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The National Hydrography Datasets (NHD) as a Spatial Framework

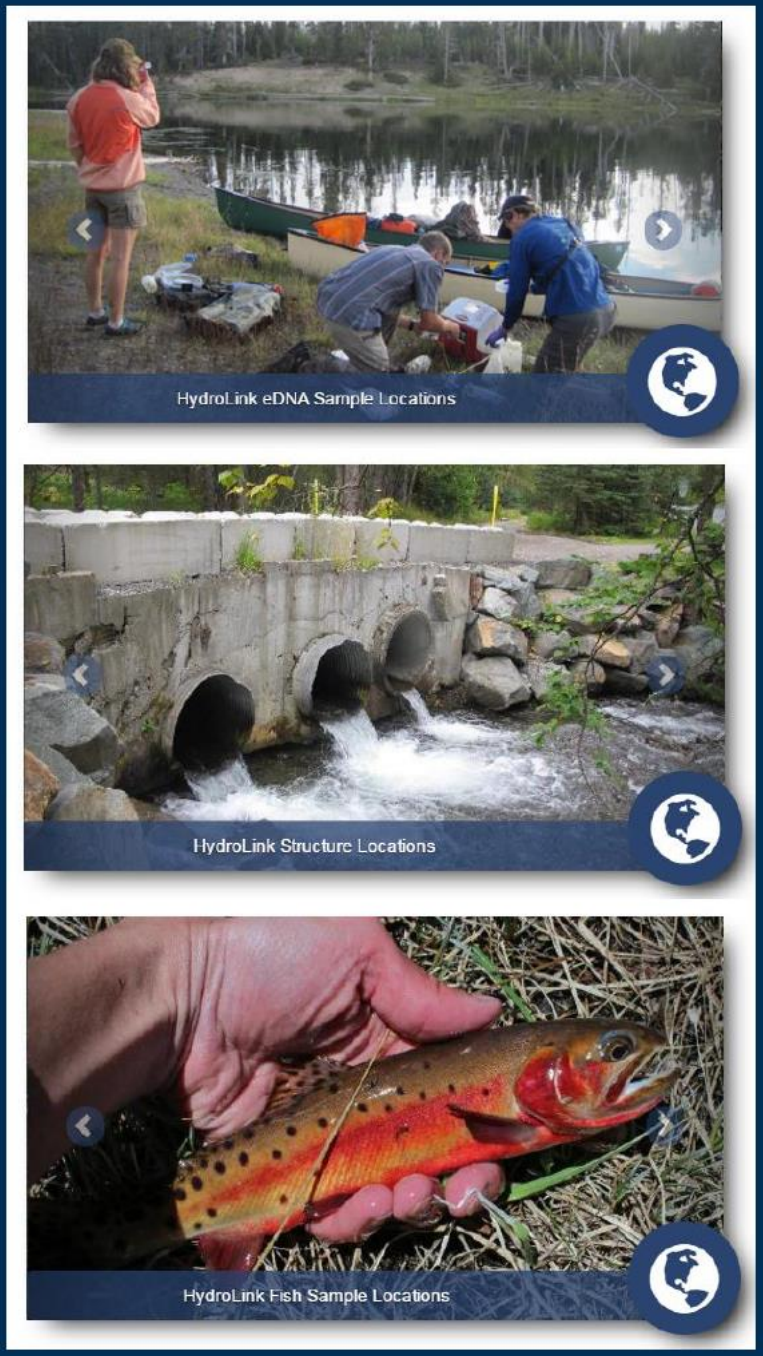
Daniel Wieferich

U.S. Geological Survey

April 24th , 2018

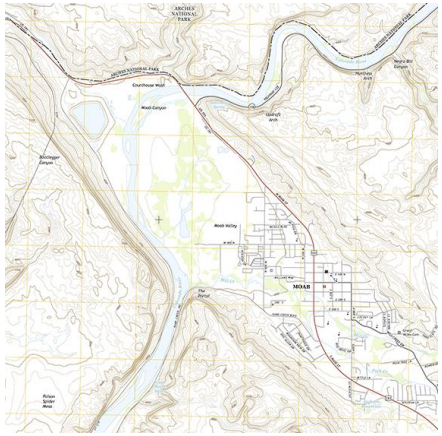
Instream Flow Council 2018

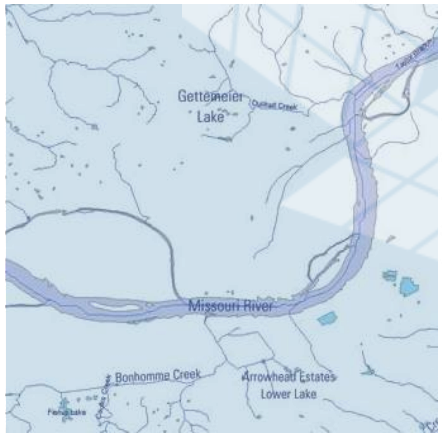
U.S. Department of the Interior
U.S. Geological Survey

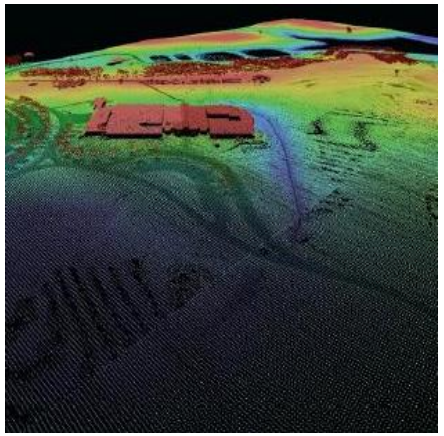


USGS National Hydrography

Products and Services







Thanks to the NHD Team for Slides

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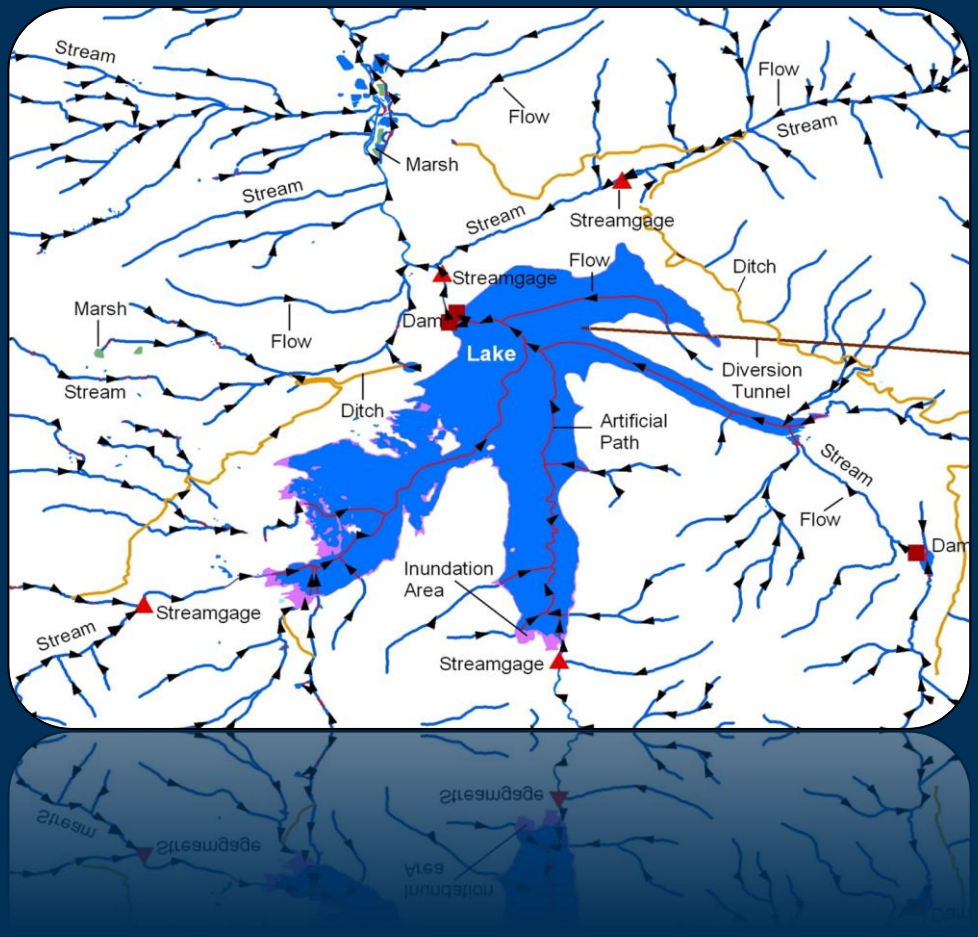
National Hydrography Dataset (NHD)

Water network for mapping and modeling

- The drainage network with features such as rivers, streams, canals, lakes, ponds, and stream gages



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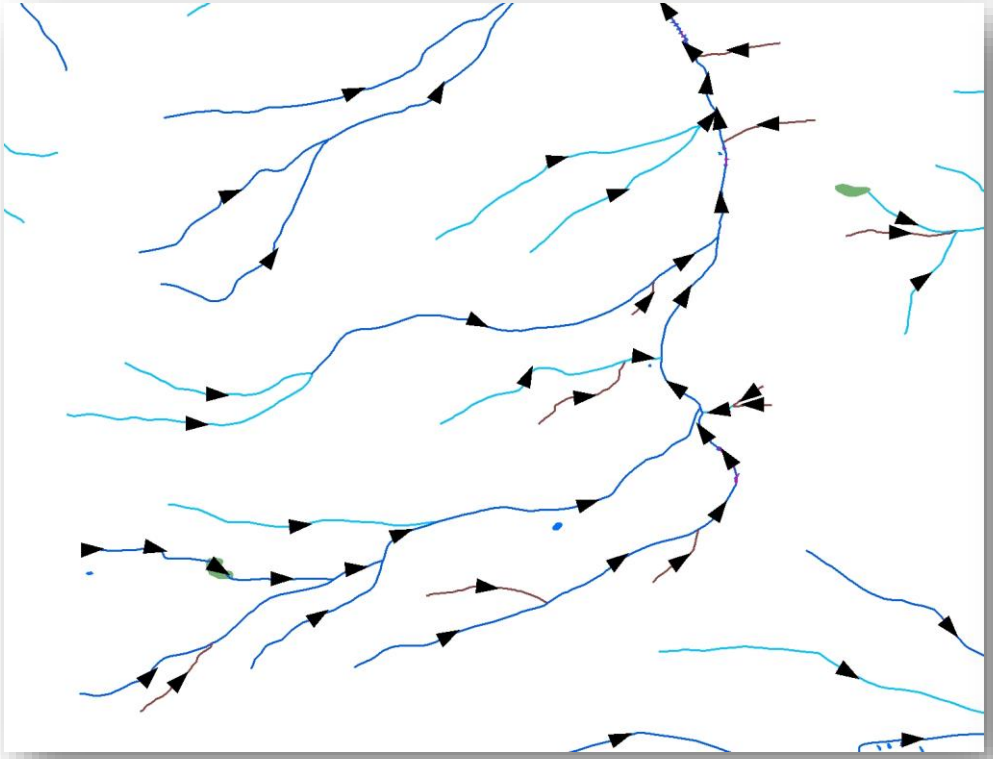
Credit: NHD Team

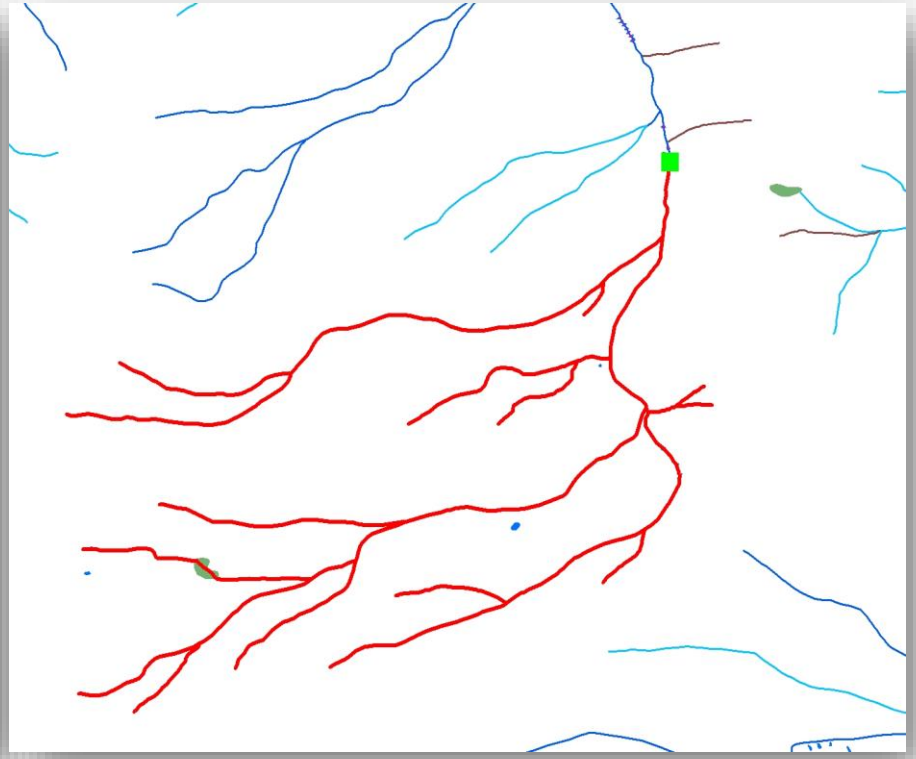
Flow Direction

A key piece of intelligence



Navigation

The basis for analysis



Values to NHD Linkage

- Provides a nationally consistent geospatial framework
- Provides network tools and information

- Creates collaborative opportunities to share information across projects and agencies

USGS, Jeff Duda

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Values to NHD Linkage

- Provides a nationally consistent framework
- Provid
- ss projects and agencies

QUICK INTEGRATION OF INFORMATION!!!

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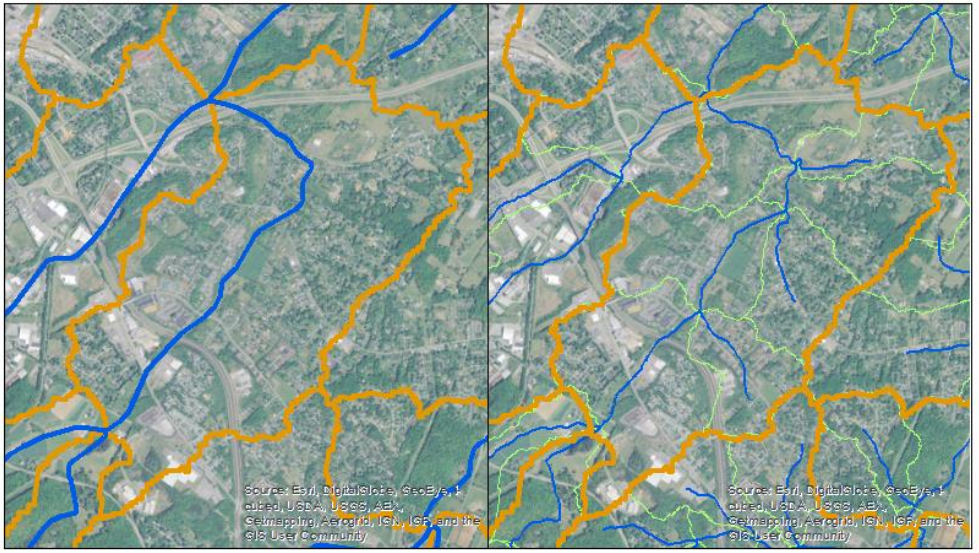
NHDPlus HR Applications

The power of a common hydrography framework

- Enables complex models such as the National Water Model to bring flood forecasting down to the neighborhood level



Comparison of medium (1:100,000, left) and high (1:24,000, right) resolution NHDPlus. Blue lines represent the stream network. Orange lines delineate medium-resolution catchments and green lines are catchments of the streams added at the higher resolution.

- Observational data can be linked to NHDPlus HR to supporting limitless applications such as:
  - Predicting the risk, timing, and magnitude of flood events
  - Estimating when and where an event such as a toxic spill will affect downstream populations and ecosystems
  - Enabling property owners to better understand upstream water availability impacts

Values of NHD Linkage: Flow Modeling Example

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Ariel Bates[1], Jeff Simley[1], Tommy Dewald[2], Tim Bondelid[3]

Natural Stream Flow Estimates for Washington

Using the NHDPlus Unit Runoff Method

Purpose

This map presents the methodology and results of the NHDPlus Unit Runoff Method (UROM) calculations for modeling natural streamflow in Washington. The map does not represent actual streamflow, but rather modeled streamflow based on the UROM model. The intent of the map is to show the characteristics of Washington's drainage network and how the tributary system converges into larger and larger arteries to form the major rivers that drain the state. By reviewing this drainage pattern it is possible to better understand Washington's drainage.

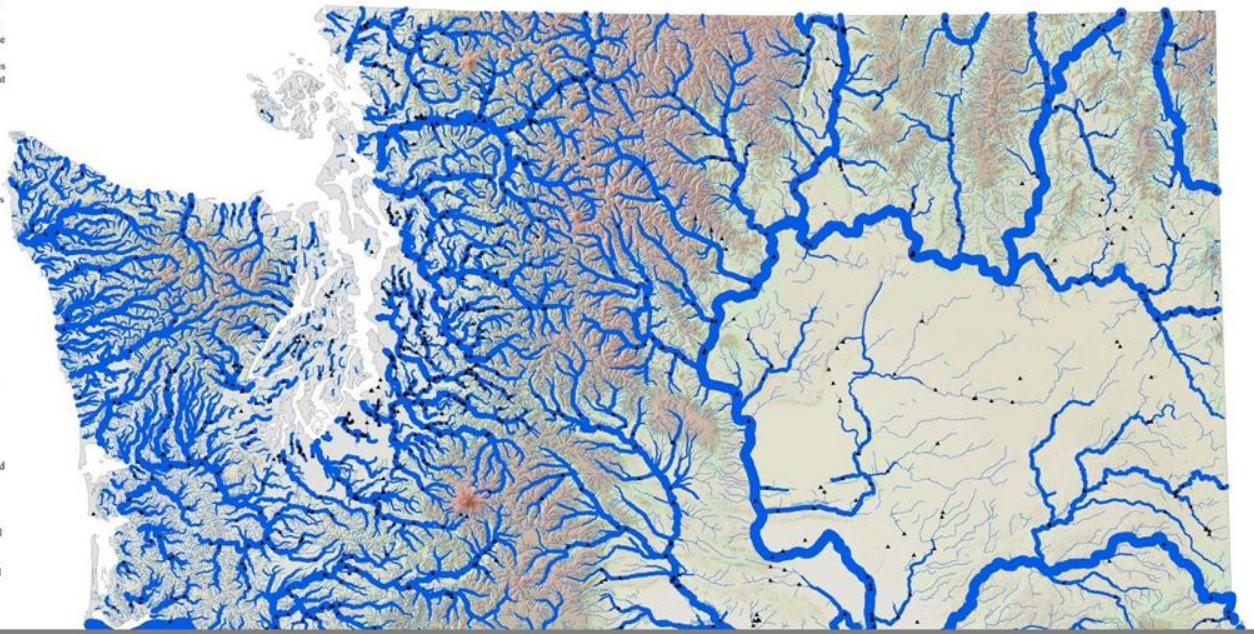
The Map

The stream lines come from NHDPlus, a joint U.S. Environmental Protection Agency (USEPA)-U.S. Geological Survey (USGS) program to develop enhancements to the 1:100,000-scale National Hydrography Dataset. The line weights represent ranges in mean annual streamflow measured in cubic feet per second (cfs). Streams with a UROM streamflow less than 1.0 cfs are not shown. This eliminates approximately half of the 1:100,000-scale streams from being shown and results in good map clarity at the map scale of 1:767,000 (as shown).

NHDPlus

NHDPlus is an integrated suite of application-ready geospatial data sets that incorporates many of the best features of the National Hydrography Dataset (NHD), and National Elevation Dataset (NED). NHDPlus includes a stream network based on the medium resolution NHD, improved networking, name attributes, and "value-added attributes" (VAA's) providing additional flowline characteristics. Flowlines are the basic linear hydrologic features in the NHD, such as streams, rivers, etc. NHDPlus also includes elevation-derived catchments (flowline-based drainage areas) produced using a drainage enforcement technique dubbed "The New-England Method". This technique modifies the National Elevation Dataset (NED) by "burning-in" the 1:100,000-scale NHD, and when available, building "walls" using the national Watershed Boundary Dataset (WBD). The resulting modified Digital Elevation Model (DEM) is used to produce hydrologic derivatives that agree with the NHD and WBD. Over two years an interdisciplinary team from the USGS and USEPA found this method to produce the best quality catchments feasible in a relatively short time frame.

Unit Runoff Method



UROM Calculations

Using streamflow data from the selected gages, mean annual and mean summer unit runoffs ($ft^3/sec/km^2$) were calculated for each subbasin. The nearest HCDN gages were identified using a 200-mile maximum search radius from the centroid of a subbasin. In most subbasins, five gages were selected but some had fewer than five within the 200-mile search radius. Mean annual and mean summer unit runoffs for each subbasin were calculated using a weighted-average technique based on the square of the distance of the selected HCDN gages from the centroid of the subbasin. The computations are defined as follows:

$$Q_{CU_MA} = \Sigma(Q_{HCDN_MA} \times 1/D^2_{CU_HCDN}) / \Sigma(1/D^2_{CU_HCDN})$$

Where

Q_{CU_MA} = estimated mean annual unit discharge for the 8-digit Subbasin of interest,

Q_{HCDN_MA} = mean annual unit discharge for the selected HCDN gage,

$D^2_{CU_HCDN}$ = square of distance from the selected HCDN gage to the centroid of the 8-digit Subbasin of interest.

Flows for each NHDPlus flowline were then calculated as follows:
IncrFlowU is the incremental flow at the bottom of flowline, computed as:

$$IncrFlowU = A * CU_MA$$

Where

A = Drainage Area of the catchment (km^2), and
CU_MA = Unit Runoff for the 8-digit Subbasin (cfs/km^2)

The UROM based mean annual flow for each flowline, (MAFlowU) is computed as:

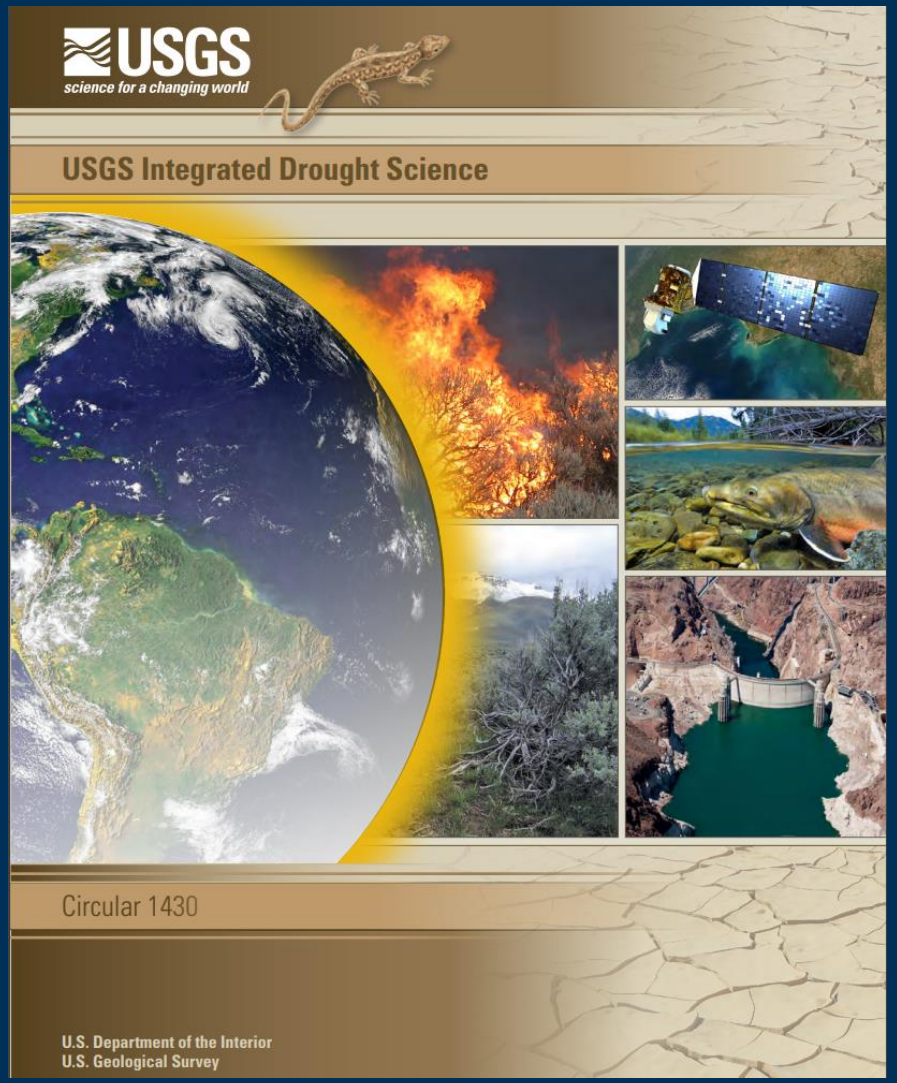
$$MAFlowU = \sum_{i=1 \text{ to } n} (IncrFlowU_i) \text{ for each } i \text{ to } n \text{ upstream flowline.}$$

UROM Tuning Using Intermittent Flow Adjustment Factors

The UROM was developed as part of the National Water Pollution Control Assesment Model (NWPCAM) (Research Triangle Institute, 2001). For hydrologic regions west of the Mississippi, initial UROM estimates of routed discharge generally were observed to be greater than the HCDN gage flow values. Consequently, for the western hydrologic regions, a method was developed to better relate discharge estimates to observed flow data. The discharge estimates were lowered (tuned) by incorporating only a percentage of the reach-specific runoff for intermittent stream reaches. The method calculates discharge estimates assuming various contributions (e.g., 100, 50, 25, 10, and 1 percent) of the

Values of NHD Linkage: USGS Drought Science Plan

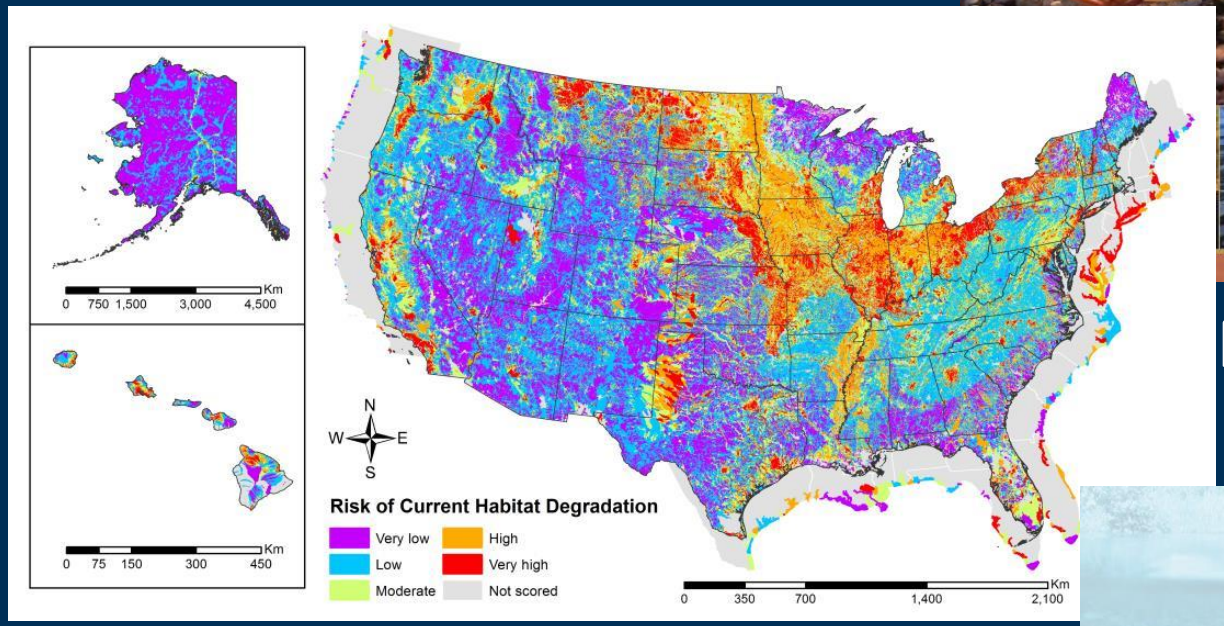
"A common framework is essential for linking information among USGS programs concerning streamflow, groundwater, and water quality; climate and land use; ecosystems; and geospatial mapping."



https://pubs.usgs.gov/circ/1430/cir1430.pdf

Wang, L., D. M. Infante, P. C. Esselman, A. Cooper, D. Wu, W. W. Taylor, D. Beard, G. Whelan, and A. Ostroff. 2011. A hierarchical spatial framework and database for the National river fish habitat condition assessment. Fisheries 36:436-449

NATIONAL FISH HABITAT PARTNERSHIP



National Assessment of Fish Habitats

Dana Infante, Dept of Fisheries & Wildlife, Michigan State University
Kristan Blackhart, NOAA Fisheries, Office of Science and Technology

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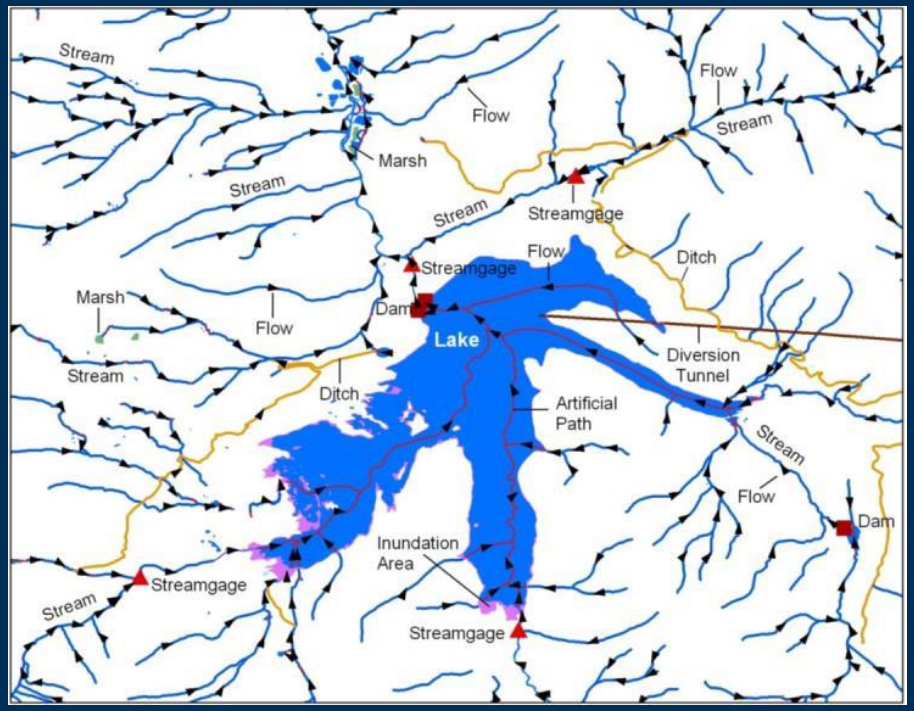
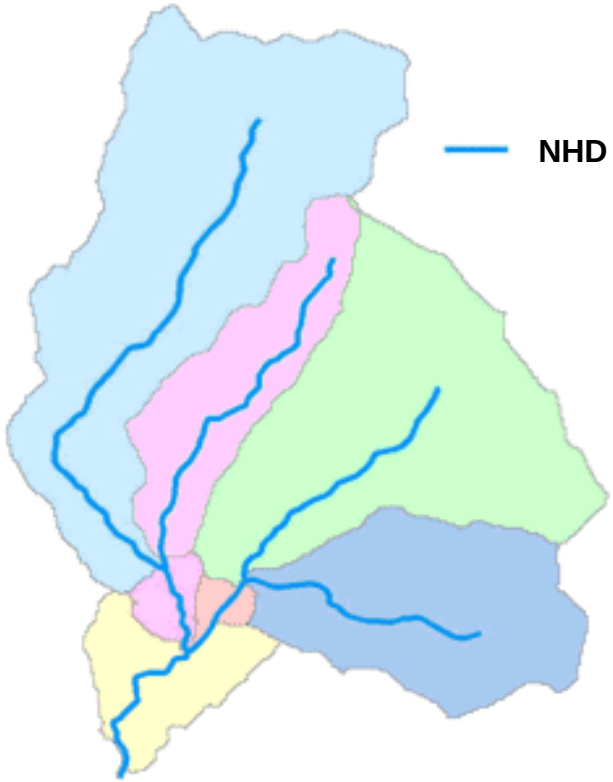
National Hydrography Datasets

NHD High Resolution
>= 1:24,000 scale
NHD HighRes
NHD HR



NHDPlus MR
1:100,000 scale
Medium Resolution



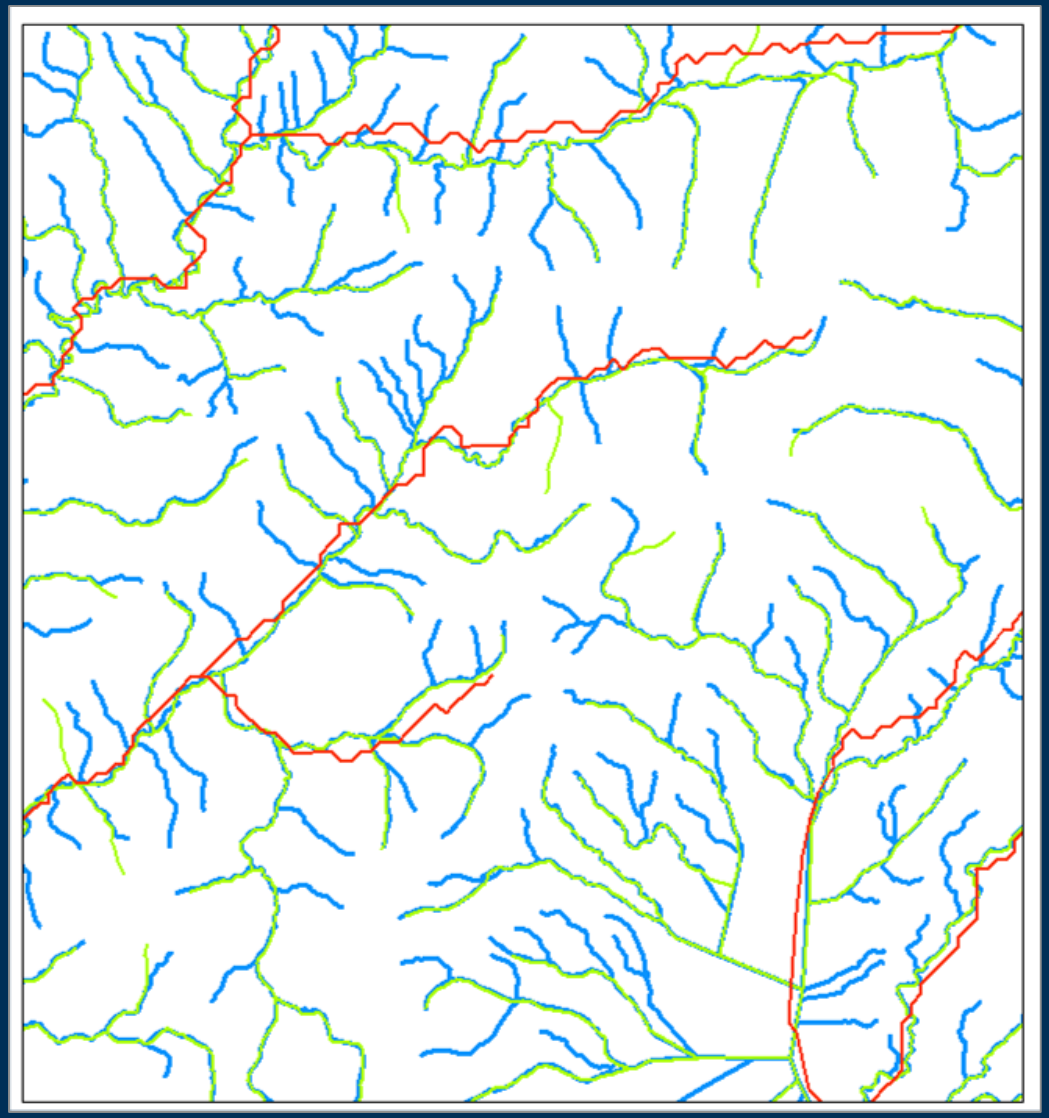
Catchments for each unique NHDPlus stream segment (flowline) shown.

Scale Comparison

RF1 (1:500,000)

NHDPlus MR (1:100,000)

NHD HR (>= 1:24,000)



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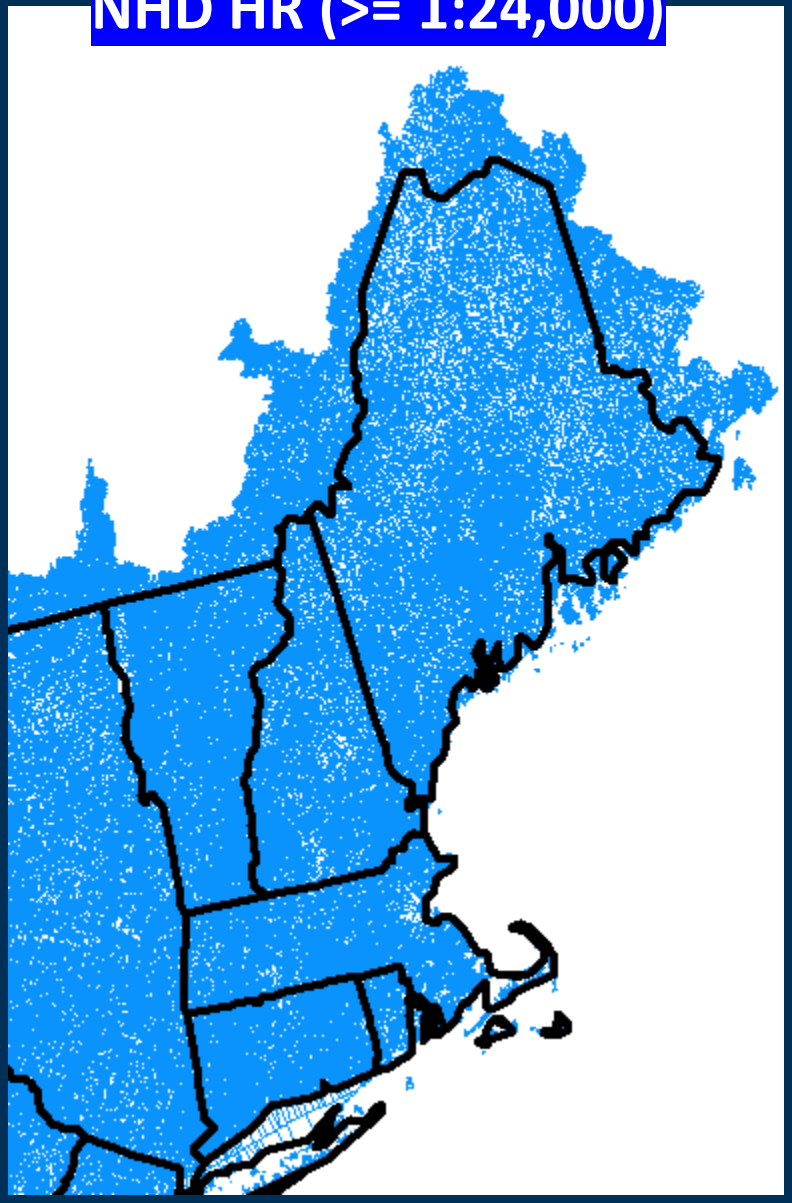
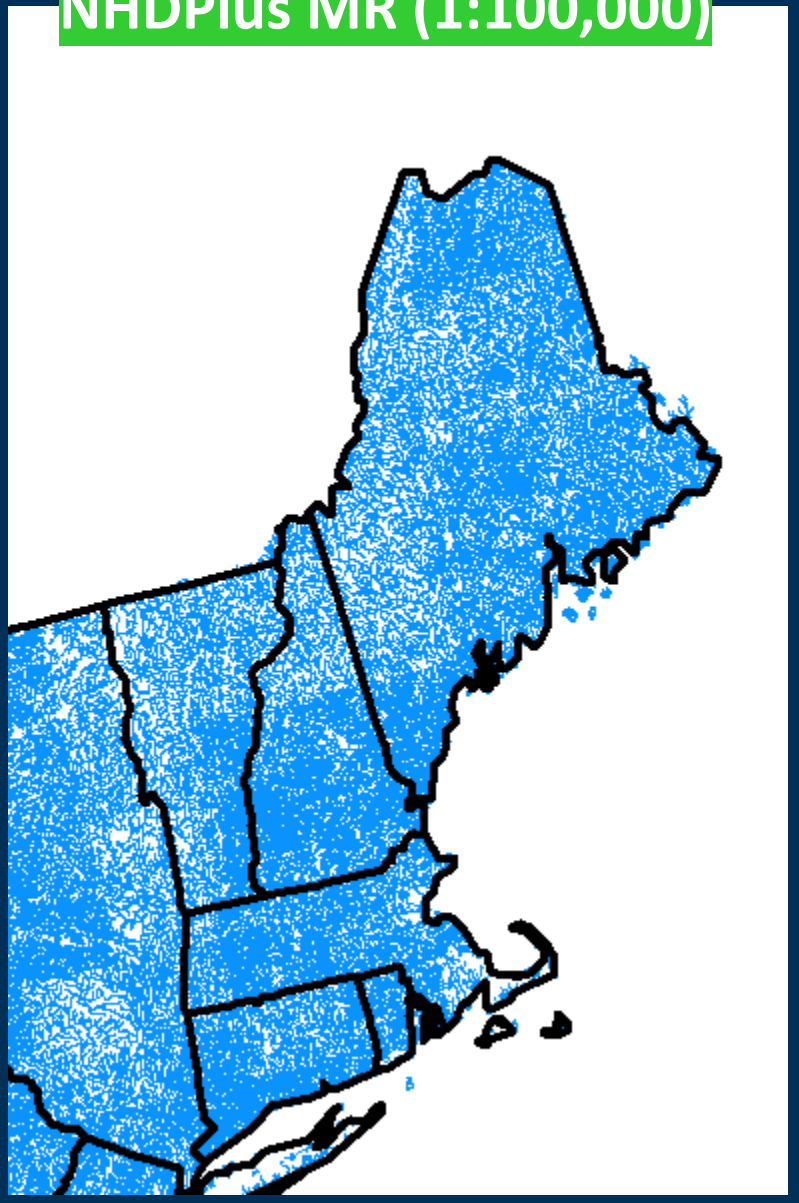
Scale Comparison

NHD HR (>= 1:24,000)



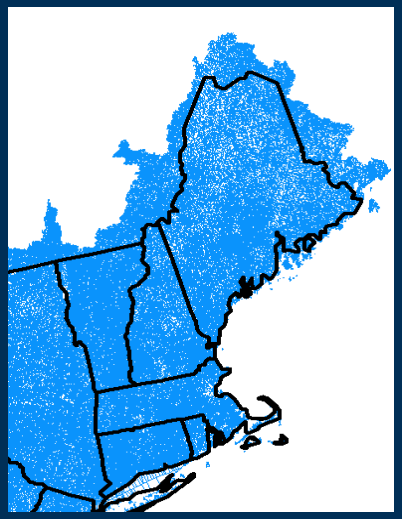
NHDPlus MR (1:100,000)



Comparison of Current NHD Versions

NHD High Resolution

- 1:24,000 scale or better, except Alaska 1:63,360 scale)
- Regional or local studies/models
- Catchments in Development
- 26 million flowlines for U.S., including Alaska, Hawaii and Territories
- Maintained



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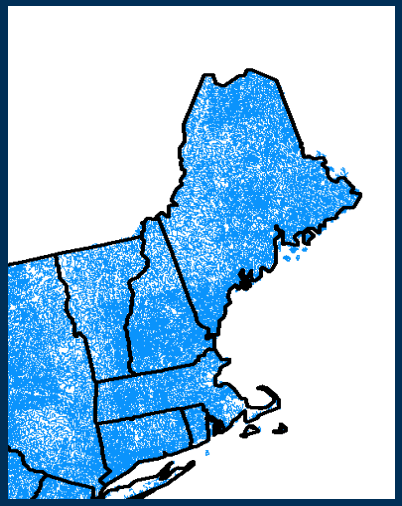
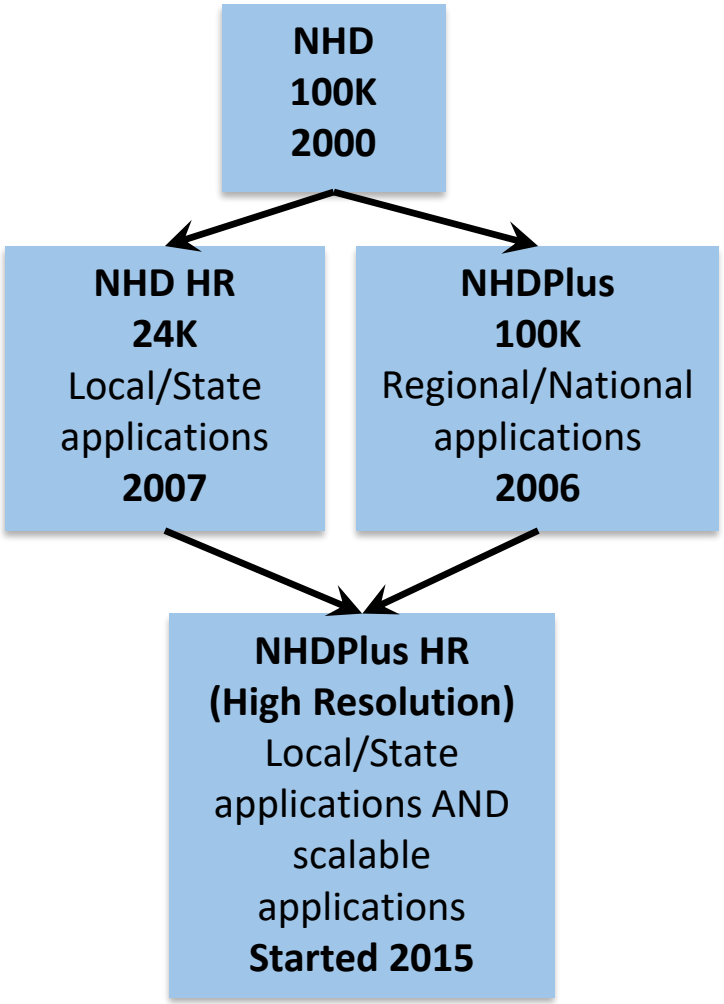
NHD Medium Resolution

- 1:100,000 scale
- Basis of NHDPlus V1 & V2
- Regional and national studies/models
- ~2.7 million flowlines for Conterminous U.S.
- Not available in Alaska
- Local Catchments
- Value Added Attributes
- Static



Evolution of NHDPlus HR

Taking NHDPlus v2 (Med Res) to a new level



- The best of NHDPlus and NHD HR (24K or better) data
- Addresses the need for a single hydrographic frame of reference
- Link data to one network and generalize to many different scales

USGS National Hydrography Datasets

Hydrologic networks, units, catchments, and more…

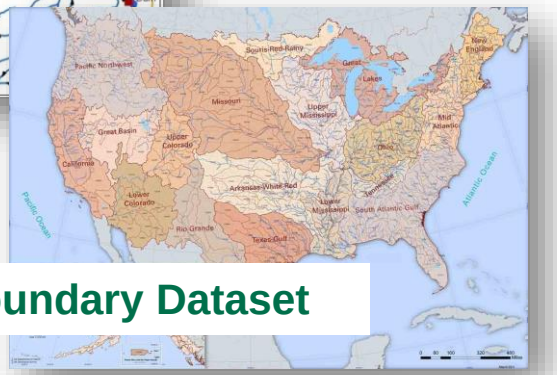
National Hydrography Dataset (NHD)

- The drainage network with features such as rivers, streams, canals, lakes, ponds, and stream gages

National Hydrography Dataset

Watershed Boundary Dataset (WBD)

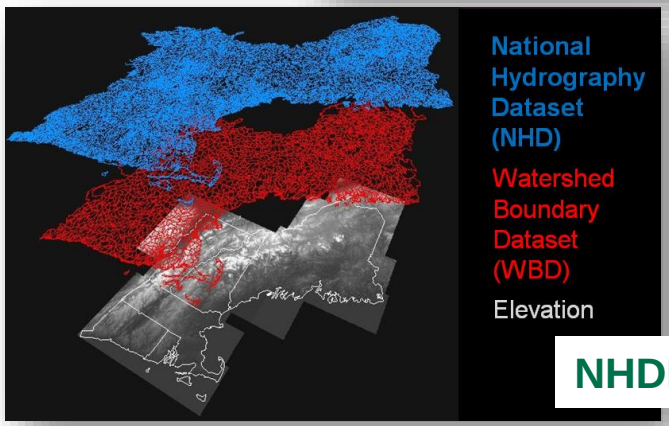
- The drainage basins at 8 scales of a nested hierarchy; defines the areal extent of surface water drainage to a point



Watershed Boundary Dataset

NHDPlus

- Incorporates features of the NHD, WBD and 3DEP elevation data to create a networked hydrography framework that incorporates the entire landscape



NHDPlus

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NHDPlus Data Comparison

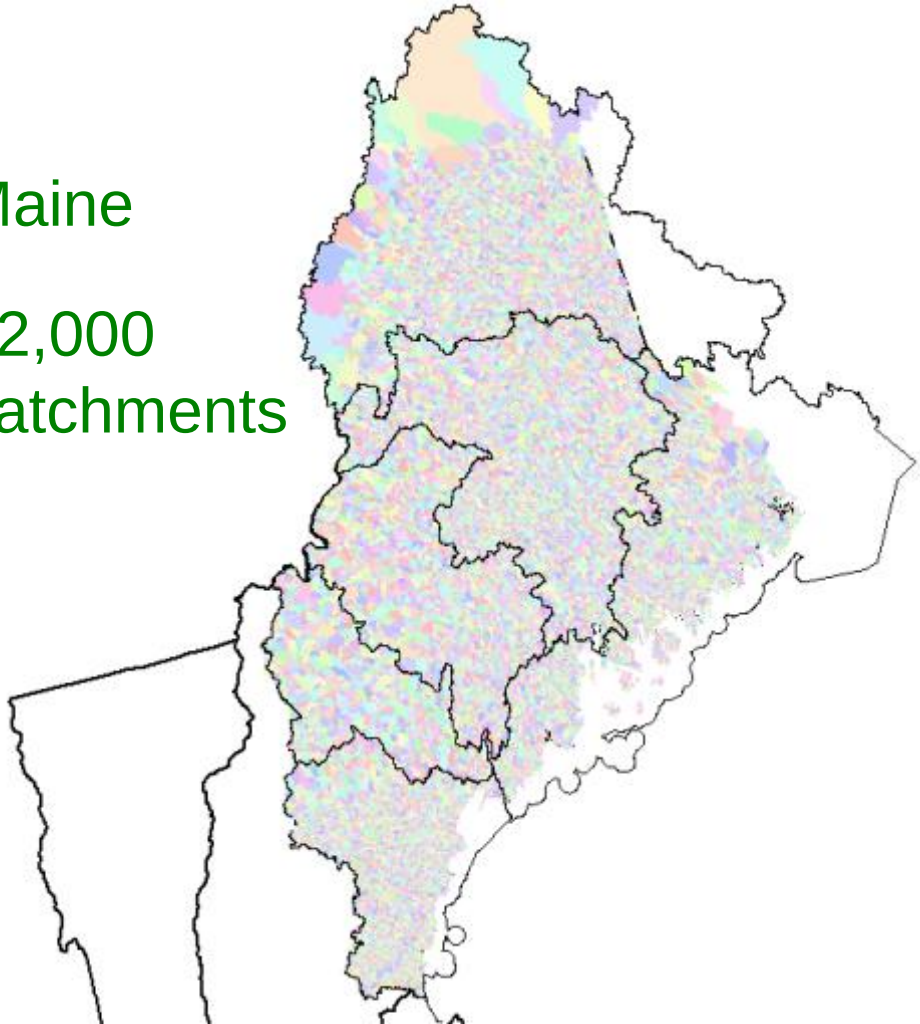
Medium Resolution versus High Resolution

	NHDPlus Medium Resolution (V2)	NHDPlus High Resolution
Number of catchments	~2.7 Million nationally	~26 Million nationally
Elevation Input	National 1 Arc-Second Seamless DEM (30 meters)	National 1/3 Arc-Second Seamless DEM from 3DEP (10 meters)
NHD Input	Medium Resolution NHD 1:100K	High Resolution NHD 1:24K or better
WBD Input	Composite 2010-2012	Updated WBD
Catchment size	Avg. 1.2 square miles	Avg. ~0.2 square miles
Flow estimates	Mean annual, mean monthly	Mean annual

NHDPlus V21 “Medium Resolution” 1:100,000 scale

Maine

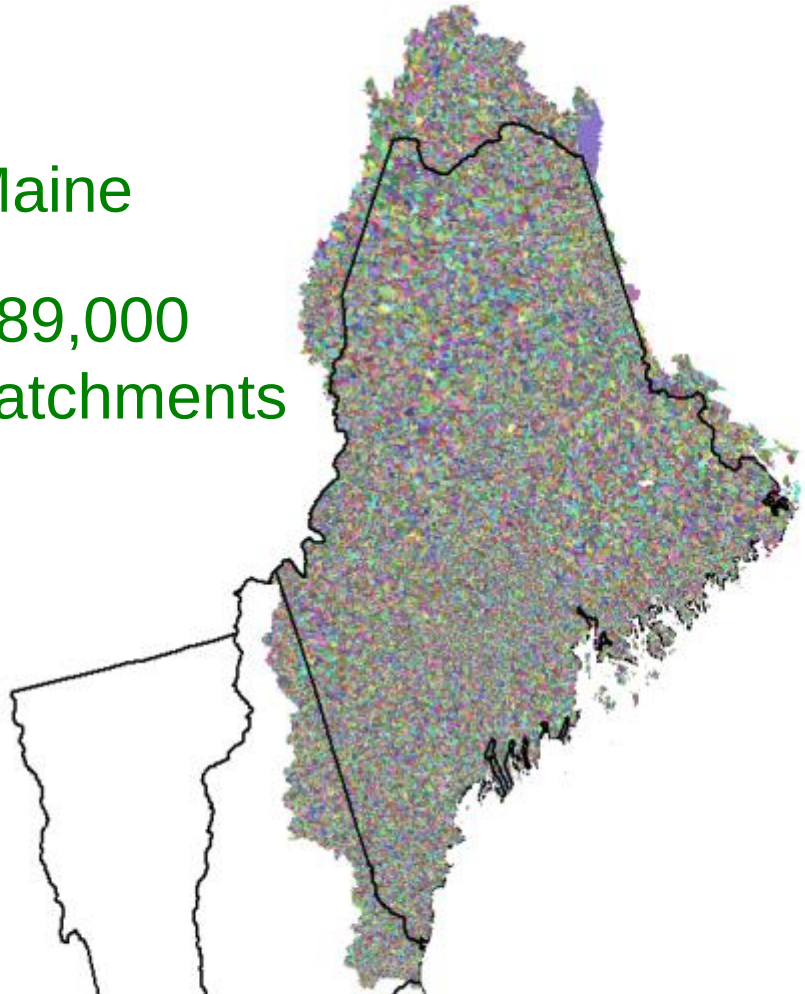
32,000 catchments



NHDPlus HR “Full Resolution” 1:24,000 + scale

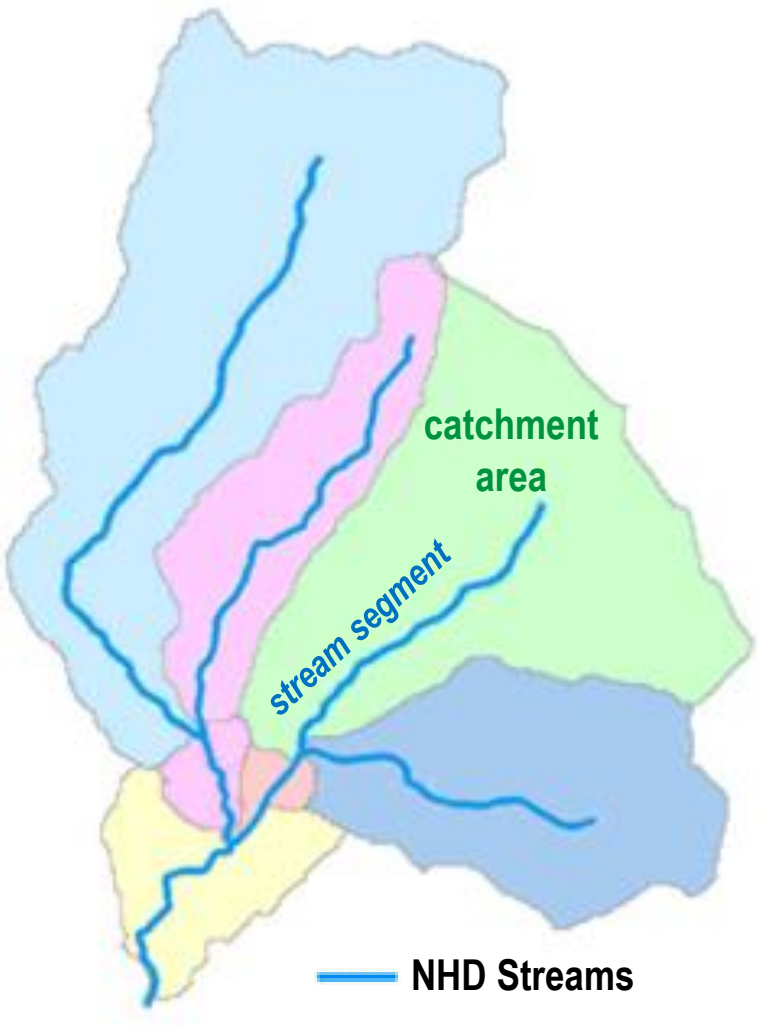
Maine

189,000 catchments



NHDPlus includes…

- A nationally seamless network of stream reaches
- Value-added attributes for stream network navigation and analysis
- Flow surfaces in raster format
- Elevation-based catchment areas for each stream segment that
  - Create a seamless, scalable hydrologic framework
  - Enable modeling of water flow across the landscape, linking terrestrial characteristics to the stream network



NHDPlus High Resolution

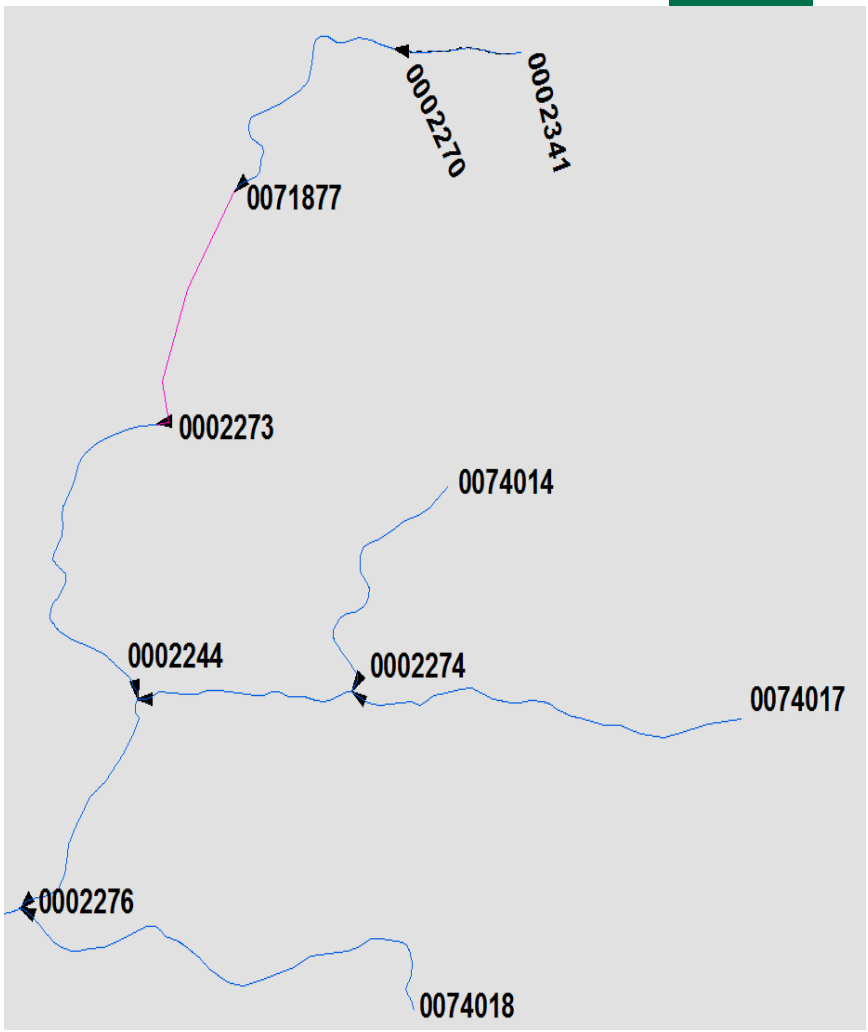
NHD Plus HR

- The Hydrography Requirements and Benefits Study: ~ 80% of users need the functionality of NHDPlus but ***at a higher resolution***
- USGS is building NHDPlus HR from the highest available resolution NHD and WBD data, and 10m 3DEP data
- The results are more accurate and better maintained than the current, medium resolution NHDPlus
- NHDPlus HR will have multi-scale representation capabilities with the new VisibilityFilter attribute

NHDPlus Value Added Attributes (VAAs)

From node/To node

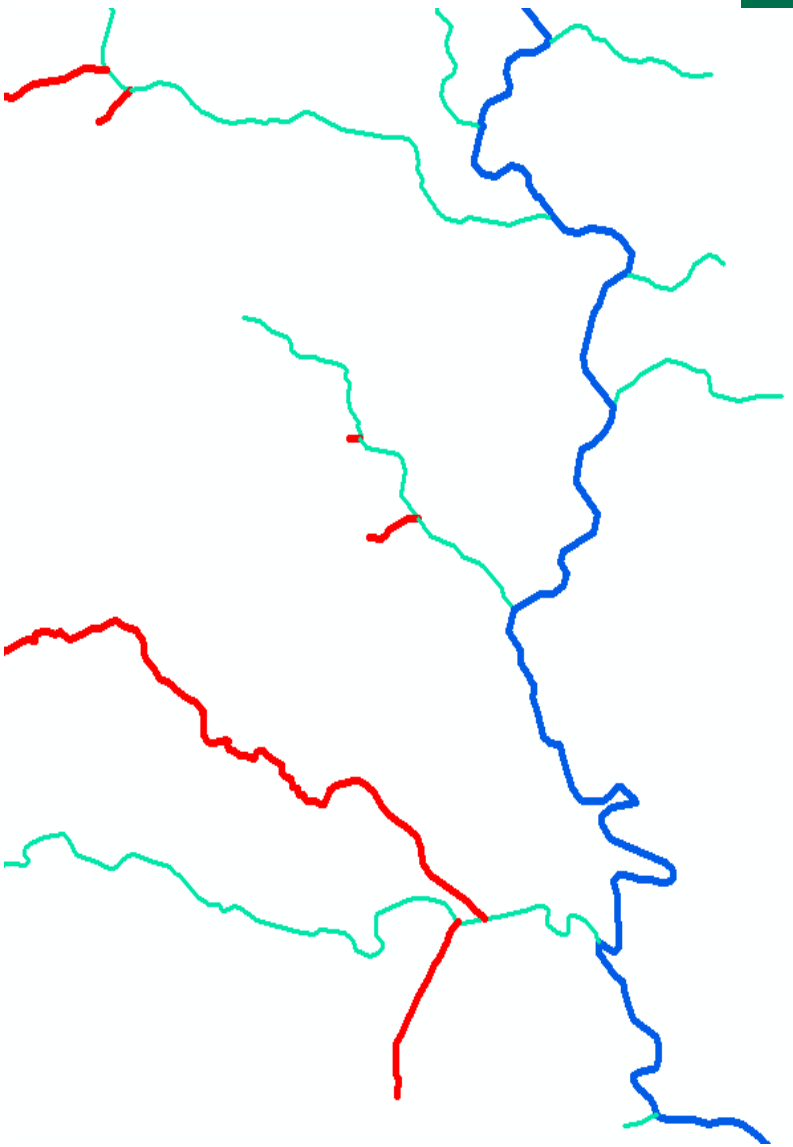
- A set of nationally unique identifiers for the node endpoints of the flowlines
- This supports the many models that use linked node navigation



NHDPlus Value Added Attributes (VAAs)

StreamLevel

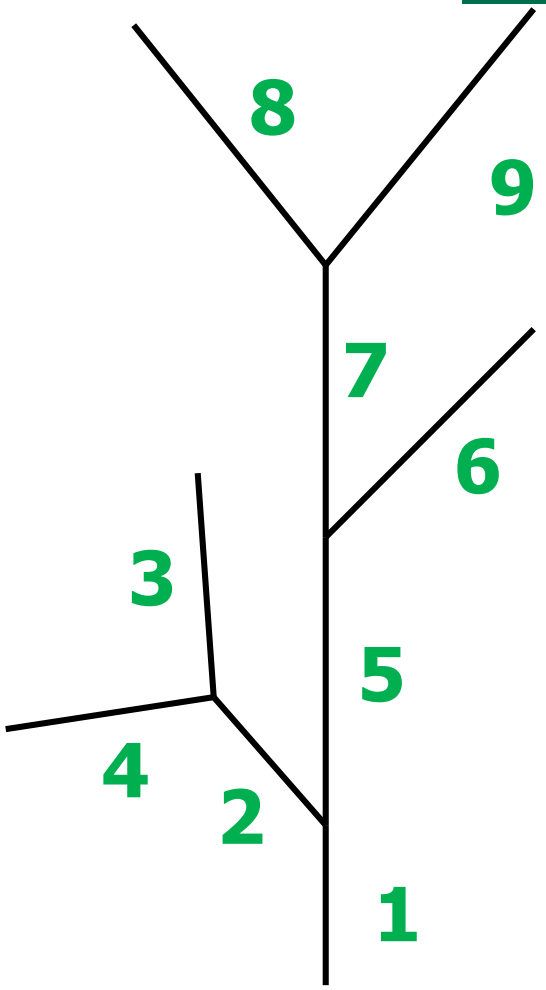
- Provides the information necessary to determine the main path upstream at each confluence
  - **Blue** = StreamLevel 1
  - **Green** = StreamLevel 2
  - **Red** = StreamLevel 3
- This supports upstream navigation of a river mainstem



NHDPlus Value Added Attributes (VAAs)

Hydrologic Sequence Number (HydroSeq)

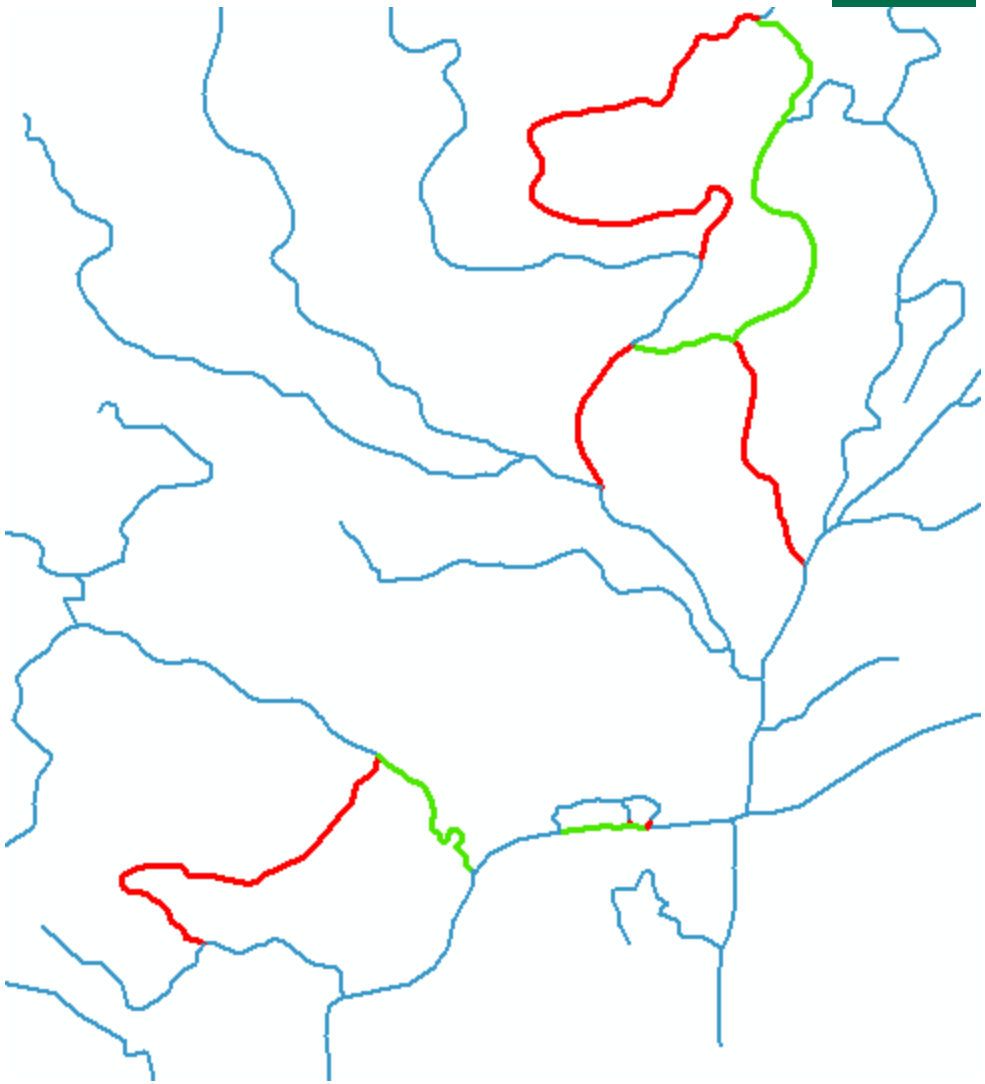
- A nationally unique sequence number that places NHD flowline features in hydrologic sequence
  - Ascending = downstream to up
  - Descending = upstream to down
- Enables models to process the network in a tabular manner without using geometry flowlines



NHDPlus Value Added Attributes (VAAs)

Divergence

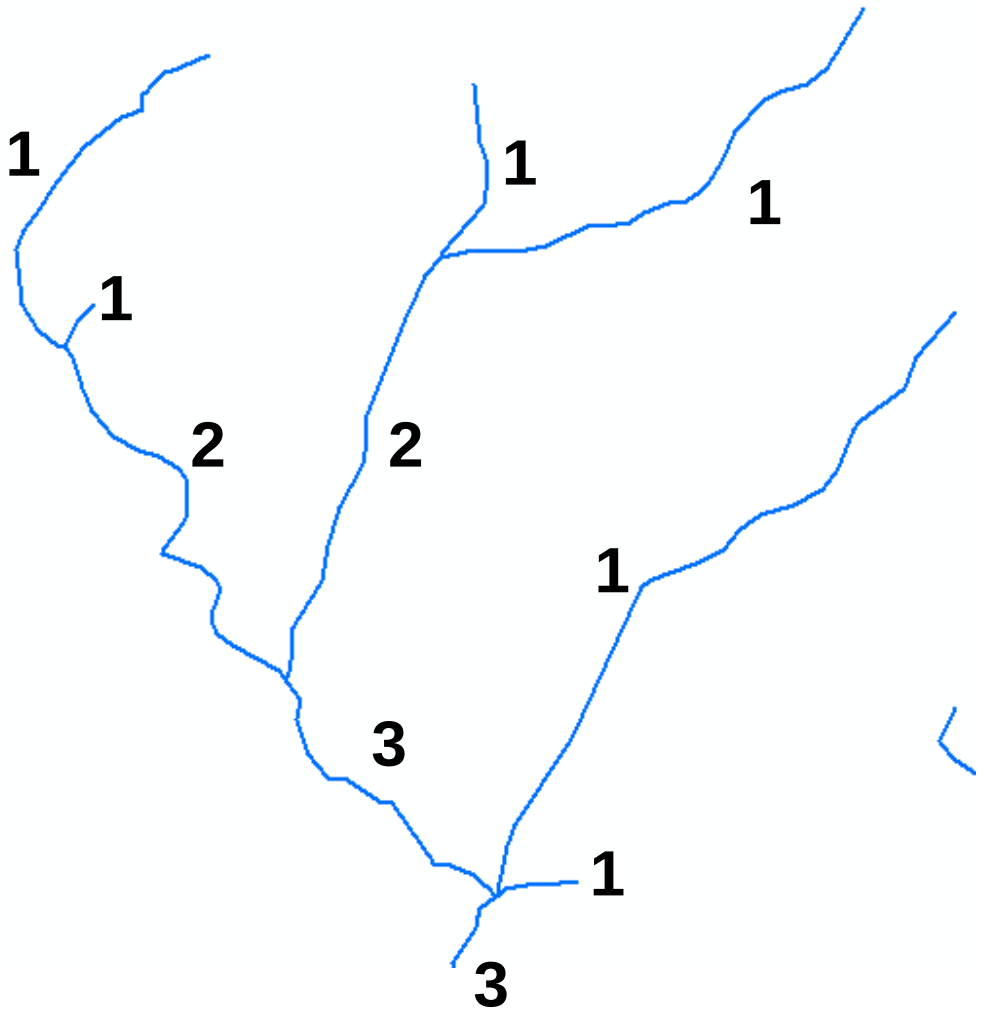
- A flag which defines the major and minor branches of a flow split (divergence)
- This supports downstream navigation of the network mainstem



NHDPlus Value Added Attributes (VAAs)

Strahler Stream Order

- A surrogate for stream size
- A popular analysis attribute.



NHDPlus Value Added Attributes (VAAs)

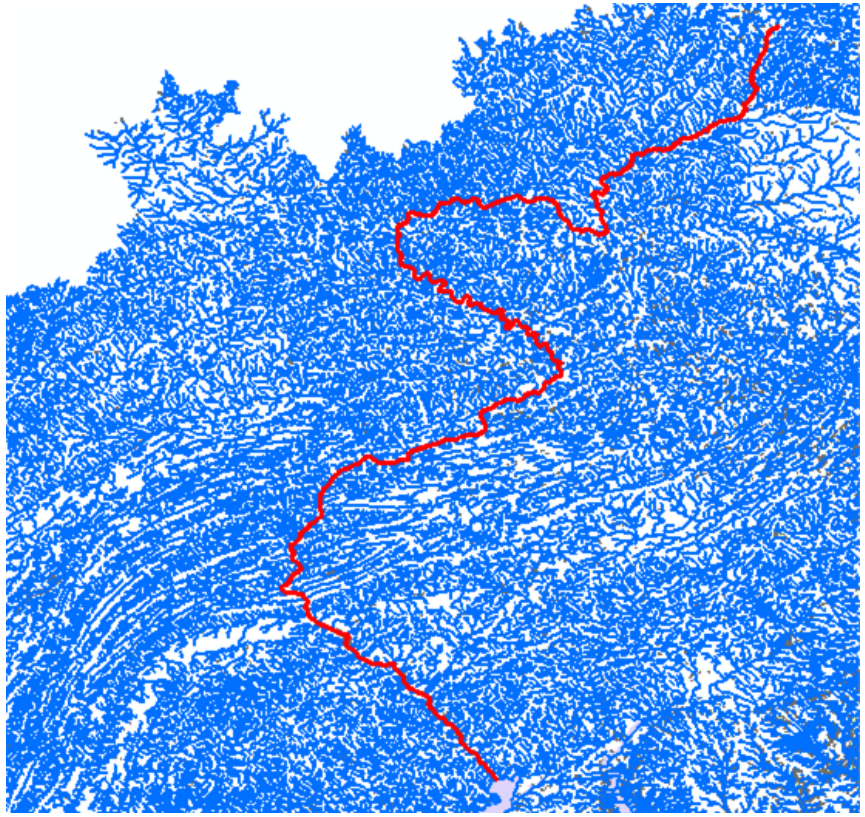
PathLength

- The distance downstream to the network terminus

NHDPlus Value Added Attributes (VAAs)

Level Path Identifier

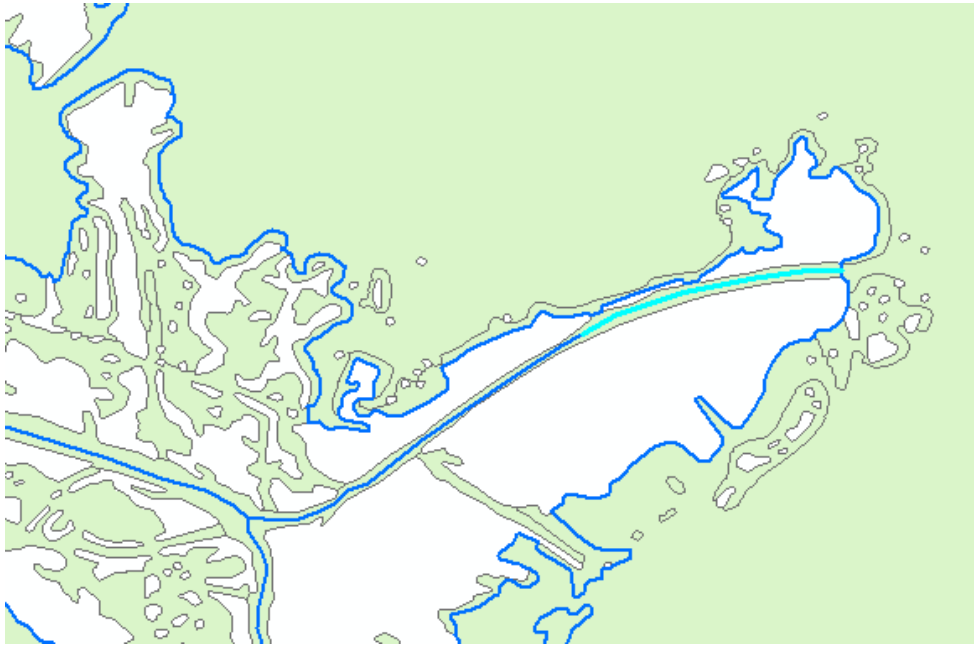
- The identifier (HydroSeq) for all the flowlines on a level path from mouth to headwaters
- River Main Stem



NHDPlus Value Added Attributes (VAAs)

Terminal Identifier

- The identifier (HydroSeq) for the terminal flowline in this network



NHDPlus Value Added Attributes (VAAs)

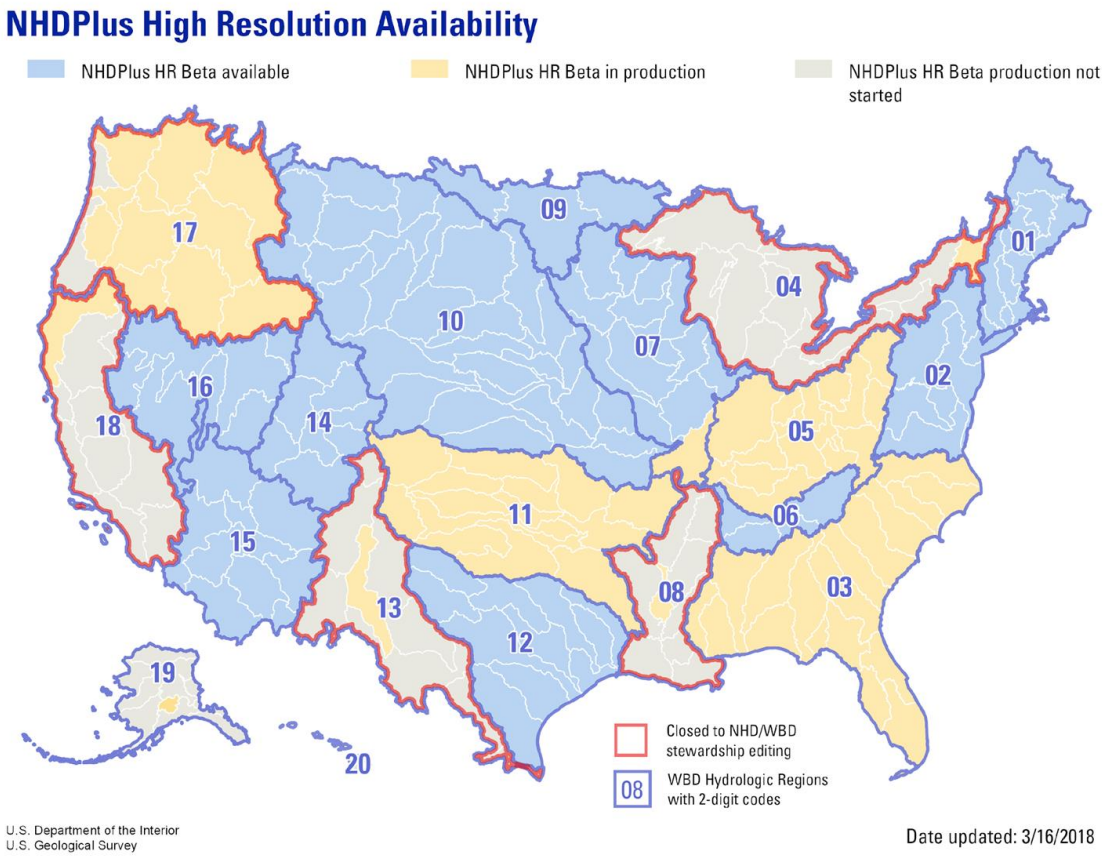
Total Upstream Drainage Network

- A simple select to identify the upstream drainage network

NHDPlus HR Status

First datasets released in April, 2017

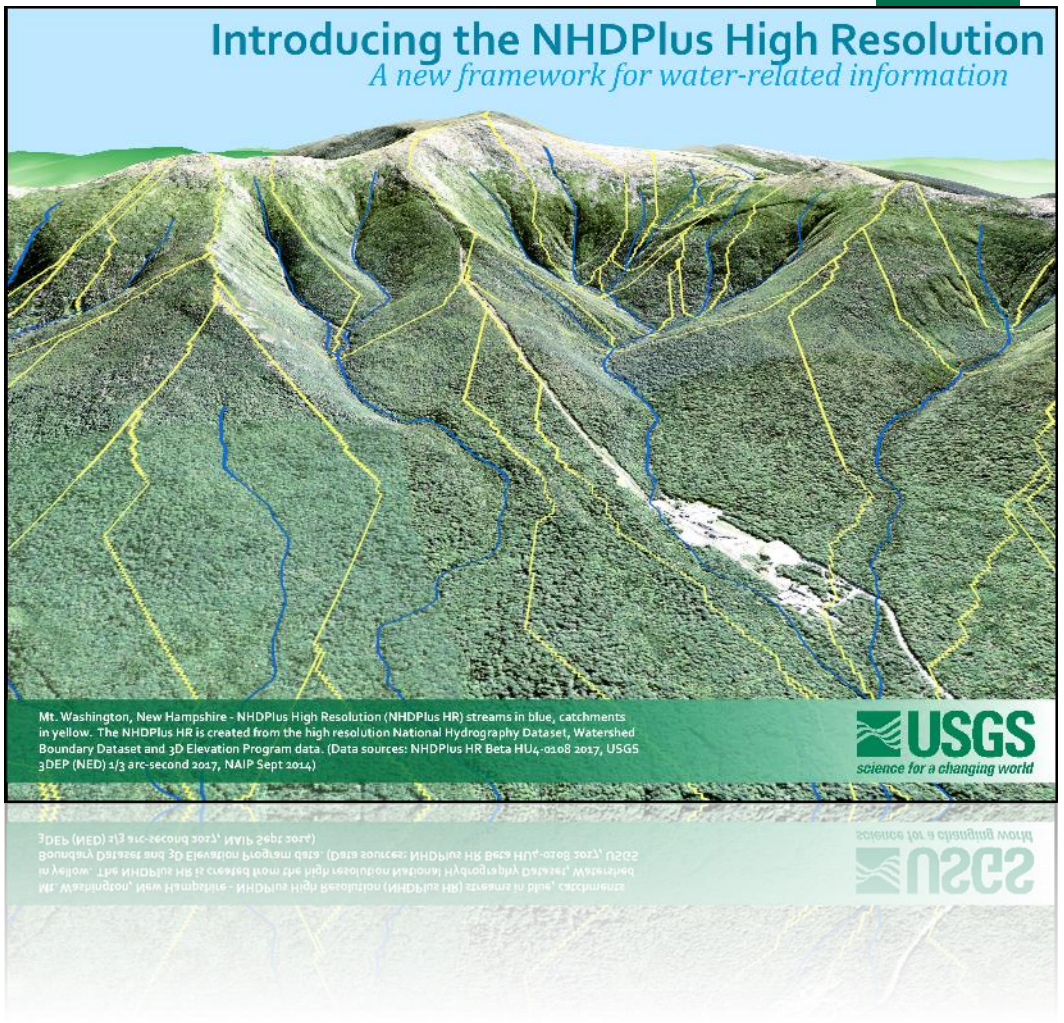
- NHDPlus HR Beta will be completed in 2019 for the conterminous U.S., followed by AK, HI, and territories in later years
- Users are invited to review and provide feedback to the Beta version datasets
- Feedback will be used to update and improve the refreshed data release, beginning in 2018



NHDPlus HR Beta QC

Quality Control Volunteers needed

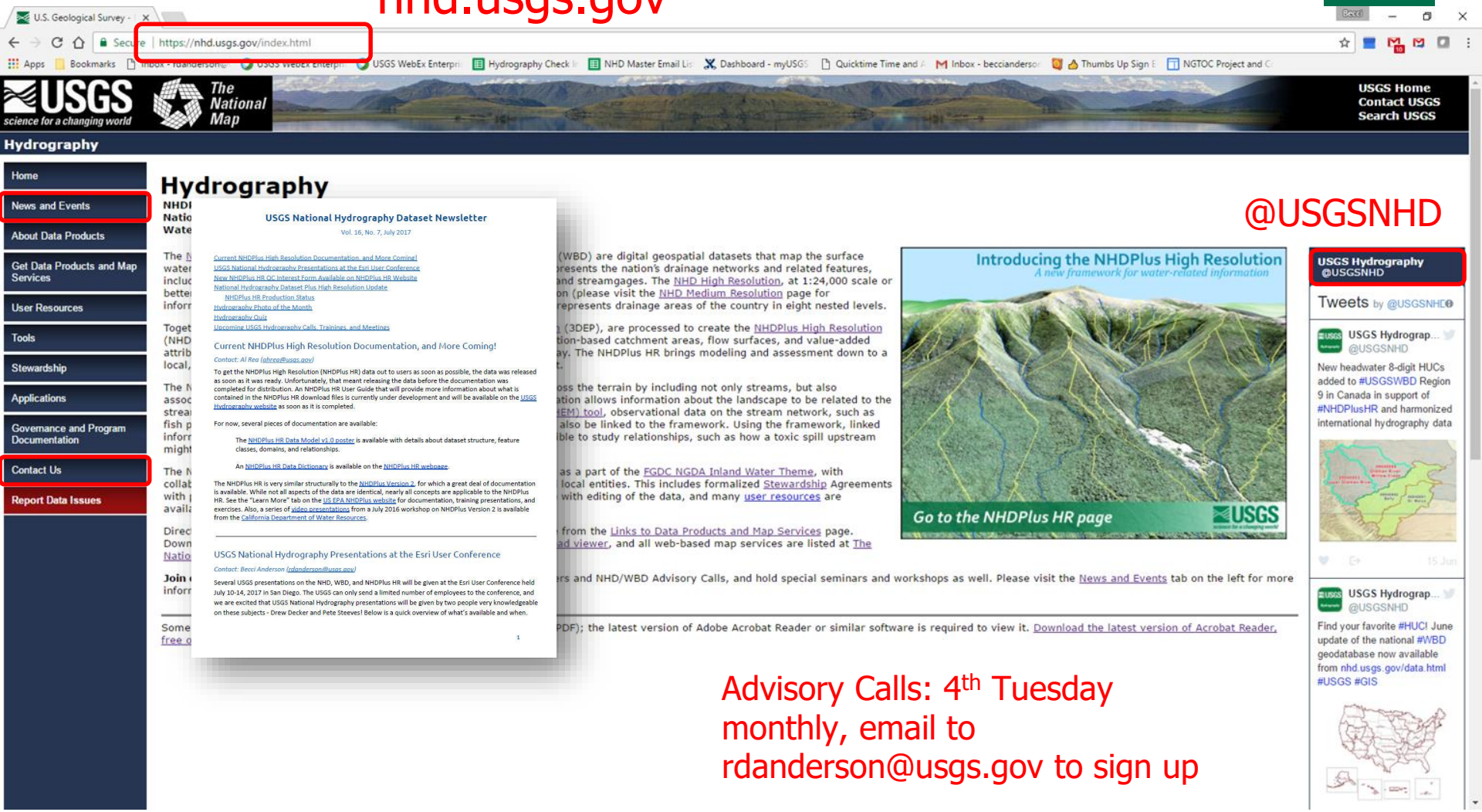
- We are seeking local experts to participate in Beta QC review
- Beta QC improves *not only* the NHDPlus HR, *but also* the NHD/WBD
- Please spread the word!
- For information about NHDPlus HR Beta QC and how to volunteer, see nhd.usgs.gov/NHDPlus_HR.html



USGS science for a changing world
The National Map Your Source for Topographic Information

How to Join the Community!

nhd.usgs.gov



@USGSNHD

Advisory Calls: 4th Tuesday monthly, email to rdanderson@usgs.gov to sign up

Email: rdanderson@usgs.gov

Markup Application

More user contributions = better product for everyone

USGS

Access the Data: NHDPlusV2 Medium Resolution

Download:

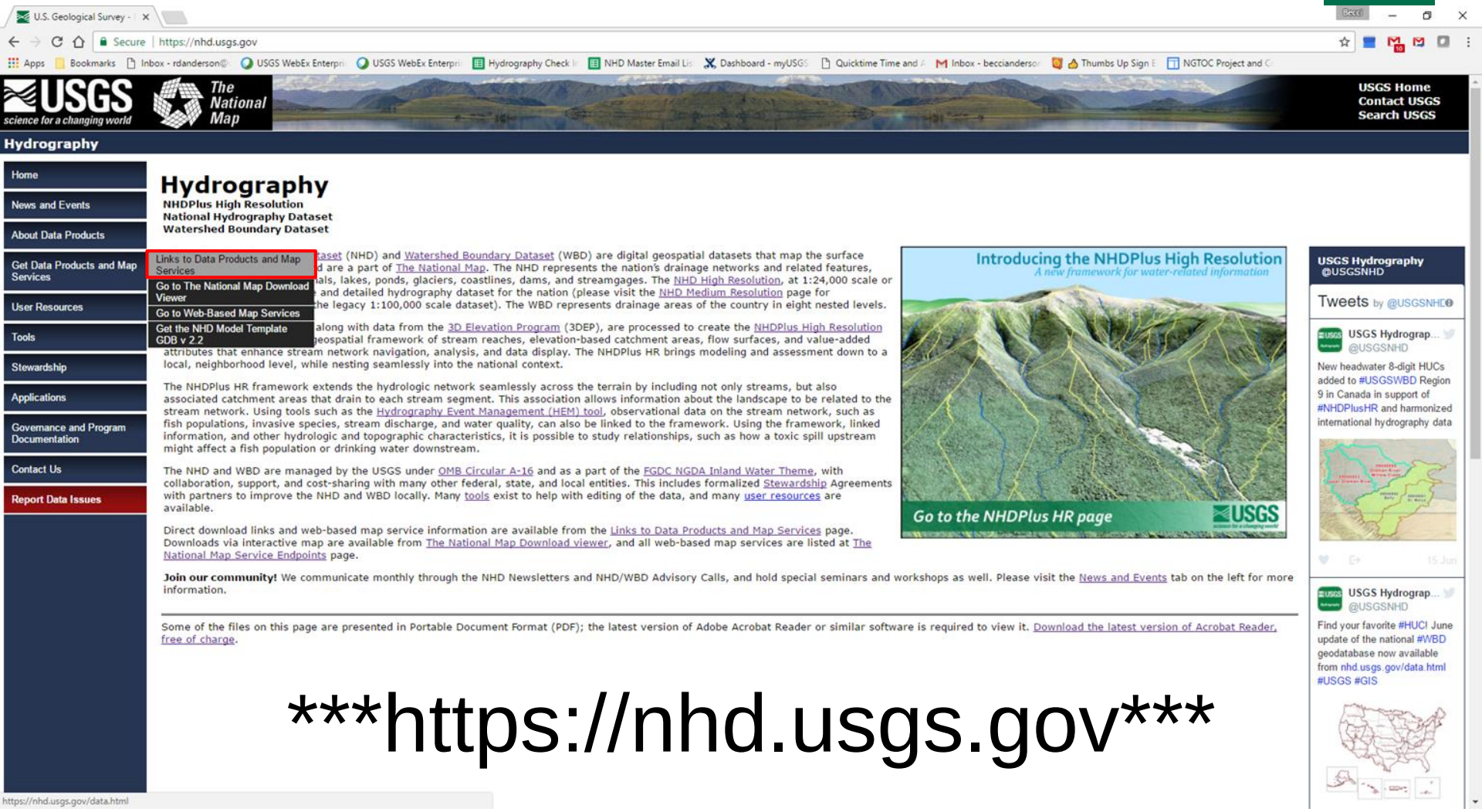
http://www.horizon-systems.com/NHDPlus/NHDPlusV2_data.php

Web services:

https://www.epa.gov/waterdata/waters-tools

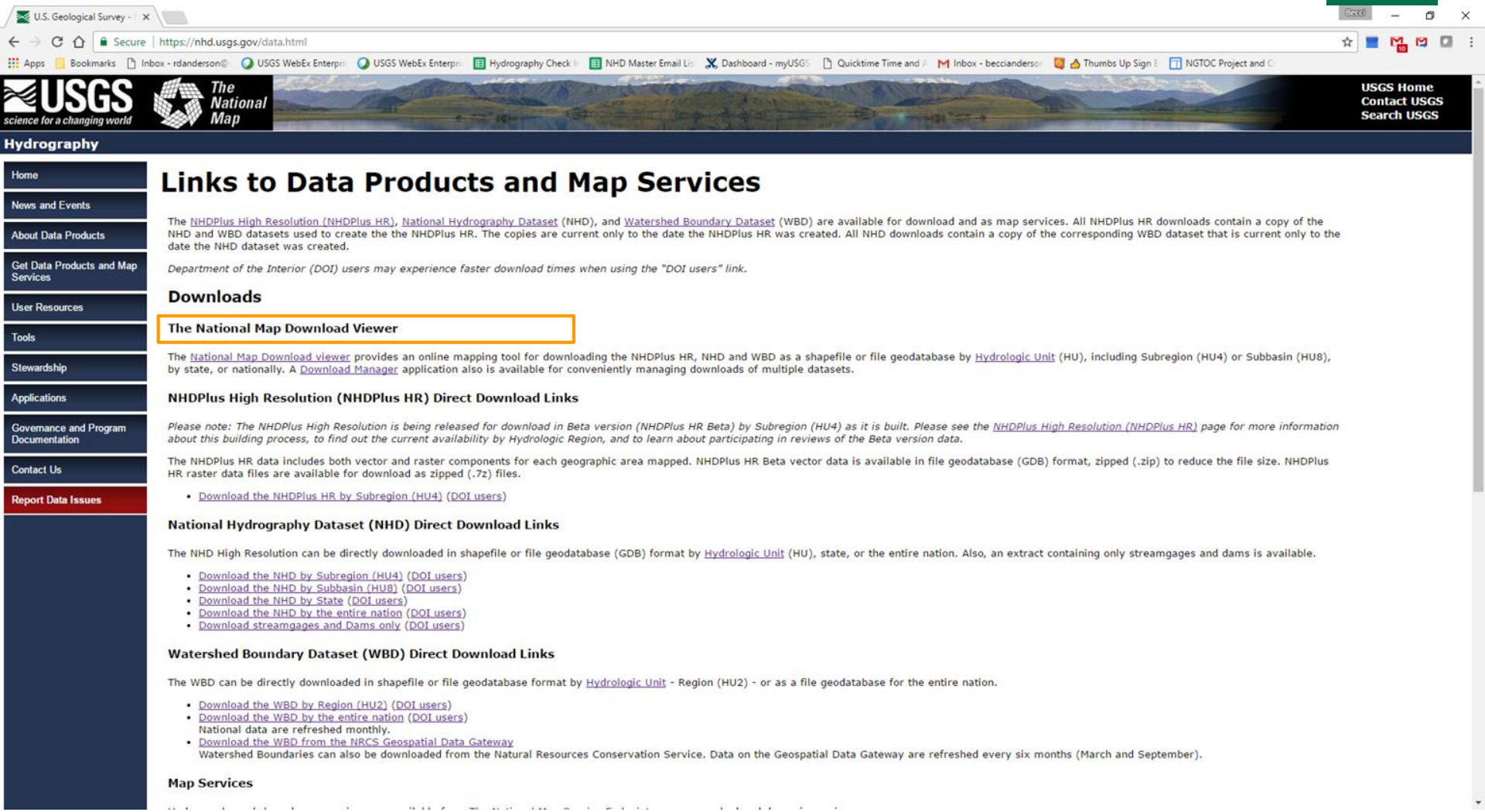
USGS

Access the Data: NHD High Resolution
Links to Data Products and Map Services

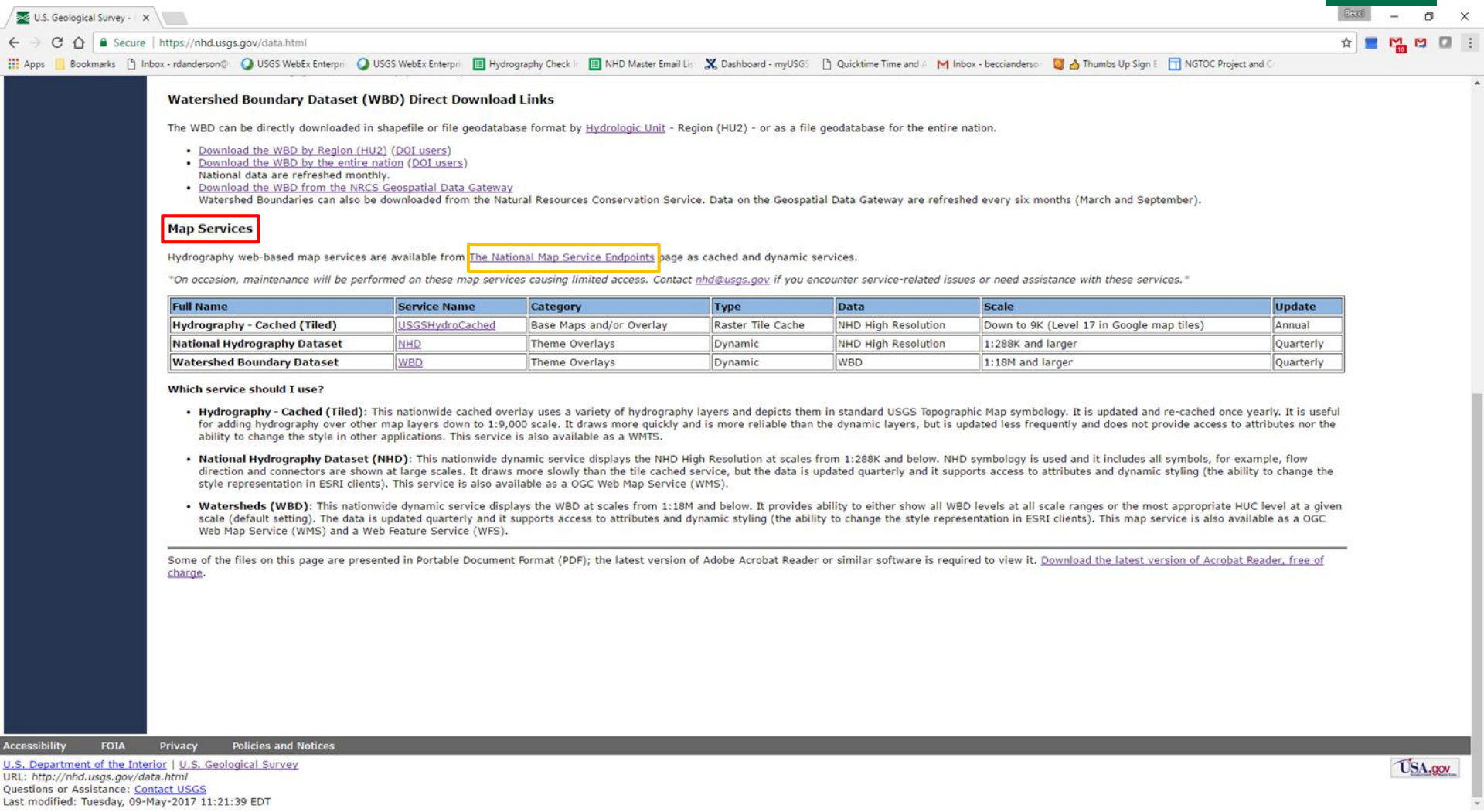


https://nhd.usgs.gov

Access the Data: NHD High Resolution The National Map Download Viewer



Access the Data: NHD High Resolution Web-Based Map Services



U.S. Geological Survey

Secure | https://nhd.usgs.gov/data.html

Apps Bookmarks Inbox - rdanderson@ USGS WebEx Enterpri USGS WebEx Enterpri Hydrography Check li NHD Master Email Lis Dashboard - myUSGS Quicktime Time and A Inbox - becciandersor Thumbs Up Sign E NGTOC Project and C

Watershed Boundary Dataset (WBD) Direct Download Links

The WBD can be directly downloaded in shapefile or file geodatabase format by Hydrologic Unit - Region (HU2) - or as a file geodatabase for the entire nation.

- Download the WBD by Region (HU2) (DOI users)
- Download the WBD by the entire nation (DOI users)
  National data are refreshed monthly.
- Download the WBD from the NRCS Geospatial Data Gateway
  Watershed Boundaries can also be downloaded from the Natural Resources Conservation Service. Data on the Geospatial Data Gateway are refreshed every six months (March and September).

Map Services

Hydrography web-based map services are available from The National Map Service Endpoints page as cached and dynamic services.

"On occasion, maintenance will be performed on these map services causing limited access. Contact nhd@usgs.gov if you encounter service-related issues or need assistance with these services."

Full Name	Service Name	Category	Type	Data	Scale	Update
Hydrography - Cached (Tiled)	USGSHydroCached	Base Maps and/or Overlay	Raster Tile Cache	NHD High Resolution	Down to 9K (Level 17 in Google map tiles)	Annual
National Hydrography Dataset	NHD	Theme Overlays	Dynamic	NHD High Resolution	1:288K and larger	Quarterly
Watershed Boundary Dataset	WBD	Theme Overlays	Dynamic	WBD	1:18M and larger	Quarterly

Which service should I use?

- **Hydrography - Cached (Tiled)**: This nationwide cached overlay uses a variety of hydrography layers and depicts them in standard USGS Topographic Map symbology. It is updated and re-cached once yearly. It is useful for adding hydrography over other map layers down to 1:9,000 scale. It draws more quickly and is more reliable than the dynamic layers, but is updated less frequently and does not provide access to attributes nor the ability to change the style in other applications. This service is also available as a WMTS.
- **National Hydrography Dataset (NHD)**: This nationwide dynamic service displays the NHD High Resolution at scales from 1:288K and below. NHD symbology is used and it includes all symbols, for example, flow direction and connectors are shown at large scales. It draws more slowly than the tile cached service, but the data is updated quarterly and it supports access to attributes and dynamic styling (the ability to change the style representation in ESRI clients). This service is also available as a OGC Web Map Service (WMS).
- **Watersheds (WBD)**: This nationwide dynamic service displays the WBD at scales from 1:18M and below. It provides ability to either show all WBD levels at all scale ranges or the most appropriate HUC level at a given scale (default setting). The data is updated quarterly and it supports access to attributes and dynamic styling (the ability to change the style representation in ESRI clients). This map service is also available as a OGC Web Map Service (WMS) and a Web Feature Service (WFS).

Some of the files on this page are presented in Portable Document Format (PDF); the latest version of Adobe Acrobat Reader or similar software is required to view it. Download the latest version of Acrobat Reader, free of charge.

Accessibility FOIA Privacy Policies and Notices

U.S. Department of the Interior | U.S. Geological Survey
URL: http://nhd.usgs.gov/data.html
Questions or Assistance: Contact USGS
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USA.gov

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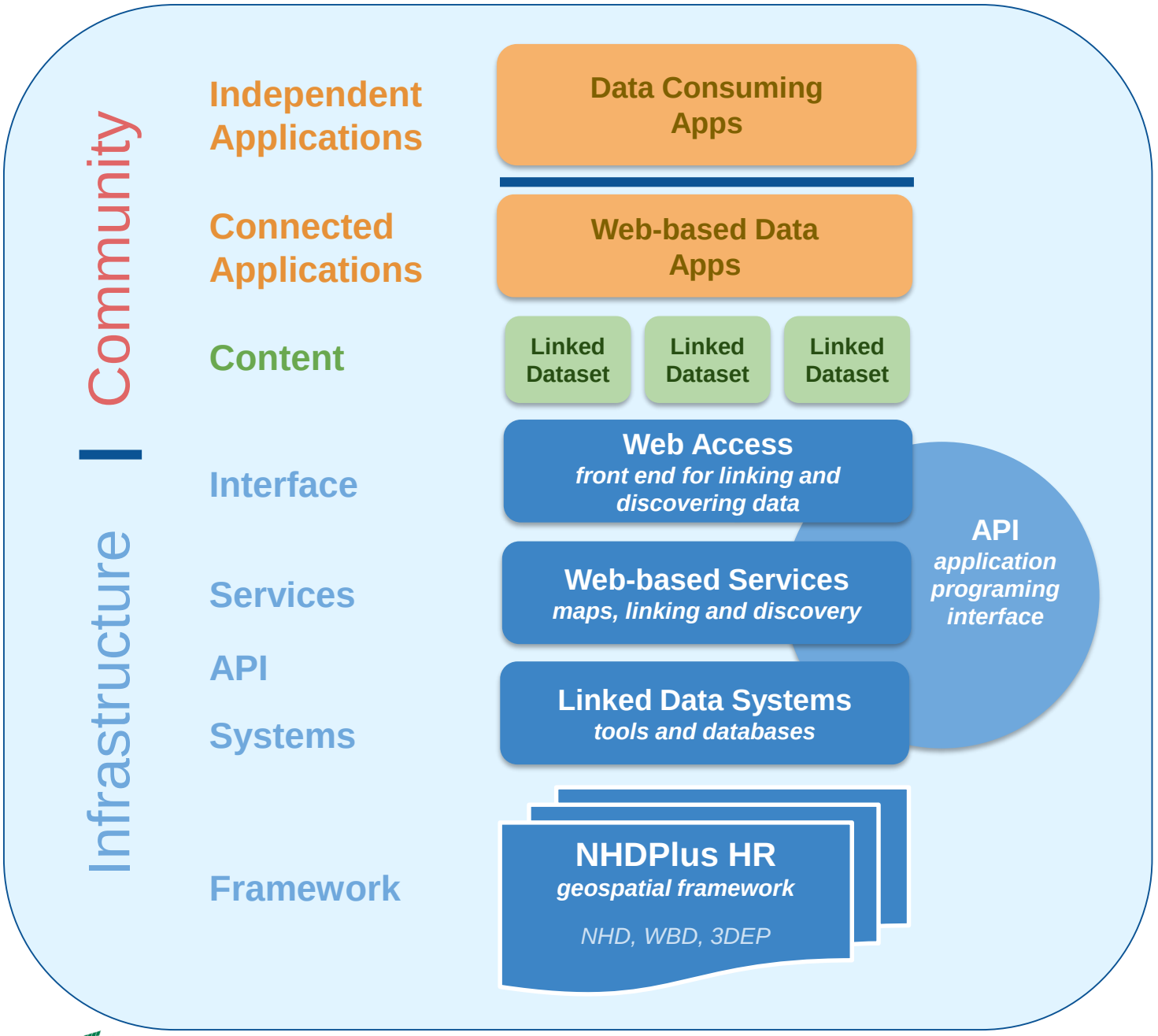
Community
Infrastructure
Independent Applications
Connected Applications
Content
Interface
Services
API
Systems
Framework
Data Consuming Apps
Web-based Data Apps
Linked Dataset
Linked Dataset
Linked Dataset
Web Access
front end for linking and discovering data
Web-based Services
maps, linking and discovery
Linked Data Systems
tools and databases
API
application programing interface
NHDPlus HR
geospatial framework
NHD, WBD, 3DEP