST)
5. Improved controls that allow for better display and interaction with the data (e.g., filtering, symbol sizing)
6. Improved ability to communicate information via a "Share this Map" and improved fact sheets
7. Coordination with the Southeast Aquatic Resources Partnership (SARP) to integrate the Chesapeake data into their national barrier database. SARP will maintain the dam data in the future (e.g., annual updates of dam removals) and a system was developed to extract the data for future updates of the Tool.

This revised report adds sections to address these changes (in particular Sections 6 and 7), modifies the original report elsewhere as needed (e.g., revised weights for the resident fish scenario in Table 4-3), while leaving other sections unaltered from the previous versions.

For additional information on the approach used in this analysis, please refer to the peer-reviewed journal article that covers this and its sibling projects, "Assessing and Prioritizing Barriers to Aquatic Connectivity in the Eastern United States" (Martin 2018).

2 Background, Approach, and Outcomes

2.1 Background

The anthropogenic fragmentation of river habitats through dams and poorly designed culverts is one of the primary threats to aquatic species in the United States (Collier et al. 1997, Graf 1999). The impact of fragmentation on aquatic species generally involves loss of access to quality habitat for one or more life stages of a species. For example, dams and impassable culverts limit the ability of anadromous fish species to reach preferred spawning habitats and prevent brook trout populations from reaching thermal refuges.

Some dams provide valuable services to society including low carbon electricity, flood control, and irrigation. Many more dams, however, no longer provide the services for which they were designed (e.g., old mill dams) or are inefficient due to age or design. However, these dams still create barriers to aquatic organism passage. Through the signing of multiple Chesapeake Bay program agreements, the fish passage workgroup has committed to opening 3,357 stream miles to benefit Alewife, blueback herring, American shad, hickory shad, American eel, or brook trout. In addition, fish ladders have long been used to provide fish passage in situations where dam removal is not a feasible option. In many cases, these connectivity restoration projects have yielded ecological benefits such as increased anadromous fish runs, improved habitat quality for brook trout, and expanded mussel populations. These projects have been spearheaded by state agencies, federal agencies, municipalities, NGOs, and private corporations – often working in partnership. Notably, essentially all projects have had state resource agency involvement. Most funding for these projects has come from the federal government (e.g., NOAA, USFWS), but funding has also come from state and private sources. All funding sources have been impacted by recent fiscal instability, and federal funding for connectivity restoration is subject to significant budget tightening and increased accountability for ecological outcomes.

Figure 2-1: Bloede Dam, the first barrier to migratory fish on the Patapsco River before its removal in 2018

To many working in the field of aquatic resource management it is apparent that given likely future constraints on availability of funds and staffing, it will be critical to be more strategic about investments in connectivity restoration projects. One approach to strategic investment is to assess the likely ecological "return on investment" associated with connectivity restoration.

The Northeast Aquatic Connectivity project (Martin & Apse 2011) assessed dams in the Northeast United States based on their potential to provide ecological benefits for one or more targets (e.g., anadromous fish species or resident fish species) if removed or bypassed. Funded by the NOAA Restoration Center and USFWS, the Chesapeake Fish Passage Prioritization project (CFPP or "the project") grew out of and builds on the conceptual framework of the Northeast Aquatic Connectivity work. The sections that follow detail the data, methods, results, and tools developed for the CFPP.

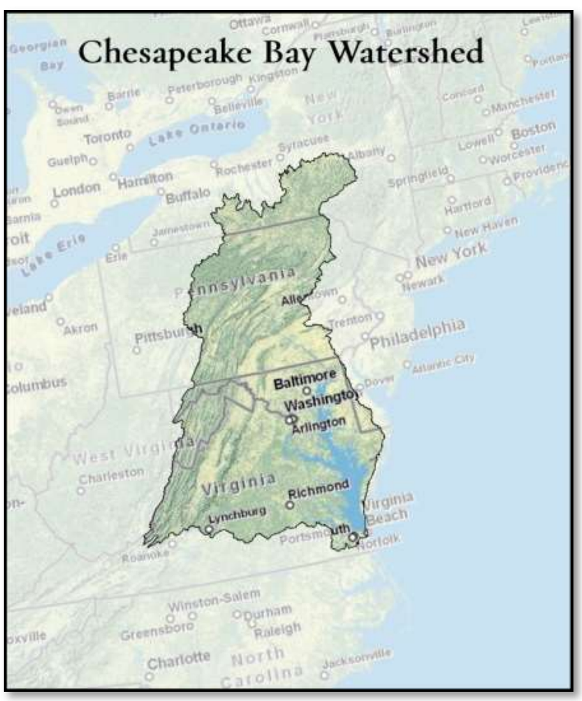
2.2 Approach

2.2.1 Workgroup

The CFPP project was guided by the Chesapeake Fish Passage Workgroup, composed of members from federal and state agencies, NGOs, and academia. A full list of Workgroup participants can be found in Appendix I. Further, a subset of this group consisting of state fish passage coordinators and NOAA representatives served as a core Steering Committee. Meetings for this revision of the Tool were held virtually. The Workgroup and particularly the Steering Committee were involved in several key aspects of the project including data acquisition and review, decision making, and review of draft results. This collaborative workgroup approach built upon TNC's successful experience working with a state agency team to complete the Northeast Aquatic Connectivity project. In addition to providing input throughout the project, the Workgroup and Steering Committee members form a core user base, are active in aquatic connectivity restoration, and have a direct and vested interest in the results.

Central among the key decisions made by the Workgroup was to define the objectives of the prioritization. That is: 1) What do we want to benefit from the prioritization?; and 2) What aspects of a dam or its location would make its removal help achieve the objective? This process of selecting targets, and especially the metrics that would be used to evaluate the dams, was both a collaborative and subjective process. The Workgroup selected three targets: diadromous fish, resident fish, and more specifically brook trout. Different metrics were used to create three separate prioritization scenarios for these three targets resulting in three prioritized lists of dams.

Figure 2-2: Chesapeake Bay watershed



2.2.2 Project extent

The Chesapeake Bay watershed covers over 64,000 square miles, has over 140,000 miles of mapped rivers and streams, and over 6,500 dams. With the bulk of the project funding coming from NOAA, which has a focus on migratory fish species, previous versions of the Tool were centered on the three main states of the Chesapeake Bay watershed with significant diadromous fish habitat: Virginia, Maryland, and Pennsylvania. However, for the 2023 revision, the Steering Committee elected to expand the scope of the Tool to include the New York, West Virginia, and Delaware portions of the Bay watershed. Barrier data for these states had been collected for previous versions of the Tool and the preceding Northeast Aquatic Connectivity assessment and were incorporated into the input barrier dataset.

3 Data Collection and Preprocessing

Spatial data for the project were gathered from multiple data sources and processed in a Geographic Information System (GIS) to generate descriptive metrics for each dam. The core datasets included river hydrography, dams, diadromous fish habitat, and natural waterfalls. Additional datasets were brought in as needed to generate metrics of interest to the Workgroup. These datasets included information on land cover, impervious surface, roads, rare species, and brook trout. A complete list of data used in the project can be found in Appendix II. The following section describes the core datasets and how they were used in the project.

3.1 Definitions

Several terms are used throughout the discussion of data and metrics. The sections below detail some important terms for understanding the data and how metrics were calculated.

3.1.1 Functional River Networks

A dam's functional river network, also referred to as its connected river network or simply its network, is defined by those stream reaches that are accessible to a hypothetical fish within that network. A given target dam's functional river network is bounded by other dams, headwaters, or the river mouth, as is illustrated in Figure 3-1. A dam's total functional river network is simply the combination of its upstream and downstream functional river networks. The total functional network represents the total distance a fish could theoretically swim if that dam was removed.

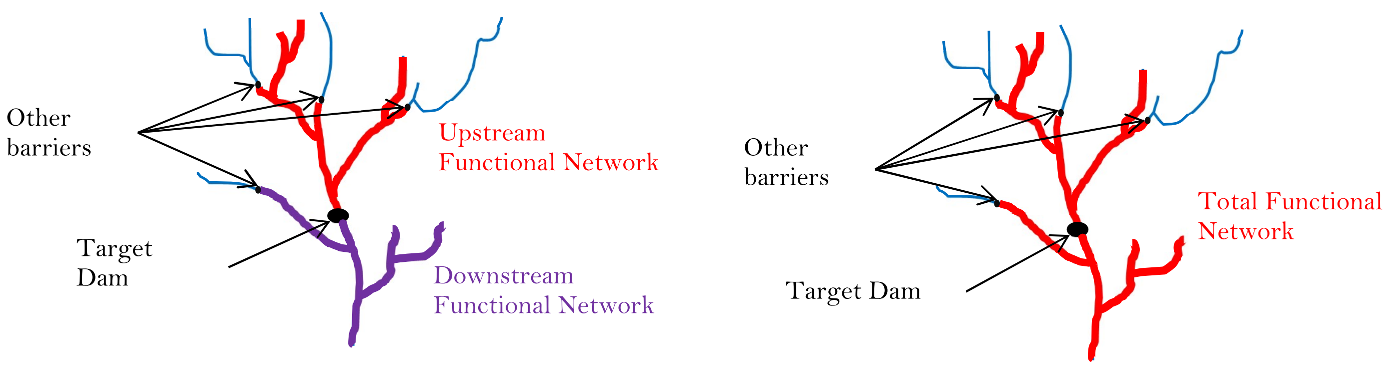


Figure 3-1: Conceptual illustration of functional river networks

3.1.2 Watersheds

For any given dam, metrics involving three different watersheds are used in the analysis. The contributing watershed, or total upstream watershed, is defined by the total upstream drainage area above the target dam. Several metrics are also calculated within the local watershed of a target dam's upstream and downstream functional river networks. These local watersheds are bounded by the watersheds of the next upstream and downstream functional river networks, as illustrated in Figure 3-2.

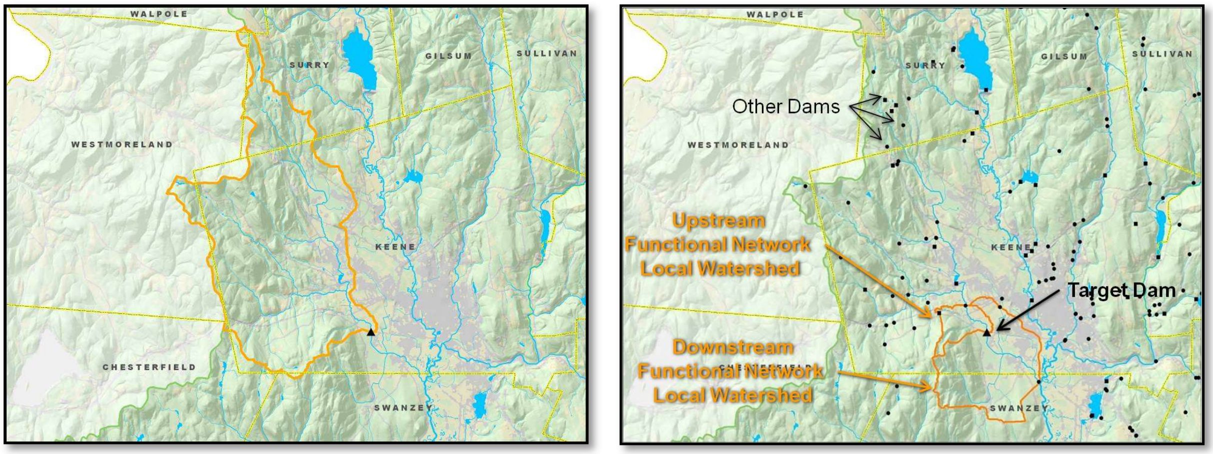


Figure 3-2: The contributing watershed is defined by the total drainage upstream of a target dam. The local watersheds of the upstream and downstream functional river network are bounded by the watershed of the next dams up and down stream.

3.1.3 Stream size class

Stream size is a critical factor for determining aquatic biological assemblages (Olivero & Anderson 2008, Vannote et al. 1980, Mathews 1998). In this analysis, river size classes, based on the catchment drainage size thresholds developed for the Northeast Aquatic Habitat Classification System (Olivero & Anderson 2008), were calculated for each segment of the project hydrography and in turn assigned to each dam (Figure 3-3). Size classes are used in several ways throughout the analysis including as a proxy for habitat diversity and to define fish habitat (e.g., American shad use classes ≥ Size 2).

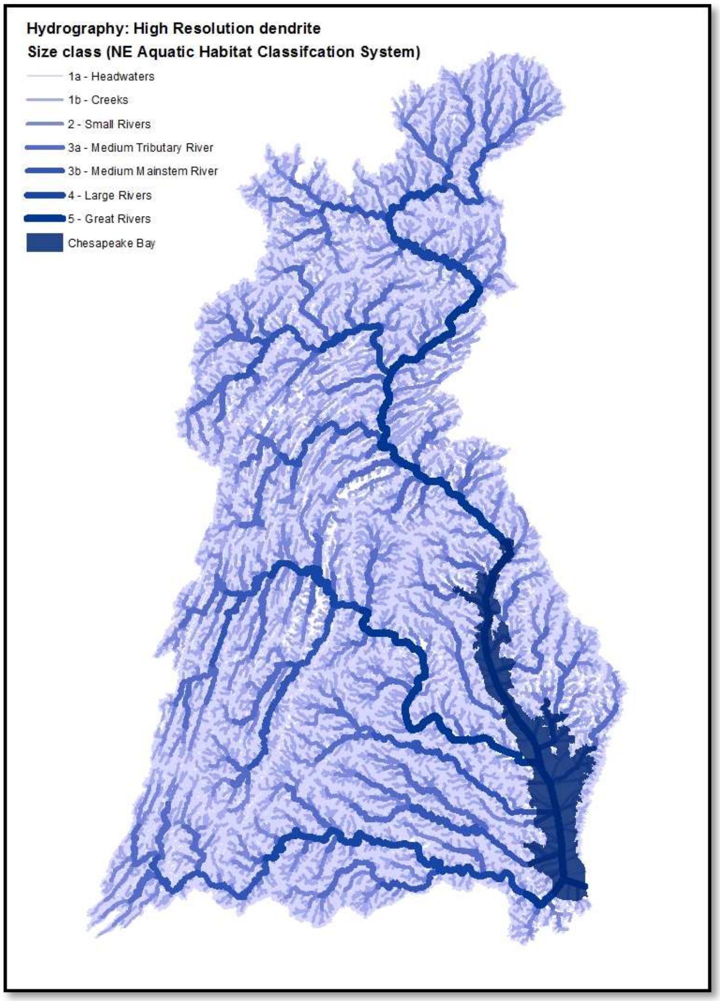


Figure 3-3: Size class definitions and map of rivers by size class in the Chesapeake Bay watershed.

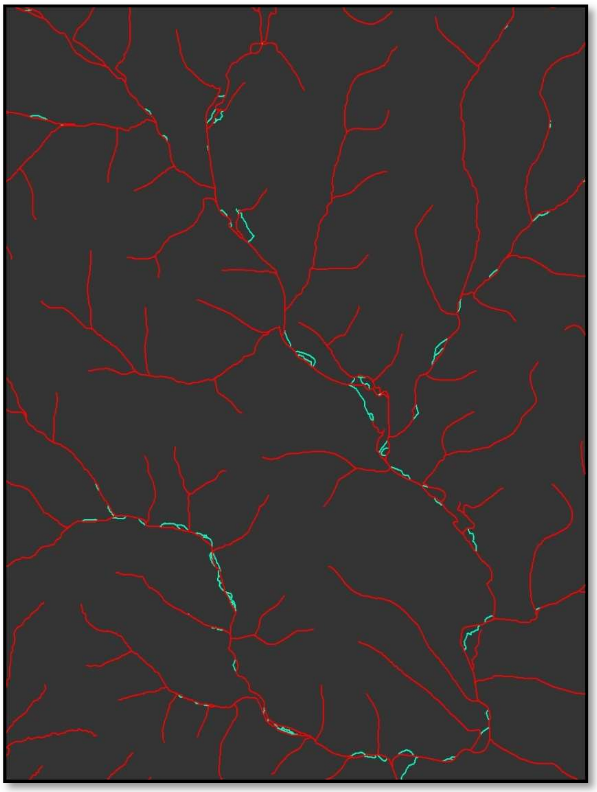
1a) Headwaters (<3.861 mi^2)
1b) Creeks (>= 3.861<38.61 mi^2)
2) Small River (>=38.61<200 mi^2)
3a) Medium Tributary Rivers (>=200<1000 mi^2)
3b) Medium Mainstem Rivers (>=1000<3861 mi^2)
4) Large Rivers (>=3861 < 9653 mi^2)
5) Great Rivers (>=9653 mi^2)
(Defining measure = upstream drainage area)

3.2 Hydrography

In order for dams to be included in the analysis, they had to fall on the mapped river network, or hydrography, that was used in the project: a modified version of the High Resolution National Hydrography Dataset (NHD). This hydrography was digitized by the United States Geological Survey (USGS) primarily from 1:24,000 scale topographic maps.

For use in this analysis, the hydrography had to be processed to create a dendritic network, or dendrite which is a single-flowline network with no braids or other downstream bifurcation (Figure 3-4). Unlike the medium-resolution NHDPlus, which includes an attribute to select the mainstem of a river from a braided section, the High-Resolution NHD has no such attribute, thus this process was largely a manual one. To do this, a Geometric Network was created from the hydrography in ArcGIS 10.0 so that offending loops and bifurcations could be selected. Each offending section was then manually edited by selecting the mainstem or otherwise removing line segments to create a dendritic network.

Figure 3-4: Braided segments highlighted in blue had to be removed to generate a dendritic network.



In Maryland and Pennsylvania, dendrites had been previously developed by USGS using an older (2004) hydrography for their StreamStats program. To speed up the editing process, these older dendrites were obtained from the USGS and joined to the current hydrography using the “REACHCODE” attribute. Those records in the current data which did not join were therefore loops or other extraneous line segments. This process identified and removed the vast majority of problem segments. However, since the hydrography had changed between the two versions, some additional manual editing was required. In Virginia, where no previous dendrite existed, TNC partnered with the USGS Virginia Water Science center which had an unrelated need for the same dendrite. Subwatersheds in Virginia were divvied up and manually edited.

The result of this process was a single-flowline dendrite, based on the current (as of 2011) High Resolution NHD, for the entire Chesapeake Bay watershed. This dendrite (hereafter referred to as the "project hydrography") was then further processed using the ArcHydro toolset in ArcGIS 10.0 to establish flow direction, consistent IDs, and the 'FromNode' and 'ToNode' for each segment. Additional processing using ArcGIS Spatial Analyst, ArcHydro, and custom Python scripts in ArcGIS was performed to accumulate upstream attributes. This processing produced attributes including the total upstream drainage area, percent impervious surface, and slope for each line segment.

3.3 Dams

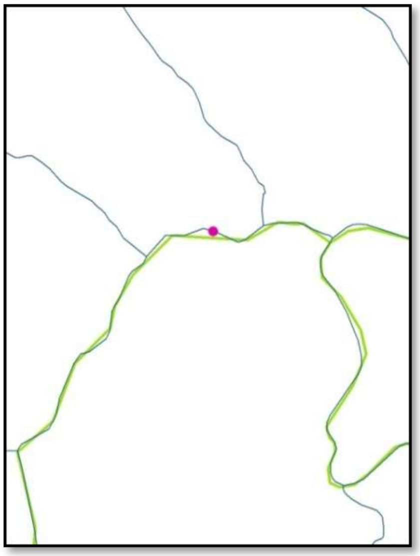
Dam data were originally obtained from the Northeast Aquatic Connectivity project. Dam data for the Northeast Aquatic Connectivity project were in turn obtained from several sources including state agencies, the U.S. Army Corps' National Inventory of Dams (NID), and the USGS Geographic Names Information System (GNIS) database. Additional dams were provided by the Chesapeake Bay Program office, as well as by Workgroup members.

Data preprocessing and review began after all available data were obtained for each state from the sources listed above. To perform network analyses in a GIS, the points representing dams must be topologically coincident with lines that represent rivers. This was rarely the case in the dam datasets as they came from various data sources. To address this problem, dams were "snapped" in a GIS to the project hydrography (Figure 3-5).

Figure 3-5: Illustration of snapping a dam to the river network

Dams that were obtained from the Northeast Aquatic Connectivity project had previously been snapped to the medium resolution (1:100,000) NHD and error checked as part of that project's review process. Thus, it was assumed that dams obtained from that project were in the correct location, and only needed to be snapped to the project hydrography from the medium resolution hydrography (Figure 3-6).

Figure 3-6:Dam point snapped to the project hydrography (blue) from the medium-resolution NHD (green).



Snapping was originally performed using the ArcGIS Geospatial Modeling Environment extension (Beyer 2009) and in subsequent edits using tools from Esri's *arcpy* module. Although snapping is a necessary step which must be run prior to performing the subsequent network analyses, it can also introduce error into the data. For example, if the point in Figure 3-5 is, in fact, a dam on the main stem of the pictured river, the snapping will correctly position it on the hydrography. However, if the point represents a farm pond next to the main stem, the snapping will still move it, incorrectly, onto the hydrography. A snapping tolerance, or "search distance" can be set to help control which points are snapped. The project team selected a 100-m snapping tolerance and developed a review process to error check the results.

The review process for dams that were obtained from the Northeast Aquatic Connectivity project involved comparing the snapping distance as well as the "REACHCODE" attribute, which persists between different versions of the NHD. Dams that snapped to the project hydrography within the 100-m snap tolerance and which had matching REACHCODEs were considered to be in the correct location. All other dam locations were manually reviewed and edited if necessary.

For the 2019 version, edits to dam data were solicited and collected from Workgroup members. Many of these edits had been submitted in the intervening years following the conclusion of the 2013 analysis. Edits included new dams that had not been in any of the source databases, dams that were moved to their correct location, and dams that had been removed through on-the-ground actions.

In the 2023 revision, additional dam data, including dam removals, were incorporated from American Rivers, the USGS Dam Removal Information Portal (DRIP), Virginia Department of Conservation and Recreation, and the USGS Fishways database. The metadata for the dams can be accessed via the tool or directly from this link.

Moving forward, authorized users can make edits to the dam data through the SARP data editing portal (See Section 7.2.2).

3.4 Road – Stream Crossings

One substantive change in the 2023 revision of the Tool is the inclusion of some road-stream crossings (culverts) as prioritized barriers in the analysis. Previously, road-stream crossings were only used in the generation of the crossing density metrics (see Table 4-1). However, the increase in the number of field-surveyed road stream crossings through partner surveys using the NAACC protocol has enabled the incorporation of road-stream crossings as prioritized barriers. The field-surveyed information gathered by partners is used within the NAACC numeric scoring system to rate the passability of each given culvert. The numerical score that results from this system is then binned into passability ratings that range from “insignificant” to “severe.” Barriers deemed to be substantial impediments to fish passage can be included as prioritized barriers while those that are not can be excluded (all crossings are still used in the generation of the road-stream crossing density metrics). Through consultation with the Steering Committee, it was decided that only those crossings rated as “Severe” in the NAACC scoring protocol would be included as prioritized barriers in the analysis. The barriers in the analysis were those that had been surveyed and available on the NAACC database as of October 2022.

3.5 Diadromous Fish Habitat

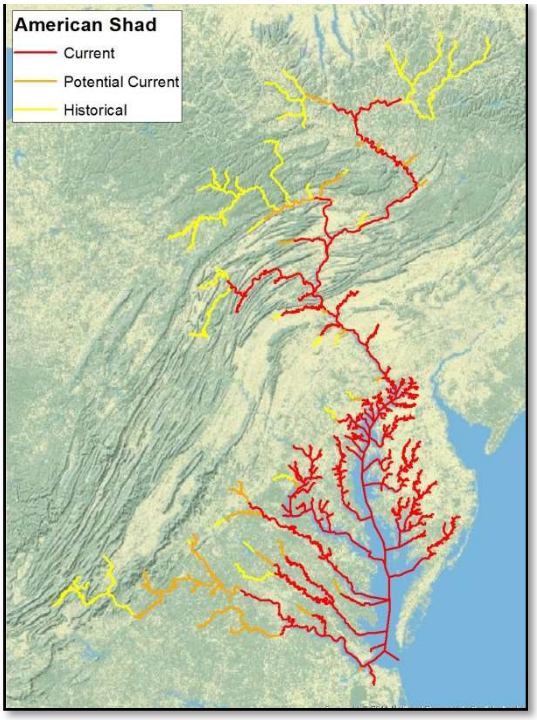
Identifying opportunities to improve aquatic connectivity for the benefit of diadromous fish populations was one of the key goals of the project. Diadromous fish habitat downstream of a dam was one of the most important factors chosen by the Workgroup to determine which dams, if removed or mitigated, have the greatest potential to ecologically benefit diadromous fish.

Baseline habitat data was collected for American shad, hickory shad, blueback herring, alewife, striped bass, Atlantic sturgeon, and shortnose sturgeon from the Atlantic States Marine Fisheries Commission (ASMFC 2004). This data was extensively reviewed and edited by fisheries biologists in the fall of 2011 through a series of in-person meetings and follow-up virtual meetings. This review process incorporated additional fish observance data as well as field knowledge from on-the-ground biologists. A new dataset for American eel was also developed through the meeting process in the fall of 2011. For the 2019 and 2023 Tool revisions, edits to the anadromous fish data were solicited and collected from Workgroup members, though these edits were generally minor. In the 2023 revision, more substantive edits were made to the diadromous fish habitat data using dam removal data. See Section 6.3 for additional details on the expansion of the fish habitat data using the dam removal projects.

Figure 3-7: Field sampling fish on the Patapsco River in Maryland. Field observations for eight diadromous fish were incorporated into the project's diadromous fish habitat layers.

Fish habitat was classified into four categories. Each line segment in the hydrography was assigned one of the four categories for each species in the study.

Figure 3-8: Habitat extent data for American shad. All reaches not depicted are coded as "none documented"



1. Current: There is documentation (observance record or other direct knowledge) of a given species using a given reach. "Using" in this context refers to spawning or other critical life stages *and the reaches that would need to be traversed to access that reach from the Bay.*
2. Potential Current: There is not documented evidence of a given species using a given reach, but based on similar streams/rivers, there is an expectation that they might be or could be using that reach.
3. Historical: – A given species does not currently use a given reach, but historically (prior to the erection of anthropogenic barriers), they would be expected to.
4. None Documented: No use or expected historical use of a given reach by a given species.

Potential Current and Historical categories were assigned based on the consensus of the Workgroup using simple size class and/or gradient rules or professional judgment. The data used to categorize each reach for each species can be accessed by clicking on a given reach of a species layer, which can be found under the "Layers" section of the web map: https://maps.tnc.org/chesfpp/

3.6 Waterfalls

Waterfalls, like dams, can act as barriers to fish passage. Including them in the analysis was important due to the impact barriers have across a network. For example, a waterfall just upstream of a dam would drastically affect the length of that dam's upstream functional network, or the number of river miles that would be opened by removing that dam. Thus, although waterfalls are excluded from the project results, they were included in the generation of functional networks.

The original primary data source for waterfalls was the USGS GNIS database, which includes named features from 1:24,000 scale topographic maps. Additional waterfalls were available for portions of Pennsylvania. Waterfall data were subjected to a similar review process as that used for dams. Waterfalls were snapped to the project hydrography using the same method described above for dams. For the 2019 revisions, edits to the waterfall data were solicited and collected from Workgroup members. These edits were generally minor.

The 2023 revision included new waterfall data from the Waterfalls and Rapids in the Conterminous United States Linked to the National Hydrography Datasets (Wieferich et al. 2020).

4 Analysis Methods

The conceptual framework of the Chesapeake Fish Passage Prioritization project rests on a suite of ecologically relevant metrics calculated for every dam in the study area. These metrics are then used to evaluate the benefit of removing or providing passage at any given dam relative to any other dam. At its simplest, a single metric could be used to evaluate dams. For example, if one is interested in passage projects to benefit diadromous fish, then the dam's upstream functional network, or the number of river miles that would be opened by that dam's removal, could be used to prioritize dams. In this case, the dam with the longest upstream functional network—the dam whose removal would open up the most river miles—would rank at the top of the list. As multiple metrics are evaluated, weights can be applied to indicate the relative importance of each metric in a given scenario, as described in further detail in Section 4.2**Error! Reference source not found.**.

4.1 Metric Calculation

A total of 64 metrics were calculated for each dam in the study area using Esri's ArcGIS Pro. The process used to generate each metric was scripted in Python 3.9 using Esri's arcpy and other freely available Python packages.

Metrics are organized into four categories for convenience: Network, Landcover, Ecological, and System Type. These categories help organize the metrics into logical groups but they have no impact on the analysis. Additionally, each metric is sorted in either ascending or descending order to indicate whether large values or small values are desirable in a given scenario. For example, upstream functional network length is sorted descending because large values are desirable – a passage project on a dam that opens up more river miles is desired over a passage project which opens up few miles. Conversely, percent impervious surface is sorted ascending because small values are desirable – a passage project that opens up a watershed that has little or no impervious surface is desired over a dam that opens up a watershed with a high percentage of impervious surface. Each of the metrics is listed in Table 4-1 , and a more complete description of each metric can be found in Appendix III. Additional details about each metric, including a description and list of the source data, can be found in the tool's help dialog for the radar plot (see Section 6.2.6).

Category	Metric	Unit	Order
Network	# Dams Downstream	#	A
	# Fish Passage Facilities Downstream	#	D
	# Natural Barriers Downstream	m	D
	# Hydropower Facilities Downstream	#/m	A
	Total Upstream River Length	#/m	A
	Upstream Barrier Density	#/m²	A
	Upstream Functional Network Length	m	D
	The total length of upstream and downstream functional network	m	D
	Absolute Gain	m	D
Watershed / Local Condition	% Impervious Surface in Contributing Watershed (NLCD 2019)	%	A
	% Natural LC in Contributing Watershed (NLCD 2019)	%	D
	% Forested LC in Contributing Watershed (NLCD 2019)	%	D
	% Agricultural LC in Contributing Watershed (NLCD 2019)	%	A
	% Impervious Surface in riparian zone of Upstream Functional Network (NLCD 2019)	%	A
	% Impervious Surface in riparian zone of Downstream Functional Network (NLCD 2019)	%	A
	% Agricultural LC in riparian zone of Upstream Functional Network (NLCD 2019)	%	A
	% Agricultural LC in riparian zone of Downstream Functional Network (NLCD 2019)	%	A
	% Natural LC in riparian zone of Upstream Functional Network (NLCD 2019)	%	D
	% Natural LC in riparian zone of Downstream Functional Network (NLCD 2019)	%	D
	% Forested LC in riparian zone of Upstream Functional Network (NLCD 2019)	%	D
	% Forested LC in riparian zone of Downstream Functional Network (NLCD 2019)	%	D
	% Conserved Land within 100m Buffer of Upstream Functional Network	%	D
	% Conserved Land within 100m Buffer of Downstream Functional Network	%	D
	% Tree Cover in riparian zone of Upstream Functional Network (Ches Bay Land Cover)	%	D
	% Tree Cover in riparian zone of Downstream Functional Network (Ches Bay Land Cover)	%	D
	% Herbaceous Cover in riparian zone of Upstream Functional Network (Ches Bay Land Cover)	%	D
	% Herbaceous Cover in riparian zone of Downstream Functional Network (Ches Bay Land Cover)	%	D
	% Barren Cover in riparian zone of Upstream Functional Network (Ches Bay Land Cover)	%	D
	% Barren Cover in riparian zone of Downstream Functional Network (Ches Bay Land Cover)	%	D
	% Road Impervious Surface in riparian zone of Upstream Functional Network (Ches Bay Land Cover)	%	A
	% Road Impervious Surface in riparian zone of Downstream Functional Network (Ches Bay Land	%	A
	% Non-Road Impervious Surface in riparian zone of Upstream Functional Network (Ches Bay Land	%	A
	% Non-Road Impervious Surface in riparian zone of Downstream Functional Network (Ches Bay Land	%	A
	% Structure Cover (buildings) in the riparian zone of the Upstream Functional network (Ches Bay LC)	%	A
	% Structure Cover (buildings) in the riparian zone of the Downstream Functional network (Ches Bay	%	A
	% Shrub Cover in riparian zone of Upstream Functional Network (Ches Bay Land Cover)	%	D
	% Shrub Cover in riparian zone of Downstream Functional Network (Ches Bay Land Cover)	%	D
	% Wetland Cover in riparian zone of Upstream Functional Network (Ches Bay Land Cover)	%	D
	% Wetland Cover in riparian zone of Downstream Functional Network (Ches Bay Land Cover)	%	D
	% Tree Cover Over Other Surface in riparian zone of Upstream Functional Network (Ches Bay Land	%	A
	% Tree Cover Over Other Surface in riparian zone of Upstream Functional Network (Ches Bay Land	%	A
	Barrier is on Conservation Land	Boolean	D
	NFHAP Cumulative Disturbance Index by Catchment	unitless	D
	Density of Off-Channel Dams in Upstream Functional Network Local Watershed	#/m²	A
	Density of Off-Channel Dams in Downstream Functional Network Local Watershed	#/m²	A
	Density of road-stream Xings in Upstream Functional Network Local Watershed	#/m²	A
	Density of road-stream Xings in Downstream Functional Network Local Watershed	#/m²	A
Ecological	# Diadromous Spp in DS Network (incl Eel)	#	D
	Presence of Anadromous Spp in DS Network	unitless	D
	CBP Stream Health	unitless	D
	# of rare (G1-G3) fish species in HUC8	#	D
	# of rare (G1-G3) mussel HUC8	#	D
	# of rare (G1-G3) crayfish HUC8	#	D
	Native fish species richness - HUC 8	#	D
	Barrier within Eastern Brook Trout Joint Venture 2012 Catchments	Boolean	D
	Barrier Block EBTJV 2012 Catchment	Boolean	D
	Barrier within DeWeber & Wagner modeled Brook Trout Catchment	Boolean	D
	Barrier blocks DeWeber & Wagner modeled Brook Trout Catchment	Boolean	D
Size / System Type	# Upstream Size Classes >0.5mi gained	#	D
	Total Reconnected # stream sizes (upstream + downstream) >0.5 Mile	#	D
	# Upstream Size Classes >0.5mi	#	D
	Miles of Cold-Water Habitat in Total Functional Network	Miles	D
	Miles of Cold / Cool water habitat in Total Functional Network	Miles	D

Table 4-1Metrics calculated for each barrier in the study

Depending on the objectives of a prioritization scenario, some metrics will be more important than others. For example, upstream functional network length may be of particular interest in a prioritization scenario focused on diadromous fish, while the percent impervious surface in the riparian zone of a dam's upstream functional river network may be less important, and the presence of rare crayfish species may be of no interest. Relative weights, which must sum to 100, can be assigned to each metric to indicate its importance in a given scenario. Table 4-2, Table 4-3, and Table 4-4 depict the weights chosen by the Workgroup for the Diadromous Fish Scenario, Resident Fish Scenario, and Brook Trout Scenario, respectively.

Metric weights are subjective in nature; there are no hard and fast rules regarding how to properly select and weight metrics for a given target like diadromous fish. To arrive at the weights presented in the tables below, the Workgroup went through an iterative process of selecting draft weights based on their knowledge of the species of interest, then adjusting them in light of draft results produced from the selected weights and their current on-the-ground removal priorities. This process allowed the Workgroup to both understand the impact of making an adjustment to a given metric weight and better calibrate the results to known priorities.

Table 4-2: Workgroup consensus metric weights for the Diadromous Fish Scenario

Metric Category	Metric	Diadromous Weight
Network	# Dams Downstream	10
	# Fish Passage Facilities Downstream	5
	Total Upstream River Length	10
	Upstream Functional Network Length	10
Watershed / Local Condition	Density of Road & Railroad / Small Stream Crossings in Upstream Functional Network Local Watershed	5
	% Impervious Surface in Contributing Watershed	5
	% Impervious Surface in riparian zone of Upstream Functional Network	5
	% Natural LC in riparian zone of Upstream Functional Network	5
Ecological	# Diadromous Spp in DS Network (incl Eel)	10
	Presence of Anadromous Spp in DS Network	20
	CBP Stream Health	10
Size / System Type	# Upstream Size Classes >0.5mi gained	5

Table 4-3: Workgroup consensus metric weights for the Resident Fish Scenario. These weights were modified by the workgroup as part of the 2019 revision.

Metric Category	Metric	Resident Weight
Network	Total Upstream River Length	5
	Upstream Barrier Density	5
	Upstream Functional Network Length	5
	The total length of upstream and downstream functional network	5
	Absolute Gain	20
Watershed / Local Condition	Density of Road-Stream Crossings in US Functional Network Local Watershed	5
	Density of Road-Stream Crossings in DS Functional Network Local Watershed	5
	% Natural LC in riparian zone of Upstream Functional Network	10
	% Natural LC in riparian zone of Downstream Functional Network	10
Ecological	CBP Stream Health	5
	# of rare (G1-G3) fish species in HUC8	5
	# of rare (G1-G3) mussel HUC8	5
	Native fish species richness - HUC 8	5
Size / System	Total Reconnected # stream sizes (upstream + downstream) >0.5 Mile	10

Table 4-4: Workgroup consensus metric weights for the Brook Trout Scenario. In addition to the weights listed below, only barriers in the analysis that fall within mapped brook trout habitat (based on either Eastern Brook Trout Joint Venture 2012 catchments or DeWeber and Wagner watersheds) were included.

Metric Category	Metric	Brook Trout Weight
Network	The total length of upstream and downstream functional network	10
	Absolute Gain	20
Watershed / Local Condition	Density of Off-Channel Dams in Upstream Functional Network Local	5
	Density of Off-Channel Dams in Downstream Functional Network Local	5
	Density of Road-Stream Crossings in Upstream Functional Network Local	5
	Density of Road-Stream Crossings in Downstream Functional Network Local	5
	% Impervious Surface in Contributing Watershed	10
	% Forested LC in Contributing Watershed	10
	% Conserved Land within 100m Buffer of Upstream Functional Network	3
	% Conserved Land within 100m Buffer of Downstream Functional Network	2
Ecological	CBP Stream Health	5
	Barrier Block EBTJV 2012 Catchment	10
	Barrier blocks DeWeber & Wagner modeled Brook Trout Catchment	10

As noted in the caption for Table 4-4 above, in addition to assigning relative weights for metrics, the universe of dams that are included in an analysis can be defined. Thus, in the Workgroup consensus Brook Trout Scenario, only dams in watersheds with mapped brook trout habitat were included. In custom analyses, filters like this can be based on geography (e.g., state, watershed) or other attributes (e.g., dam purpose, presence of a specific diadromous species). Additional details on using filters can be found in Section 6.4.

4.2 Prioritization

Once metric values were calculated and relative weights assigned to the metrics of interest, metrics were combined through a weighted ranking process to develop a prioritized barrier list for each scenario. The ranking process involved four steps and simple mathematical operations, as illustrated in Figure 4-1.

Figure 4-1: A hypothetical example ranking four dams based on two metrics.

Dam Name	US Functional Network Length (m)	DS Functional Network Length (m)
Dam A	239,569	2,572
Dam B	342,665	62,525
Dam C	572,554	6,233
Dam D	125,664	87,425

1

Dam Name	US Functional Network Length (% rank)	DS Functional Network Length (% rank)
Dam A	25.49	0
Dam B	48.56	70.66
Dam C	100	4.31
Dam D	0	100

2

Dam Name	US Functional Network Length	DS Functional Network Length
Dam A	25.49 * 0.6	0 * 0.4
Dam B	48.56 * 0.6	70.66 * 0.4
Dam C	100 * 0.6	4.31 * 0.4
Dam D	0 * 0.6	100 * 0.4

3

Dam Name	US Functional Network Length (weighted rank)	DS Functional Network Length (weighted rank)
Dam A	15.29	0
Dam B	29.13	28.26
Dam C	60	1.73
Dam D	0	40

Summed Ranks
15.29
57.4
61.73
40

4

Dam Name	Final Ranks
Dam A	4
Dam B	2
Dam C	1
Dam D	3

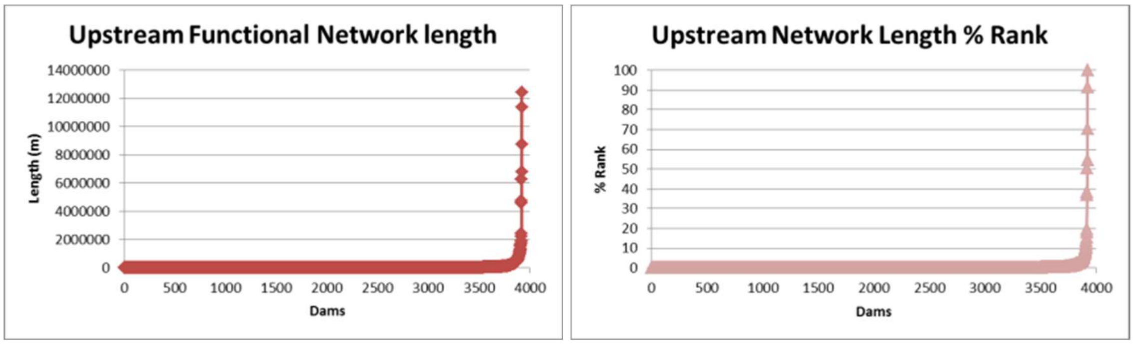
5

Dam Name	Final Ranks
Dam C	1
Dam B	2
Dam D	3
Dam A	4

- Step 1: All values are normalized to a percent scale where the optimal value is assigned a score of 100 and the least desirable value is assigned a score of 0.
- Step 2: Multiply the percent rank by the chosen metric weight
  - In this hypothetical example, assume upstream functional network length weight = 60 and downstream functional network length weight = 40.
- Step 3: Sum the weighted ranks for each dam
  - All metrics which are included in the analysis (weight > 0) are totaled to give a summed rank.
- Step 4: Rank the summed ranks
  - The summed ranks are, in turn, ranked
- Step 5: Sort and display the results
  - The final ranks are sorted for presentation. In the analysis results, dams are grouped and displayed alphabetically within tiers that contain 5% of the total dams.

One consequence of converting values directly to a percent scale rather than first ranking them is that metrics with outliers can bias the results. For example, if a handful of dams have vastly larger upstream functional networks, these values can overwhelm other metrics, even if the weight on those other metrics is greater. As can be seen in Figure 4-2, converting the values to percent ranks preserves the magnitude of difference between dams.

Figure 4-2: Graph of upstream functional networks showing outliers in their original values (m) and converted to a percent scale.



This is an accurate representation for this metric; the outlying dams have upstream networks that are proportionally that much larger than the other dams. However, when this metric is combined with another metric that has a more even distribution, the value of the metric is diminished for most dams.

Figure 4-3: A comparison of metrics with outliers and with a more even distribution.

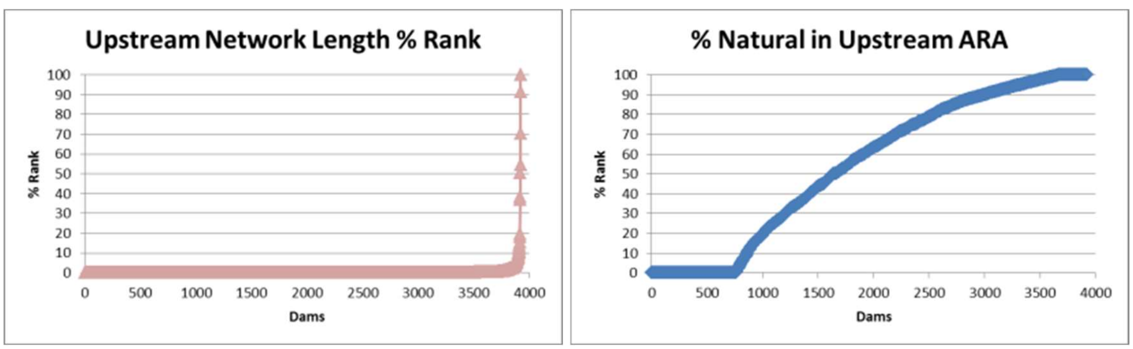
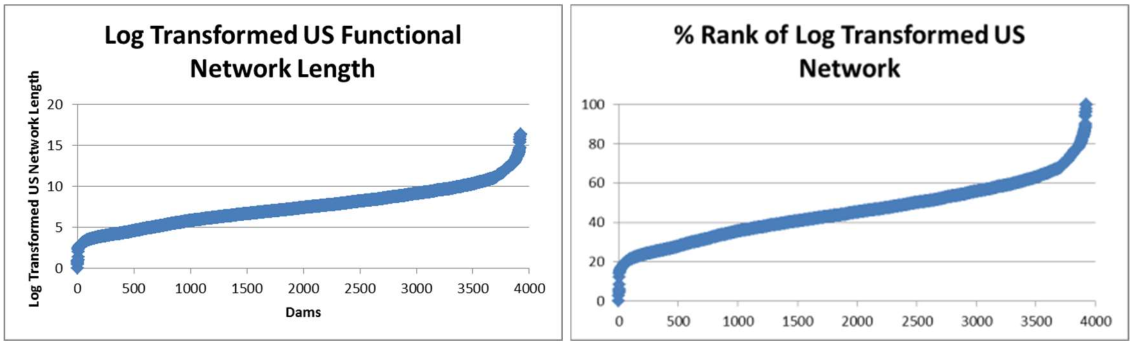


Figure 4-3 compares the distribution of upstream functional network length with percent natural landcover in the Active River Area of each dam's upstream functional network for dams in the study (where natural landcover is an aggregation of National Landcover Database categories, as detailed in Appendix II). As can be seen, the percent natural landcover metric has a much more even distribution: a middle value has a percent rank of 60, whereas a middle value for the upstream network length metric is < 1. When these metrics are combined, the dams with the large outlying values rise to the top, while dams with mid-range values become dominated by the other metric.

To address this problem, metric values can be log transformed prior to converting to percent ranks. This has the effect of smoothing the distribution of values so that outliers do not distort the results, as illustrated in Figure 4-4.

Figure 4-4: Log-transformed upstream functional network values for dams in the Chesapeake Bay watershed & those values converted to a percent scale.



When this log-transformed metric is combined with other metrics, outliers no longer have the same dominating impact as without the log-transformed values.

Figure 4-5 compares a hypothetical example of a prioritization run first without log transforming values (left side) and a second time first log transforming (ln) values (right side). When values aren't log transformed, Dam C which has a vastly longer upstream functional network than all the other dams, is ranked as the top dam even though it has a low percentage of natural land cover—the metric which is given greater weight. Likewise, Dam D, which has a very short upstream network, ranks out disproportionally high relative to Dam B, when its values aren't first log transformed.

The Workgroup elected to log transform the following metrics, based on their distributions, prior to their use in prioritization scenarios: Upstream Functional Network Length, Absolute Gain, Total Functional Network Length, Total Length Upstream, Upstream & Downstream Crossing Density, and Upstream & Downstream Off-Channel Dam Density.

Figure 4-5: Hypothetical example of a prioritization with a metric having outlying values. The prioritization on the right log transforms the values before converting to a percent rank.

Values in real units

Name	Upstream Functional Network Length (m)	% Natural LC in riparian of Upstream Functional Network
Dam A	10124	98
Dam B	6539	93
Dam C	572554	81
Dam D	451	95
Dam E	1560	91
Dam F	8912	60
Dam G	12102	89

1: Percent Rank

Name	Upstream Functional Network Length (% rank)	% Natural LC in riparian of Upstream Functional Network (% rank)
Dam A	1.690779	100
Dam B	1.064144	86.8421
Dam C	100	55.26316
Dam D	0	92.10526
Dam E	0.193846	81.57895
Dam F	1.47893	0
Dam G	2.036521	76.31579

2: Weighted Rank

Name	Upstream Functional Network Length (weighted rank) Weight=40	% Natural LC in riparian of Upstream Functional Network (weighted rank) Weight=60
Dam A	0.676312	60
Dam B	0.425658	52.10526
Dam C	40	33.15789
Dam D	0	55.26316
Dam E	0.077538	48.94737
Dam F	0.591572	0
Dam G	0.814609	45.78947

3: Summed Rank

Name	Summed Ranks
Dam A	60.67631
Dam B	52.53092
Dam C	73.15789
Dam D	55.26316
Dam E	49.02491
Dam F	0.591572
Dam G	46.60408

4: Final Rank

Name	FinalRank
Dam A	2
Dam B	4
Dam C	1
Dam D	3
Dam E	5
Dam F	7
Dam G	6

Values in real units

Name	Upstream Network Length (m) --> *Log Transformed (ln)*	% Natural LC in riparian of Upstream Functional Network
Dam A	10124 --> ***9.223***	98
Dam B	6539 --> ***8.786***	93
Dam C	572554 --> ***13.258***	81
Dam D	451 --> ***6.111***	95
Dam E	1560 --> ***7.352***	91
Dam F	8912 --> ***9.095***	60
Dam G	12102 --> ***9.401***	89

1: Percent Rank

Name	Upstream Functional Network Length (% rank)	% Natural LC in riparian of Upstream Functional Network (% rank)
Dam A	43.53519	100
Dam B	37.41848	86.8421
Dam C	100	55.26316
Dam D	0	92.10526
Dam E	17.36503	81.57895
Dam F	41.75093	0
Dam G	46.03242	76.31579

2: Weighted Rank

Name	Upstream Functional Network Length (weighted rank) Weight=40	% Natural LC in riparian of Upstream Functional Network (weighted rank) Weight=60
Dam A	17.41408	60
Dam B	14.96739	52.10526
Dam C	40	33.15789
Dam D	0	55.26316
Dam E	6.946013	48.94737
Dam F	16.70037	0
Dam G	18.41297	45.78947

3: Summed Rank

Name	Summed Ranks
Dam A	77.41408
Dam B	67.07265
Dam C	73.15789
Dam D	55.26316
Dam E	55.89338
Dam F	16.70037
Dam G	64.20244

4: Final Rank

Name	FinalRank
Dam A	1
Dam B	3
Dam C	2
Dam D	6
Dam E	5
Dam F	7
Dam G	4

5 Results, Uses, & Caveats

5.1 Results

Results from the project include lists of dams prioritized based on three Workgroup consensus scenarios: diadromous fish scenario, brook trout scenario, and resident fish scenario. These scenarios were developed by selecting metrics and applying relative weights (see Section 4.2) from the dams and data compiled for the project (see Section 3). These results can be viewed and downloaded from the Tool at https://maps.tnc.org/chesfpp.

Of note, dams with existing fish passage facilities are included in the results. The Workgroup debated if these dams should be included – if a passage project has already been completed why should it remain in the analysis as a candidate for a passage project? However, given the variability of fish passage efficacy and the species passed during various flow conditions, as well as the relative lack of data to describe passage success rates, it was determined that they should remain in the analysis. Even dams with passage facilities are barriers to one degree or another and, if circumstances are conducive, their removal will still benefit aquatic connectivity.

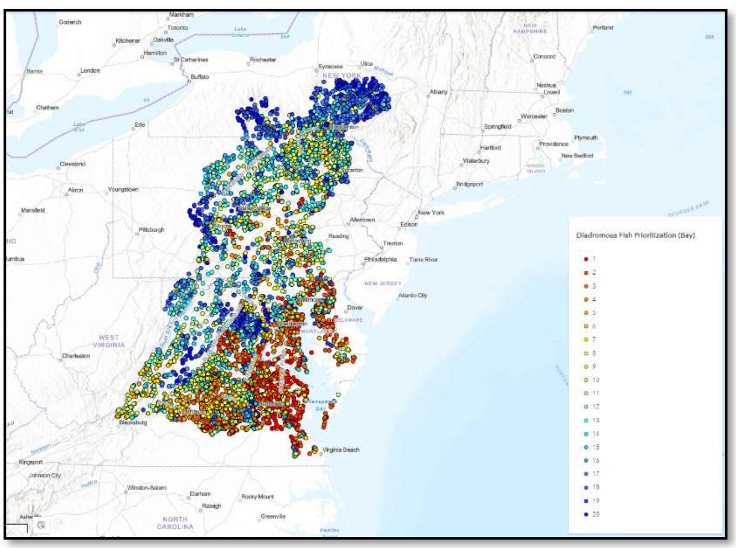


Figure 5-1: Workgroup consensus Diadromous Fish Scenario results. Warmer colors are higher priorities for passage improvement projects to benefit diadromous fish, cooler colors are lower priorities.

Although the prioritization produces a sequential list of dams, the precision with which metrics can be calculated in a GIS is not necessarily indicative of ecological differences. Therefore, throughout this report and on the project web map, results are binned in Tiers where each Tier includes 5% of the dams in the study area. Thus, 5% of the total dams are in the top Tier, Tier 1. These dams would provide the greatest ecological benefit to the given target if removed or otherwise remediated.

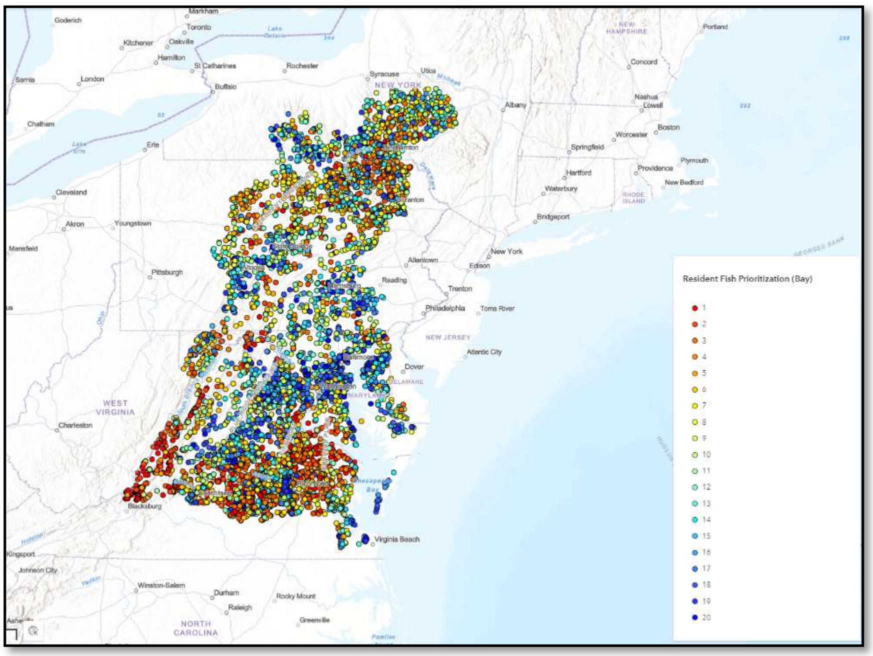
5.1.1 Diadromous Fish Scenario

Of particular interest to the Workgroup was a scenario to prioritize dams based on their potential to benefit diadromous fish species if removed or bypassed. This scenario was developed using the metric weights presented in Table 4-2**Error! Reference source not found.** and produced the results depicted in Figure 5-1. As one would expect in a scenario designed to benefit diadromous fish, the dams in the higher tiers, those whose removal would provide the greatest benefit to diadromous fish, tend to be found closer to the Bay and on the larger mainstem rivers. These include the major rivers in Virginia and Maryland on the west side of the Bay (Rappahannock, James, Potomac, Mattaponi, Rapidan) as well as the mainstem Susquehanna and many smaller coastal streams. These results directly reflect the metrics chosen and weights applied to them, including anadromous fish presence (weight=20), number of dams downstream (weight = 10), and total upstream network length (weight = 10).

5.1.2 Resident Fish Scenario

Using the metrics and metrics weights that were revised in 2019 by the Workgroup (presented in Table 4-3), a Resident Fish Scenario was developed. This scenario was intended to reflect priorities for a set of non-migratory fish species like brook trout, shiners, or darters (though the Workgroup also developed a brook trout-specific scenario). As illustrated in Figure 5-2, these results differ substantially from the Diadromous Fish Scenario results. They are driven by absolute gain (weight=20), and a suite of land cover condition metrics.

Figure 5-2: Workgroup consensus Resident Fish Scenario results. Warm colors are higher priorities while cool colors are lower priorities.

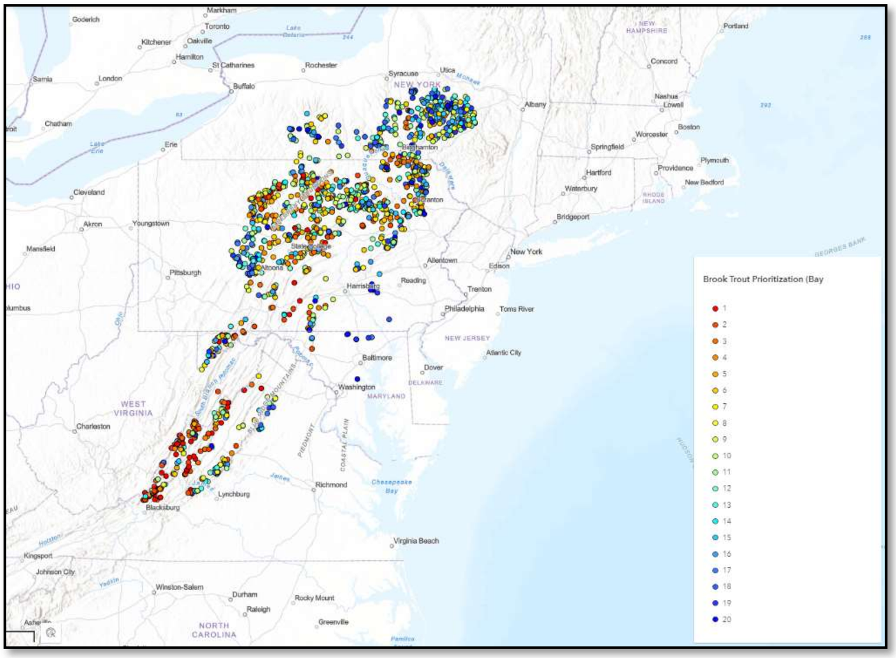


High priorities in this scenario are clustered in areas with a high proportion of natural land cover and long functional networks like the West Branch of the Susquehanna in western Virginia. A cluster of high priority dams is also found in the Rappahannock and Mattaponi drainages where relatively high percentages of natural land cover occur, despite their proximity to Richmond and Washington D.C.

5.1.3 Brook Trout Scenario

In addition to the Resident Fish Scenario, the Workgroup elected to produce a brook trout-specific scenario. This scenario is based on the weights in Table 4-4 and prioritizes dams as presented in Figure 5-3. In addition to the weights selected by the Workgroup, this scenario is limited to dams in catchments with documented brook trout populations, based on either the EBTJV data (Hudy 2012) or the DeWeber and Wagner (2015) data. Barriers outside these catchments were excluded.

Figure 5-3: Workgroup consensus Brook Trout Scenario. Warm colors are higher priorities while cool colors are lower priorities.



This scenario is driven to a large extent by the absolute gain, land cover metrics, and whether a dam is a barrier between EBTJV catchments or DeWeber and Wagner's modeled brook trout catchments. As can be seen in Figure 5-3, this puts an even greater emphasis on those regions where brook trout would be expected, notably in the mountainous areas in the western parts of the watershed.

5.2 Result Uses

The Chesapeake Fish Passage Prioritization project can be used in several different ways to inform and support on-the-ground efforts to restore aquatic connectivity.

- **Project Selection**: A primary use is to help managers direct their limited resources to projects that can have the greatest benefit; to help them move away from a purely opportunistic approach to more of an ecological benefits approach (recognizing that opportunity among other non-ecological factors do and will continue to play an important role in project selection).

- **Improve Understanding of Current Conditions**: Project results have already been used to help direct managers to previously unvisited dams to assess them for potential passage projects (Jim Thompson, personal communication March 13, 2013). In some cases, this may reveal errors in the source data while in others it may direct attention to potential projects that had not been considered previously.

Figure 5-4: Simkins dam on the Patapsco River, before and after its removal in 2011

- **Database of Ecologically Relevant Metrics**: Prioritization aside, the results form a database of 40 ecologically relevant metrics. These metrics can be used to investigate many aspects of aquatic connectivity on a dam-by-dam basis or other offshoot analyses. As described further in Section 6, custom analyses can be run as if one or more dams have been removed. Metric values and the prioritization are recalculated as if that dam had been removed, thus allowing managers to assess the potential impacts of proposed projects.
- **Funding**: The prioritized results can be used both by managers seeking funding for a potential project as well as by funders looking for information to inform or support a funding allocation decision.
- **Watershed Analysis**: Subwatersheds can be assessed based on the project results. Summary statistics can be generated via the custom analysis tool to provide an understanding of potential opportunities for passage projects in watersheds across the region.
- **Communication**: Results can be used to communicate the value of a given project to the local community, elected officials, or others with an interest in aquatic connectivity issues.

5.3 Caveats & Limitations

As with any modeled analysis, there are several caveats and limitations that are important to bear in mind when considering the results and data produced by this project and the custom analysis tool. First among them, the results are *not intended to be a hit list* of dams for removal. There are many cases where the benefits provided by a given dam outweigh the ecological benefits of removing it, although other passage projects can be considered when removal is not the best option.

Next, this project, by design, only considers ecological factors. It does *not include any social, economic, or feasibility factors*, largely because this information is difficult or impossible to capture through regionally-available GIS data. These factors could be layered onto the project results through a subsequent site-scale analysis.

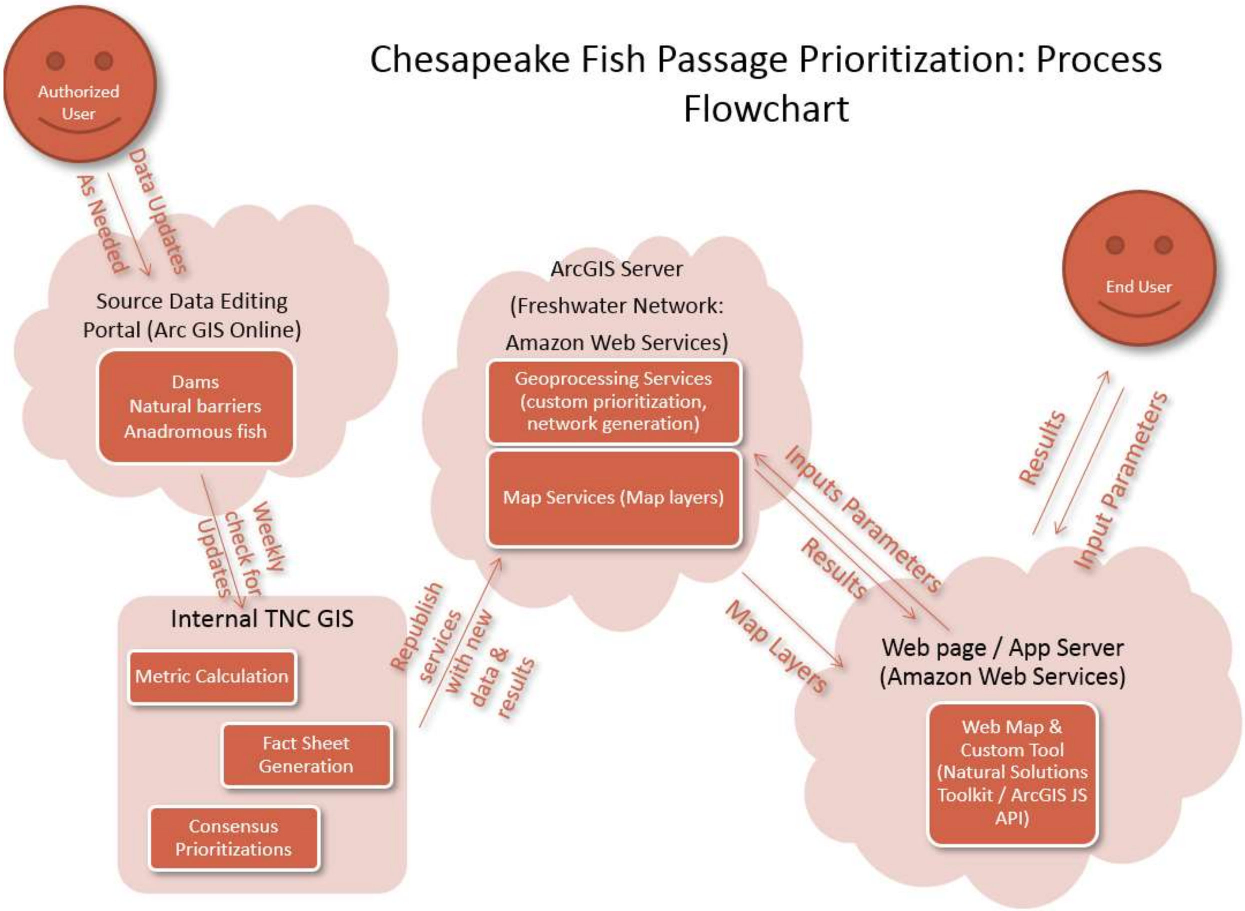
Results produced for this project are intended to be *screening-level* information that can *help* inform on-the-ground decision making, using the best available regional data. They are not a replacement for site-specific knowledge and field work.

Finally, it is important to note that any aquatic connectivity project will have ecological benefits and if an opportunity arises, it should not be rejected solely on the grounds that it does not rank highly in this project. Ultimately, whether the benefits provided by a given passage project justify the costs is a decision that rests with managers using all of the best information at their disposal. We hope that this project will be a useful and important tool in the aquatic connectivity toolkit, not the only one.

6 Web Map & Analysis Tools

Project results and a tool to run custom user-defined scenarios can be found at https://maps.tnc.org/chesfpp/. This web mapping platform allows users to view results in the context of other relevant data including project data and various base maps, query results, download data, annotate a map, and print or save a map. Map data is served to the internet using a cloud-based (Amazon Web Services) instance of ArcGIS Server (http://www.esri.com/software/arcgis/arcgisserver). This data is consumed via a custom web map that was built using the Vue 3 JavaScript Framework (https://vuejs.org) and the ArcGIS JavaScript API (https://developers.arcgis.com/javascript/latest/). Likewise, the processing that underlies the custom analysis tool and upstream functional network generation tool runs on Python-based geoprocessing scripts served to the internet via ArcGIS Server Geoprocessing Services. Figure 6-1 illustrates the conceptual architecture of the web map and custom analysis tool.

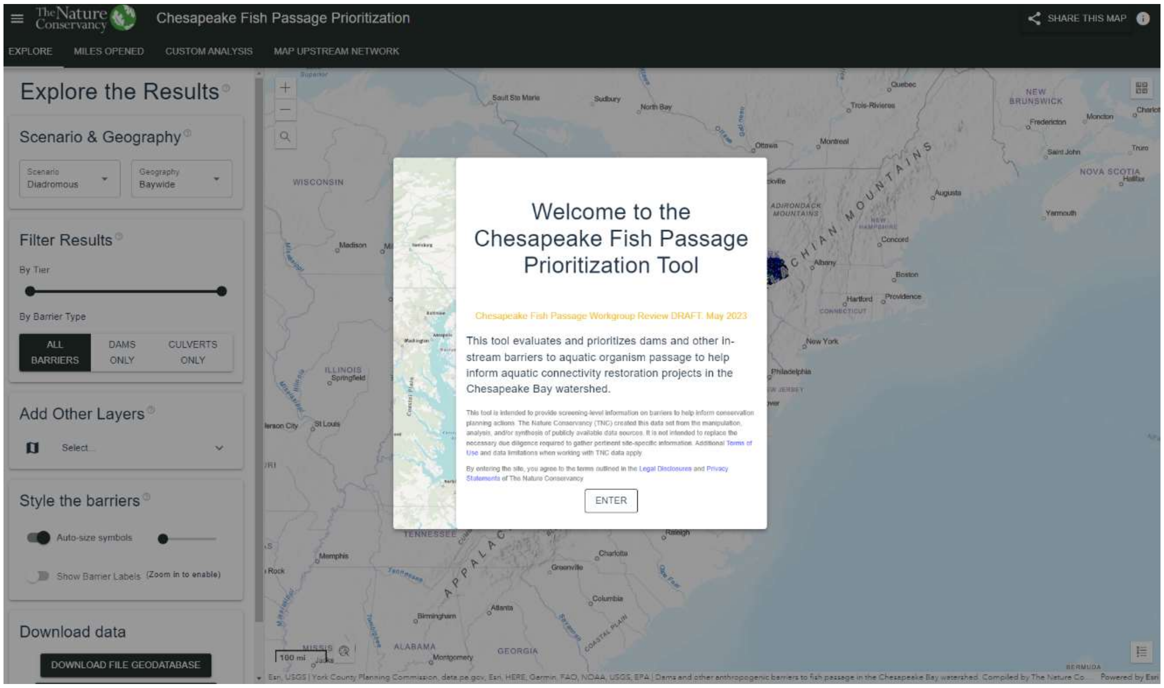
Figure 6-1: Conceptual architecture of the CFPP web map and custom prioritization tool



6.1 General Tool Functionality & Organization

Upon first entering the map, a general welcome "splash" screen is displayed to the user. This includes a brief description of the Tool along with caveats and TNC's legal statements.

Figure 6-2: Click on "Enter" to access the tool from the welcome splash screen.



Along the top of the tool is a black header which is always present when the tool is open. There are multiple tabs on the left side of the header that can be clicked to expose content or functionality. Upon entering, the "Explore" tab is initially selected. This tab allows users to explore the results of the three

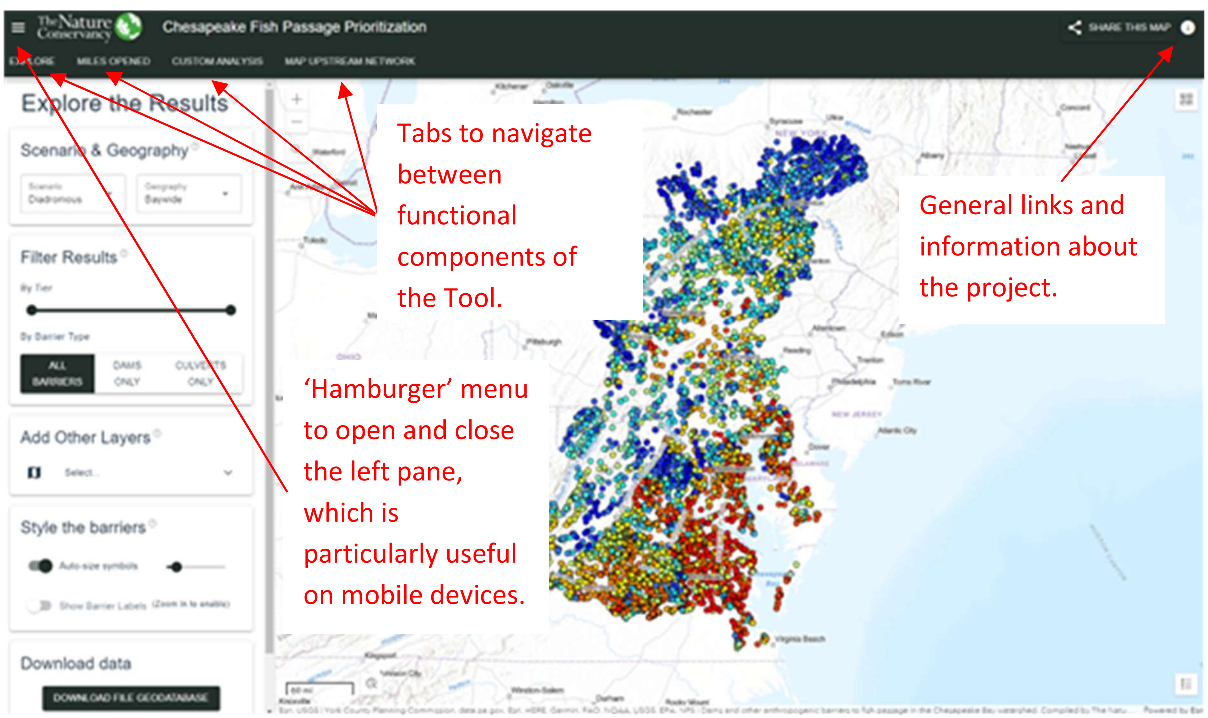


Figure 6-3 Tabs and controls on the tool header

consensus scenarios. Other buttons on the header include a hamburger menu at the top left to open and close the left side content pane and an info button at the top right which expands a pane with general information and links. Also included is a “Share This Map” button that can be clicked to copy a URL to the user’s clipboard that stores the current state of the map (see Section 6.1.3).

6.1.1 Embedded help and info buttons

Throughout the tool, small help icons are embedded adjacent to content elements: ⓘ. Clicking on these icons will raise a popup dialog with information and/or additional context about that element.

6.1.2 Mobile devices

The Tool was designed primarily for desktop systems. Mobile devices smaller than an iPad may be used but will not result in an optimal experience. On these mobile devices, the left content pane and the map are not simultaneously viewable. Swiping left will hide the content pane to display the map while clicking the hamburger menu at the top left of the header will expose the content pane. Panning the map is done with two fingers on mobile devices.

6.1.3 Share the current map

The 2023 version of the Tool improves on the ability to share the current state of the map. Clicking the “Share This Map” button at the top right side of the header will copy a URL with multiple parameters embedded in it. This URL can be pasted into an email or otherwise saved or shared with another person. When loaded, the map will return to the extent and tab (Explore, Miles Opened, etc.) that were active at the time the link was created. Further, if the explore tab was active, the selected scenario and geography, any selected barrier, and additional layers will automatically load. Likewise, if the “Miles Opened” tab was active, the time span and visible layers that were active at the time the link was created are loaded. Custom analysis parameters and custom upstream functional network parameters are not saved.

6.2 Explore the Consensus Results

The Explore tab allows users to investigate the consensus prioritization scenarios and includes several aspects of functionality within it.

6.2.1 Select a consensus scenario and geography

A region, either “Baywide” or one of the three states, along with a prioritization scenario can be selected using dropdown menus at the top of the “Explore the Results” tab. When a region is selected, the results for the selected scenario will be displayed, stratified by (relative to) that region. In addition to stratifying by states, results can also be stratified by barrier type: dams and culverts. The option to do this is also nested under the “Geography” dropdown. Analyses for other regions or subsets of data (e.g., watershed) can be run by applying a filter in a custom analysis (see Section **Error! Reference source not found.**)

6.2.2 Filter the results in the map

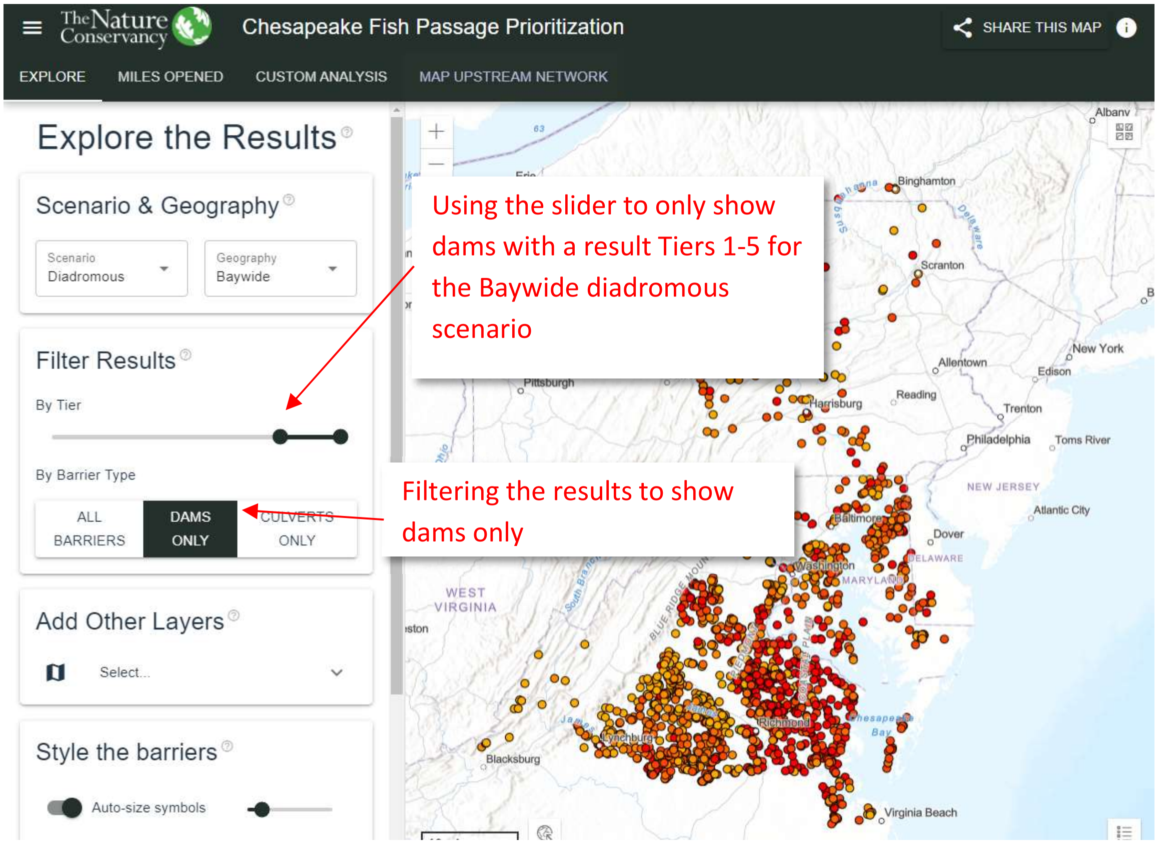
The consensus results that are displayed in the map can be filtered by Tier or barrier type to reduce clutter and facilitate the viewing of relevant data.

A slider bar can be used to limit visible barriers to those whose tiered result are in the range selected for the consensus scenario and geography that are currently selected.

Barriers can also be filtered by type, using the buttons to display all barriers, dams only, or culverts only.

Note that filters applied via these two methods work together. That is, if results are filtered to show only result Tiers 1-5 and the button to only show dams is selected, the map will display dams in Tiers 1-5.

Figure 6-5: Applying a filter to limit the barriers that are displayed in the map to show only dams in Tiers 1-5.

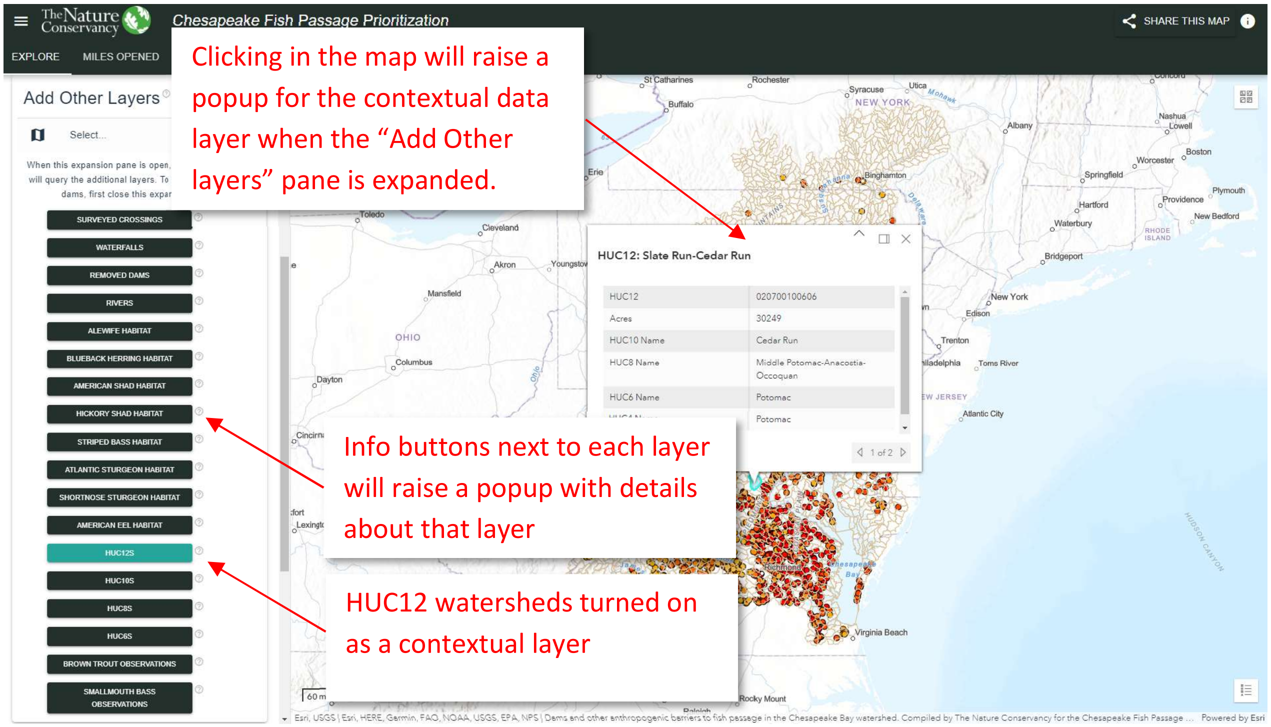


6.2.3 Additional layers

Additional contextual data can be added to the map. Expanding the pane under “Add Other Layers” will reveal a list of layers displayed as buttons that will turn each layer on or off. These layers include road-stream crossings, diadromous fish habitat, river hydrography, watershed boundaries, non-native fish observations, natural waterfalls, and previously removed dams.

Next to each layer is an info button which, when clicked, will bring up a popup with a brief description of that data layer and a link to its metadata.

Figure 6-6:Turning on and querying additional contextual layers

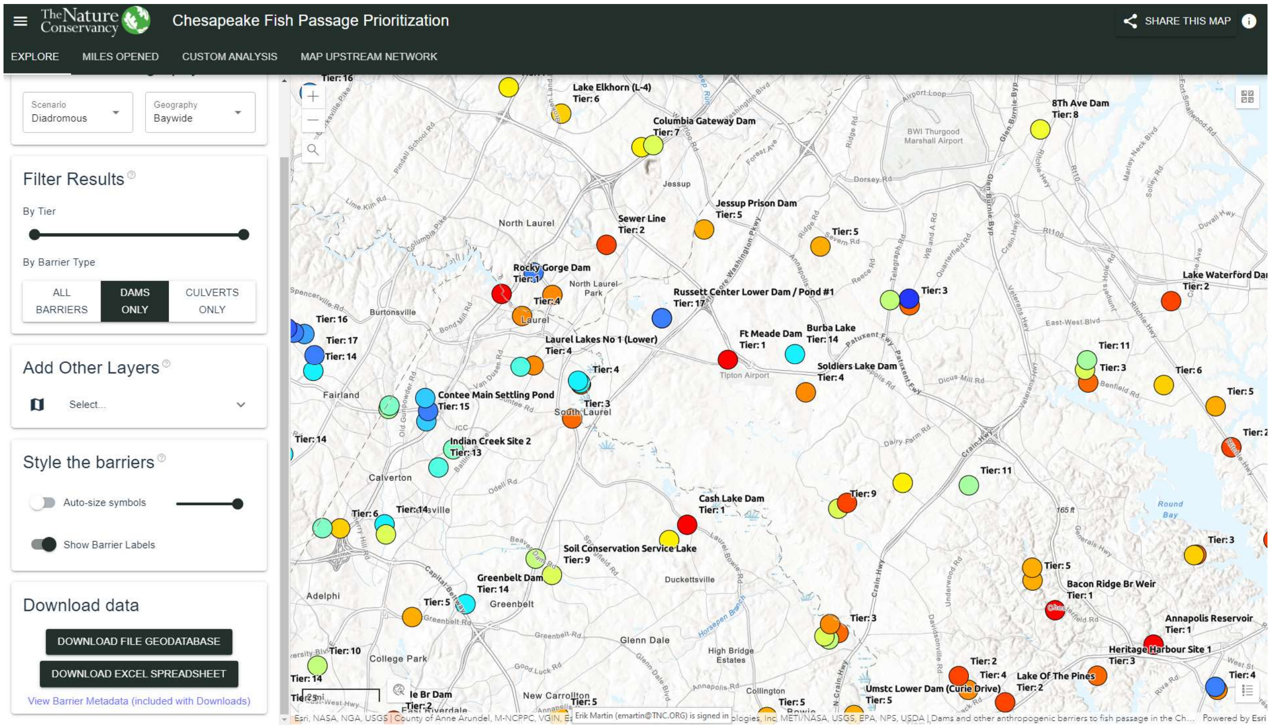


Note: When the layers menu is expanded, clicking on a feature in the map will bring up a popup dialog in the map with information about that feature. Closing this pane will leave any additional layers turned on in the map, but map-click queries are restricted to the prioritized barriers.

6.2.4 Style the barriers

By default, the barriers in the map are set to change size based on the scale of the current map view. This is designed to help users comfortably view barriers regardless of map scale. However, this default

Figure 6-7: Barriers styled as large points with labels turned on.



behavior can be modified and the size of the barrier points manually sized using the slider.

Additionally, when zoomed in to local scales, an option is available to turn on map labels showing each barrier's name and Tiered value for the currently selected scenario.

6.2.5 Download data

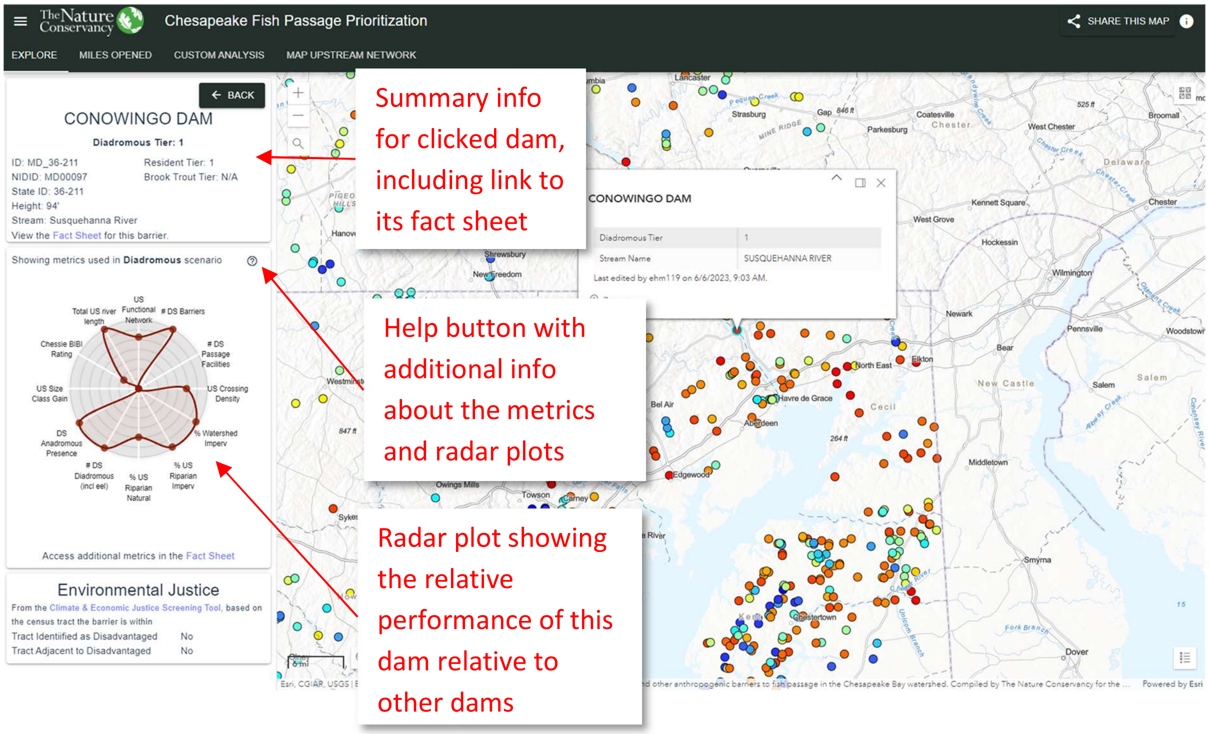
The data for the consensus scenarios displayed in the "Explore" section of the tool can be downloaded as a file geodatabase or Excel spreadsheet from the bottom section of the Explore content tab. Metadata is included with downloads, or can be viewed or downloaded separately from the View Barrier Metadata link.

6.2.6 Assess a barrier

Clicking on a barrier will show, in the left window, information about that barrier including its name, ID, result tier for each of the consensus scenarios, a link to a fact sheet with all the metric information for that dam, link to the NAACC page for culvert barriers, and a radar plot that displays the relative values for each metric. The radar plot can be used to see what factors are driving its prioritized result – values near the perimeter of the plot perform better for a given metric than most other barriers. That is, the radar plot shows the relative performance of the barrier for each metric, relative to the other barriers in the stratification region. Hovering the cursor over a metric in the plot will display the actual value for that metric. The metrics shown in the radar plot correspond to the metrics that are used in the selected consensus scenario (diadromous, resident, or brook trout). Additional metrics for a barrier can be viewed by clicking on the Fact Sheet link for the barrier.

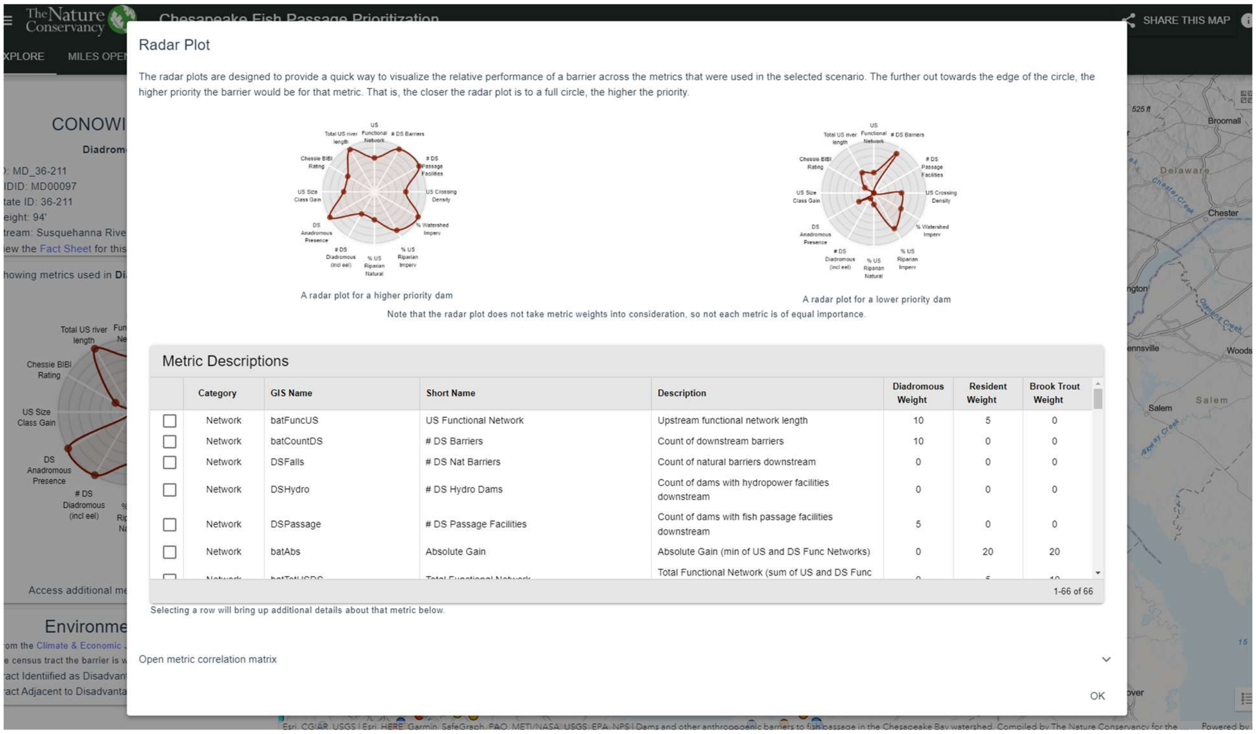
Clicking the Back button at the top of the left content pane will return to the main Explore content.

Figure 6-8: "Assess a barrier" functionality that is exposed when a barrier is clicked in the map



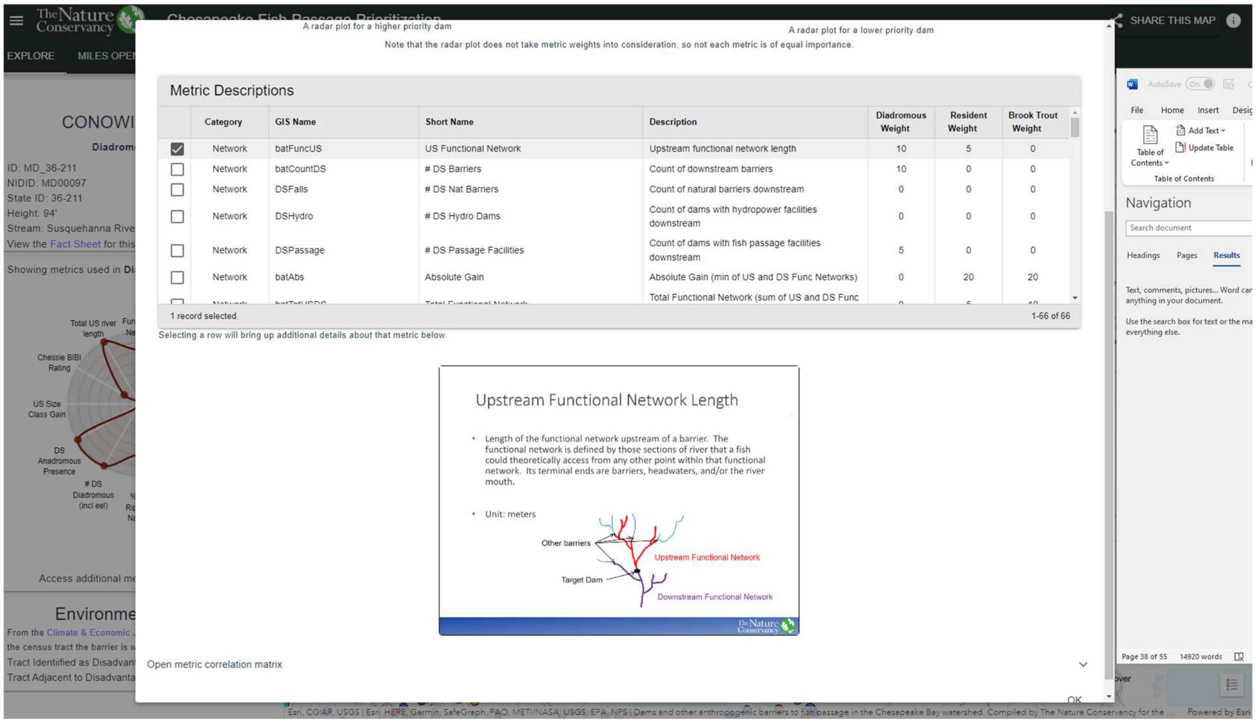
Additional information about the radar plots and metrics is available by clicking on the help button above and to the left of the radar plot. Clicking this button will bring up a popup with a brief explanation of how to interpret the radar plots, a table with descriptions and consensus scenario weights for each metric, and a correlation matrix for all metrics.

Figure 6-9: Radar plot help dialog.



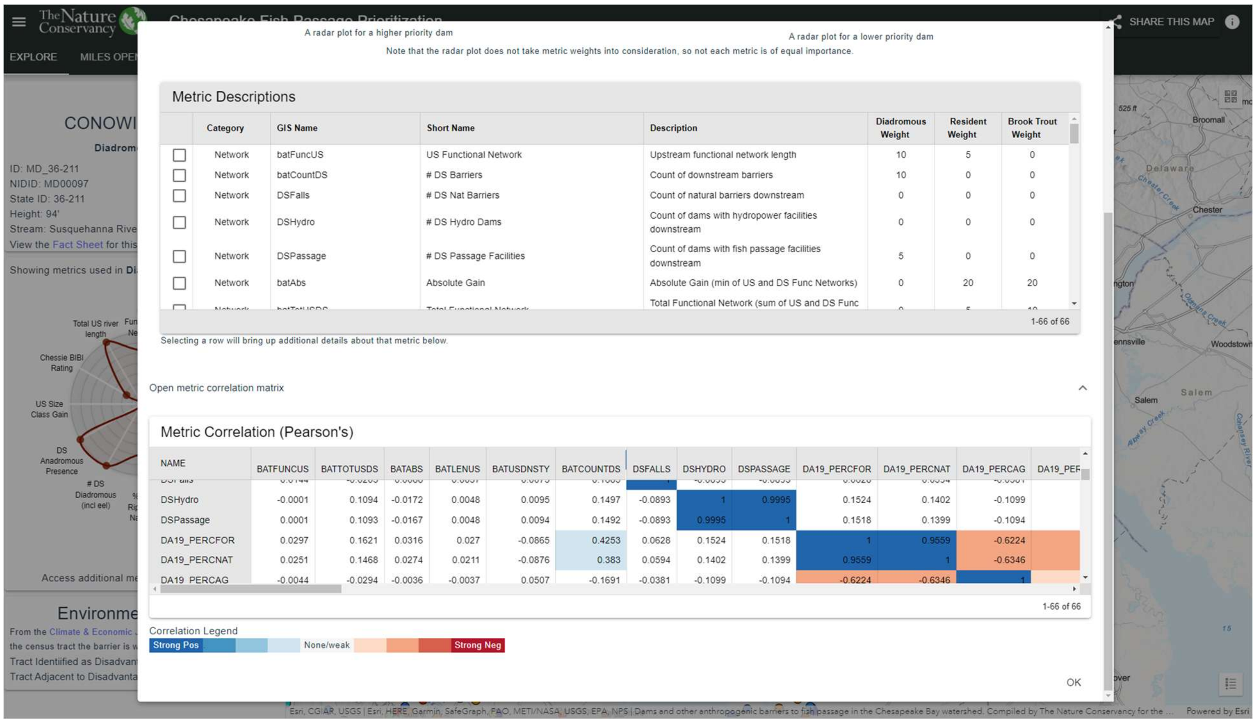
Selecting one of the metrics in the description table will bring up a more detailed description of that metric with a conceptual illustration and/or data source, as applicable.

Figure 6-10: The upstream functional network metric selected in the metric description table and its additional descriptive information below the table.



The metric correlation table is particularly useful when evaluating the metric weightings selected by the Steering Committee or when selecting weights for a custom scenario. The correlation matrix (Pearson's) quantifies the degree of positive or negative correlation between each metric which can help reduce the unintentional overweighting of a criterion.

Figure 6-11: Expanded correlation matrix on the radar plot info dialog.



In addition to the metrics used in the prioritization, basic environmental justice information for the census tract where the dam is located is included in the results. Information on whether the tract has been identified as disadvantaged or is adjacent to a disadvantaged tract is shown at the bottom of the dam information. This data is sourced from the Climate and Economic Justice Screening Tool (https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5) and is passed along for informational purposes.

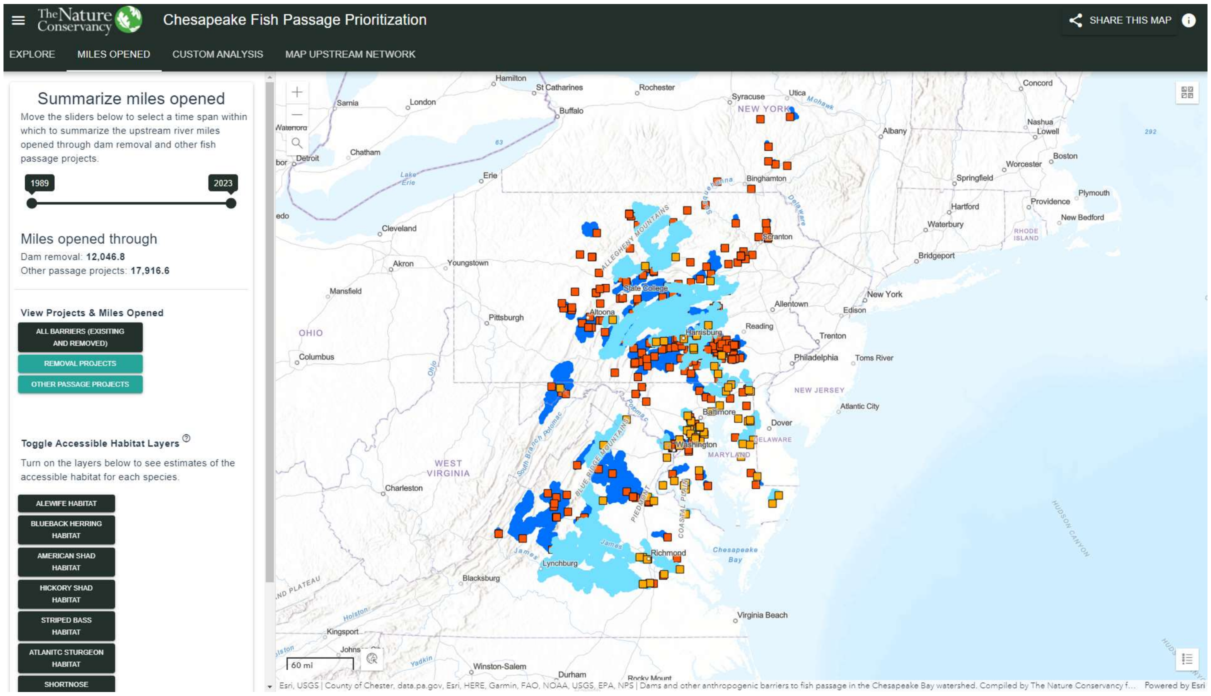
6.3 Track Miles Opened Over Time

The functionality to track upstream miles opened over time was developed in the 2019 revision of the Tool. To access this functionality, select the "Miles Opened" tab from the header. This will open the tab, remove other content from the map and load the data to track miles opened over time. In its initial state, the map will display rivers that were connected to the Chesapeake Bay in 1988 and all dam removal and other fish passage projects between 1989 and 2023. Buttons are available to turn on or off dam removal projects, other fish passage projects, and all other dams (which bound the upstream networks of removed dams).

From this point, the time slider can be used to select a range of years within which to display dams that have been removed as well as dams where other fish passage projects have been implemented. In addition to showing the dams that have been removed or had passage projects, the upstream functional networks of these dams will be shown in the map. The pane on the left side of the screen will also show a cumulative total of miles opened by dam removal and by other passage projects. Zooming in to one of these dams on the map will display the dam’s name and the year the passage project was completed.

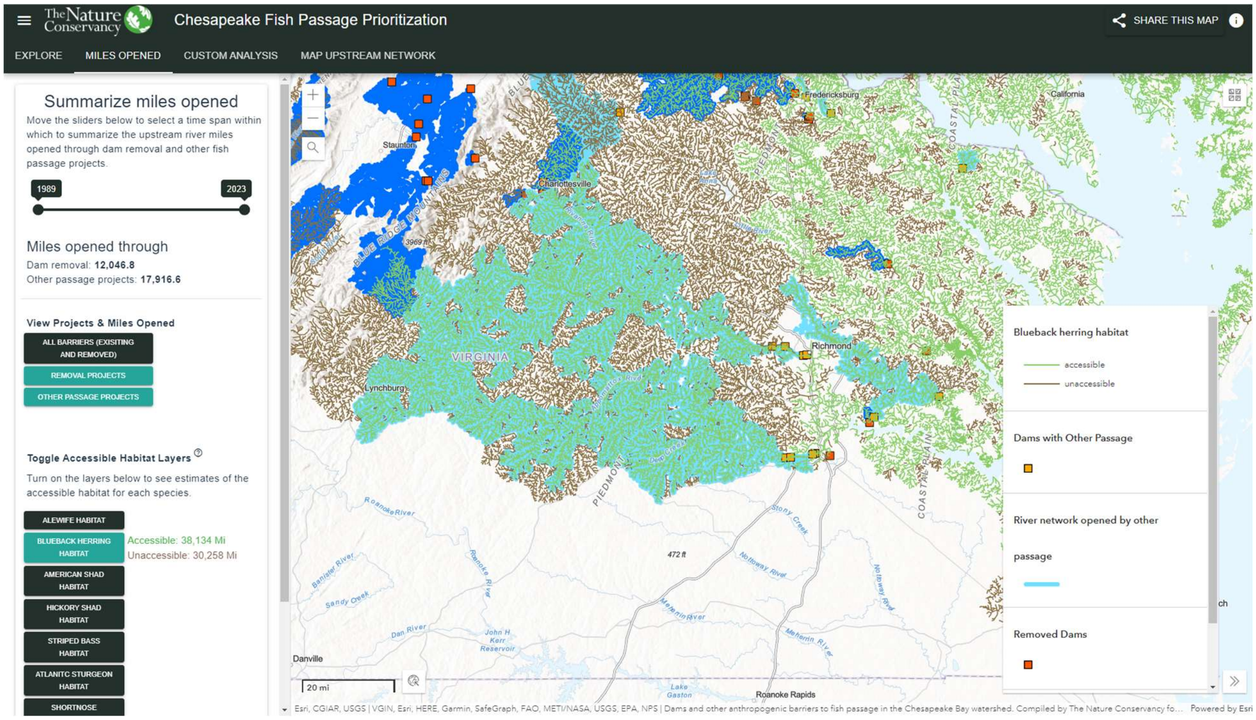
New in the 2023 revision of the Tool is the addition of estimates of accessible river miles for each of the anadromous species evaluated in the Project. The anadromous fish habitat data that was developed

Figure 6-12: Functionality to track upstream miles opened by dam removals and other fish passage projects



over the previous versions of the project (see Section 3.5) was updated using dam removal and other passage project information. Thus, accessible fish habitat was determined by identifying river segments that were both within a network opened via dam removal or other passage, were contiguous with existing contiguous habitat for each species, and met the stream size qualifications for each species (e.g., Sturgeon not found on headwater streams, even if there are no obstructions). “Accessible” was defined using both the “Current” and “Potential Current” classes of fish habitat. The miles in the “accessible” category were summed and are presented when one of the fish habitat layers is turned on.

Figure 6-13: The "Miles Opened" tab content showing accessible habitat for blueback herring in green and inaccessible habitat in brown.

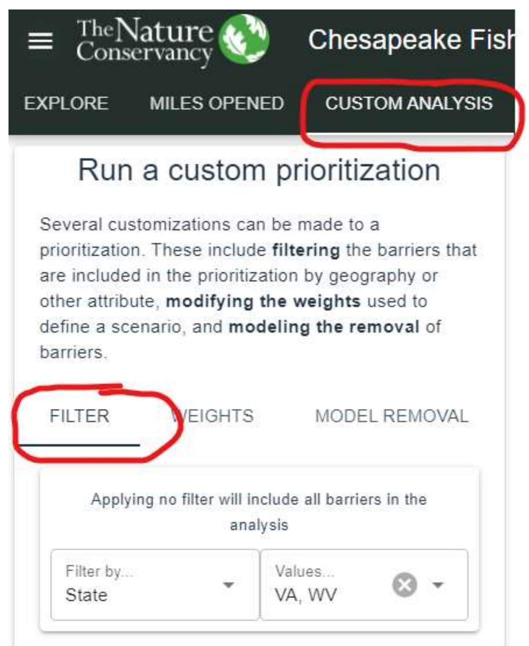


6.4 Custom Dam Prioritization Tool

The Custom Dam Prioritization tool allows users to modify and build off of the three scenarios developed by the Chesapeake Fish Passage Workgroup (see Section 5.1) by altering metric weights, filtering the input dams (e.g., by state or watershed), running “removal scenarios” as if one or more dams had been removed from the network, and generating summary statistics of the results.

Custom prioritizations can be run by first clicking on the “Custom Analysis” tab.

Figure 6-14: Interface for applying a filter to limit the barriers included in an analysis



6.4.1 Filter

The first option allows users to limit the dams that are included in the analysis based on geography or some other subset of data. Menus are available to help users select what barriers are included in the analysis. Selecting the type of unit to filter by from the left-side drop down will then populate the right-side drop down with values to include. Multiple values can be selected. For example, selecting to filter by “State” will populate the right-side drop down with the names of the states in the Bay watershed.

6.4.2 Weights

As described in Section 4.1**Error! Reference source not found.**, weights can be applied to metrics to indicate the relative importance of each metric in a given prioritization scenario. The Chesapeake Fish Passage Workgroup developed three weighting scenarios for diadromous fish, resident fish, and brook trout. These consensus weights can be used in a custom analysis by selecting the scenario of choice under the “Use Consensus Scenario Weights” section.

Figure 6-15: Selecting to use consensus scenario weights in a custom analysis. In this case, the weights from the Resident fish scenario are selected.

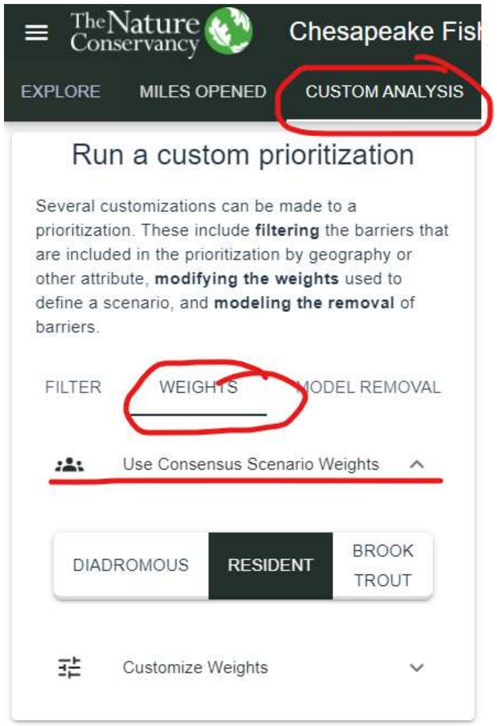
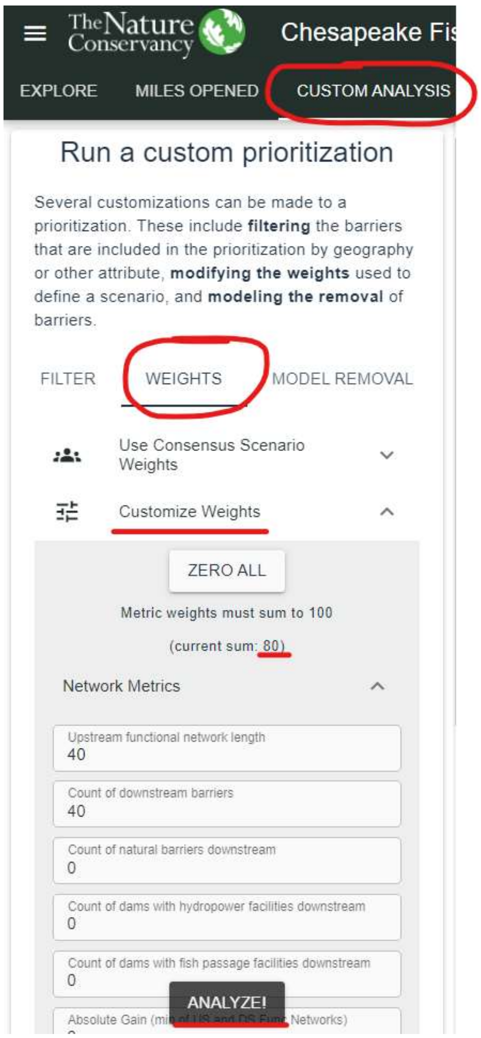


Figure 6-16: Customizing weights for a custom analysis. In this image the metric weights only sum to 80 and so the "Analyze" button is disabled



However, any number of alternate scenarios could be developed based on the needs and objectives of the user. For example, if the primary objective of a user was to open up the most possible upstream river miles, then 100% of the weight could be applied to “Upstream Functional Network Length.” The results of this prioritization would be analogous to sorting the dams so that the one with the longest upstream functional network was on top. Expanding the “Customize Weights” section of the weights tab will reveal all of the available metrics grouped by logical category. Weights can be distributed between metrics as desired by the user so long as they sum to 100. A running tally of metric weights is provided at the top of the screen. If weights do not sum to 100, the “Analyze” button which begins the analysis will be disabled.

6.4.3 Dam removal scenarios

Up to ten dams can be selected for "removal" when a prioritization is run. This functionality allows users to model the impact of a proposed project on the remaining dams in the network. When dams are modeled for removal, all of the metric values are recalculated as if that dam doesn't exist so users can assess the impact on a metric-by-metric level. For example, if a given dam is "removed," all the upstream dams will have one fewer dam downstream of them, the next downstream dam will have a longer upstream functional network, the next upstream dam will have a longer downstream functional network, etc. This can be particularly useful when there are multiple dams in a series which might be treated as a single removal project. That is, by "removing" all but one of a series of dams, the one remaining dam will have metric values which reflect the group, rather than its individual components.

To run a prioritization scenario that includes modeled removals, select the "Model Removal" tab. This will load a data layer of dams (all styled as black points) which allows for barriers to be interactively selected for removal through the web map. This is simply done by clicking on a point, which will highlight the barrier in red. If a mistake is made, clicking on a highlighted barrier will unselect it.

Note that barriers that are modeled as "removed" in a custom analysis do not alter the source dam database. The custom analysis results are only valid for the current user's session.

6.4.4 Starting the analysis, viewing, and exporting results

When all inputs are completed, the "Analyze" button can be clicked to begin the analysis. The time required to run a prioritization varies based on the number of dams included in the analysis, the number of metrics included in the analysis, the number of dams being modeled for removal, whether summary statistics are being calculated, as well as server load. Generally, a custom analysis can be expected to run between 15 seconds and two minutes.

6.4.4.1 Results

When the analysis is complete, the results are added to the map and the "Custom Analysis Results" pane is opened. The pane will include buttons to download the results as a zipped File Geodatabase for use in a GIS.

In the map, symbols of the result features in the map use the same color ramp as the pre-loaded Workgroup-consensus results to indicate Tier (Tier 1 in red toTier 20 in blue).

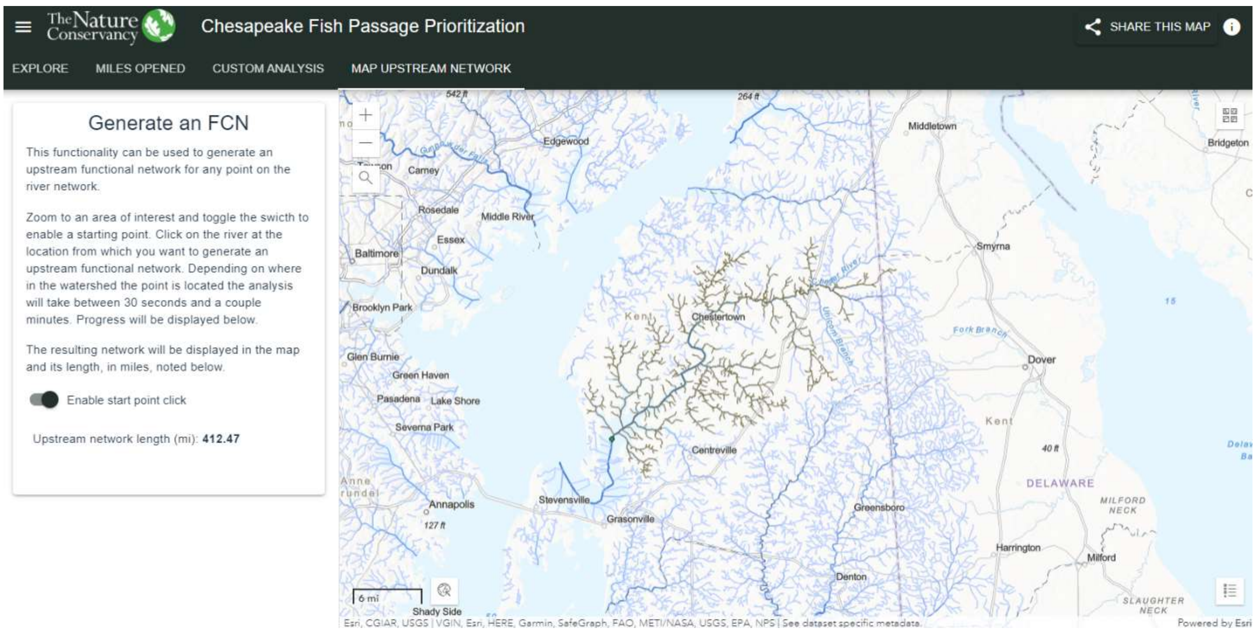
As long as the "Custom Analysis" tab is selected, clicking on a barrier in the map will bring up information about the barrier from the results. Thus, if dams are modeled as removed, the metrics for the remaining dams will reflect those removals. Exiting the Custom Analysis Results pane will remove the results. So, for example, clicking on the "Explore" pane will remove the custom results and load the consensus results.

It is strongly recommended that input parameters always be saved with results. File names are set up with a date/time stamp so inputs and results can be easily tracked.

6.5 Upstream Network for a Clicked Point

In the 2019 revision of the Chesapeake Fish Passage Prioritization functionality was added to generate an upstream functional river network for any location on the river network. First, select the “Map Upstream network” tab. Next, zoom in until you are able to clearly see the location of the point from which you want to trace an upstream network. Next, flip the switch to “Enable start point click”. Subsequently, clicking on a river line (be sure to click within 100m of the river line as it’s represented in the map) will automatically start the analysis. A status message will appear in the active pane and, when processing is completed the upstream functional network will appear in the map and its length will be displayed in the pane. Processing time for generating an upstream functional network varies based on the river where the point is located, but general takes 1-2 minutes.

Figure 6-17: An upstream functional river network generated for a point clicked within the map



7 Data Management and Tool Updates

One of the characteristics of aquatic connectivity analyses that utilize metrics based on river networks is their sensitivity to changes or errors in the data. For example, any metric calculated for the upstream functional network of a dam (e.g., upstream network length, forest cover in the riparian zone of the upstream network, etc.) will be impacted if the next upstream dam is removed. This sensitivity, coupled with the potential for data processing to introduce errors (e.g., see Section 3.3 on snapping dams), increases the importance of regular data updates so that the tool is as accurate as possible and reflects data changes due to both on-the-ground actions as well as error fixes.

In the original version of the tool, edits to the core source datasets (dams, natural barriers, and anadromous fish habitat) were collected over time via email submissions from workgroup members. For example, a workgroup member with direct knowledge of a dam removal would send an email to TNC with the relevant information such as the dam name, dam ID, and the date of removal. These emails would be collected and retained until time and funds were available to run an update which typically occurred after receipt of a new grant and over time periods of a year or more.

In the 2019 revision of the Tool, substantial back-end work was undertaken to streamline and automate the data updating process. This new system allowed authorized users to make edits to the core source datasets via a dedicated data editing portal.

In practice, however, the frequency of data edits submitted by users was not frequent enough to warrant maintaining a near-real-time system of weekly updates to the tool.

7.1 Southeast Aquatic Resources Partnership (SARP) Aquatic Barrier Prioritization Tool

Concurrently, the Southeast Aquatic Resources Partnership (SARP) has been funded by the United States Fish and Wildlife Service (USFWS) to develop a national aquatic barrier database and prioritization tool (https://aquaticbarriers.org/). Discussions were held with the Steering Committee to determine the extent to which the forthcoming SARP tool will overlap with the Chesapeake Fish Passage Prioritization Tool. It was decided that while there is substantial conceptual overlap, the prioritization approach used in the Chesapeake tool has been vetted by and is familiar to the fish passage community in the Chesapeake watershed. Further, much of the functionality that is included in the Chesapeake Tool will not be available in the SARP tool at present (e.g., tracking miles opened over time, custom prioritizations, and mapping an upstream functional network for a user-defined point). To that point, SARP has been clear that they are not trying to, nor would they be able to, incorporate all functionality from regional-scale tools in their national-scale work. Therefore, the Chesapeake Tool will remain an important resource for the regional fish passage community for the foreseeable future.

At the same time, there was value seen in having the two tools “talk” to each other. All involved have an interest in each tool using the best available data and not conflicting with each other.

The solution that emerged was for SARP to take over the barrier data management for the Chesapeake Bay watershed. As managers of the data, they will incorporate national-scale edits to data on a regular basis. This includes collecting dam removal information from partners (e.g., American Rivers) and updated data from the U.S. Army Corps' National Inventory of Dams. They also host an editing portal where authorized users can edit data.

When updates to the Chesapeake data are made, a scripted process is used (Python, using Esri's arcpy module) to extract the data from the SARP database for the Chesapeake and format it for use in the Tool. The data is then plugged into the existing process that updates the metrics, runs the prioritization, and updates the Tool resources (fact sheets, data for download, custom analysis tool, miles opened functionality, and upstream network generation).

7.2 Barrier Data Updates

The core source datasets are hosted by SARP on a USFWS-owned ArcGIS Online account. It is accessed via a dedicated web mapping application that is only accessible to authorized users. Edits made in the portal are automatically tracked by user and the date of edit.

7.2.1 Batch data edits

As part of their work to maintain the national aquatic barrier tool, SARP runs regular updates of the barrier data based on the aggregation of national barrier datasets. These include downloading and merging dams from the National Inventory of Dams (https://nid.sec.usace.army.mil/#/), dam removals from American Rivers (https://www.americanrivers.org/threats-solutions/restoring-damaged-rivers/dam-removal-map/), and/or the USGS Dam Removal Information Portal (https://data.usgs.gov/drip-dashboard/). These updates will be implemented on a yearly basis. Road stream crossing data from the NAACC (https://naacc.org/naacc_search_crossing.cfm) will be updated approximately four times per year. Natural barrier data from the USGS Waterfalls and Rapids in the Conterminous United States (https://www.usgs.gov/data/waterfalls-and-rapids-conterminous-united-states-linked-national-hydrography-datasets-v20) will be updated when data are updated in the source data.

7.2.2 Individual Barrier Updates

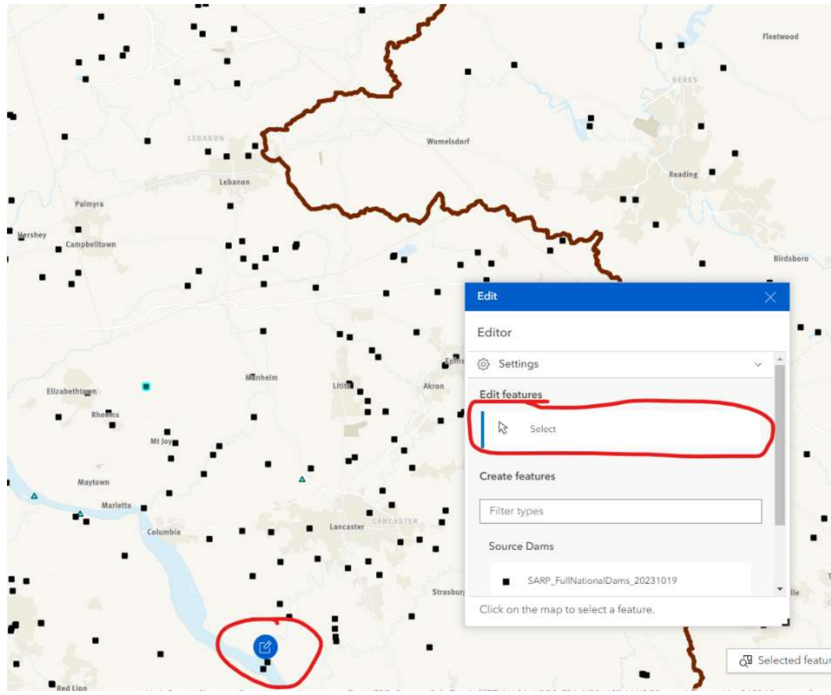


Figure 7-1: Data editing portal for making changes to individual dams or natural barriers. The Edit widget is opened by clicking the blue button at the bottom of the image. The editing window is open in this image.

Outside of the batch data updates described above, individual barrier updates can be made by the Chesapeake Fish Passage Community. Existing editors of the Chesapeake data (the core steering committee) have access to the new portal. Other users who identify errors in the barrier data used in the Chesapeake tool can contact the author to obtain credentials to edit the source data (e.g., add a dam, remove a dam). The data editing portal is available for authorized users at https://experience.arcgis.com/experience/334477305cc54ba9a2238608c0be8a23. This portal provides a venue for making edits directly to the SARP-hosted dam and natural barrier data. Edits to road-stream crossing data should be made through the NAACC-framework (https://streamcontinuity.org/naacc/about/get-involved).

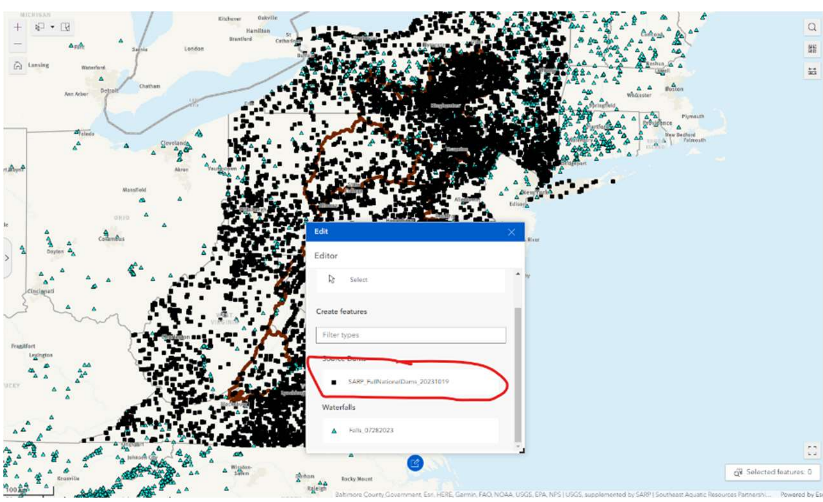


Figure 7-2: Adding a new dam point using the Edit widget.

Within the editing portal, the Edit widget can be opened by selecting the blue button at the bottom of the tool. To edit an existing point, chose the "select" tool from the Edit widget then click on a dam. This will bring up a dialog box with attributes which can be edited. Note that points cannot be deleted. If a point is not a barrier, the "Barrier Status" attribute can be updated to "No Barrier."

To add a point, open the Edit widget and select the layer for which you want to add a point under the "Create Features" heading. In **Error! Reference source not found.**, selecting "SARP_FullNationalDams_20231019" will add a new dam point to the layer when the map is clicked.

7.3 Download & Preprocess Data

Data are downloaded from the SARP data editing portal to TNC's cloud-based GIS infrastructure (AWS EC2 instance, known internally as 'Nimbus'). Barriers are snapped and field mapping translates attributes to match with the schema used in the Tool.

Before the analysis steps begin, all the input and derived data from the previous update of the Tool are given a date stamp and archived. Archived data include the individual core source data layers, the geodatabase with all the intermediate datasets used to generate metrics, and the geodatabases which underlie the map and geoprocessing services for the tool. Having these archived products makes it possible to easily revert to a previous version, should any errors be accidently introduced.

7.4 Generate Metrics

After the source data has been updated in the TNC cloud GIS environment, all the metrics that are used in the analysis (see Section 4.1) are regenerated. This step includes recalculation of the functional river networks, local watersheds, and other intermediate datasets in addition to the metric values calculated for each dam. This process is automated using Python 3 and Esri's arcpy Python package, along with other freely available Python packages. These scripts are hosted on GitHub and are available by request to the author. They have also been provided to the Chesapeake Bay Trust with the other deliverables for the Project.

7.5 Run Consensus Scenarios

When metrics have been recalculated, the consensus prioritization scenarios are rerun. Using the metric weights and methods described in Section 4, the three consensus prioritization scenarios are run. These scenarios are saved to a file geodatabase and reprojected for use in the web tool.

7.6 Publish Map & Geoprocessing Services

Using the consensus results and other relevant intermediate data, the map and geoprocessing services that underlie the tool and the custom analysis functionality are republished. Two distinct map services are published. The first one provides map layers for the functionality that falls within the "Explore" tab (see Section 6.1.2) while the second provides the map layers used in the "Miles Opened" tab (see Section 6.3).

Similarly, there are two distinct geoprocessing services that get updated as part of this process. The first provides the Custom Analysis functionality (see Section 6.4) while the other provides the functionality for the "Map Upstream Network" tool (see Section 6.5).

7.7 Generate Fact Sheets

In addition to updating the map and geoprocessing services, the fact sheets that are produced for each dam must be updated. Again, due to the "ripple effect" of data changes in a network analysis, fact sheets for all dams are regenerated whenever edits are made. For example, if a dam is removed, not only will metric values for many of the remaining dams change, but the prioritized result may as well. During this step, new HTML fact sheets are generated, photos are linked (if available), and the fact sheet is staged for upload.

7.8 Update Web Application

The final step of the dynamic data processing is to update the web application. This process includes uploading fact sheets and the consensus results that are available for download in the tool. These products are held in an Amazon S3 bucket and linked to from the web application. The web application itself (i.e., Vue3 project) is not altered as part of this process.

8 References

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9 Appendix I: Chesapeake Fish Passage Workgroup

2023 Chesapeake Fish Passage Prioritization Core Group

Name	Affiliation
Mary Andrews	National Oceanic and Atmospheric Administration
Dave Dippold	PA Fish & Boat Commission
Jim Thompson	MD Department of Natural Resources
Alan Weaver	VA Dept. of Game and Inland Fisheries

Chesapeake Fish Passage Prioritization Full Workgroup (including 2013, 2019 & 2023 versions)

Name	Affiliation
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Colin Apse	The Nature Conservancy
Jose Barrios	US Fish & Wildlife Service
Kathleen Boomer	The Nature Conservancy
Mark Bryer	The Nature Conservancy
Nancy Butowski	MD Department of Natural Resources
Jana Davis	Chesapeake Bay Trust
Michele DePhilip	The Nature Conservancy
Julie Devers	US Fish & Wildlife Service
Judy Dunscomb	The Nature Conservancy
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Lisa Moss	US Fish & Wildlife Service
Tim Owen	VA Dept. of Wildlife Resources
Nikki Rovner	The Nature Conservancy
Angela Sowers	US Army Corps of Engineers
Albert Spells	US Fish & Wildlife Service
Scott Stranko	MD Department of Natural Resources
Jessie Thomas-Blate	American Rivers
Jim Thompson	MD Department of Natural Resources
Alexander Vidal	US Fish & Wildlife Service
Alan Weaver	VA Dept. of Wildlife Resources
Howard Weinberg	Chesapeake Bay Program

10 Appendix II: Input Datasets

Dataset	Source	Description
Dams	Multiple sources including: state agencies, The Nature Conservancy's Northeast Aquatic Connectivity project, and the National Inventory of Dams. Review and edits made by the Chesapeake Fish Passage Prioritization Workgroup. Edits to Virginia dams from SARP data editing portal	This dataset represents dams in the VA, MD, & PA portions of the Chesapeake bay watershed spatially linked to the correct stream flowline in the USGS High Resolution National Hydrography Dataset (High-Res NHD) 1:24,000 stream dataset. Dams that do not fall on mapped streams in the High-Res NHD are not included in the results.
Waterfalls	USGS GNIS database, Chesapeake Fish Passage Prioritization Workgroup, USGS Waterfalls and Rapids in the Conterminous United States Linked to the National Hydrography Datasets V2.0.	Point dataset representing potential natural barriers to fish passage. Waterfalls were used in the development of functional river networks, but are not included in the results as potential candidates for fish passage projects.
Hydrography	High-Resolution (1:24,000)National Hydrography Dataset. Modified to a single-flowline dendritic network.	This feature class is a single flowline dendrite derived from the high resolution NHD. NHDFlowline data were downloaded from the USGS website (http://nhd.usgs.gov/data.html) for the four source subregions (0205, 0206, 0207, 0208) and merged into a single polyline feature class in ArcGIS 10 by Erik Martin at The Nature Conservancy in summer 2011. These data were edited by selecting and removing line segments which form loops or other downstream bifurcations. This editing was done using the Geometric Network & Utility Network Analyst tools in ArcGIS and the Barrier Analysis Tool. Several pre-existing datasets were used to facilitate this process including coverages in Maryland from Pete Steeves (USGS) and Pennsylvania from Scott Hoffman (USGS). These data were dendrites, but based on outdated geometry. They were joined to the current high-res NHD using the REACHCODE attribute. This join eliminate approximately 80% of the unwanted segments (braids, loops, downstream bifurcations). Manual editing was used to eliminate the rest. In Virginia, New York and West Virginia, all edits were done manually. Several watersheds

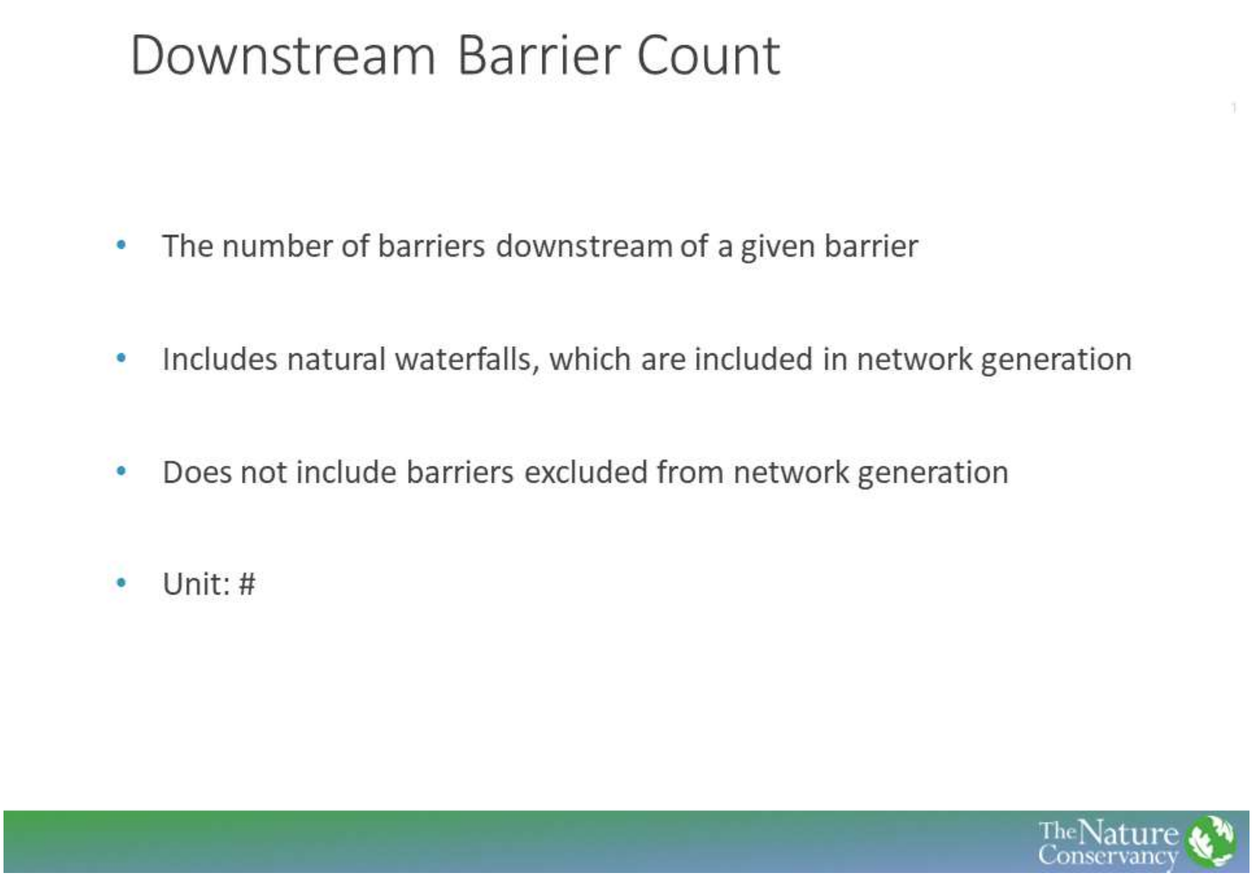
		(HUC8) in Virginia were edited by Jen Kristolic at the USGS Virginia Water Science center. Once a geometrically correct dendrite was produced, flow direction in the geometric network was set to digitized direction and edits made as needed to ensure proper flow direction. Catchments were then calculated for each line segment (COMID) using a 10m DEM and a Python scripts adapted from the "agree.aml" work done by Pete Steeves and others. The area of each segment was then summed for all upstream segments using the ArcHydro "Accumulate Attributes" tool. This produced the drainage area for each segment which, is subsequently used to calculate the size class for each segment based on ecologically relevant classes established through TNC's Northeast Aquatic Habitat Classification System.
Diadromous fish habitat	Initial data from the Northeast Aquatic Connectivity project was transferred to the project hydrography, with substantial edits and additions made by fisheries biologists in VA, MD, & PA during and following round table meetings to review and compile additional data. Further updates were incorporated to account for dam removals and fish passage projects in the watershed.	Critical habitats (spawning, nursery or other critical habitats) assigned to reaches of the project hydrography, and those reaches needed to reach the uppermost documented location, for alewife, blueback herring, American shad, hickory shad, Atlantic sturgeon, shortnose sturgeon, striped bass, and American eel. Reaches are coded for either current habitat, potential current habitat, historical habitat, or no documented habitat.
Land Cover	2019 National land Cover Database (NLCD2019)	Land use / land cover data from the NLCD2019. This 30m gridded data was grouped into natural and agricultural. (Developed was addressed via the impervious surface data). Natural landcover includes the following classes: open water, barren land, deciduous forest, evergreen forest, mixed forest, scrub/shrub, grassland/herbaceous, woody wetlands, emergent wetlands. Agricultural includes the following classes: pasture/hay, cultivated crops. The percentages of both agricultural and natural land cover are assessed for the contributing watershed of each dam, as well as within the riparian area of the dam's upstream and downstream networks.

Impervious Surface	2019 National land Cover Database (NLCD2019)	% Impervious surface data from the NLCD2019. This 30m gridded data describes the % of impervious surface within each 30m cell. The percentages of impervious surface is assessed for the contributing watershed of each dam, as well as within the riparian area of the dam's upstream and downstream networks..
Chesapeake Bay High Resolution Land Cover	Chesapeake Conservancy	One-meter resolution land cover data for approximately 100,000 square miles of land in and surrounding the Chesapeake Bay watershed. 2017/2018 version.
Riparian Zone	First Street Foundation FATHOM	The riparian zone includes the intersection of the fluvial and pluvial areas (flood areas from the accumulation of rainfall), with permanent water removed. It was used in an analogous way to how the Active River Area was used in previous version of the Tool.
Rare fish, mussels & crayfish. Native fish species richness.	NatureServe HUC8-scale data.	Each dam is assigned the number of rare fish, mussel & crayfish species as well as the number of native fish species in the 8-digit HUC within which the dam is located.
Road stream crossings	North Atlantic Aquatic Connectivity Collaborative (NAACC)	Road-stream crossings are sourced from the North Atlantic Aquatic Connectivity database. These data used are hosted in the SARP data portal and updated periodically by SARP.
Brook trout catchments	Eastern Brook Trout Joint Venture	Used to indicate whether each dam is located in a catchment that was classified as having an allopatric brook trout population, brook trout sympatric with non-native brown and rainbow trout, non-native trout only, or no trout/unknown by the Eastern Brook Trout Joint Venture (Mark Hudy 2012).
Brook trout catchments	DeWeber and Wagner (2014)	Catchments with predicted brook trout population status
Conservation Land	The Nature Conservancy	Dams that lie on conservation lands are identified. Additionally, the % of conservation land is assessed with a 100m buffer of each dam's upstream and downstream functional river networks.
Stream health / water quality	Interstate Commission on the Potomac River Basin Stream Health score "Chessie-BIBI" ;	Each barrier was assigned a stream health score based on its location within a HUC10 watershed (subdivided by bioregion).

Human disturbance	National Fish Habitat Partnership (NFHP) 2015 Cumulative Habitat Condition Indices with Limiting and Severe Disturbances for the Conterminous United States linked to NHDPlusV1 v2.0	Landscape factors representing human disturbances summarized to local and network catchments of river reaches throughout the conterminous U.S.

11 Appendix III: Glossary and Metric Definitions

The following slides describe each of the metrics calculated for each barrier in the Tool. These are static images of the slides included in the Tool. Links in these slide are not functional, however, when accessed via the radar plot help dialog in the Tool (see Section 6.2.6) the links to source data web pages are live.



Number of Hydro Dams on Downstream Flowpath

2

- Count of hydropower dams on downstream flowpath of a barrier
- Unit: #

The Nature Conservancy

Number of Natural Barriers on Downstream Flowpath

3

- Count of waterfalls on downstream flowpath of a barrier

- Unit: #

The Nature Conservancy

Number of Fish Passage Facilities on Downstream Flowpath

- Count of fish passage facilities on downstream flowpath of a barrier
- Unit: #

The Nature Conservancy

Upstream Barrier Density

- Upstream Barrier Count divided by the total length of river upstream in meters
- Includes natural waterfalls, which are included in network generation
- Does not include barriers excluded from network generation
- Unit: # / meters

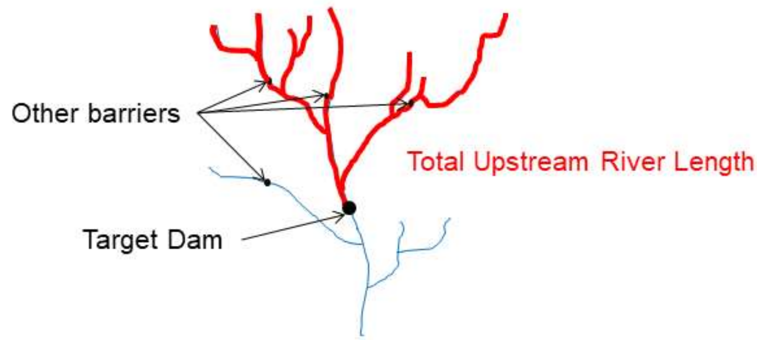
Downstream Barrier Density

6

- Downstream Barrier Count divided by the Distance to River Mouth in meters
- Includes natural waterfalls, which are included in network generation
- Does not include barriers excluded from network generation
- Unit: # / meters

Total Upstream River Length

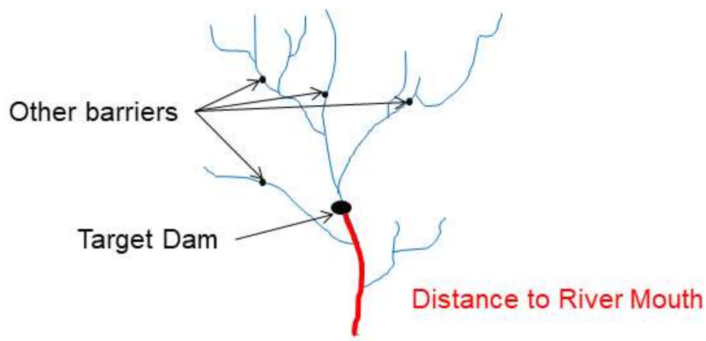
- Total length of river network upstream of a given barrier, regardless of any upstream barriers.
- Unit: meters



Distance to River Mouth

- Distance from each barrier to the network mouth in meters

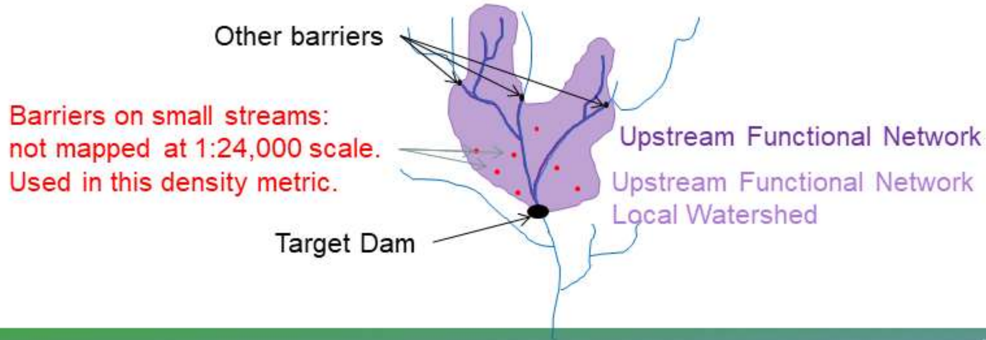
- Unit: meters



Density of Dams on Small Streams in Upstream Functional Network Local Watershed

9

- Number of dams on small streams (dams did not snap to analysis hydrography) within the local watershed of the upstream functional network divided by that watershed area
- Unit: # / m^2

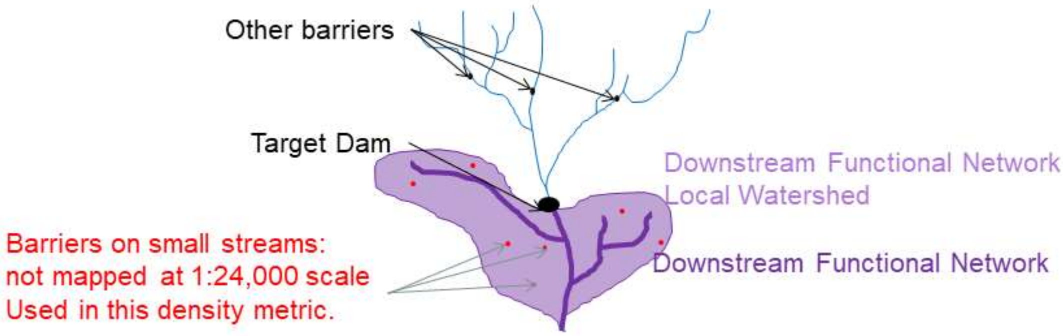


The Nature Conservancy

Density of Dams on Small Streams in Downstream Functional Network Local Watershed

10

- Number of dams on small streams (dams did not snap to analysis hydrography) within local watershed of the downstream functional network divided by that watershed area
- Unit: # / m²



The Nature Conservancy

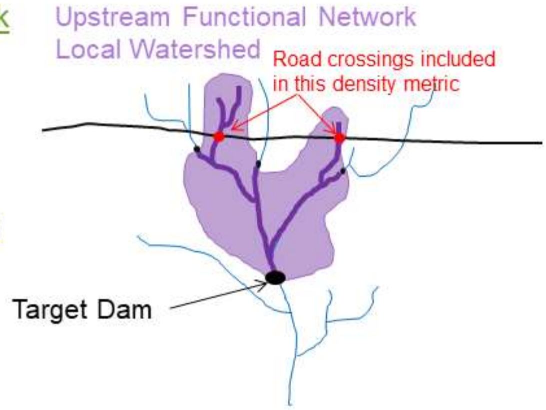
Density of Road & Railroad / Small Stream Crossings in Upstream Functional Network Local Watershed

11

- Number of road-stream crossings within upstream functional network local watershed divided by that watershed area.

- Road-stream crossing data from North Atlantic Aquatic Connectivity Collaborative

- Unit: # / m^2

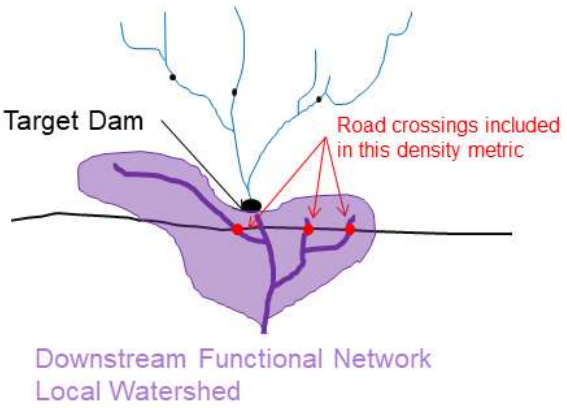


The Nature Conservancy

Density of Road & Railroad / Small Stream Crossings in Downstream Functional Network Local Watershed

12

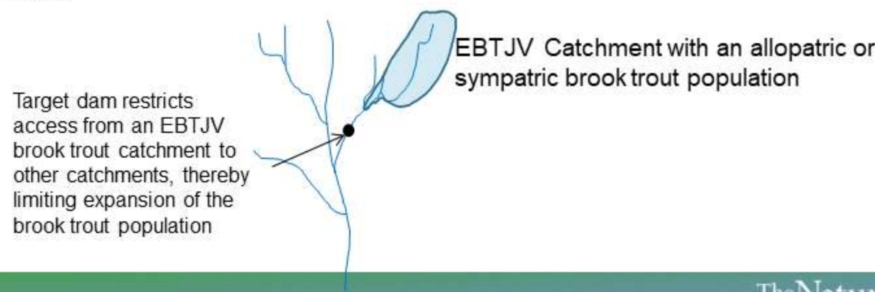
- Number of road-stream crossings within downstream functional network local watershed divided by that watershed area.
- Road-stream crossing data from North Atlantic Aquatic Connectivity Collaborative
- Unit: # / m²



The Nature Conservancy

Barrier to EBTJV Brook Trout Habitat

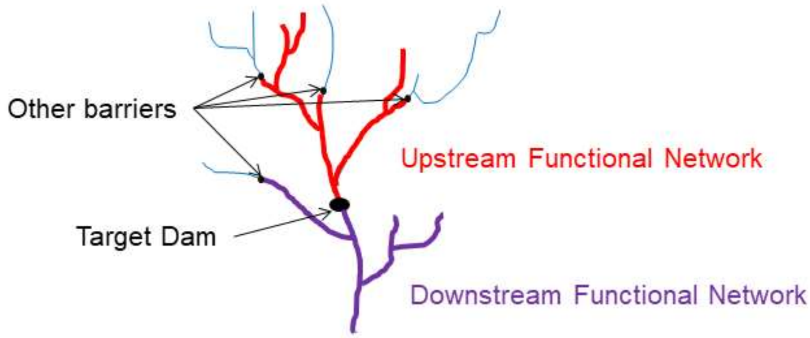
- Dam where either its Upstream Functional River Network or Downstream Functional River Network intersects an EBTJV catchment (Hudy 2012) with an allopatric brook trout population or brook trout sympatric with brown or rainbow trout *and the other does not*.
- Allopatric and sympatric brook trout catchments includes the following codes: '1.1', '1.1P', '1.2', '1.2P', '1.3', '1.3P', '1.4', '1.4P', '15', '0.5', '1.0', '1.0P', '1P', '1'
- Dams not covered by the extent of the EBTJV 2012 catchment data are not considered as barriers between EBTJV brook trout catchments
- Unit: Boolean



Downstream Functional Network Length

- Length of the functional network downstream of a barrier. The functional network is defined by those sections of river that a fish could theoretically access from any other point within that functional network. Its terminal ends are barriers, headwaters, and/or the river mouth.

- Unit: meters

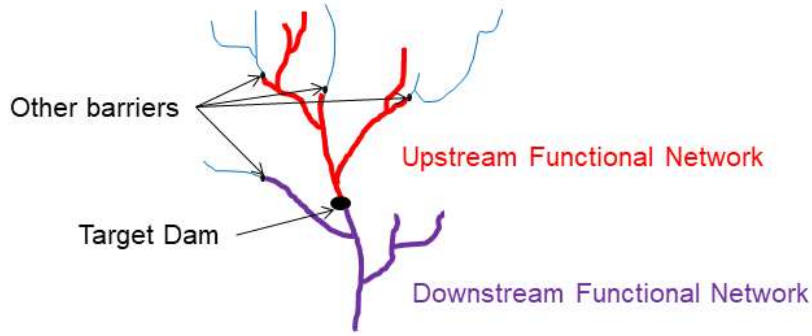


Upstream Functional Network Length

15

- Length of the functional network upstream of a barrier. The functional network is defined by those sections of river that a fish could theoretically access from any other point within that functional network. Its terminal ends are barriers, headwaters, and/or the river mouth.

- Unit: meters

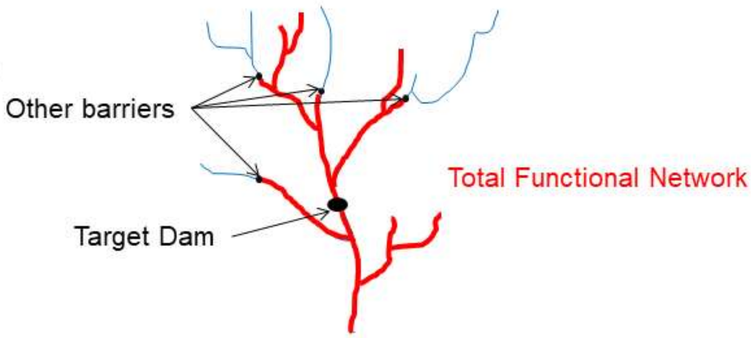


The total length of upstream and downstream functional network

16

- Summed length of the upstream and downstream functional networks of a barrier. The functional network is defined by those sections of river that a fish could theoretically access from any other point within that functional network. Its terminal ends are barriers, headwaters, and/or the river mouth.

- Unit: meters



The Nature Conservancy

Absolute Gain

- This metric is the minimum of the two functional networks of a barrier. For example if the upstream functional network was 10 kilometers and downstream functional network was 5 kilometers, then the Absolute Gain will be 5 kilometers.

- Unit: meters

The Nature Conservancy

Relative Gain

18

- This metric is Absolute gain divided by the total length of upstream and downstream functional networks.
- Unit: meters

The Nature Conservancy

% Impervious Surface in Contributing Watershed

19

- % Impervious surface in entire upstream (contributing) watershed. Calculated 2019 National Land Cover Database percent developed imperviousness.

- Unit: %

The Nature Conservancy

% Natural LC in Contributing Watershed

20

- % natural landcover in entire upstream watershed. 2019 National Land Cover Database.

- Natural landcover aggregated from the following classes: open water, barren land, deciduous forest, evergreen forest, mixed forest, scrub/shrub, grassland/herbaceous, woody wetlands, emergent wetlands

- Unit: %

The Nature Conservancy

% Forested LC in Contributing Watershed

21

- % forested landcover in entire upstream watershed. Calculated 2019 National Land Cover Database.
- Forested landcover aggregated from the following classes: deciduous forest, evergreen forest, mixed forest
- Unit: %

The Nature Conservancy

% Impervious Surface in Riparian Zone of Upstream Functional Network

22

- % impervious landcover within riparian zone of the upstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.
- 2019 National Land Cover Database data
- Unit: %

The Nature Conservancy

% Impervious Surface in Riparian Zone of Downstream Functional Network

23

- % impervious landcover within riparian zone of the downstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- 2019 National Land Cover Database data

- Unit: %

The Nature Conservancy

% Natural LC in Riparian Zone of Upstream Functional Network

24

- % natural landcover within riparian zone of the upstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- 2019 National Land Cover Database data. Includes the following classes: open water, barren land, deciduous forest, evergreen forest, mixed forest, scrub/shrub, grassland/herbaceous, woody wetlands, emergent wetlands

- Unit: %

The Nature Conservancy

% Natural LC in Riparian Zone of Downstream Functional Network

25

- % natural landcover within riparian zone of the downstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- 2019 National Land Cover Database data. Includes the following classes: open water, barren land, deciduous forest, evergreen forest, mixed forest, scrub/shrub, grassland/herbaceous, woody wetlands, emergent wetlands

- Unit: %

The Nature Conservancy

% Forested in Riparian Zone of Upstream Functional Network

26

- % forested landcover within riparian zone of the upstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- 2019 National Land Cover Database data. Includes the following classes: deciduous, evergreen & mixed forest

- Unit: %

The Nature Conservancy

% Forested in Riparian Zone of Downstream Functional Network

27

- % forested landcover within riparian zone of the downstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.
- 2019 National Land Cover Database data. Includes the following classes: deciduous, evergreen & mixed forest
- Unit: %

The Nature Conservancy

% Conserved Land within 100m Buffer of Upstream Functional Network

28

- % of land within 100m buffer of upstream functional network that intersects 2018 secured areas database (TNC)
- Unit: %

The Nature Conservancy

% Conserved Land within 100m Buffer of Downstream Functional Network

29

- % of land within 100m buffer of downstream functional network that intersects 2018 secured areas database (TNC)

- Unit: %

The Nature Conservancy

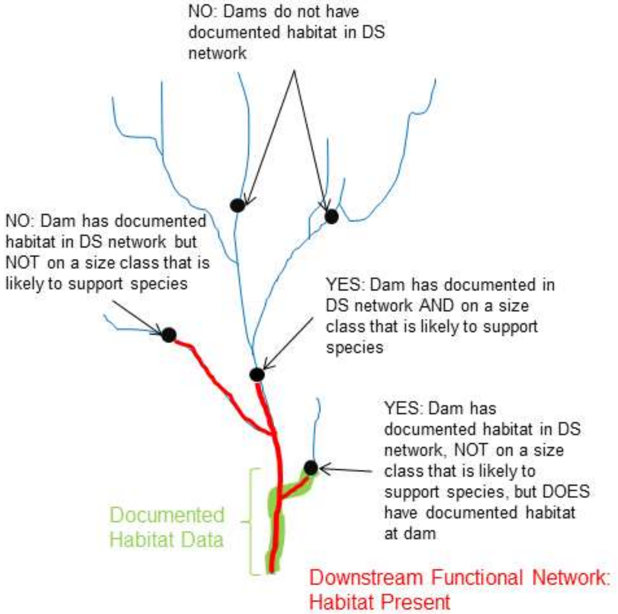
American Shad habitat in Downstream Functional Network

30

- Presence of American shad downstream of dam. Based on:
  1. Documented habitat in some portion of the dam's downstream functional network
  2. **AND** Dam is on a stream that is likely to support that species based on stream size
     1. Size 2+ Rivers
  3. **OR** There is documented habitat up to a dam on a stream that doesn't meet the above size class rule
  4. **AND** the dam has not been specifically flagged otherwise by Chesapeake Fish Passage Workgroup

- Fish habitat data from multiple sources, reviewed and edited by state fisheries biologists. Each line segment includes its data source.

- Unit: Unitless Classes: "Current", "Potential Current", "Historical"



The Nature Conservancy

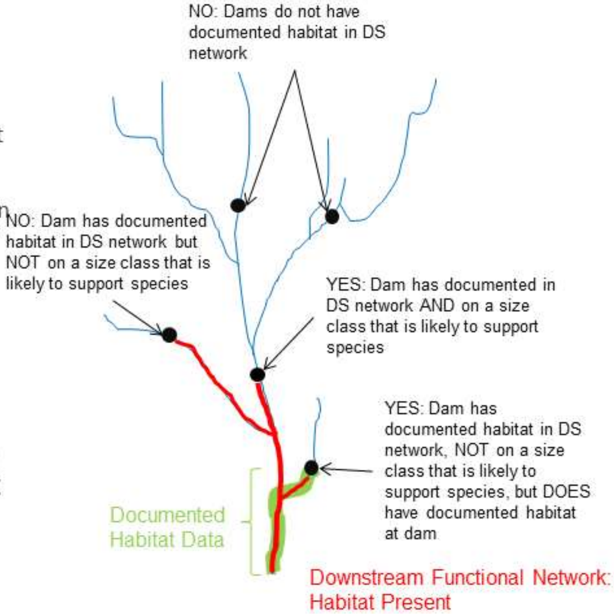
Blueback Herring habitat in Downstream Functional Network

31

- Presence of blueback herring downstream of dam. Based on:
  1. Documented habitat in some portion of the dam's downstream functional network
  2. **AND** Dam is on a stream that is likely to support that species based on stream size
     1. Size 2+ Rivers & 1a/1b if no gradient >10%
  3. **OR** There is documented habitat up to a dam on a stream that doesn't meet the above size class rule
  4. **AND** the dam has not been specifically flagged otherwise by Chesapeake Fish Passage Workgroup

- Fish habitat data from multiple sources, reviewed and edited by state fisheries biologists. Each line segment includes its data source.

- Unit: Unitless Classes: "Current", "Potential Current", "Historical"



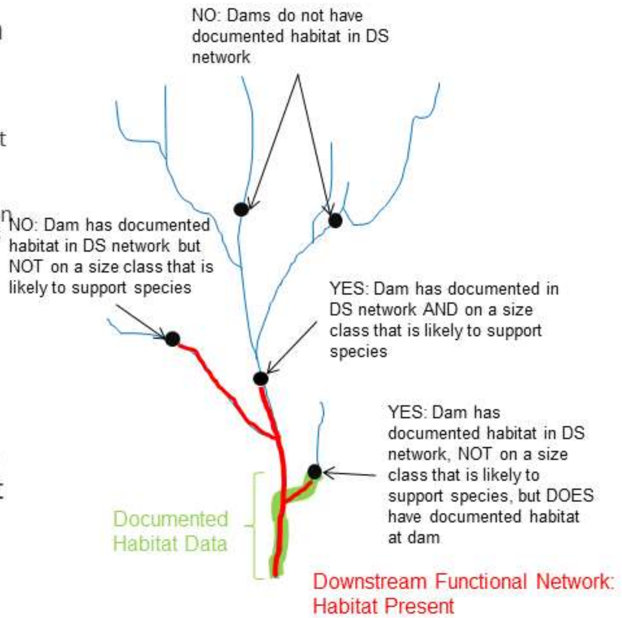
Hickory Shad habitat in Downstream Functional Network

32

- Presence of Hickory shad downstream of dam. Based on:
  1. Documented habitat in some portion of the dam's downstream functional network
  2. **AND** Dam is on a stream that is likely to support that species based on stream size
     1. Size 2+ Rivers
  3. **OR** There is documented habitat up to a dam on a stream that doesn't meet the above size class rule
  4. **AND** the dam has not been specifically flagged otherwise by Chesapeake Fish Passage Workgroup

- Fish habitat data from multiple sources, reviewed and edited by state fisheries biologists. Each line segment includes its data source.

- Unit: Unitless Classes: "Current", "Potential Current", "Historical"

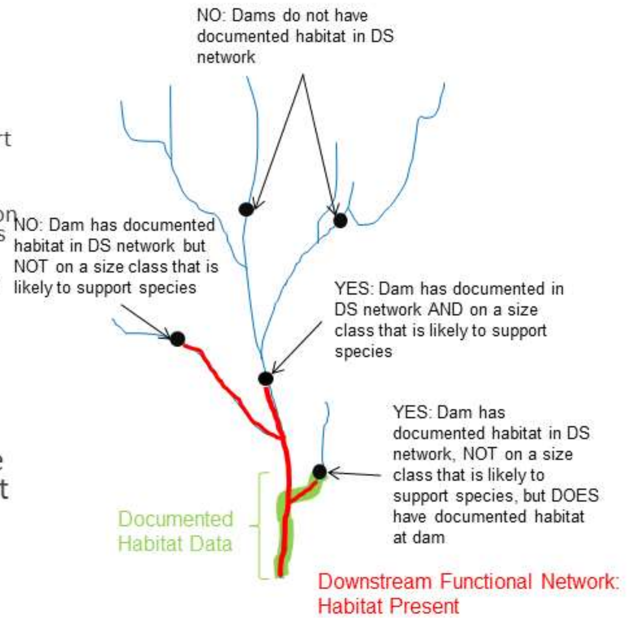


Alewife habitat in Downstream Functional Network

- Presence of alewife downstream of dam. Based on:
  1. Documented habitat in some portion of the dam's downstream functional network
  2. **AND** Dam is on a stream that is likely to support that species based on stream size
     1. Size 2+ Rivers & 1a/1b if no gradient >10%
  3. **OR** There is documented habitat up to a dam on a stream that doesn't meet the above size class rule
  4. **AND** the dam has not been specifically flagged otherwise by Chesapeake Fish Passage Workgroup

- Fish habitat data from multiple sources, reviewed and edited by state fisheries biologists. Each line segment includes its data source.

- Unit: Unitless Classes: "Current", "Potential Current", "Historical"



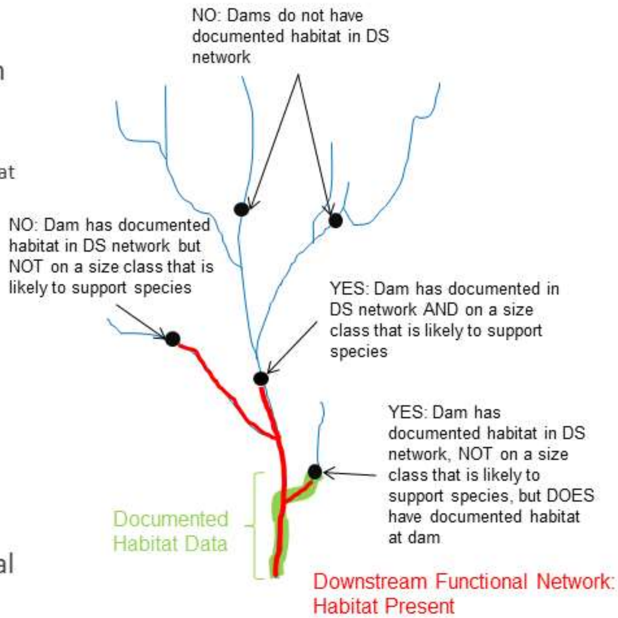
Atlantic Sturgeon habitat in Downstream Functional Network

34

- Presence of Atlantic sturgeon downstream of dam. Based on:
  1. Documented habitat in some portion of the dam's downstream functional network
  2. **AND** Dam is on a stream that is likely to support that species based on stream size
     1. Size 4+ Rivers
  3. **OR** There is documented habitat up to a dam on a stream that doesn't meet the above size class rule
  4. **AND** the dam has not been specifically flagged otherwise by Chesapeake Fish Passage Workgroup

- Fish habitat data from multiple sources, reviewed and edited by state fisheries biologists. Each line segment includes its data source.

- Unit: Unitless Classes: "Current", "Potential Current", "Historical"



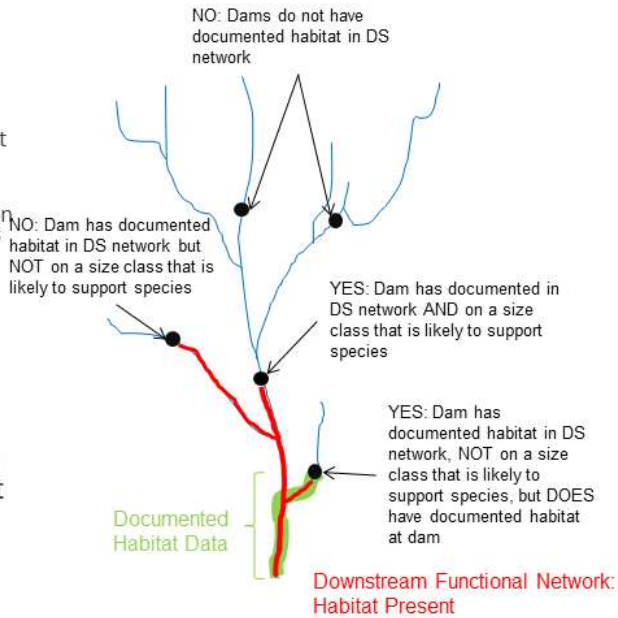
The Nature Conservancy

Striped Bass habitat in Downstream Functional Network

- Presence of striped bass downstream of dam. Based on:
  1. Documented habitat in some portion of the dam's downstream functional network
  2. **AND** Dam is on a stream that is likely to support that species based on stream size
     1. Size 3b+ Rivers
  3. **OR** There is documented habitat up to a dam on a stream that doesn't meet the above size class rule
  4. **AND** the dam has not been specifically flagged otherwise by Chesapeake Fish Passage Workgroup

- Fish habitat data from multiple sources, reviewed and edited by state fisheries biologists. Each line segment includes its data source.

- Unit: Unitless Classes: "Current", "Potential Current", "Historical"



The Nature Conservancy

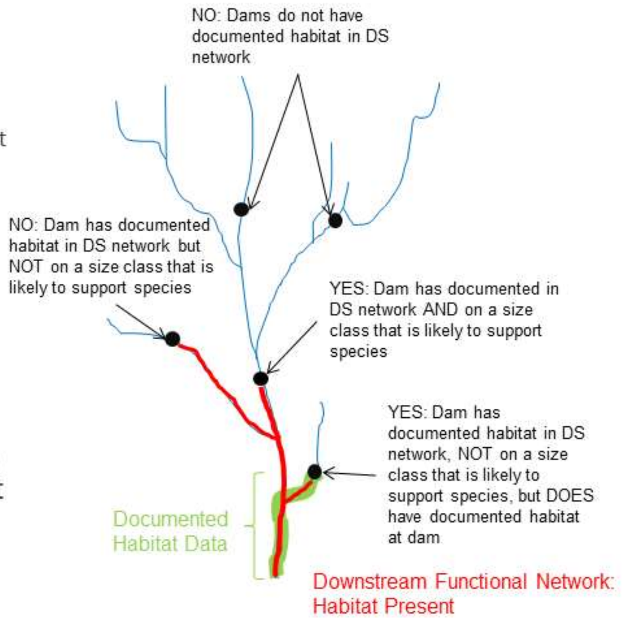
Shortnose Sturgeon habitat in Downstream Functional Network

36

- Presence of shortnose sturgeon downstream of dam. Based on:
  1. Documented habitat in some portion of the dam's downstream functional network
  2. **AND** Dam is on a stream that is likely to support that species based on stream size
     1. Size 4+ Rivers
  3. **OR** There is documented habitat up to a dam on a stream that doesn't meet the above size class rule
  4. **AND** the dam has not been specifically flagged otherwise by Chesapeake Fish Passage Workgroup

- Fish habitat data from multiple sources, reviewed and edited by state fisheries biologists. Each line segment includes its data source.

- Unit: Unitless Classes: "Current", "Potential Current", "Historical"



The Nature Conservancy

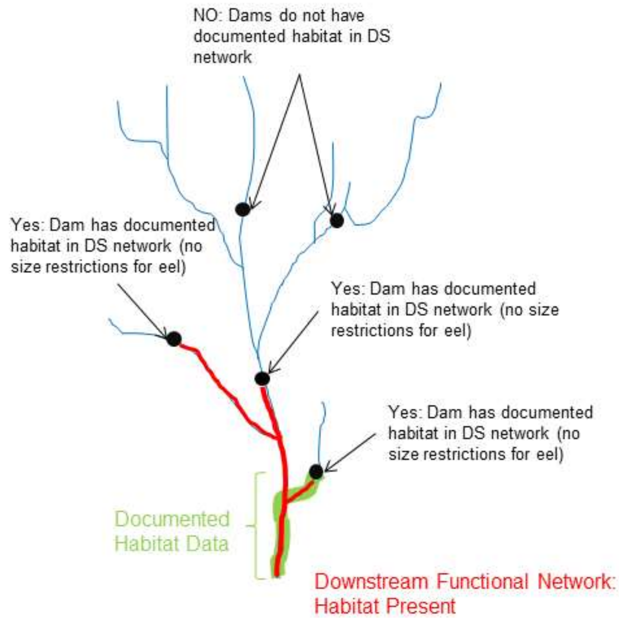
American Eel habitat in Downstream Functional Network

37

- Presence of American eel downstream of dam. Based on:
  1. Documented habitat in some portion of the dam's downstream functional network
  2. No size restrictions on eel

- Fish habitat data from multiple sources, reviewed and edited by state fisheries biologists. Each line segment includes its data source.

- Unit: Unitless Classes: "Current", "Potential Current", "Historical"



The Nature Conservancy

Presence of Anadromous Species in Downstream Network

- Presence of habitat for 1 or more of the 7 anadromous species included in this analysis based on the data and methods described for each species:
  alewife, blueback herring, American shad, hickory shad, striped bass, shortnose sturgeon, Atlantic sturgeon
- Habitat for each species is coded as "Current", "Potential Current" or "Historical"
- If current and historical habitat are documented in the downstream functional network for different species, the current habitat trumps the potential current habitat which in turn trumps the historical habitat. So if alewife habitat is "Current", American shad habitat is "Potential Current" and Atlantic sturgeon are "Historical" the metric will be "Current", indicating that habitat for 1 or more anadromous species is currently documented in the dams downstream network (based on the methods described for each species).
- Does NOT include American eel
- Unit: presence / absence

The Nature Conservancy

Number of Diadromous Species

- The number of diadromous species with documented habitat in the downstream functional network of each dam based on the data and methods described for each species:
  - alewife, blueback herring, American shad, hickory shad, striped bass, shortnose sturgeon, Atlantic sturgeon, American Eel

- Only "Current" habitat is considered for this metric

- Unit: #

The Nature Conservancy

Rare Fish in HUC8

40

- Count of rare (G1-G3) fish species in the watershed within which the dam is located

- Based on NatureServe watershed (8-digit HUC) data

- Unit: #

The Nature Conservancy

Rare Mussels in HUC8

- Count of rare (G1-G3) mussel species in the watershed within which the dam is located
- Based on NatureServe watershed (8-digit HUC) data
- Unit: #

Rare Crayfish in HUC8

- Count of rare (G1-G3) crayfish species in the watershed within which the dam is located
- Based on NatureServe watershed (8-digit HUC) data
- Unit: #

Barrier within EBTJV Catchment with Trout

- Barrier within an NHD catchment occupied by trout based on Eastern Brook Trout Joint Venture (EBTJV) data. (Hudy 2012)
- Catchments with trout identified by the query "Trout =1"

- Unit: Boolean

Native Fish Species Richness - HUC 8

44

- Current native fish species richness in the watershed within which the dam is located

- Based on NatureServe watershed (8-digit HUC) data

- Unit: #

Chesapeake Benthic Index of Biotic Integrity (ChessieBIBI) Rating

- Stream health scores developed by the Interstate Commission on the Potomac River Basin between 2000-2017
- Average Benthic Index of Biotic Integrity
- >25,000 sample locations included
- HUC10 watersheds intersected by bioregion. Each rated as excellent, good, fair, poor, very poor.
- Barriers are assigned the score from the watershed they are located within. These scores are converted to integers for use in the prioritization

The Nature Conservancy

Chesapeake Benthic Index of Biotic Integrity (ChessieBIBI) % Excellent, good Fair

- Stream health scores developed by the Interstate Commission on the Potomac River Basin between 2000-2017
- Average Benthic Index of Biotic Integrity
- >25,000 sample locations included
- HUC10 watersheds intersected by bioregion. Each rated as excellent, good, fair, poor, very poor
- The metric indicates the percent of samples in the excellent, good & fair categories in the watershed. Each barrier is assigned the value of the watershed it is within

The Nature Conservancy

Recognized Biodiversity Value

- TNC Freshwater Recognized Biodiversity Value. Recognized Biodiversity Value comprises four sources of data, the Conservancy's freshwater ecoregional portfolio sites (from planning completed in 1998-2013), state-bases assessments (mainly State Wildlife Action Plans, but also including Crucial Habitat Assessment Tool designations), the Range-Size RarityIndex for aquatic species from NatureServe's Map of Biodiversity Information (MoBI), and species-specific data on the coasts.

- Data are not used on a consensus prioritization, but are included to provide additional context on biodiversity value

The Nature Conservancy

River Size Class

48

- River size class based on NE Aquatic Habitat Classification.

1a: Headwaters (<3.861 sq.mi.)

1b: Creeks (>= 3.861<38.61 sq.mi.)

2: Small River (>=38.61<200 sq. mi.)

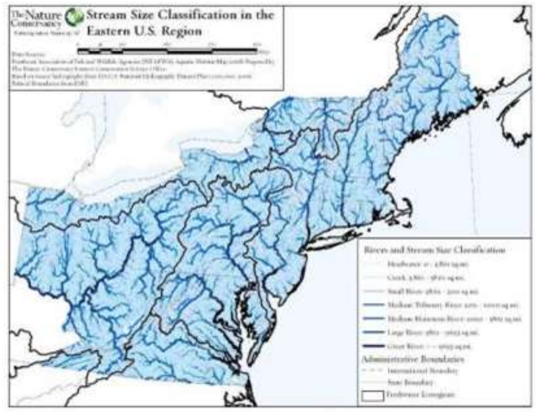
3a: Medium Tributary Rivers (>=200<1000 sq.mi.)

3b: Medium Mainstem Rivers (>=1000<3861 sq.

4: Large Rivers (>=3861 < 9653 sq.mi.)

5: Great Rivers (>=9653 sq.mi.)

(measure = upstream drainage area)



Upstream Size Classes Gained by Removal / Bypass

49

- Number of upstream stream size classes gained if dam were to be removed. Stream segments must be >0.5 miles to be considered a gain and the size class must not be present in the downstream functional network.

- e.g. If a downstream functional network had small rivers (size 2) and medium tributary rivers (size 3a), while an upstream functional network had these as well as 2 miles of creek (size 1b), the gain would be 1.

- Unit: #

The Nature Conservancy

Total # Reconnected Stream Size Classes >0.5 Miles(upstream + downstream)

- Number of unique stream size classes >0.5 miles in total upstream and downstream functional networks

- Where stream size defined as:
  - 1a: Headwaters (<3.861 sq.mi.)
  - 1b: Creeks (>= 3.861<38.61 sq.mi.)
  - 2: Small River (>=38.61<200 sq. mi.)
  - 3a: Medium Tributary Rivers (>=200<1000 sq.mi.)
  - 3b: Medium Mainstem Rivers (>=1000<3861 sq.mi.)
  - 4: Large Rivers (>=3861 < 9653 sq.mi.)
  - 5: Great Rivers (>=9653 sq.mi.)

(measure = upstream drainage area)

The Nature Conservancy

% Agricultural LC in Contributing Watershed

51

- % natural landcover in entire upstream watershed. Calculated 2019 National Land Cover Database .
- Agricultural landcover aggregated from the following classes: cultivated crops, pasture
- Unit: %

The Nature Conservancy

% Agricultural in Riparian Zone of Upstream Functional Network

52

- % agricultural landcover within riparian zone of the upstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- 2019 National Land Cover Database data. Includes the following classes: cultivated crops, pasture

- Unit: %

The Nature Conservancy

% Agricultural LC in Riparian Zone of Downstream Functional Network

53

- % agricultural landcover within riparian zone of the downstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.
- 2019 National Land Cover Database data. Includes the following classes: cultivated crops, pasture
- Unit: %

The Nature Conservancy

% Tree Cover in Riparian Zone of Upstream Functional Network

54

- % tree cover within riparian zone of the upstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).

- Unit: %

The Nature Conservancy

% Tree cover in Riparian Zone of Downstream Functional Network

55

- % tree cover within riparian zone of the downstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).

- Unit: %

The Nature Conservancy

% Herbaceous Cover in Riparian Zone of Upstream Functional Network

- % Herbaceous cover within riparian zone of the upstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.
- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).
- Unit: %

% Herbaceous cover in Riparian Zone of Downstream Functional Network

57

- % Herbaceous cover within riparian zone of the downstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).

- Unit: %

The Nature Conservancy

% Barren Cover in Riparian Zone of Upstream Functional Network

58

- % Barren cover within riparian zone of the upstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).

- Unit: %

The Nature Conservancy

% Barren cover in Riparian Zone of Downstream Functional Network

59

- % Barren cover within riparian zone of the downstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).

- Unit: %

The Nature Conservancy

% Road Impervious Surface in Riparian Zone of Upstream Functional Network

60

- % Road Impervious Surface within riparian zone of the upstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.
- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).
- Unit: %

The Nature Conservancy

% Road Impervious Surface in Riparian Zone of Downstream Functional Network

61

- % Road Impervious Surface within riparian zone of the downstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).

- Unit: %

The Nature Conservancy

% Non-Road Impervious Surface in Riparian Zone of Upstream Functional Network

62

- % Non-Road Impervious Surface within riparian zone of the upstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).

- Unit: %

The Nature Conservancy

% Non-Road Impervious Surface in Riparian Zone of Downstream Functional Network

63

- % Non-Road Impervious Surface within riparian zone of the downstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).

- Unit: %

The Nature Conservancy

% Wetlands in Riparian Zone of Upstream Functional Network

64

- % wetlands within riparian zone of the upstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).

- Unit: %

The Nature Conservancy

% Wetlands in Riparian Zone of Downstream Functional Network

65

- % Wetlands within riparian zone of the downstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).

- Unit: %

The Nature Conservancy

% Shrub cover in Riparian Zone of Upstream Functional Network

66

- % shrub cover within riparian zone of the upstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.
- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).
- Unit: %

The Nature Conservancy

% Shrub cover in Riparian Zone of Downstream Functional Network

67

- % shrub cover within riparian zone of the downstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).

- Unit: %

The Nature Conservancy

% Tree Over in Riparian Zone of Downstream Functional Network

68

- % Tree canopy over other land cover within riparian zone of the downstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.

- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).

- Unit: %

The Nature Conservancy

% Tree Over Impervious Surface in Riparian Zone of Upstream Functional Network

69

- % Tree canopy over other land cover within riparian zone of the upstream functional river network. Riparian zone defined using the FATHOM fluvial/pluvial floodplain.
- Land cover data from the Chesapeake Bay Conservancy's high resolution (1m) land cover data (2017/2018).
- Unit: %

The Nature Conservancy

Dam is on Conserved Land

70

- Dam location intersects conserved land from 2018 secured areas database (TNC)

- Unit: Boolean

The Nature Conservancy

NFHP Risk of Degradation Score

- Relative risk of habitat degradation based on the National Fish Habitat Partnership (NFHP) 2015 Cumulative Habitat Condition Indices level of disturbance to fish habitats. Cumulative fish habitat condition index (HCI) scores generated for river reaches of the conterminous United States as well as indices generated specifically for four spatial units including local and network catchments and 90 m local and network buffers of river reaches. Scores are passed to each barrier from the NHD Plus catchment it is located within, where:

  5 represents lowest risk to fish habitat degredation and 1 representing highest risk

- GIS Name: cumu_hci
- Based on the medium scale resolution NHD catchment the barrier is within. Based on:
  - Daniel, W.M, Infante, D.M, Herreman, K., Cooper, A., and Ross, J., 2019, National Fish Habitat Partnership (NFHP) 2015 Cumulative Habitat Condition Indices and Limiting Disturbances for the Conterminous United States linked to NHDPlusV1, (ver. 2.0, March 2019): U.S. Geological Survey data release, https://doi.org/10.5066/P94C5B06.

The Nature Conservancy

Barrier within Modeled Trout Catchment

- Barrier within a catchment with modeled brook trout occupancy. (DeWeber & Wagner 2015)
- Catchments occupied by brook trout identified using the "occur46" scenario from DeWeber & Wagner 2015:
  - a binary classification (1 = present; 0 = absent) of Brook Trout occurrence based on a threshold that was equal to prevalence in the training data set, which produces near-optimal classification accuracy and could be used when false positives and false negatives have equal costs.
- Unit: Boolean

- DeWeber, J.T. and Wagner, T., 2015. Predicting brook trout occurrence in stream reaches throughout their native range in the eastern United States. Transactions of the American Fisheries Society, 144(1), pp.11-24. https://doi.org/10.1080/00028487.2014.963256

The Nature Conservancy

Barrier blocks EBTJV 2012 Catchments

- Category: Ecological – Resident
- NHD catchments occupied by trout are in one of a barriers functional networks – either upstream or downstream, but not both
- Based on 2012 EBTJV data

- Unit: Boolean

The Nature Conservancy

Barrier blocks Modeled Trout Catchments

- Category: Ecological – Resident
- NHD catchments occupied by trout are in one of a barriers functional networks – either upstream or downstream, but not both
- Based on DeWeber & Wagner 2015 data

- Unit: Boolean

The Nature Conservancy

Upstream Size Classes Gained by Removal / Bypass

75

- Number of upstream stream size classes . Stream segments must be >0.5 miles to be considered a gain and the size class must not be present in the downstream functional network.

- e.g. If a downstream functional network had small rivers (size 2) and medium tributary rivers (size 3a), while an upstream functional network had these as well as 2 miles of creek (size 1b), the gain would be 1.

- Unit: #

The Nature Conservancy

Miles of Cold Water Habitat in Total Functional Network

- Miles of Cold Water habitat in the total functional network of a barrier
- Cold water habitat data from the Northeast Aquatic Habitat Classification

- Unit: Miles

The Nature Conservancy

Miles of Cold or Cool Water Habitat in Total Functional Network

- Miles of Cold or Cool Water habitat in the total functional network of a barrier
- Cold water habitat data from the Northeast Aquatic Habitat Classification

- Unit: Miles

The Nature Conservancy