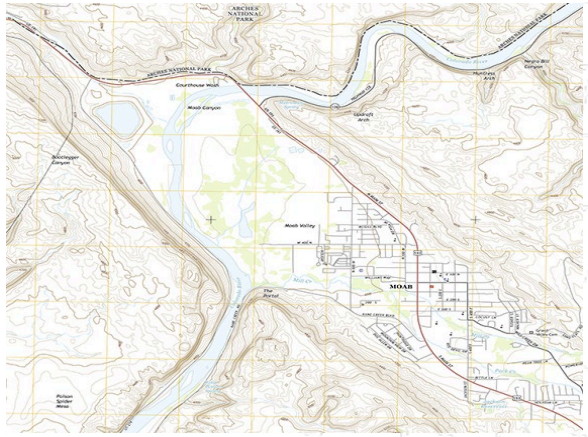
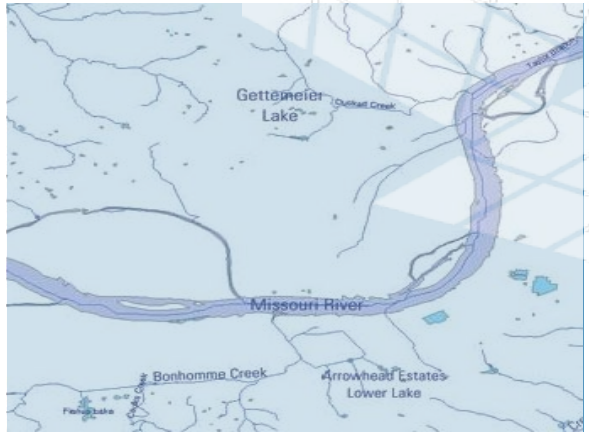
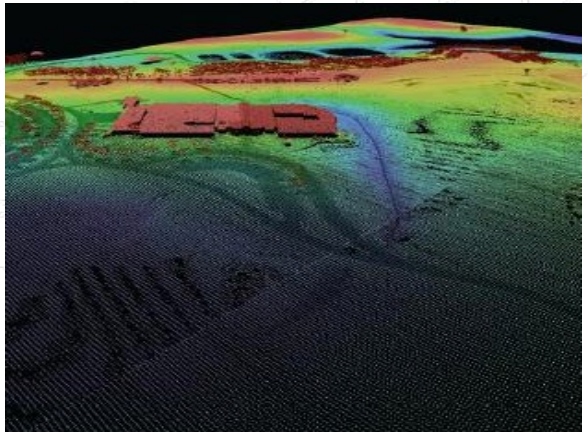
The USGS 3D National Topography Model – Updates for New Jersey







Eliza Gross, National Map Liaison (DE, NJ, NY, PA)
U.S. Geological Survey, National Geospatial Program
egross@usgs.gov

USGS science for a changing world

The National Map
Your Source for Topographic Information

New Jersey Geospatial Forum

Thursday, March 7, 2024

USGS
science for a changing world

U.S. Department of the Interior

The USGS was established March 3, 1879 under the Department of the Interior with the responsibilities of :

(1) classification of the public lands; and

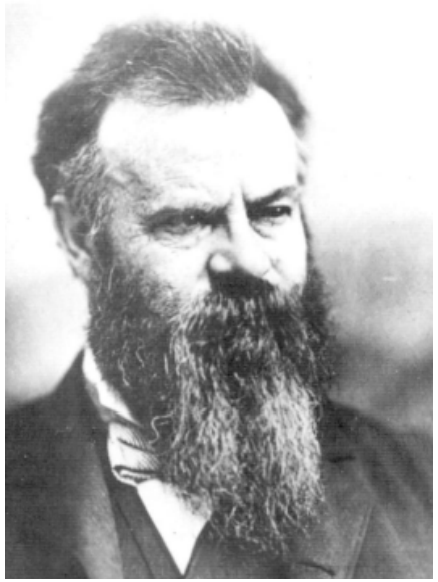
(2) examination of the geological structure, mineral resources, and products of the national domain.

Figure 1. Gentlemen engaged in geological pursuits, 1836.

https://pubs.usgs.gov/circ/1050/

USGS
science for a changing world

In 1884, John Wesley Powell convinced Congress to authorize the USGS to begin systematic topographic mapping of the US.



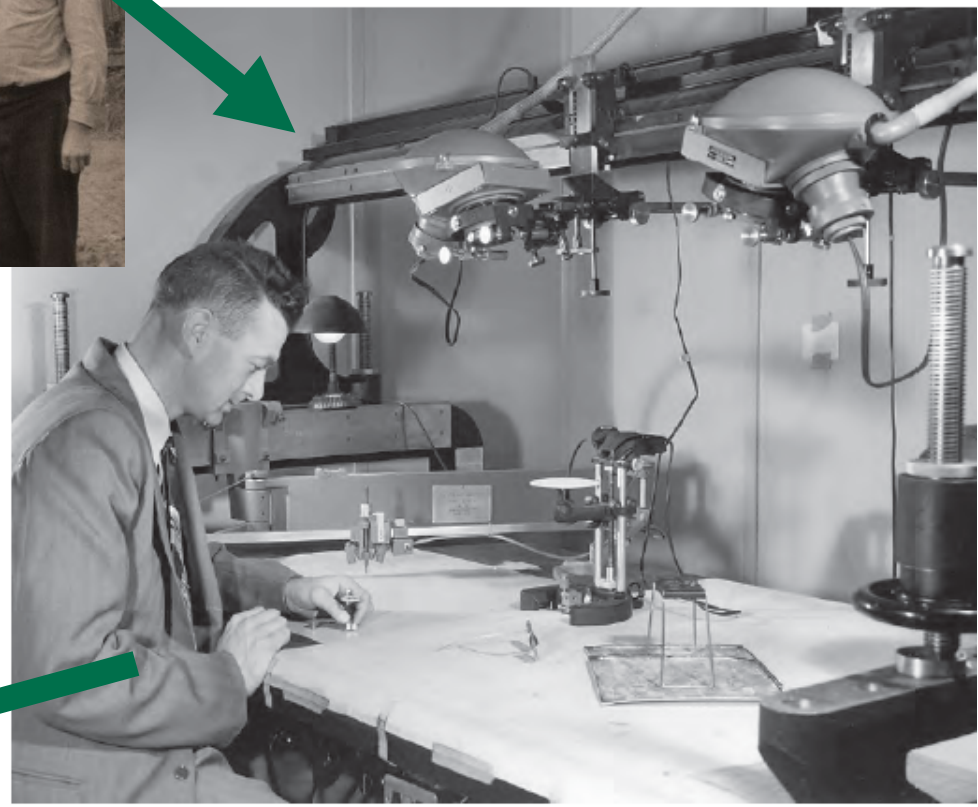
John Wesley Powell, Director of the U.S. Geological Survey, 1881-1894.

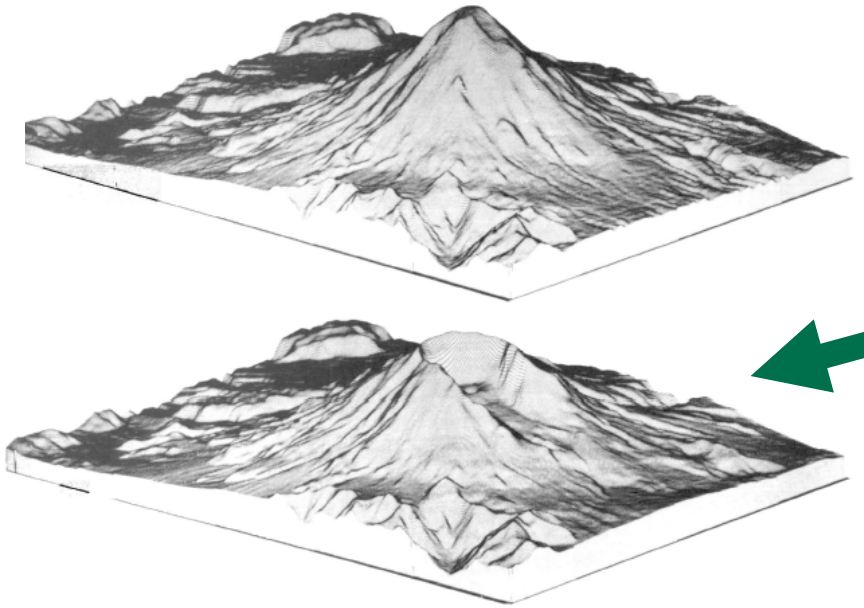
The Powell survey on its second trip down the Colorado River, 1871.

https://pubs.usgs.gov/circ/1050/
https://pubs.usgs.gov/circ/1341/

USGS
science for a changing world

During the next 125 years, mapping techniques evolved from field surveys through photogrammetry to the computer-based methods currently used.





https://pubs.usgs.gov/circ/1050/
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U.S. Department of the Interior

Fish, Wildlife & Parks
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- Bureau of Indian Education

Insular Areas
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Land & Minerals Management
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- Bureau of Ocean Energy Management
- Bureau of Safety and Environmental Enforcement
- Office of Surface Mining, Reclamation & Enforcement

Water and Science
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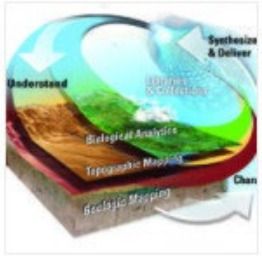
- **U.S. Geological Survey (USGS)**

U.S. Geological Survey Mission Areas



Core Science Systems

Ecosystems

Energy and Minerals

Natural Hazards

Water Resources

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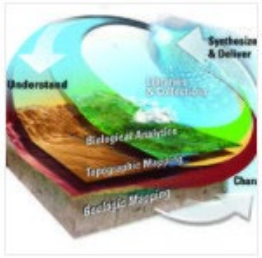

Water Resources

New Jersey Water Science Center

3450 Princeton Pike
Suite 110
Lawrenceville, NJ 08648
Phone: (609) 771-3900

Water Science Centers

Serve as hubs for critical water science located throughout the country and are funded by Federal, State, and other partners and stakeholders.

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Our staff consists of scientists, technicians, and support personnel who are committed to providing accurate and timely water science to New Jersey and the Nation.

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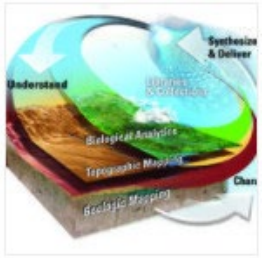
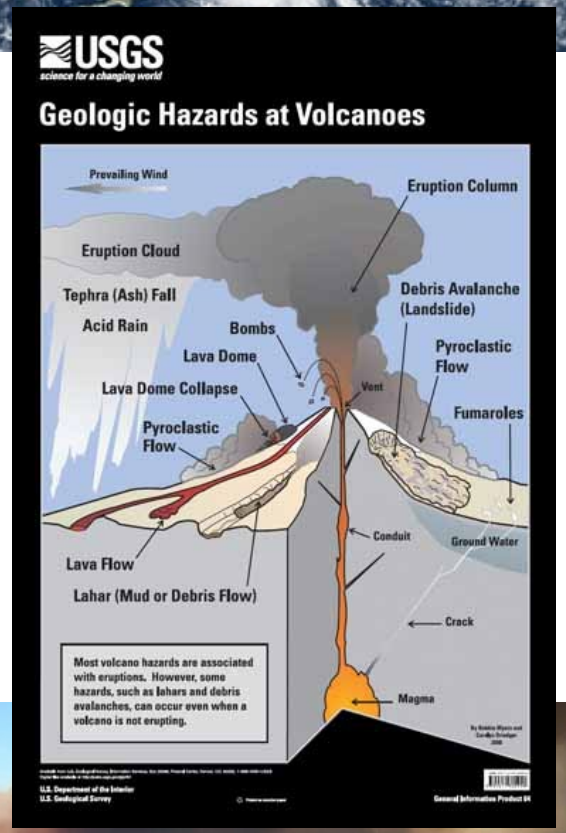


Natural Hazards

Water Resources



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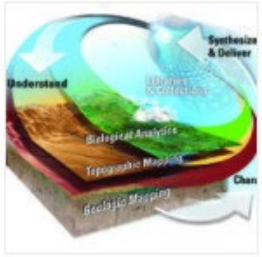

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Mineral Resources Program

Energy Resources Program

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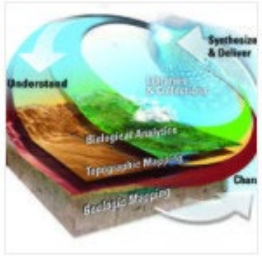

Core Science Systems

Ecosystems

Energy and Minerals

Natural Hazards

Water Resources

PROJECT
Aquatic Vegetation Monitoring

SCIENCE SNIPPET
USGS scientists coordinate the rescue of over 60 sea turtles in cold weather snap

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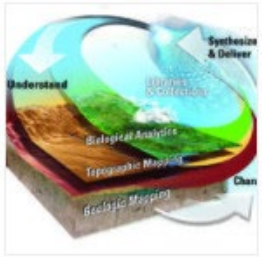

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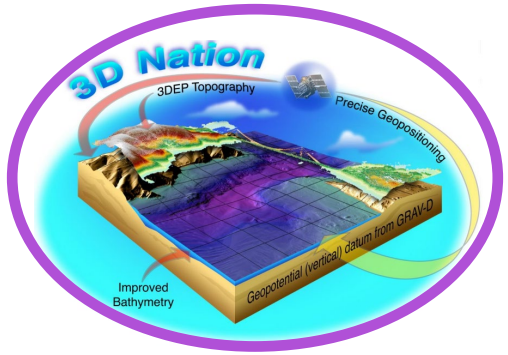
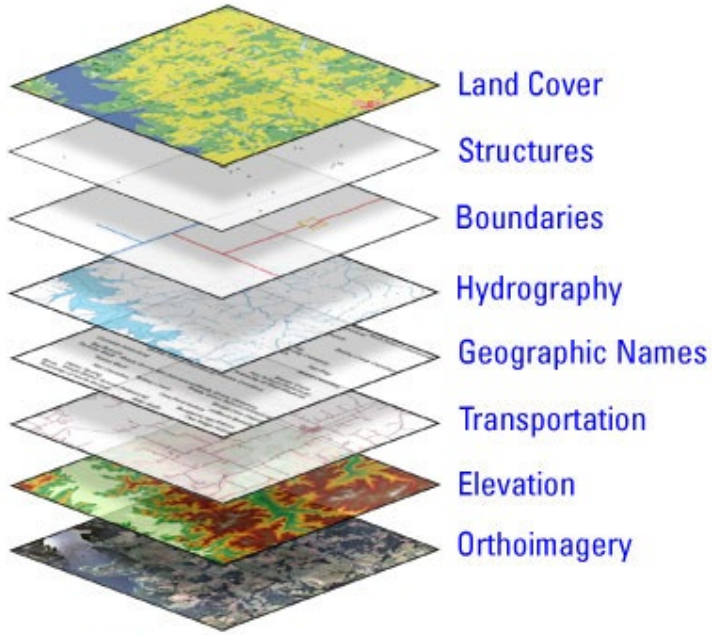
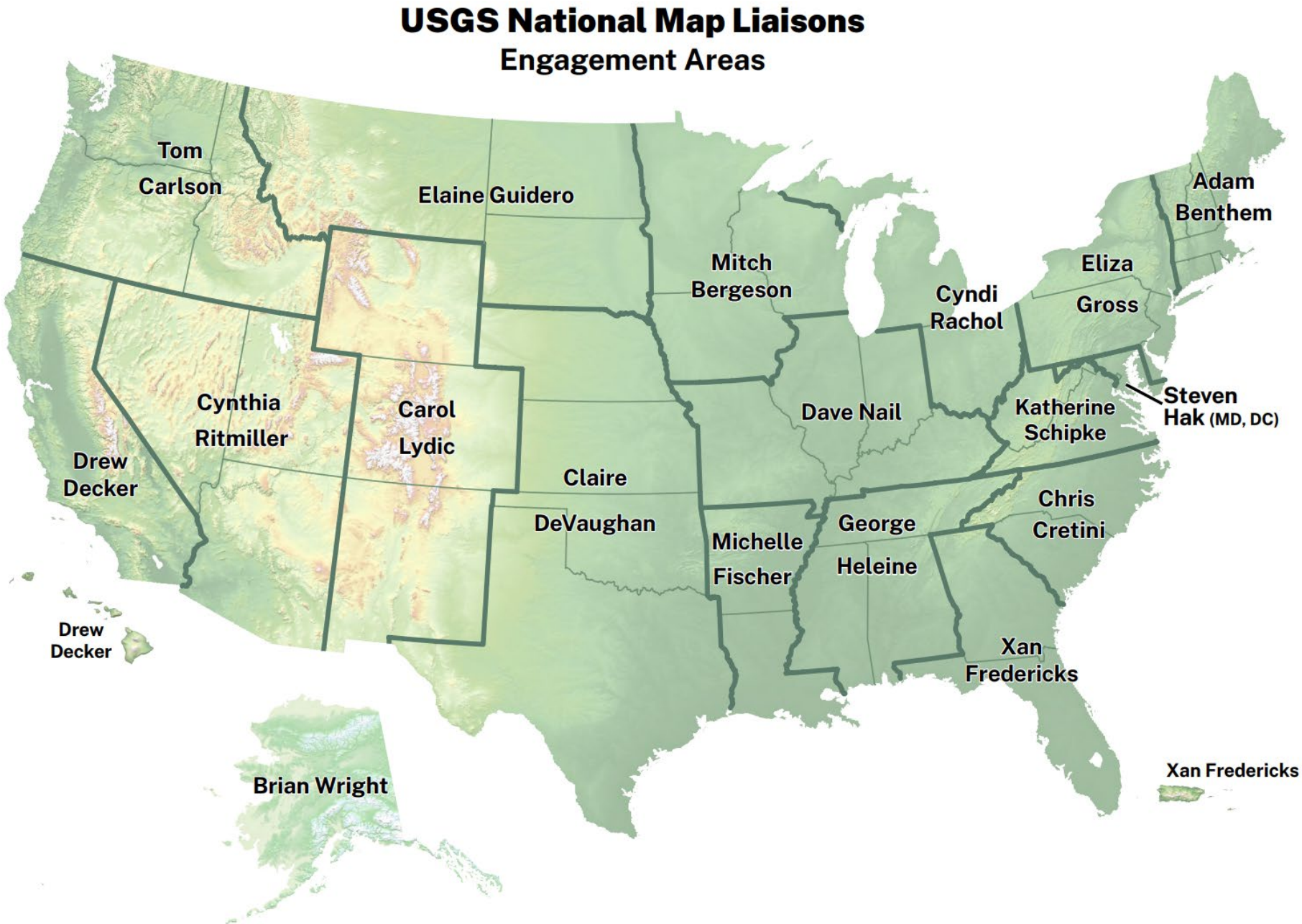
National Geospatial Program





The National Map

The National Geospatial Program



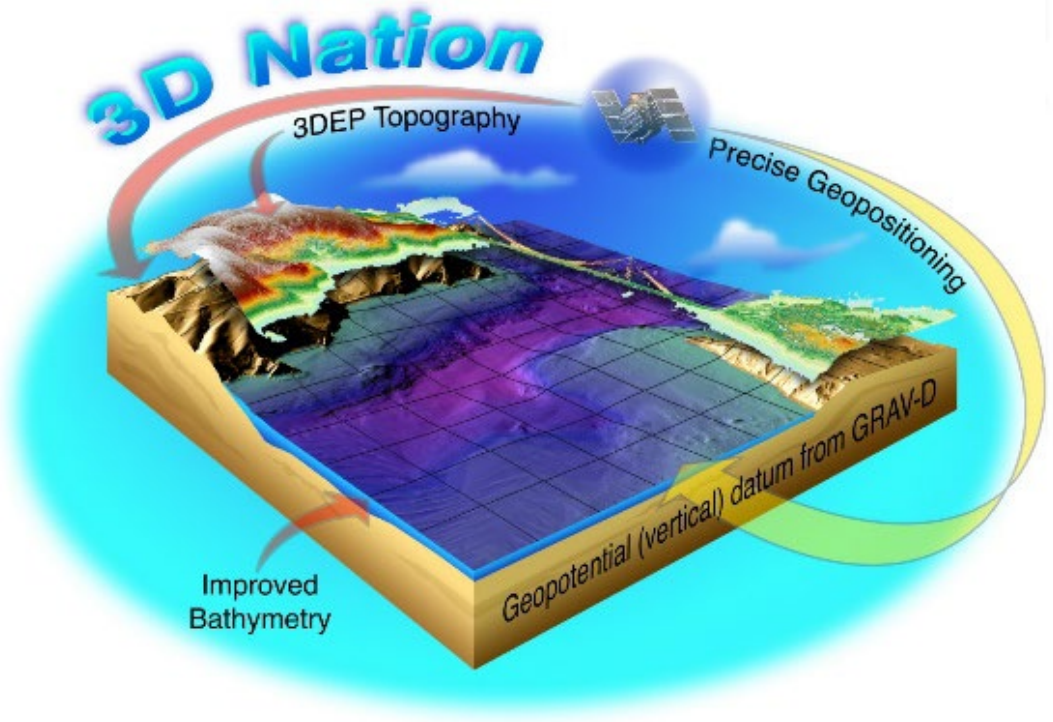
National Map Liaisons provide outreach and coordination of geospatial activities in support of NGP initiatives and USGS science.

- Providing science support to the bureau, program, or other organizations
- Outreach, tutorials, demonstrations of NGP products, services, and initiatives
- Assist with acquisition of hydrography and elevation geospatial data

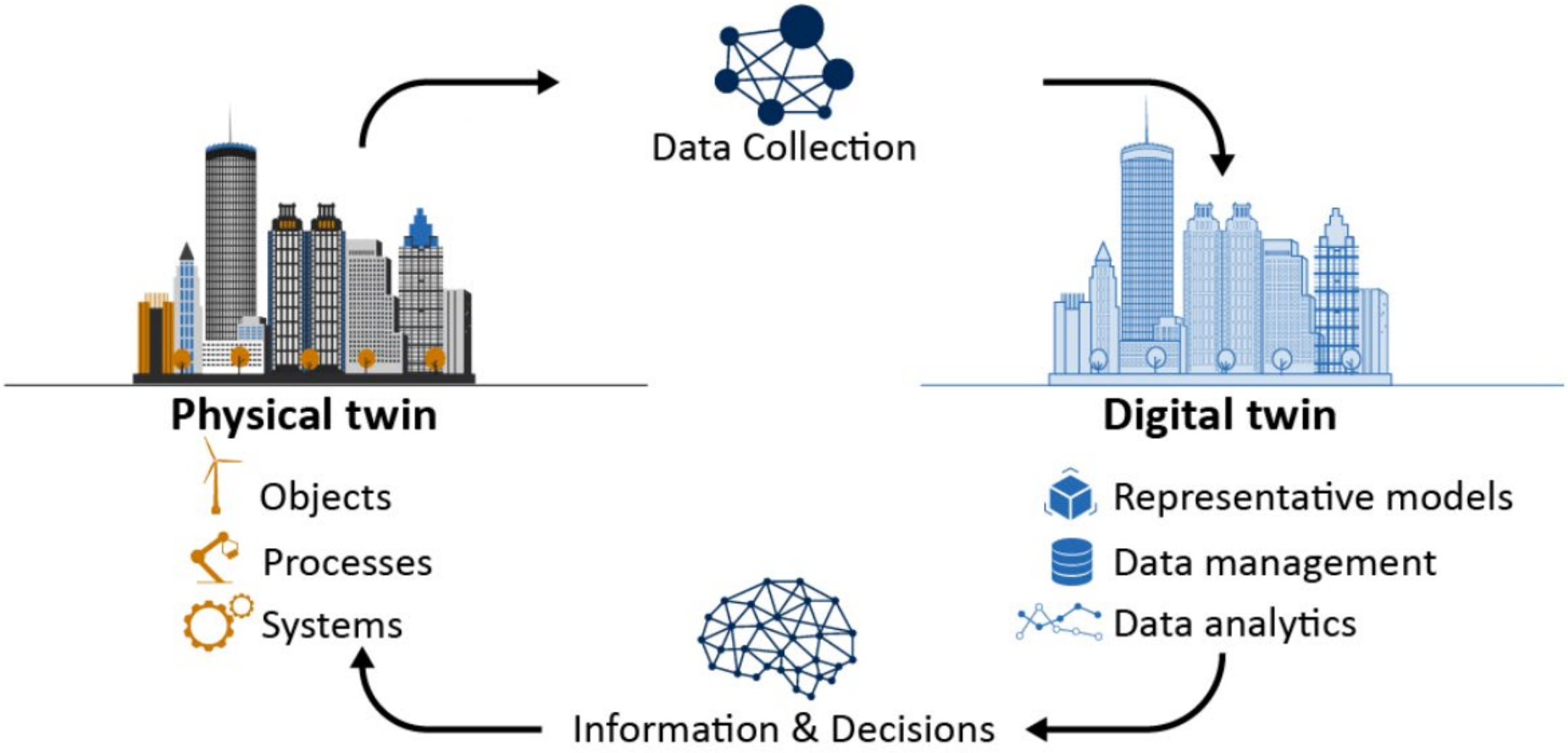
The National Geospatial Program

Eliza Gross
egross@usgs.gov
National Map Liaison (DE, NJ, NY, PA)
U.S. Geological Survey, National Geospatial Program

Updates on the National Geospatial Program's 3D National Topography Model (3DNTM)

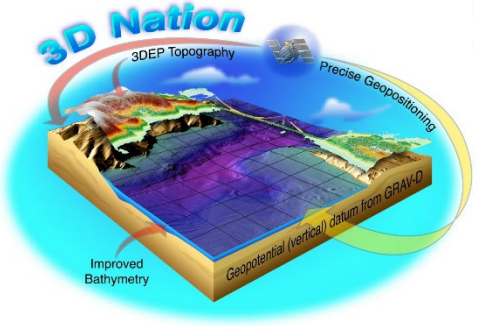


What is a digital twin?



Source: https://www.gao.gov/products/gao-23-106453

3DNTM - 3D National Topography Model



The terrestrial component of the 3D Nation vision of a continuous data surface from the depths of the oceans to the peaks of the mountains

Underpins a broad range of applications including flood risk management, drought management, hazards response and mitigation, infrastructure management, climate change science, and more

Provides universal sharing of water information as the geospatial foundation for the Internet of Water

Provides a federated system of shared elevation resources

Enables new and emerging applications

- Multiple vintages enable change detection
- Water-related applications move from the neighborhood to the street-level in accuracy

Provides foundational data to critical initiatives

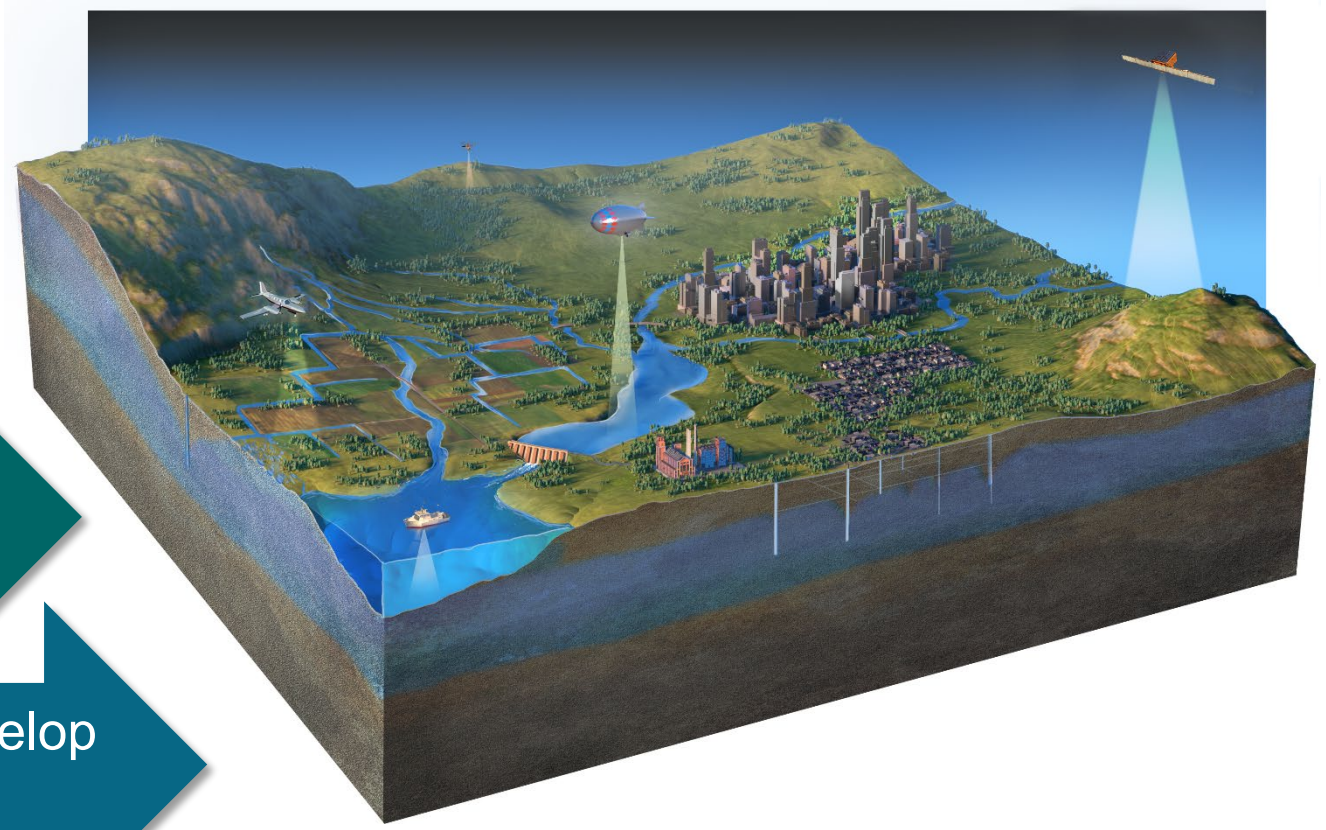
- Future of Flood Risk Data and Risk Rating 2.0
- The National Water Model
- The Clean Water Act
- The Earth Mapping Resources Initiative and critical minerals
- National Landslides Preparedness Act

3DNTM Development Tracks

Topography is defined by elevation and hydrography; elevation shapes hydrography, and hydrography shapes elevation. To support a broad range of applications, the **3D National Topography Model** integrates USGS elevation and hydrography datasets to model the Nation's topography in 3D.

The National Map
Your Source for Topographic Information

- Complete nationwide elevation and hydrography baseline datasets
- Pilot integration of hydrography and elevation
- Design and implement next generation of integrated data
- Research and develop 3D data model



3DNTM Development Tracks

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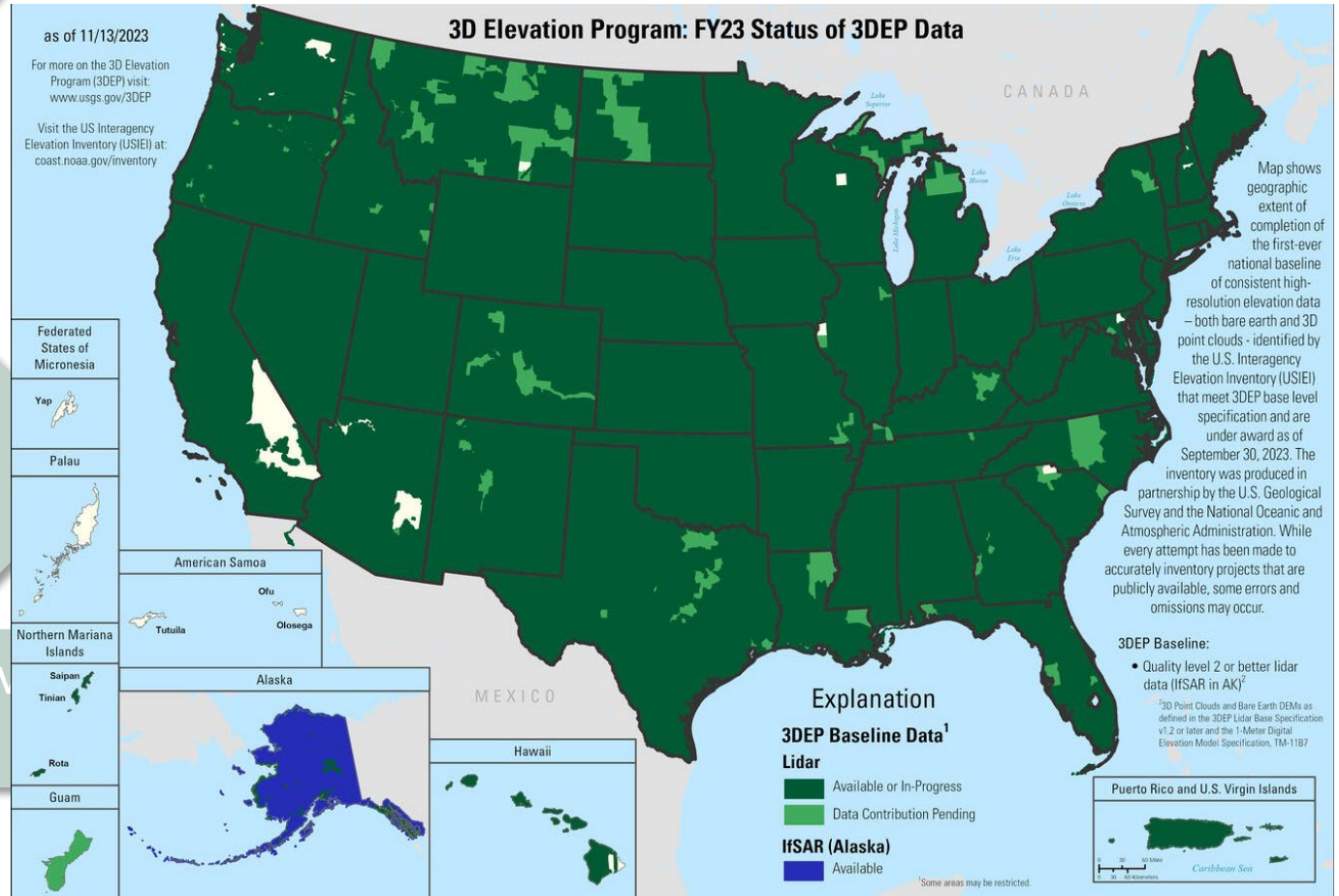
Complete nationwide elevation and hydrography baseline datasets

- **3D Elevation Program (3DEP)** – provide the first-ever national baseline of consistent **high-resolution** elevation data – both bare earth and 3D point clouds



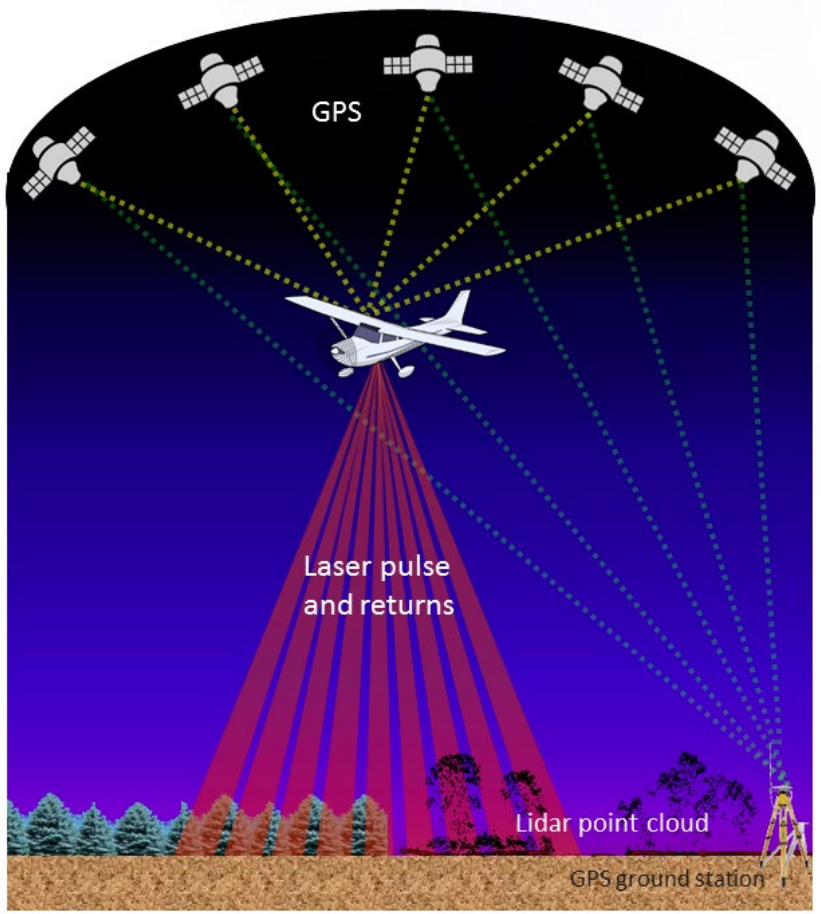
Pilot integration of hydrography and elevation

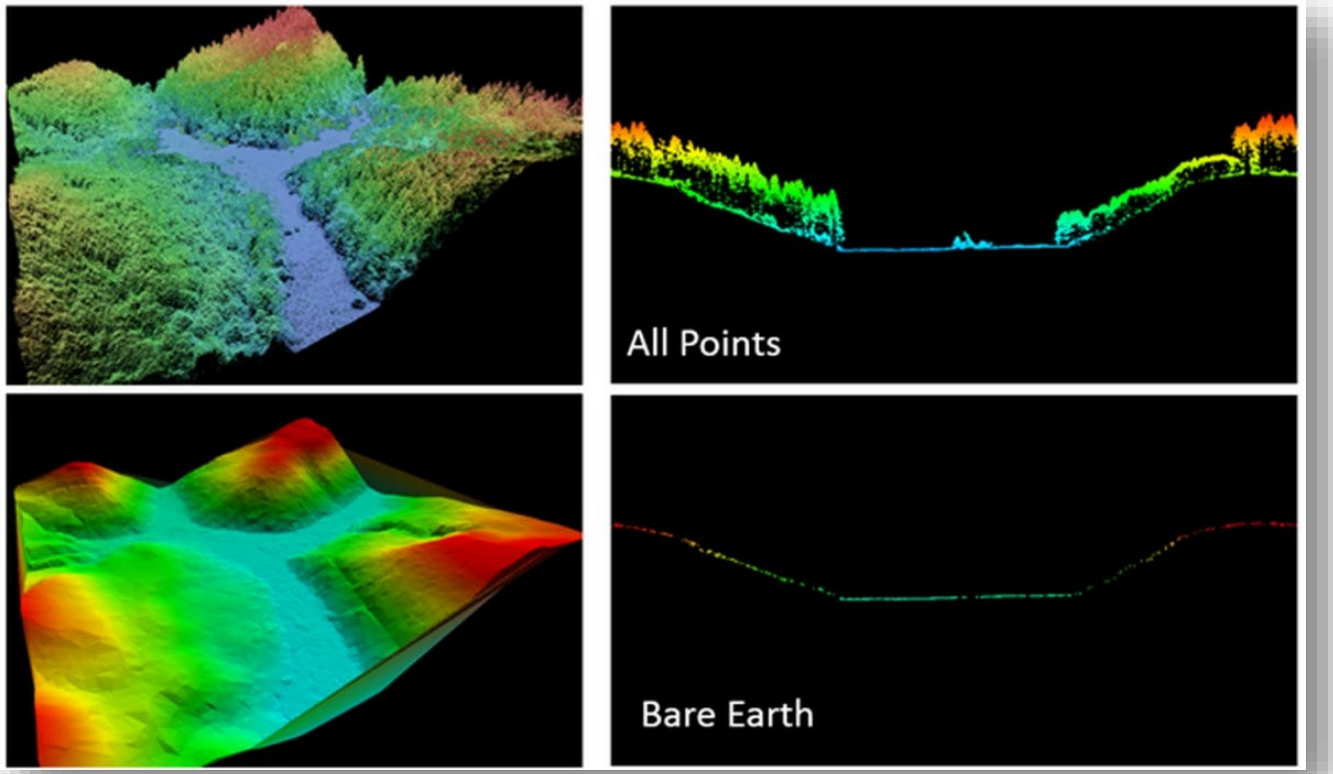
Design and implement next generation of integrated data

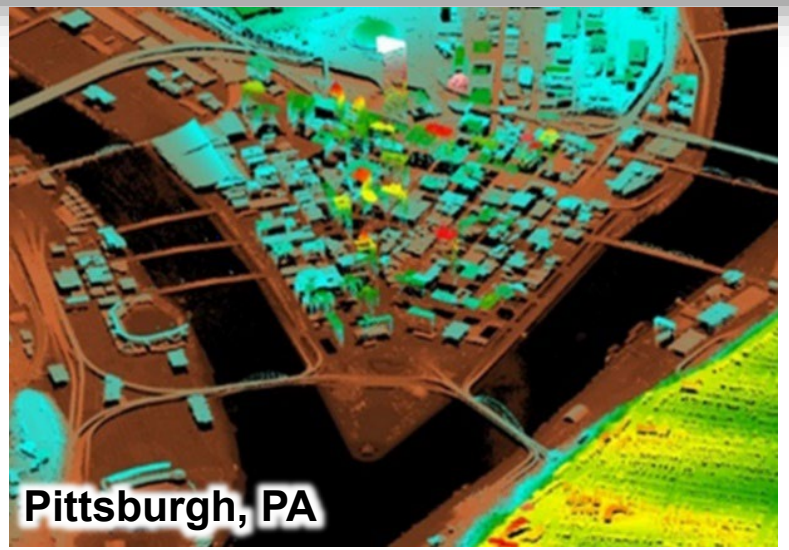
Research and dev 3D data model

What is lidar?

Light detection and ranging

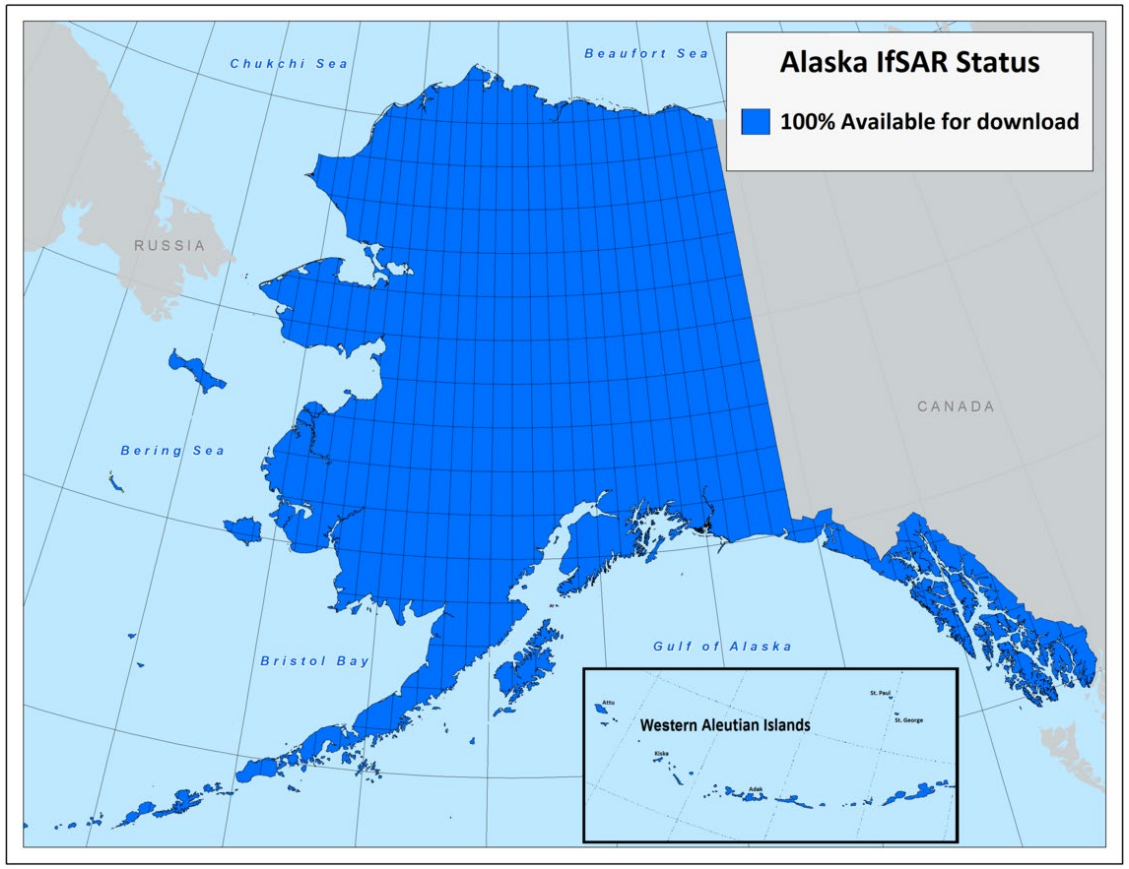


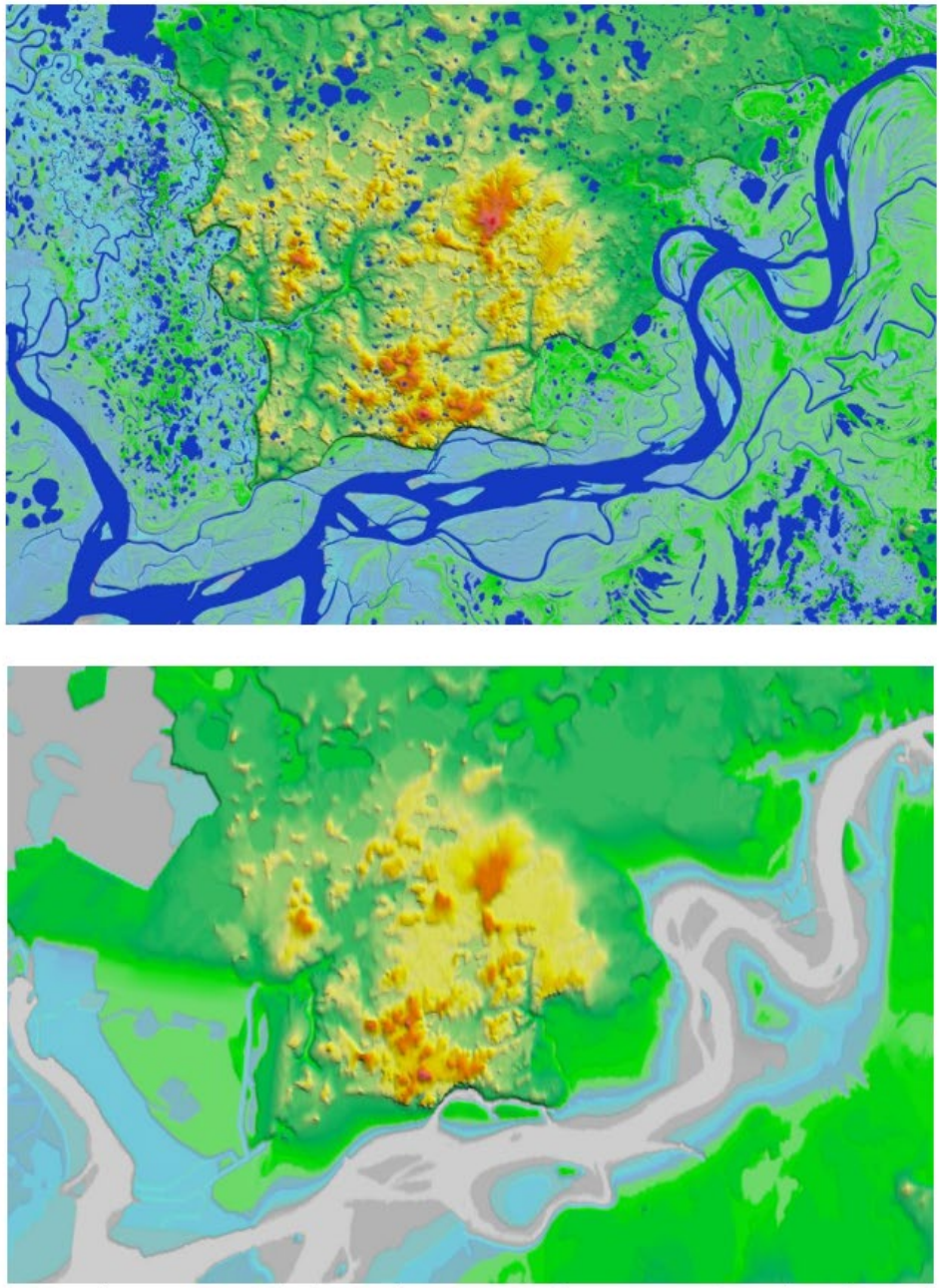




What is IfSAR?

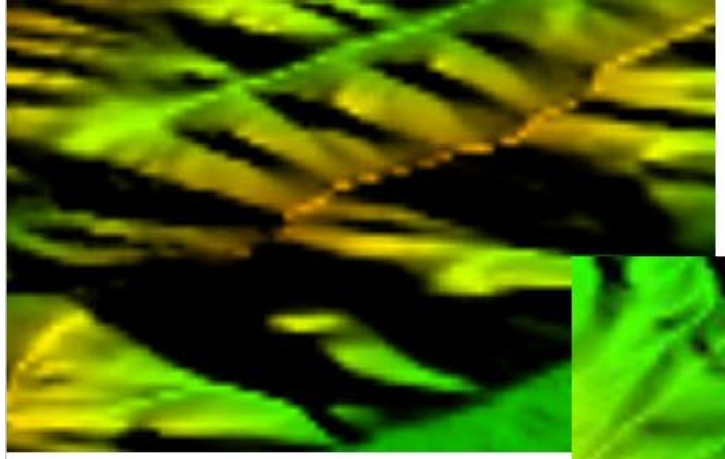
Interferometric synthetic aperture radar



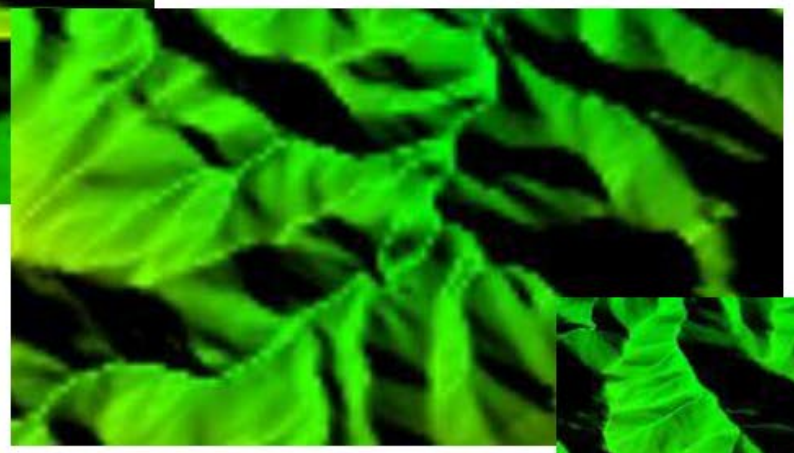


The IFSAR DEM (top) is vastly superior to the prior NED (bottom). With hydrographic features mapped "loud and clear," the IFSAR is ideal for high-resolution National Hydrography Dataset and NHD+ products.

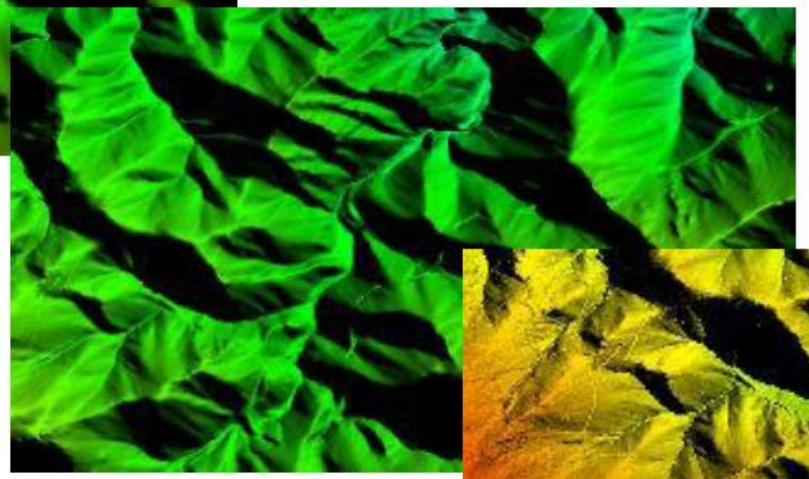
Difference between National Map elevation products: Seamless and 1-meter layers



2 Arc Second
(roughly 60 meters)



1 Arc Second
(roughly 30 meters)



1/3 Arc Second
(roughly 10 meters)

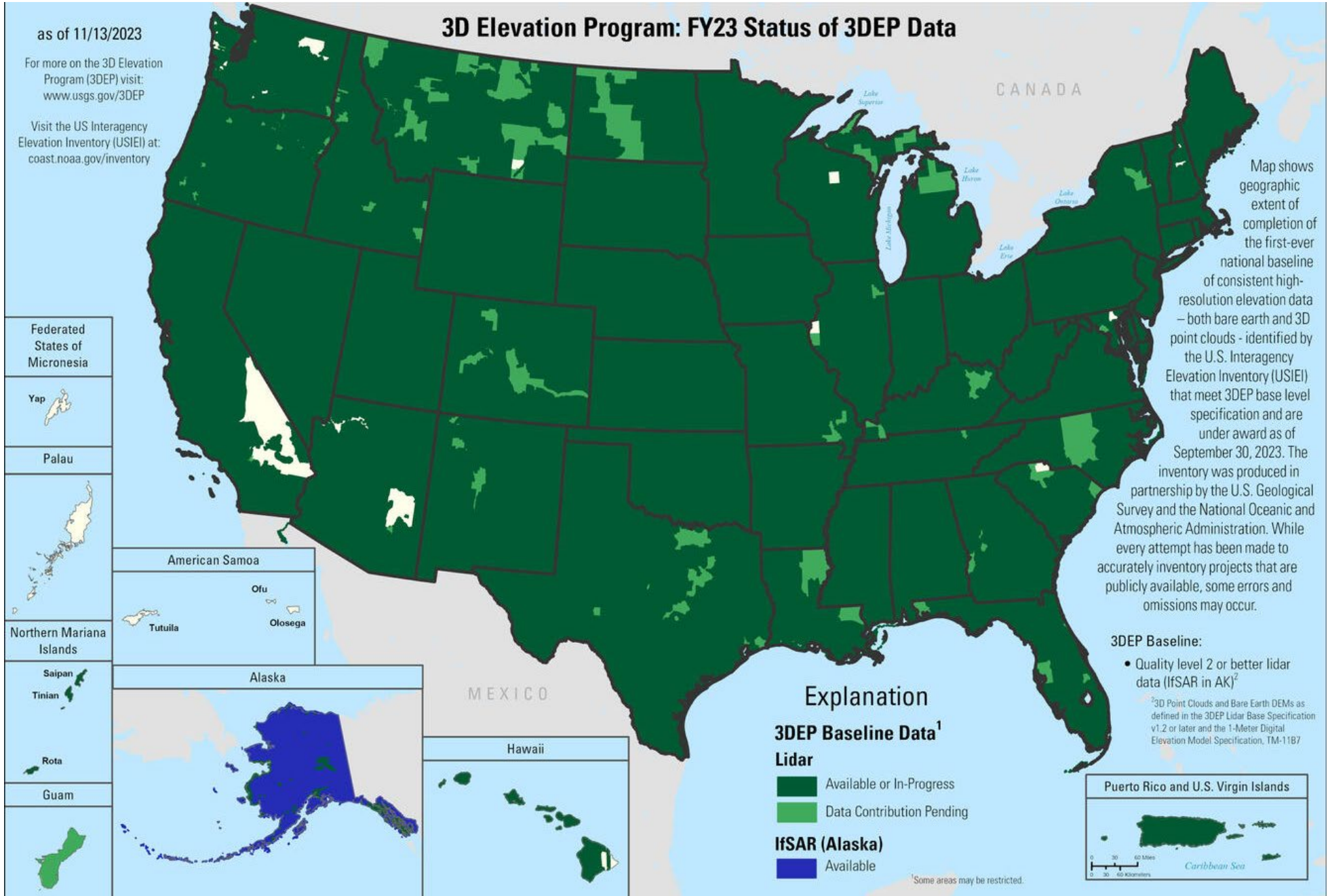
1 Meter Quality level 2 (QL2)

Lidar Base Specification – Lidar must be **QL2 or better quality to meet 3DEP specifications**

Quality level	Data Source	Vertical accuracy RMSEz (cm)	Nominal pulse spacing (meters)	Nominal Pulse Density: points per square meter	DEM cell size (meters)
QL0	Lidar	5 cm	$\leq$ 0.35	$\geq$ 8 pts/m^2	0.5 m
QL1	Lidar	10 cm	$\leq$ 0.35	$\geq$ 8 pts/m^2	0.5 m
QL2	Lidar	10 cm	$\leq$ 0.71	$\geq$ 2 pts/m^2	1 m
QL5	IfSAR	185 cm	N/A	N/A	5 m

Overview of USGS 3DEP lidar products			
Characteristic	**Lidar point cloud (LPC)**	**Original Product Resolution (OPR) DEM**	**1-meter DEM**
Applications for search and download	The National Map Download* 3DEP LidarExplorer* *Both of the above applications will download from Amazon Web Service (AWS). AWS is faster and more reliable.		
Location for direct download from rockyweb	https://rockyweb.usgs.gov/vdelivery/Datasets/Staged/Elevation/LPC/Projects/	https://rockyweb.usgs.gov/vdelivery/Datasets/Staged/Elevation/OPR/Projects	https://rockyweb.usgs.gov/vdelivery/Datasets/Staged/Elevation/1m/Projects/
Location for direct download from AWS	LPC data are not available for free download on AWS. See link below for payment instructions. LPC on AWS - Requester Pays Instructions	http://prd-tnm.s3.amazonaws.com/index.html?prefix=StagedProducts/Elevation/OPR/Projects/	http://prd-tnm.s3.amazonaws.com/index.html?prefix=StagedProducts/Elevation/1m/Projects/
Product organization	By Work Unit	By Work Unit	By project
When are they produced/available?	When each Work Unit is complete. There are subfolders for each Work Unit under each project folder.	When each Work Unit is complete. There are subfolders for each Work Unit under each project folder.	When the entire project is complete (all Work Units) and has met final vertical accuracy assessment. There is one folder for each lidar project.
Type of file	LPC data	Bare earth DEM	Bare earth DEM
File format	LAS file compressed to LAZ file format	Raster in TIF format	Raster in TIF format
Type of product	LPC source data	OPR DEMs are the original bare earth DEMs derived from the LPC source data and delivered "as-is" on a Work Unit basis.	Standard, consistent product.
Product specification	https://www.usgs.gov/ngp-standards-and-specifications/lidar-base-specification-online		https://pubs.usgs.gov/tm/11/b07/tm11-b7.pdf
Projection	Varies (Albers, UTM, others)	Varies (Albers, UTM, others)	Always UTM
Tile size	Varies	Varies, often the tile size matches the tile size of the LPC data	10-km x 10-km
Resolution	Varies. See table 1 from the Lidar Base Specification at the following link: https://www.usgs.gov/ngp-standards-and-specifications/lidar-base-specification-tables	Usually one meter, but can be .5 meter, 2 meter, 5 meter, or others, depending on the resolution of the lidar or ifsar project	1 meter* *1-meter DEMs are only generated when the OPR DEM resolution is 1 meter or less

3D Elevation Program (3DEP) Status



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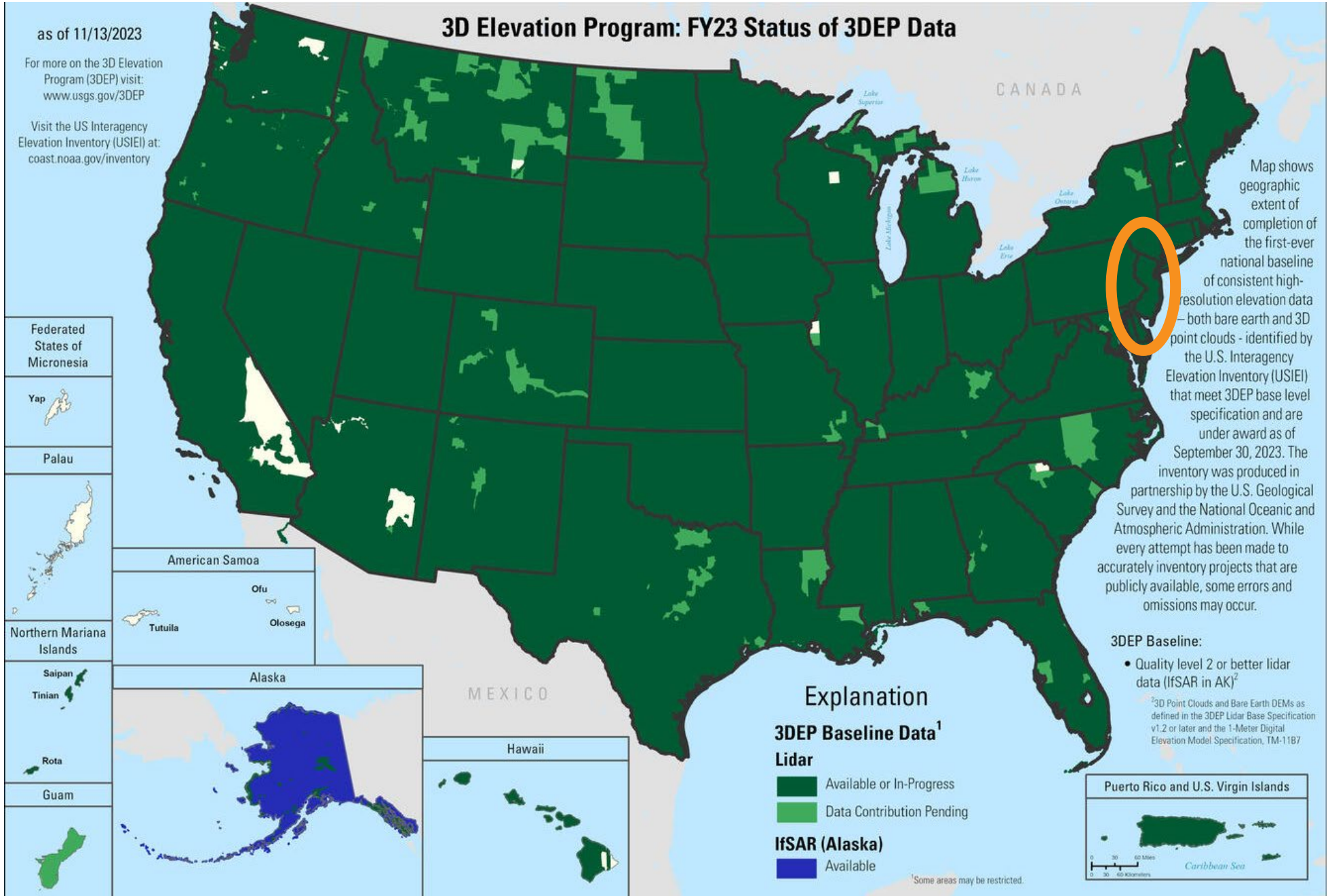

QL2 lidar acquisition projects in NJ contributing to the 3DEP baseline

Quality level	Data Source	Vertical accuracy RMSEz (cm)	Nominal pulse spacing (meters)	Nominal Pulse Density: points per square meter	DEM cell size (meters)
QL0	Lidar	5 cm	≤ 0.35	≥ 8 pts/m^2	0.5 m
QL1	Lidar	10 cm	≤ 0.35	≥ 8 pts/m^2	0.5 m
QL2	Lidar	10 cm	≤ 0.71	≥ 2 pts/m^2	1 m
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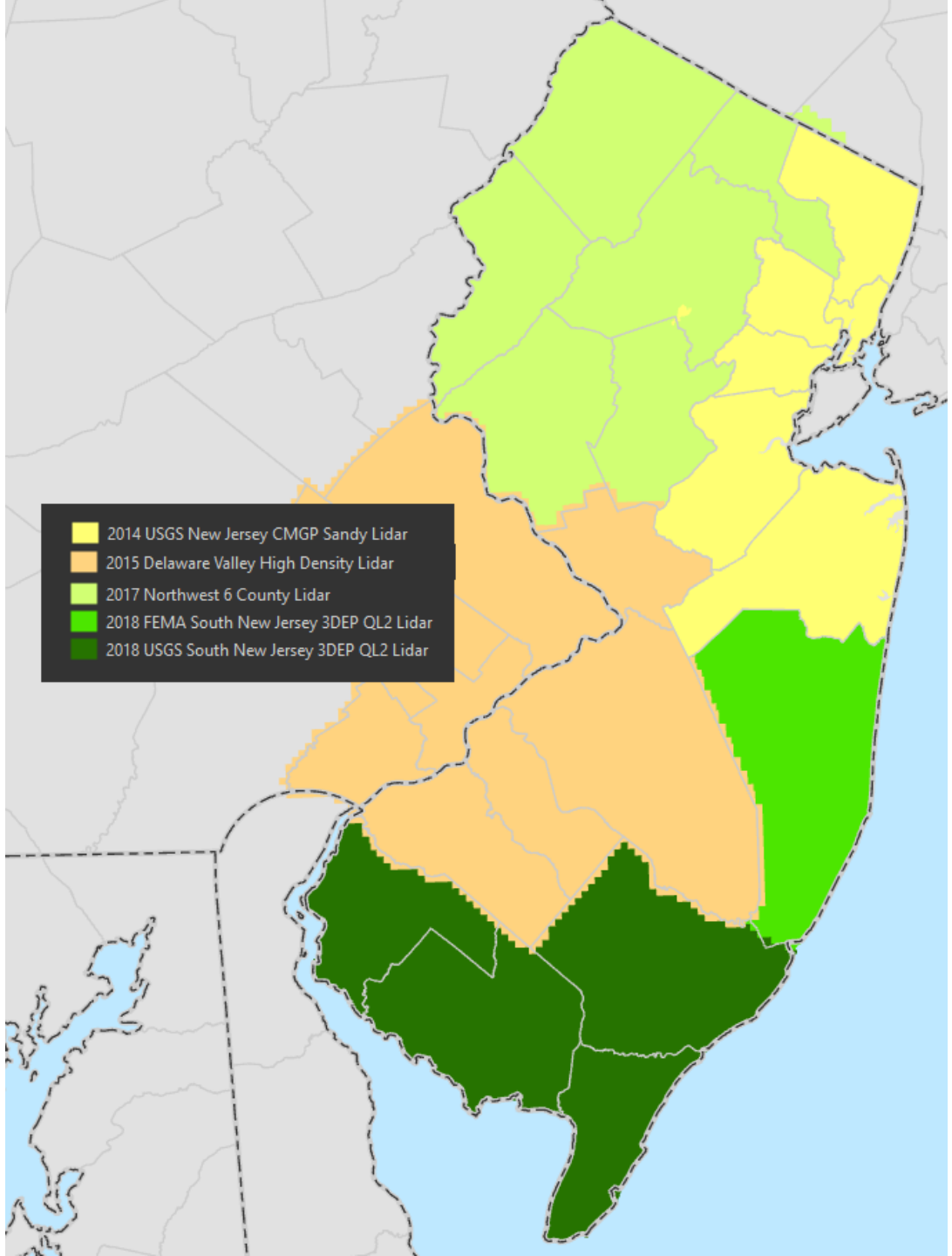

Lidar acquisitions funded by NJ state received independent QA/QC

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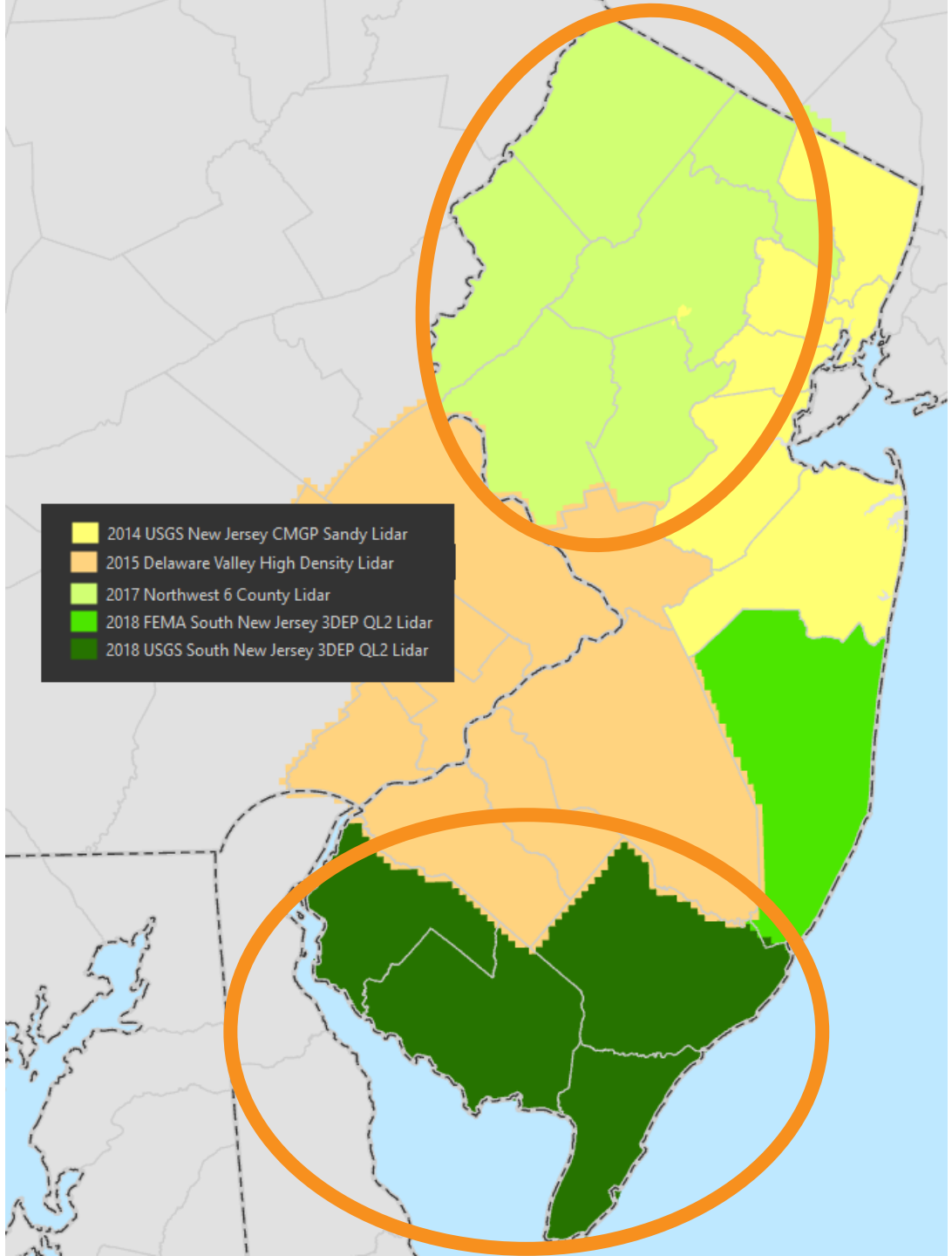

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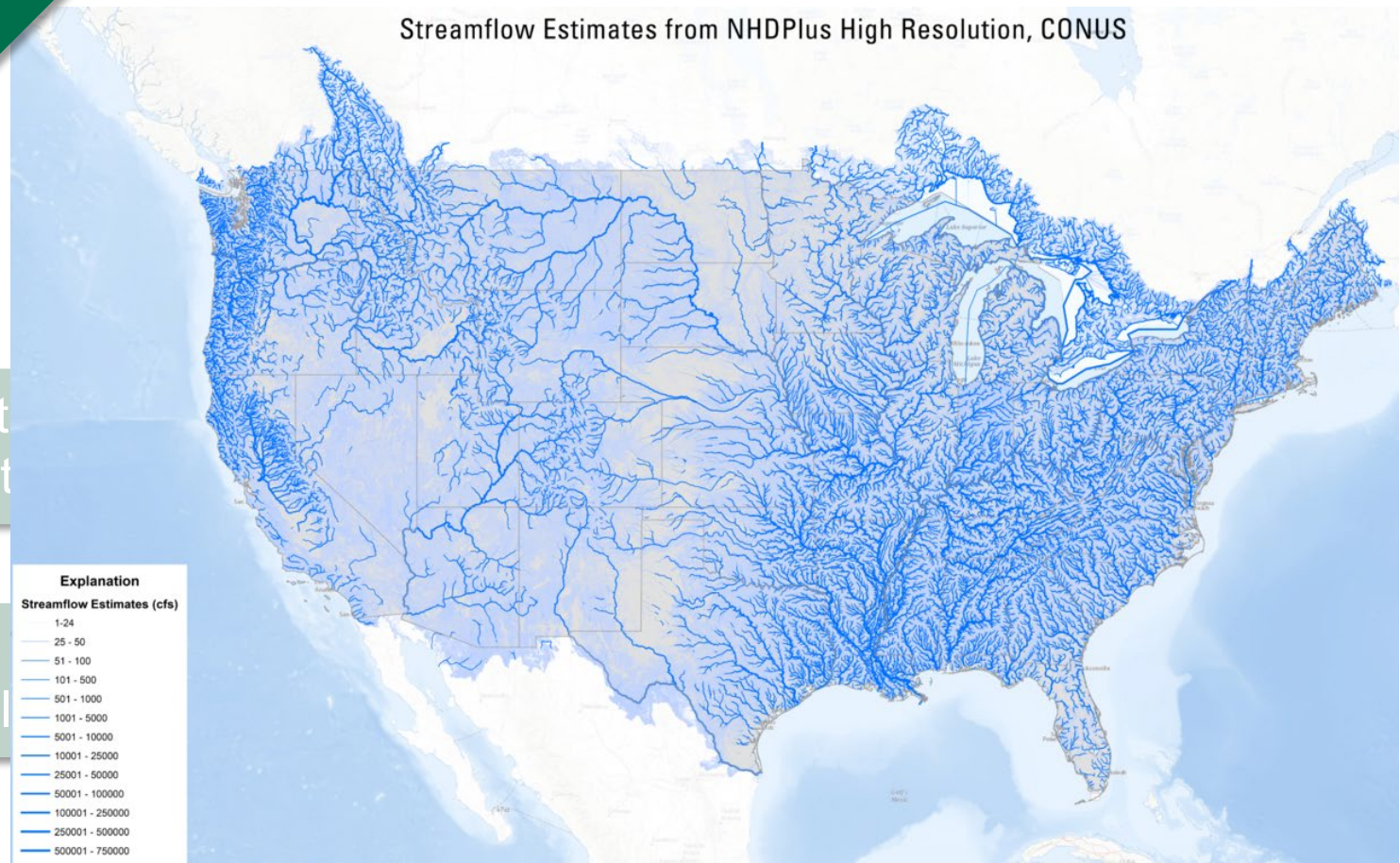
Pilot integration of hydrography and elevation

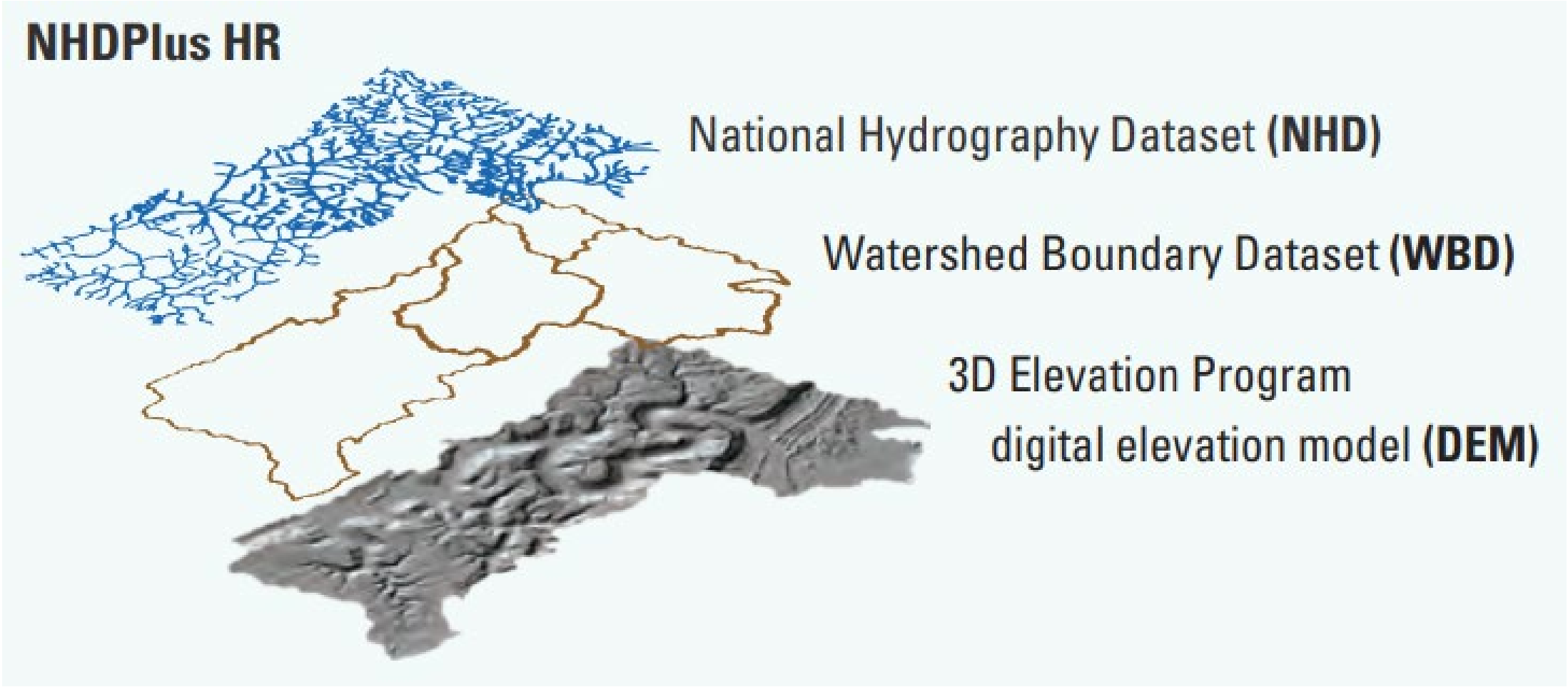
Design and implement next generation of integrated dat

Research and 3D data model

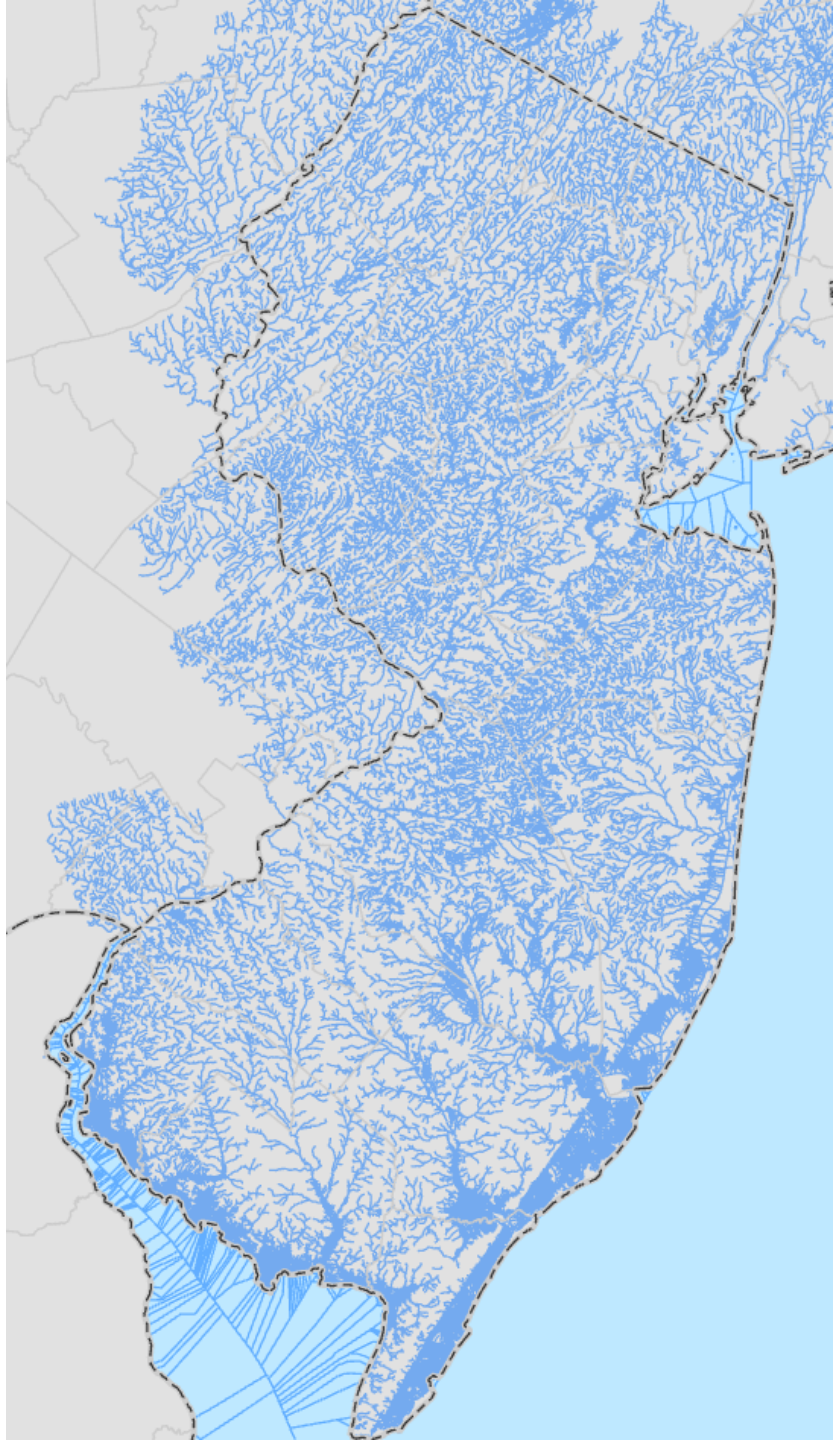
NHDPlus High Resolution (NHDPlus HR) - Unify observations and measurements onto one multiscale hydrography framework



What is the NHDPlus HR?



NHDPlus HR in NJ



3DNTM Development Tracks

Topography is defined by elevation and hydrography; elevation shapes hydrography, and hydrography shapes elevation. To support a broad range of applications, the **3D National Topography Model** integrates USGS elevation and hydrography datasets to model the Nation's topography in 3D.

The National Map
Your Source for Topographic Information

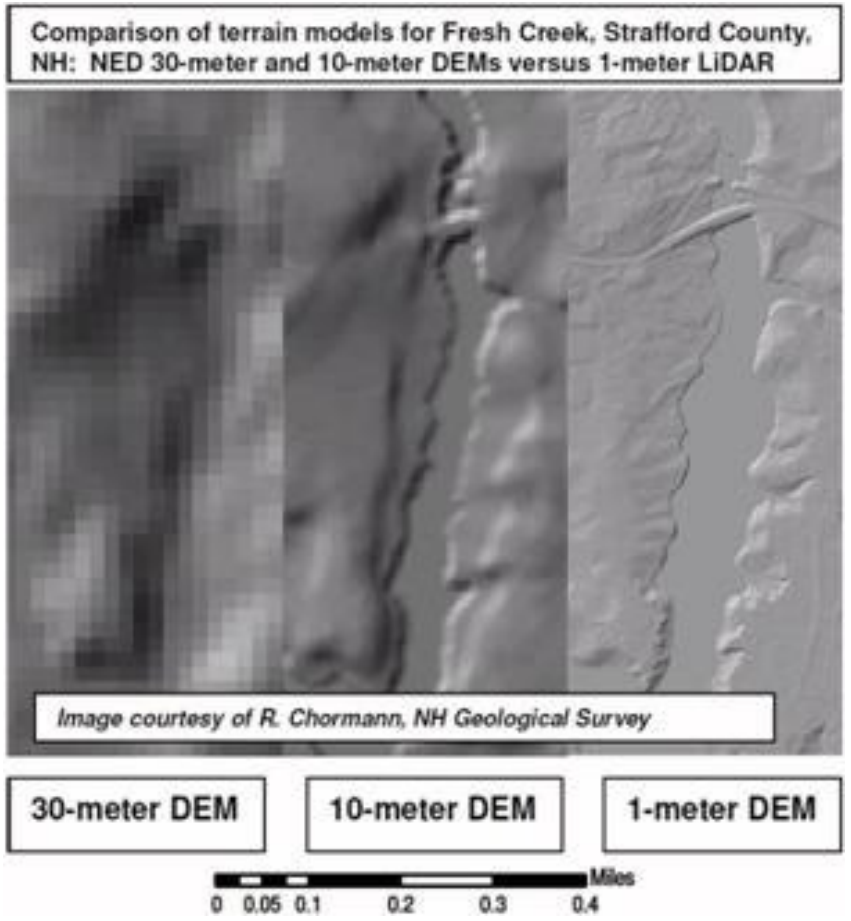
Complete nationwide elevation and hydrography baseline datasets

Pilot integration of hydrography and elevation

Design and implement next generation of integrated data

Research and develop 3D data model

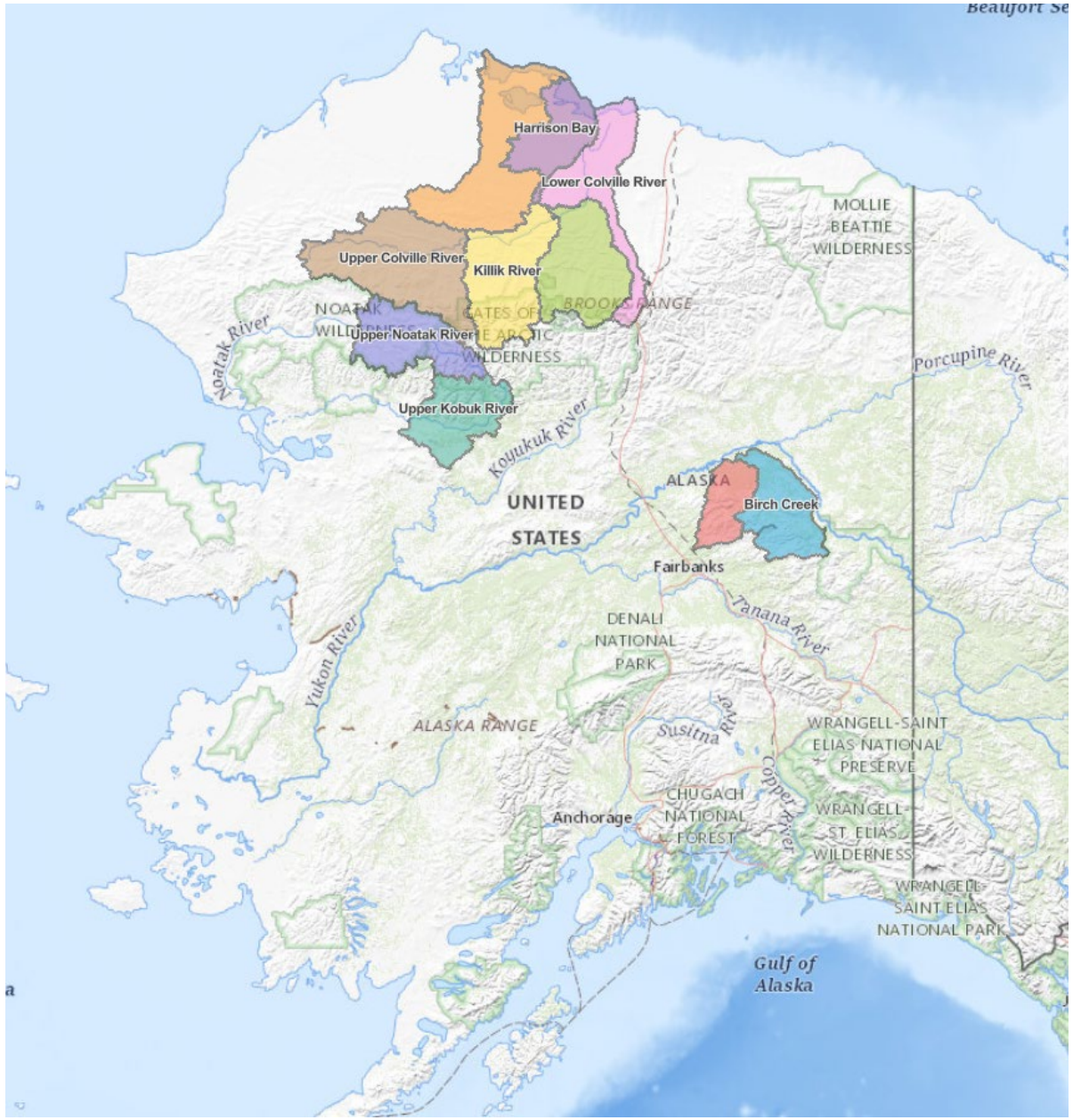
Derive hydrography with z-values from the most recent lidar data to greatly improve the level of detail, currency, and content of features

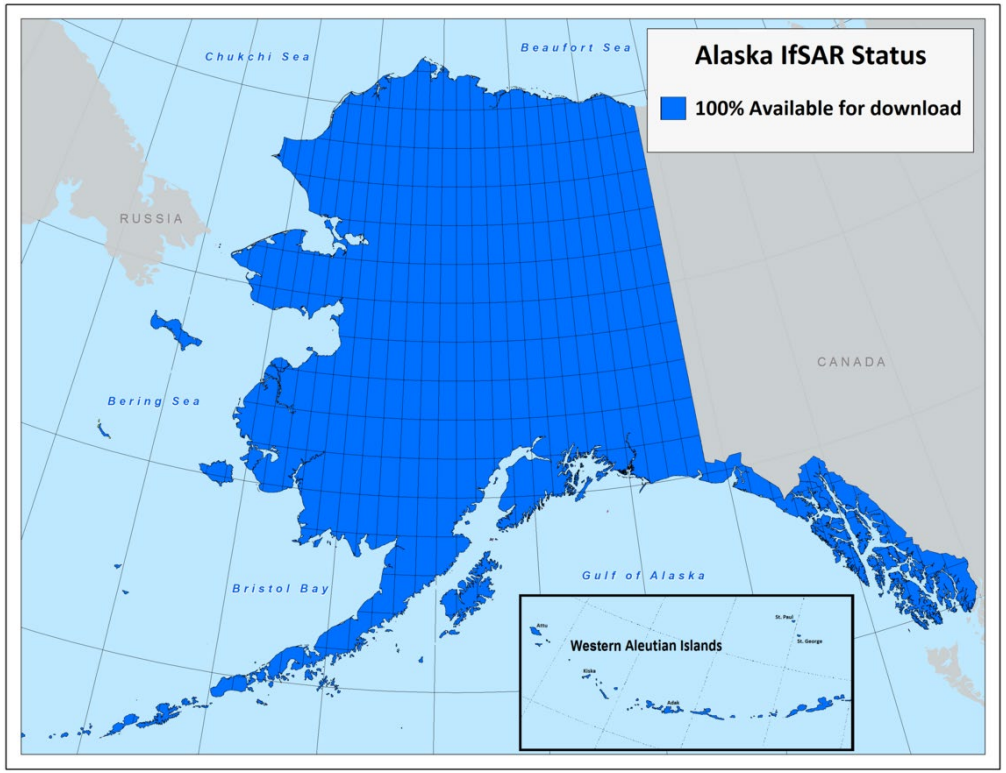


Pilot integration of hydrography and elevation

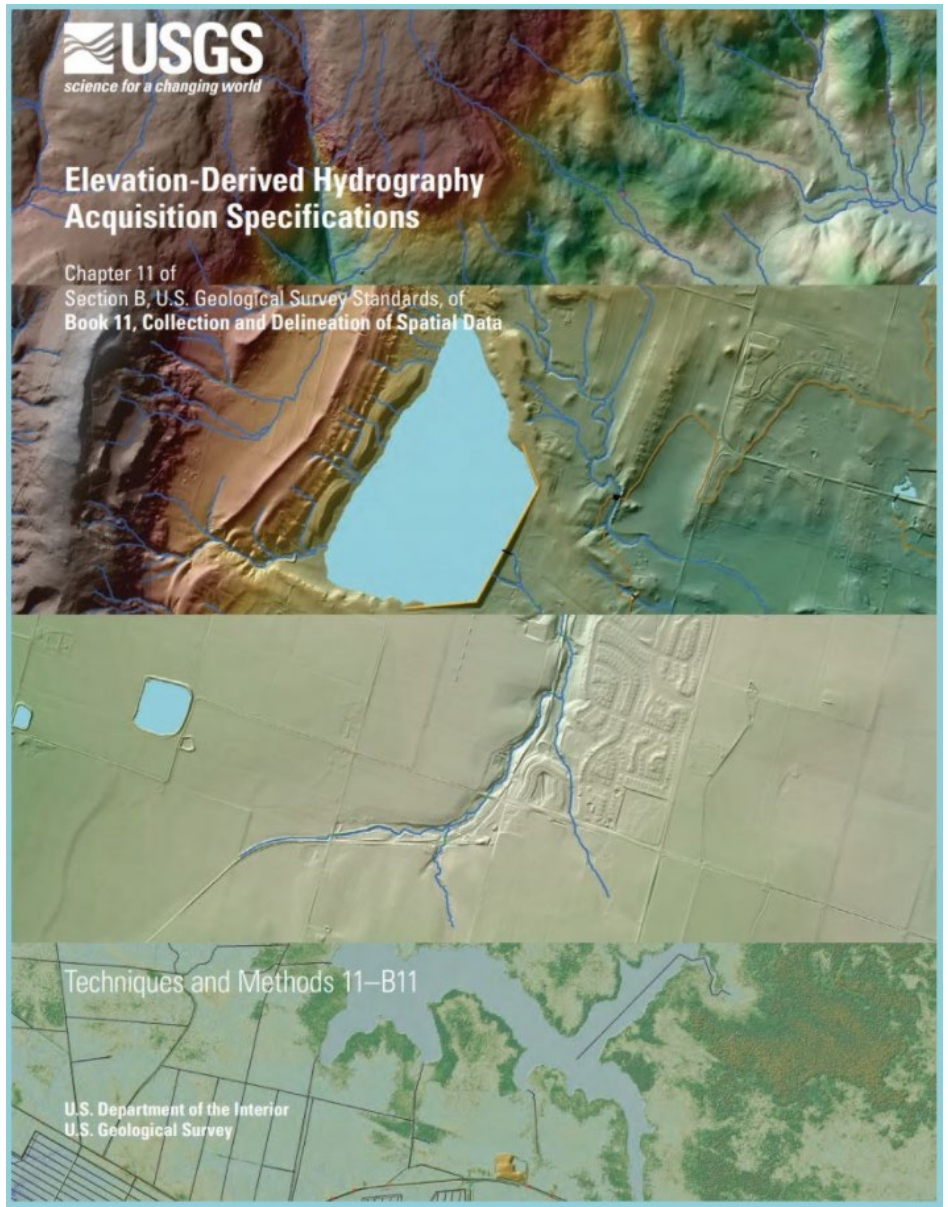
Initial 3DHP pilot projects

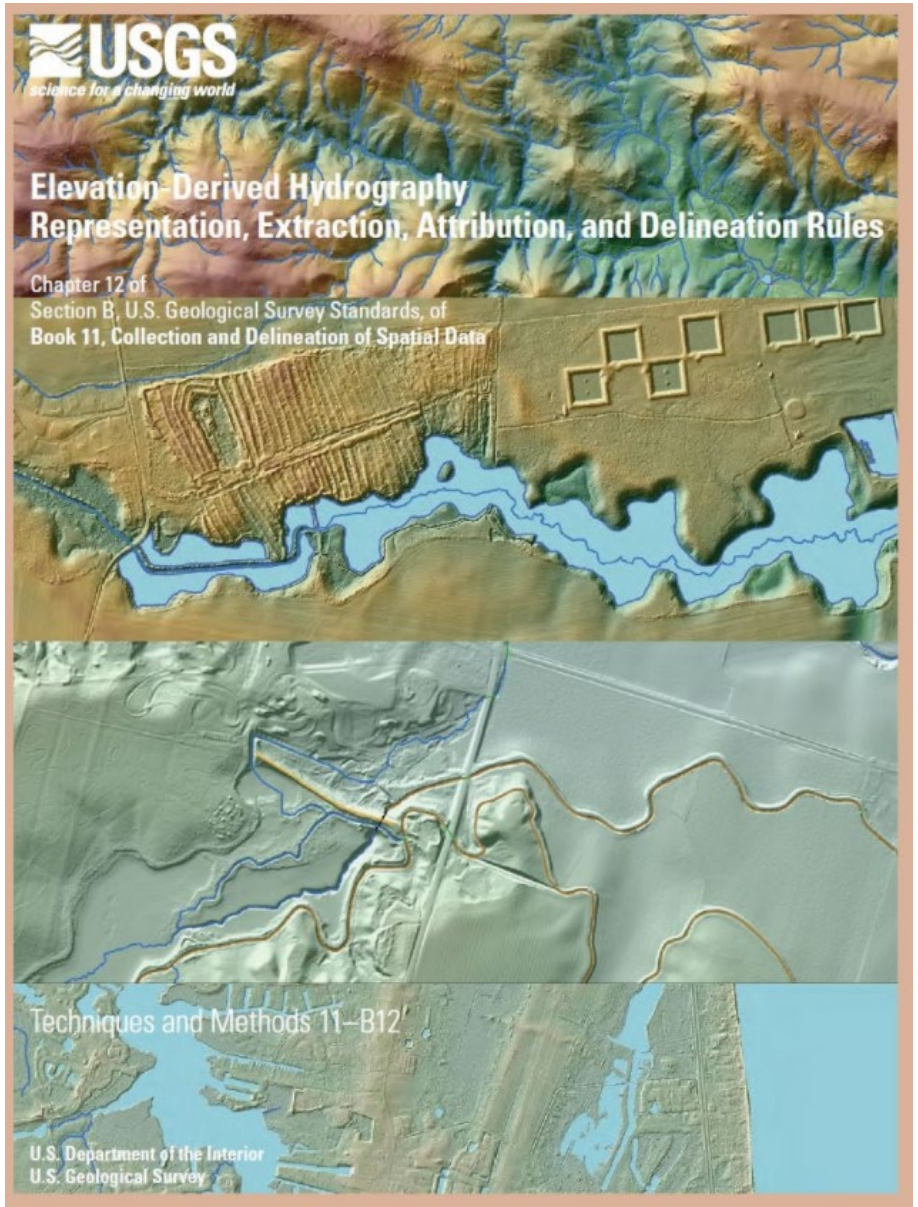
Alaska pilot projects





Publication of Specifications and READ (representation, extraction, attribution, and delineation) Rules





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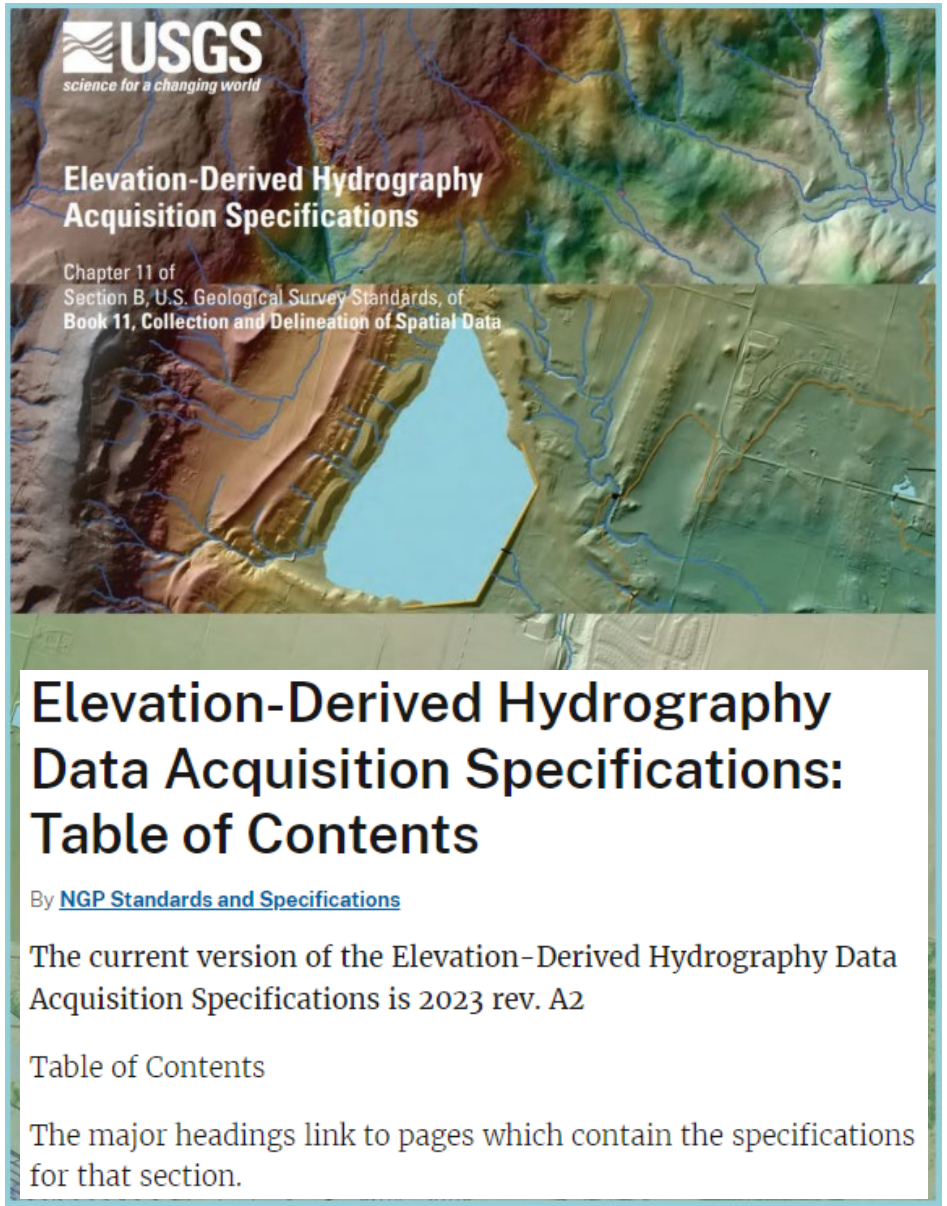
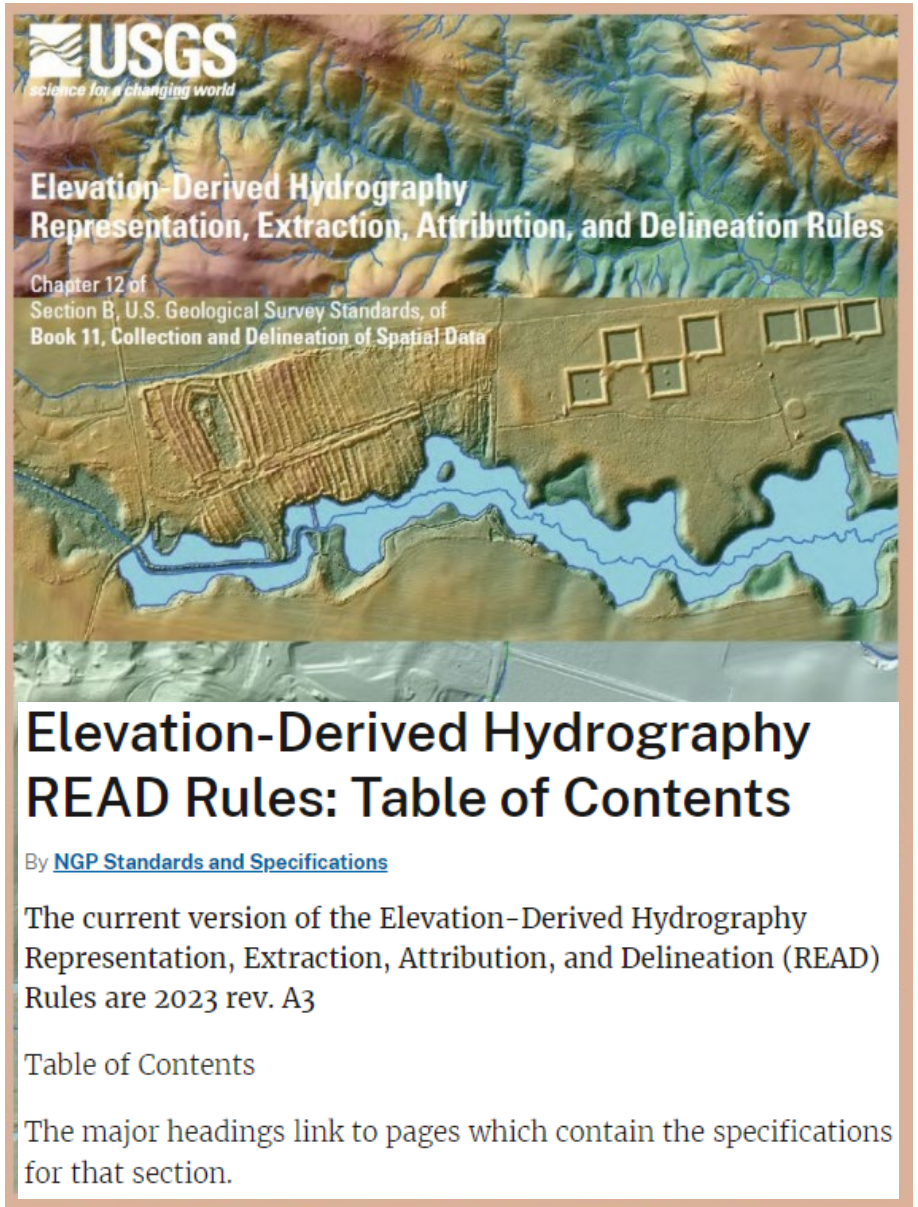
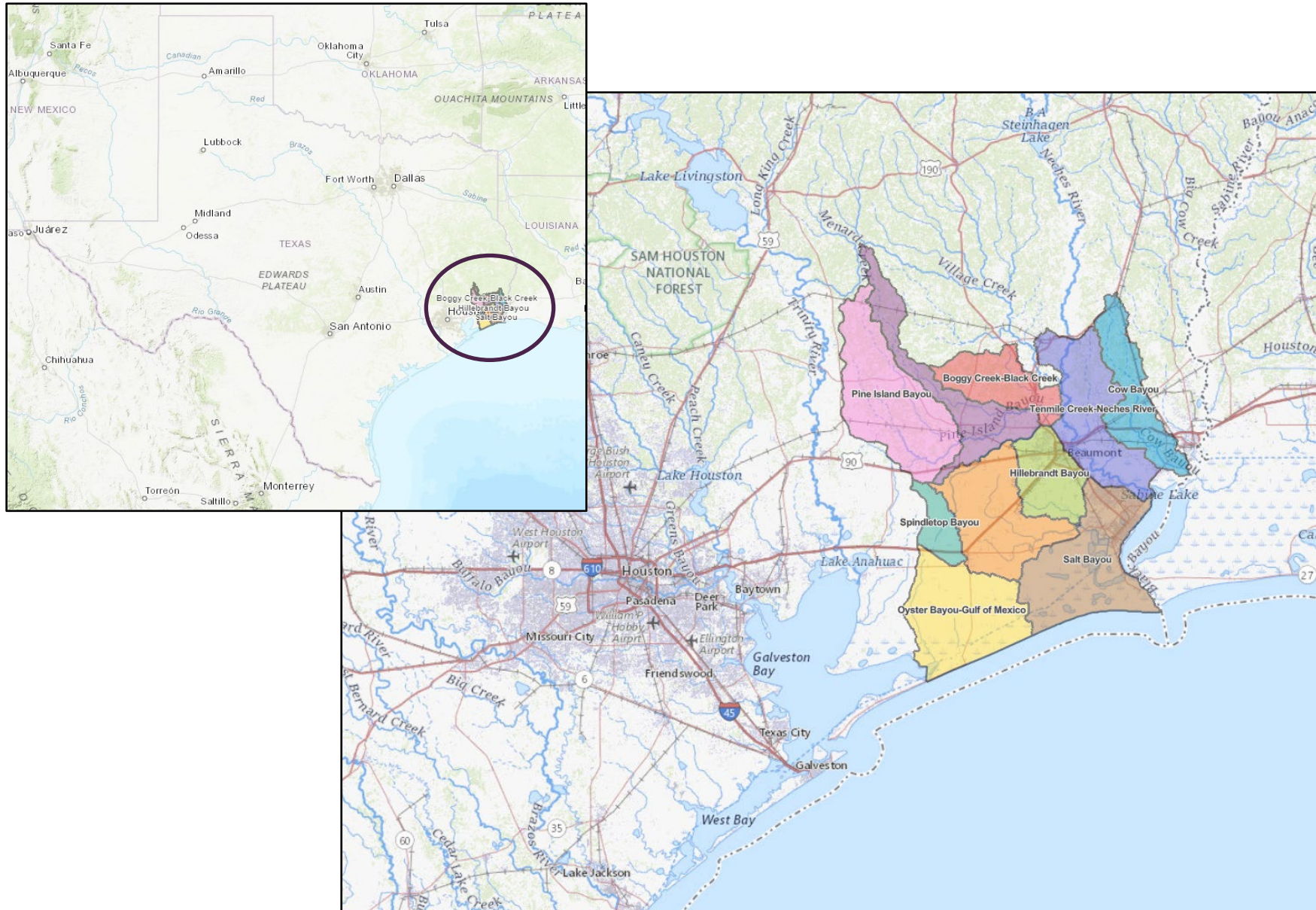




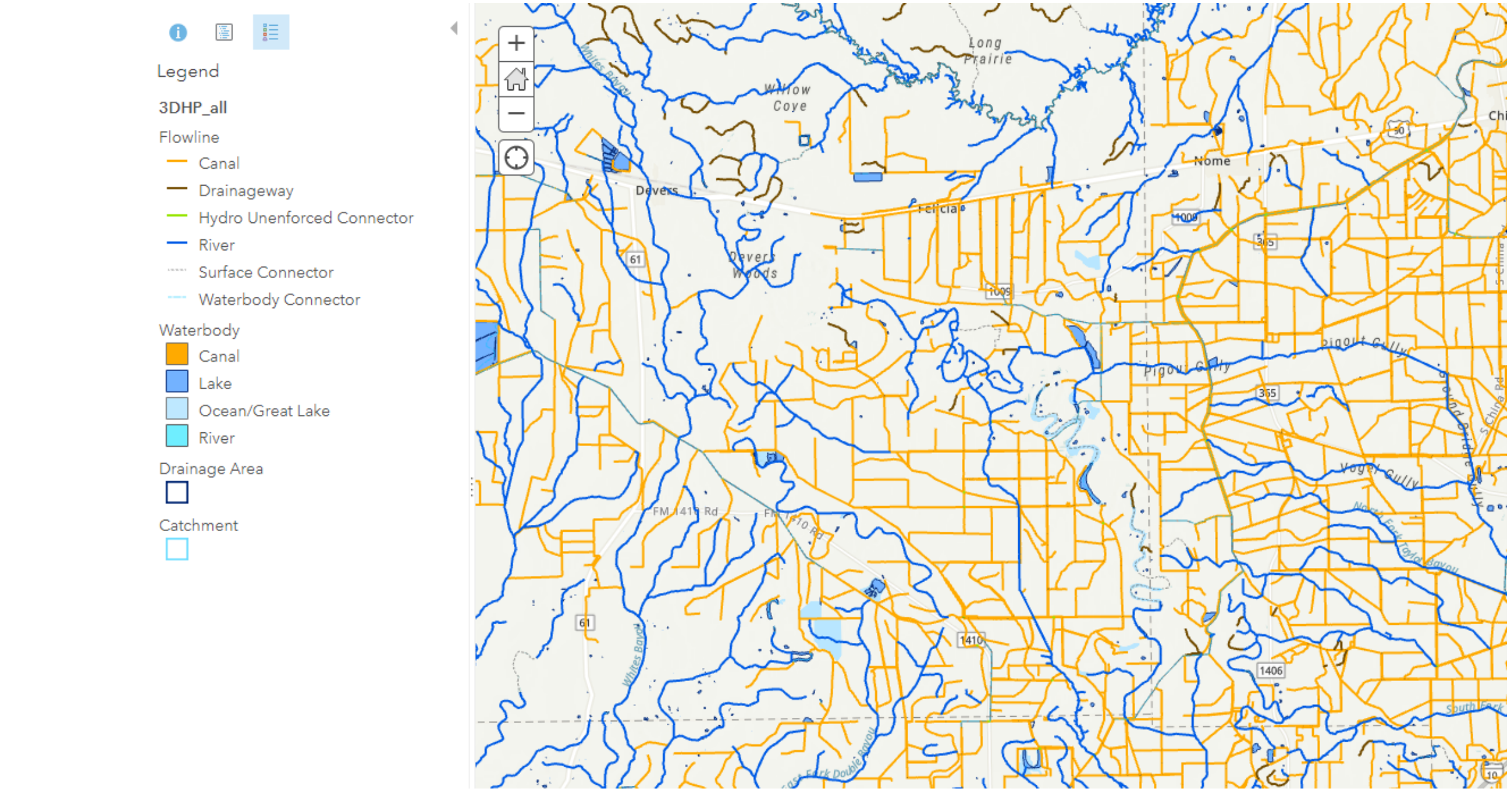
Pilot integration of hydrography and elevation

Southeast Texas pilot project – first CONUS pilot project

- Ten 10-digit hydrologic units (HU10s)
- Hydrologic units are basically watersheds – the smaller the number, the larger the watershed



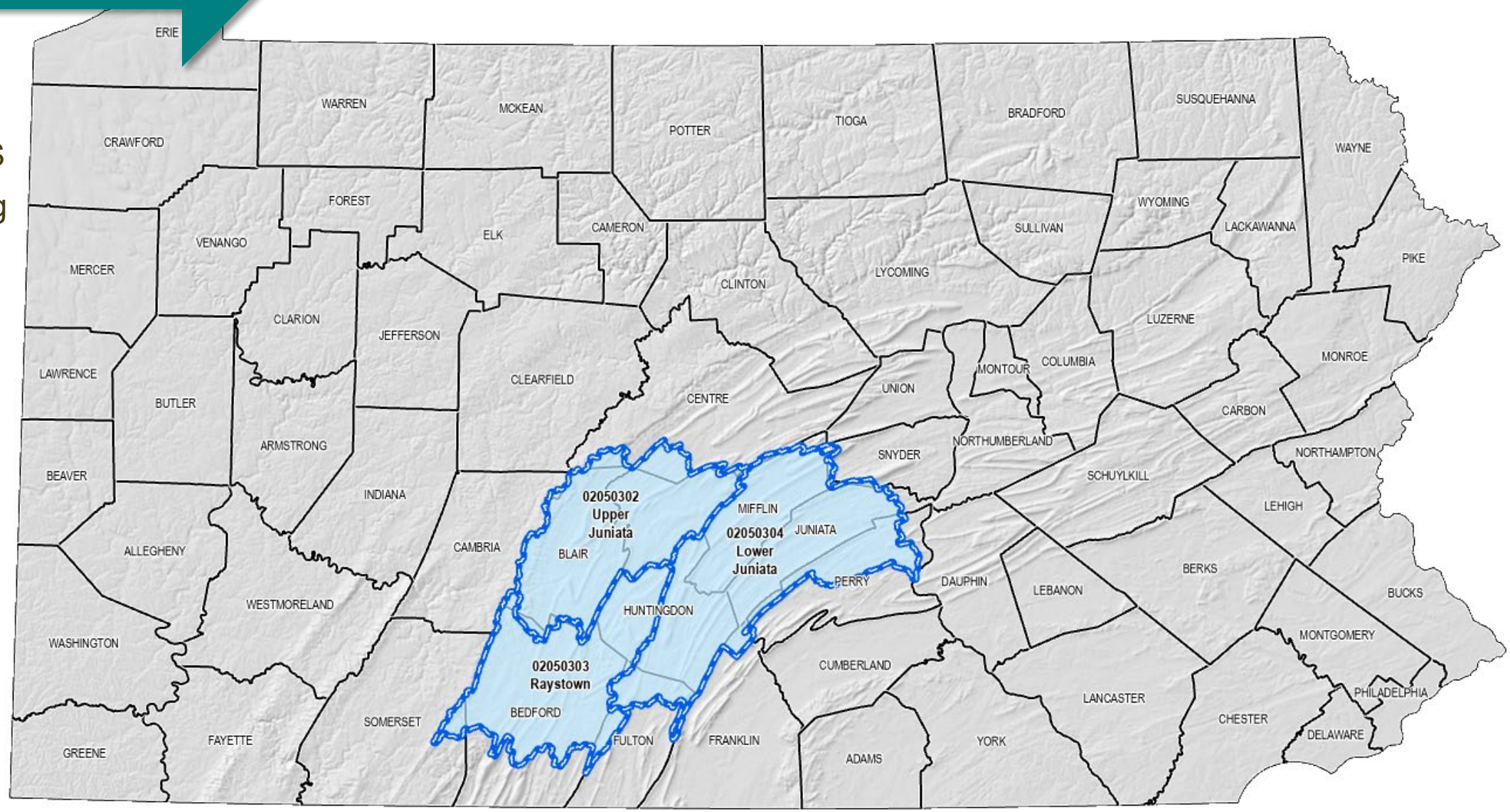
Southeast Texas pilot project



Pilot integration of hydrography and elevation

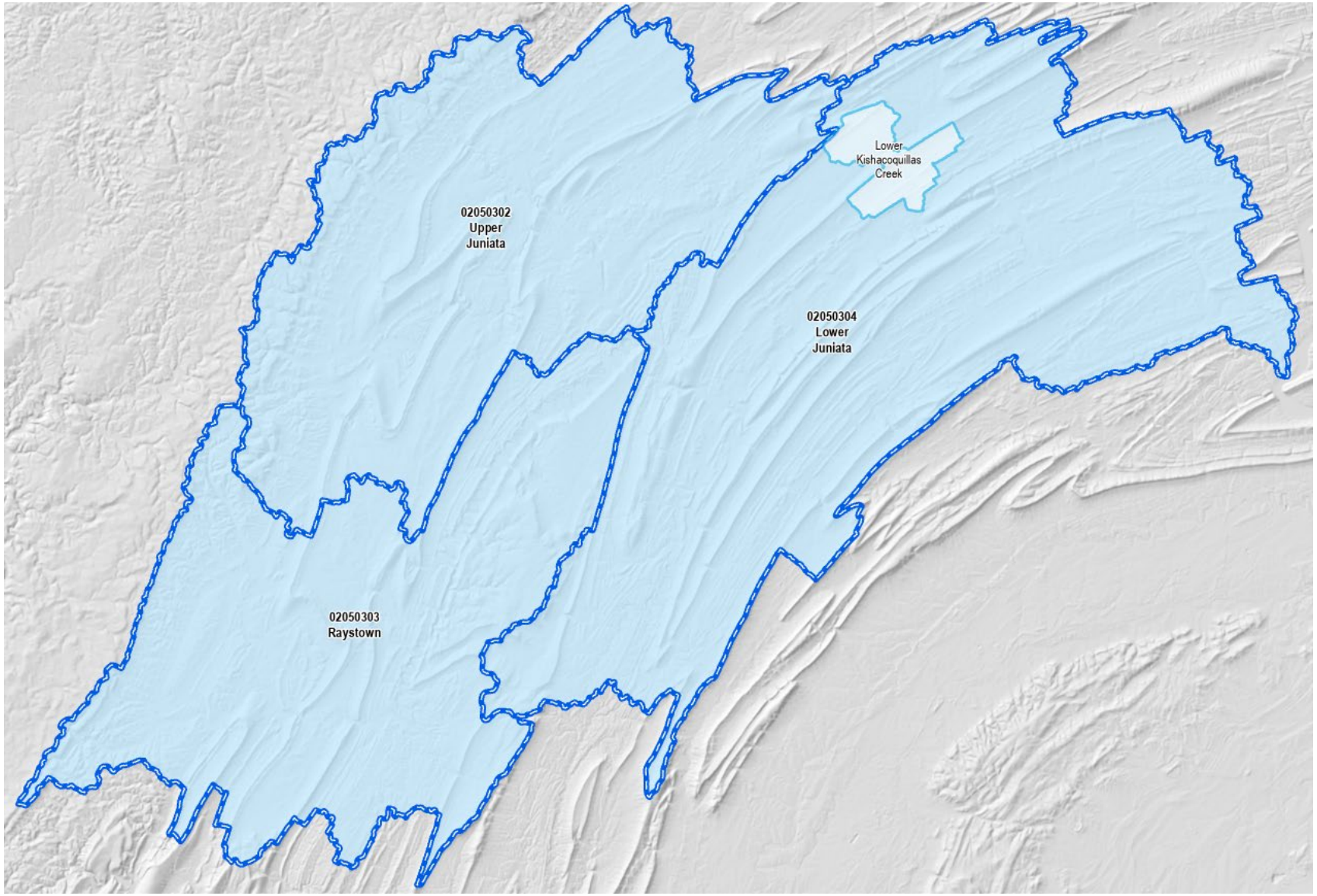
Raystown PA pilot project – second CONUS pilot project

- Second pilot project in CONUS
- PA NRCS funding partner
- Three 8-digit hydrologic units (HU8s)



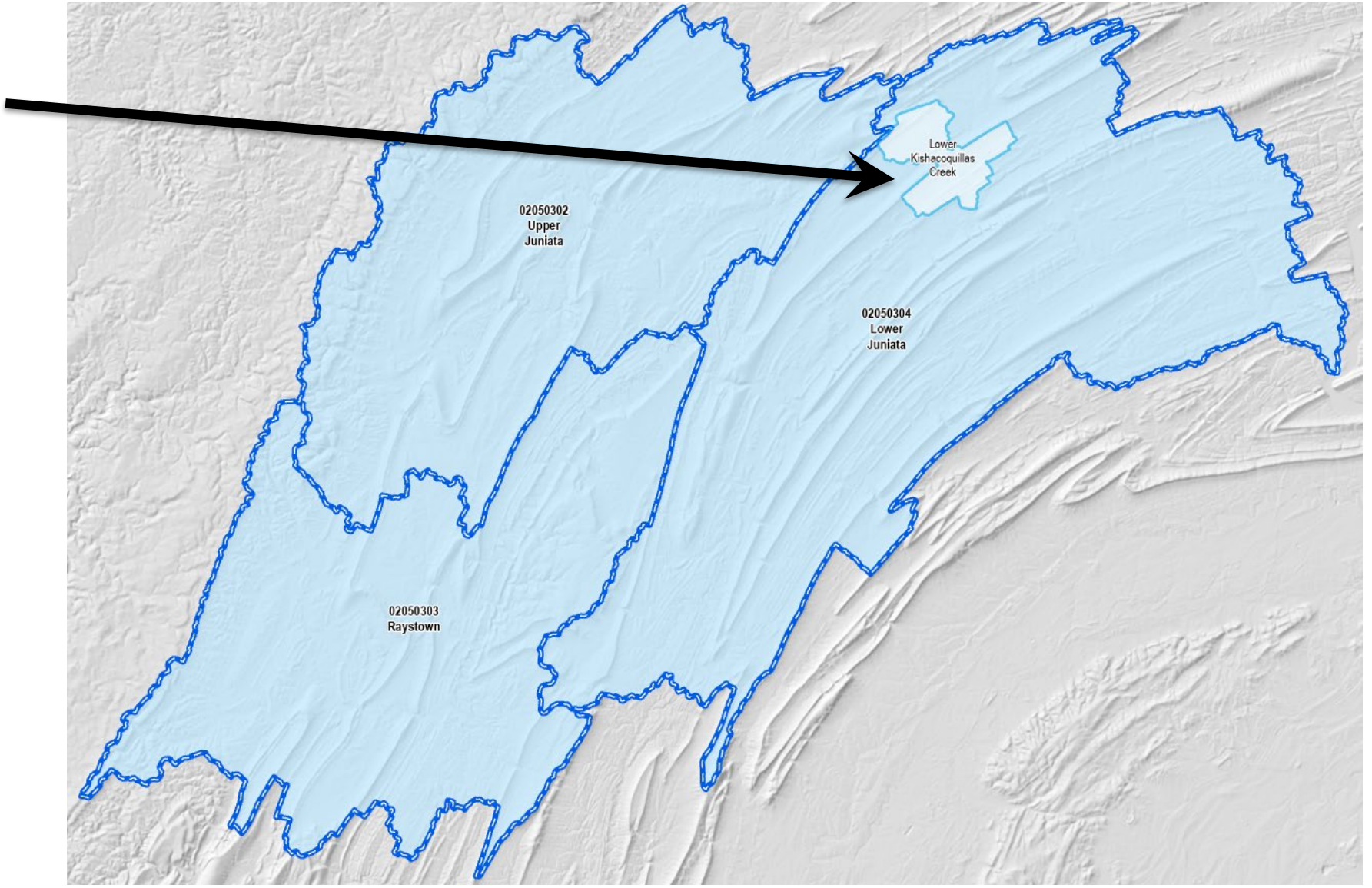
Raystown PA pilot project

- Kick-off meeting – July 2021



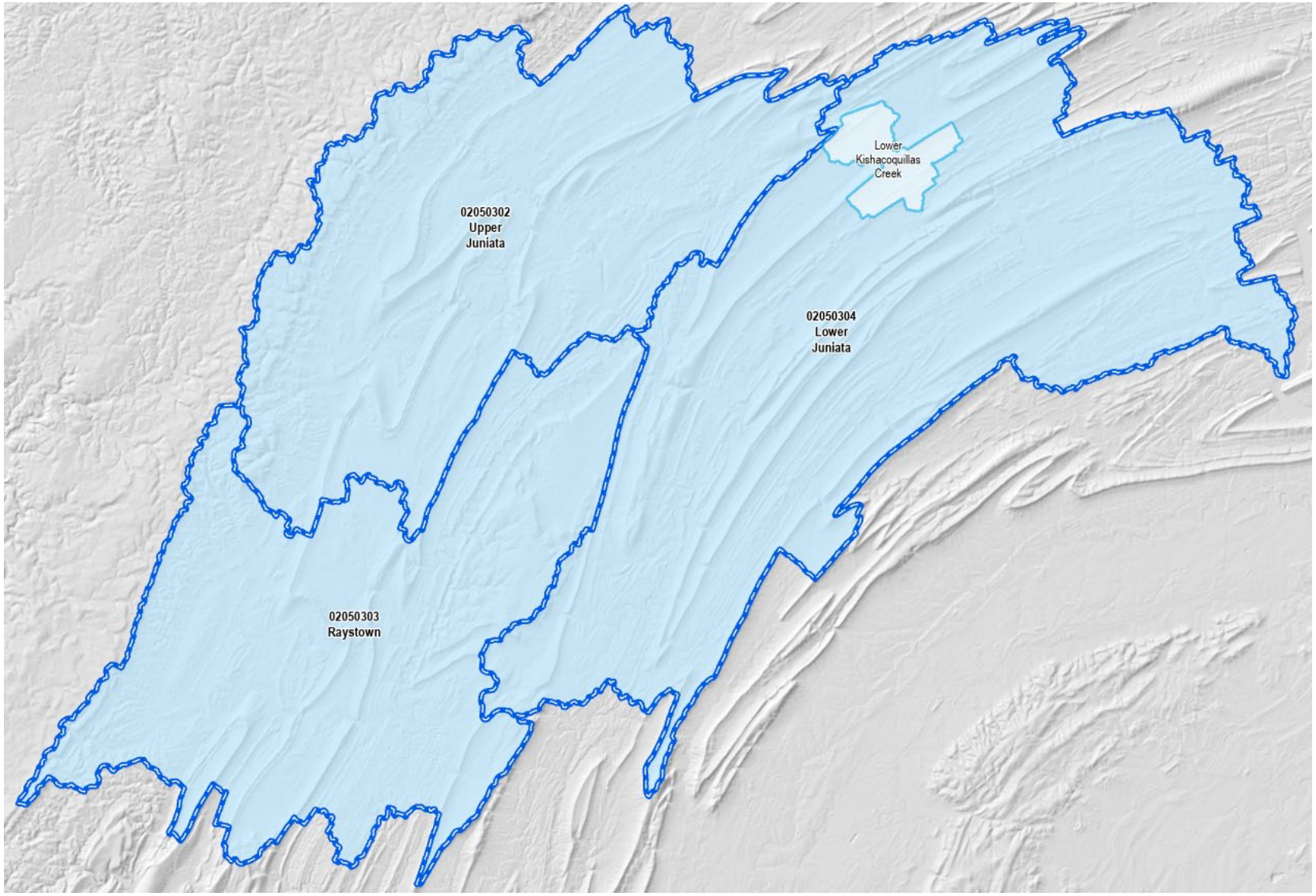
Raystown PA pilot project

- Kick-off meeting – July 2021
- Contractor delineates a sample dataset (HU12 in white on map)



Raystown PA pilot project

- Kick-off meeting – July 2021
- Contractor delineates a sample dataset (HU12 in white on map)
- USGS reviews the sample data and provides formal feedback



Raystown PA pilot project

- Kick-off meeting – July 2021
- Contractor delineates a sample dataset (HU12 in white on map)
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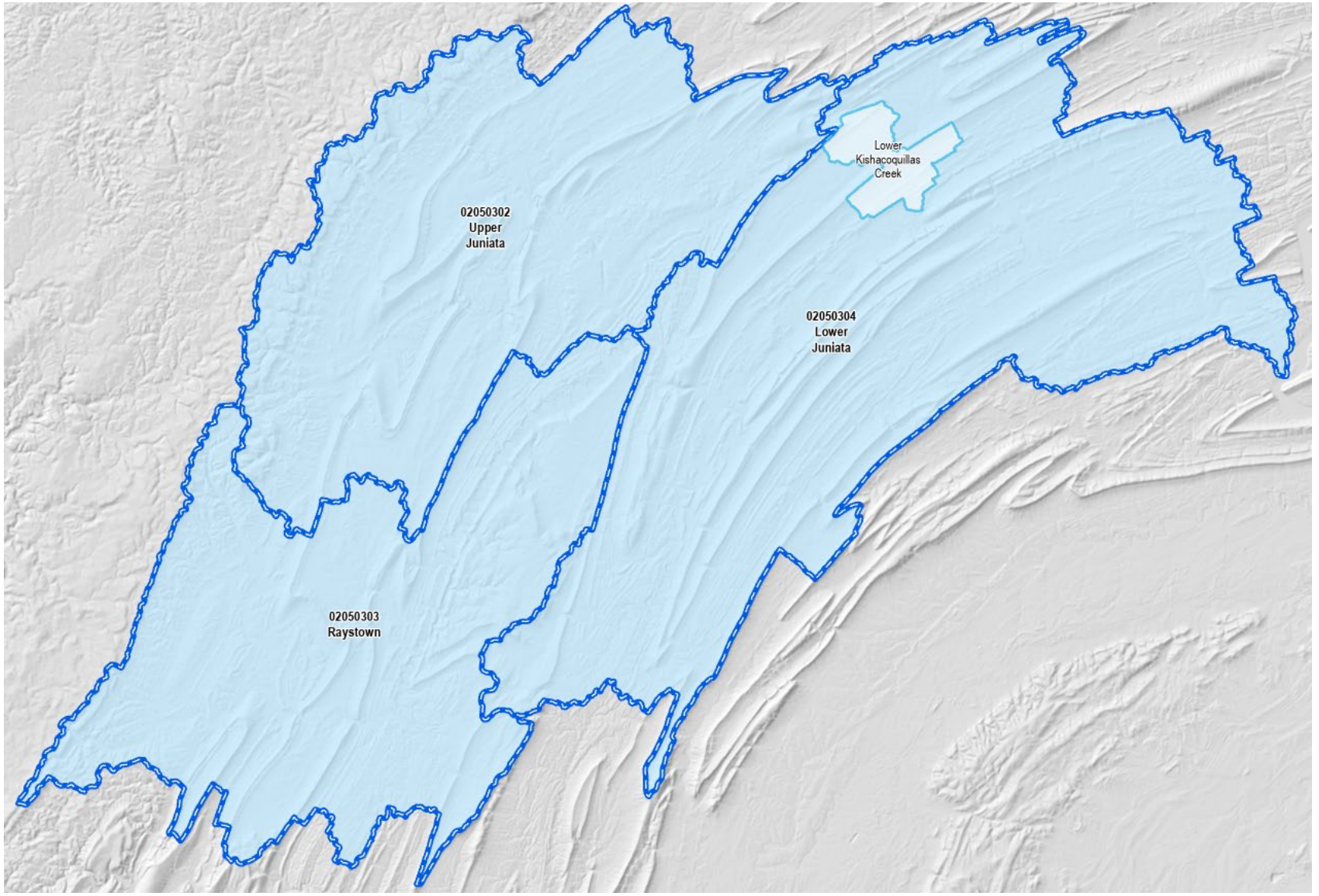
- Contractor uses the feedback to make corrections and works on the remaining project area by HU8



Raystown PA pilot project

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- Contractor delineates a sample dataset (HU12 in white on map)
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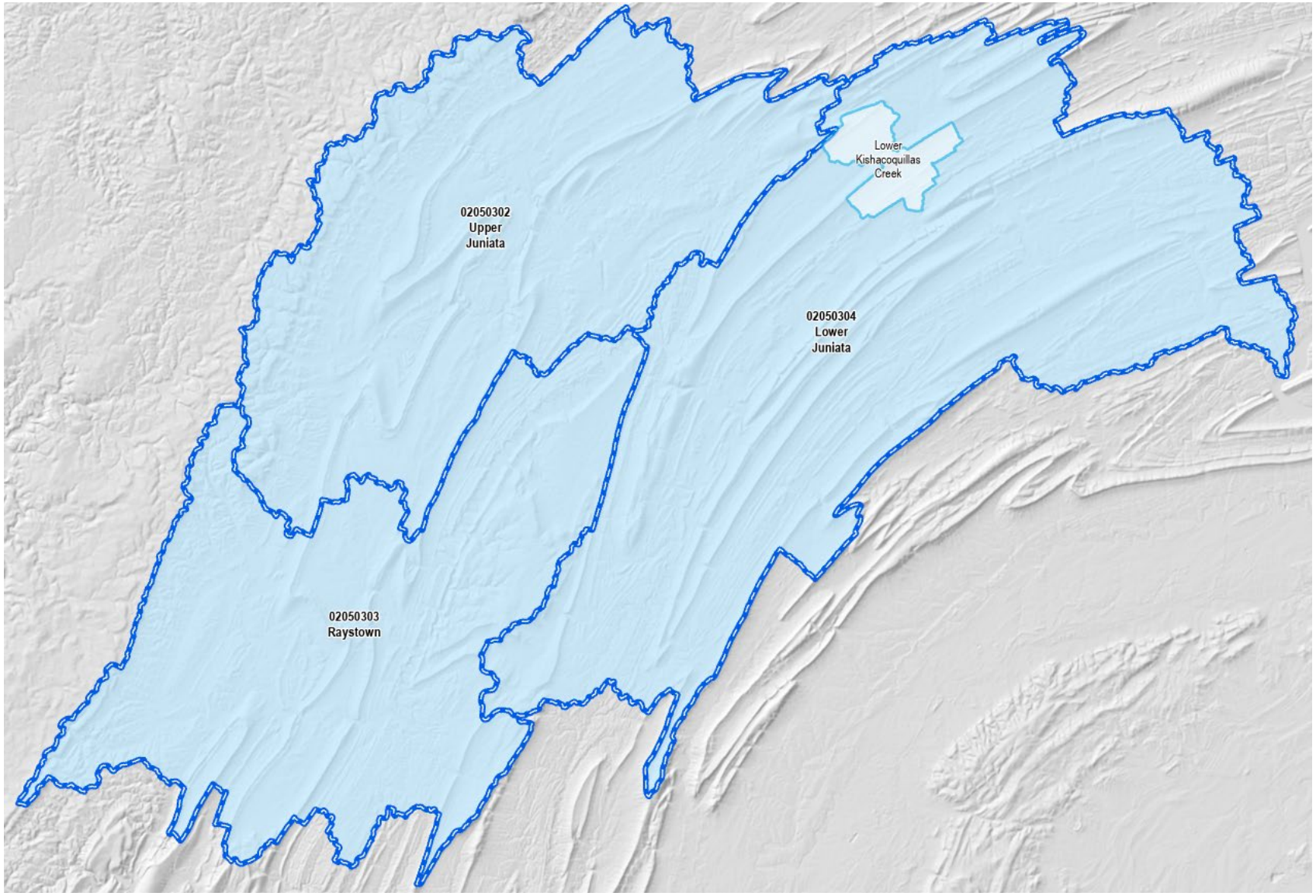
- Remaining process involves a back-and-forth review/correction interaction between the contractor and USGS
  - Contractor delivers data by HU8
  - USGS inspects data deliveries and provides feedback in the form of a report
  - This process keeps going until the data meet USGS specs



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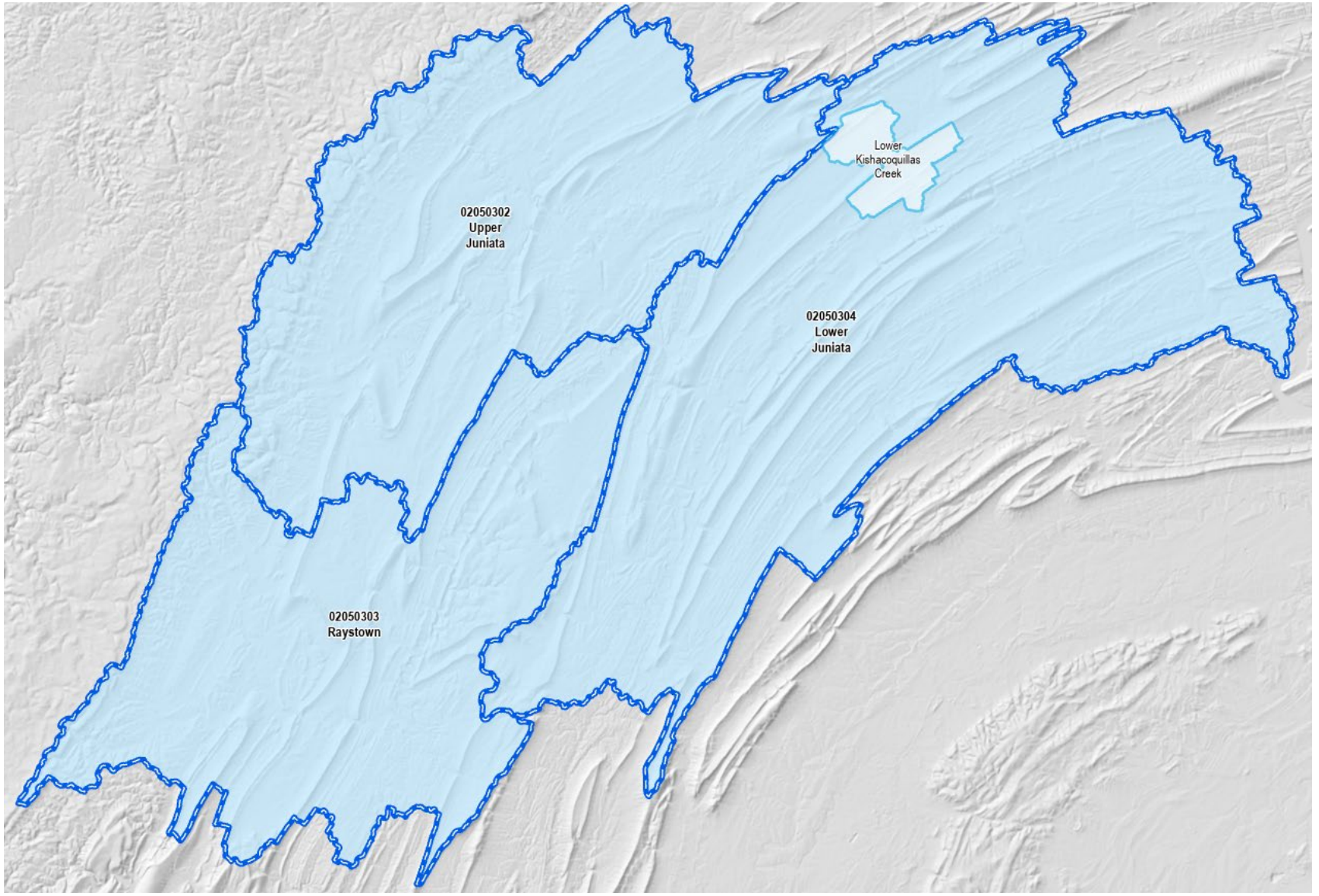
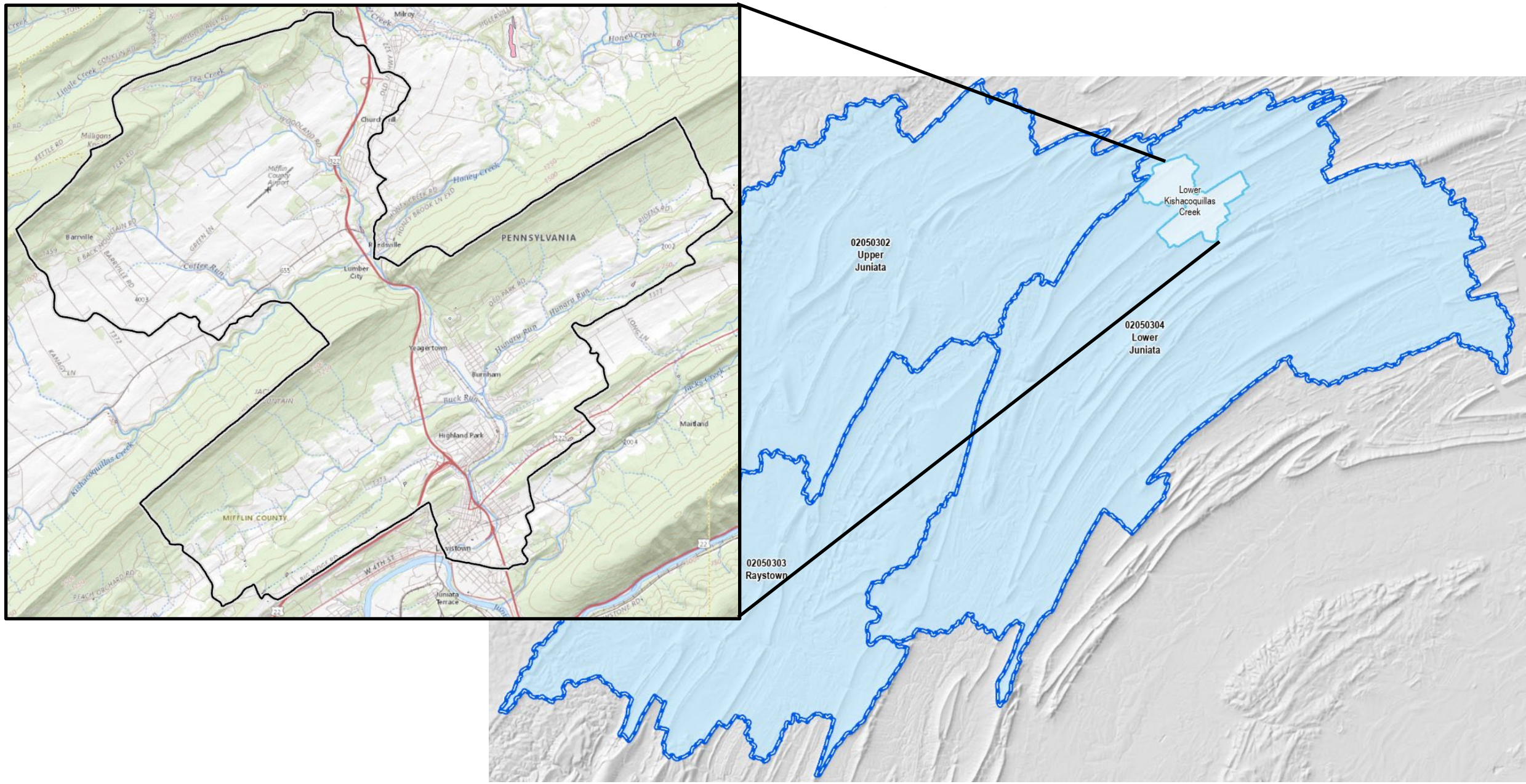
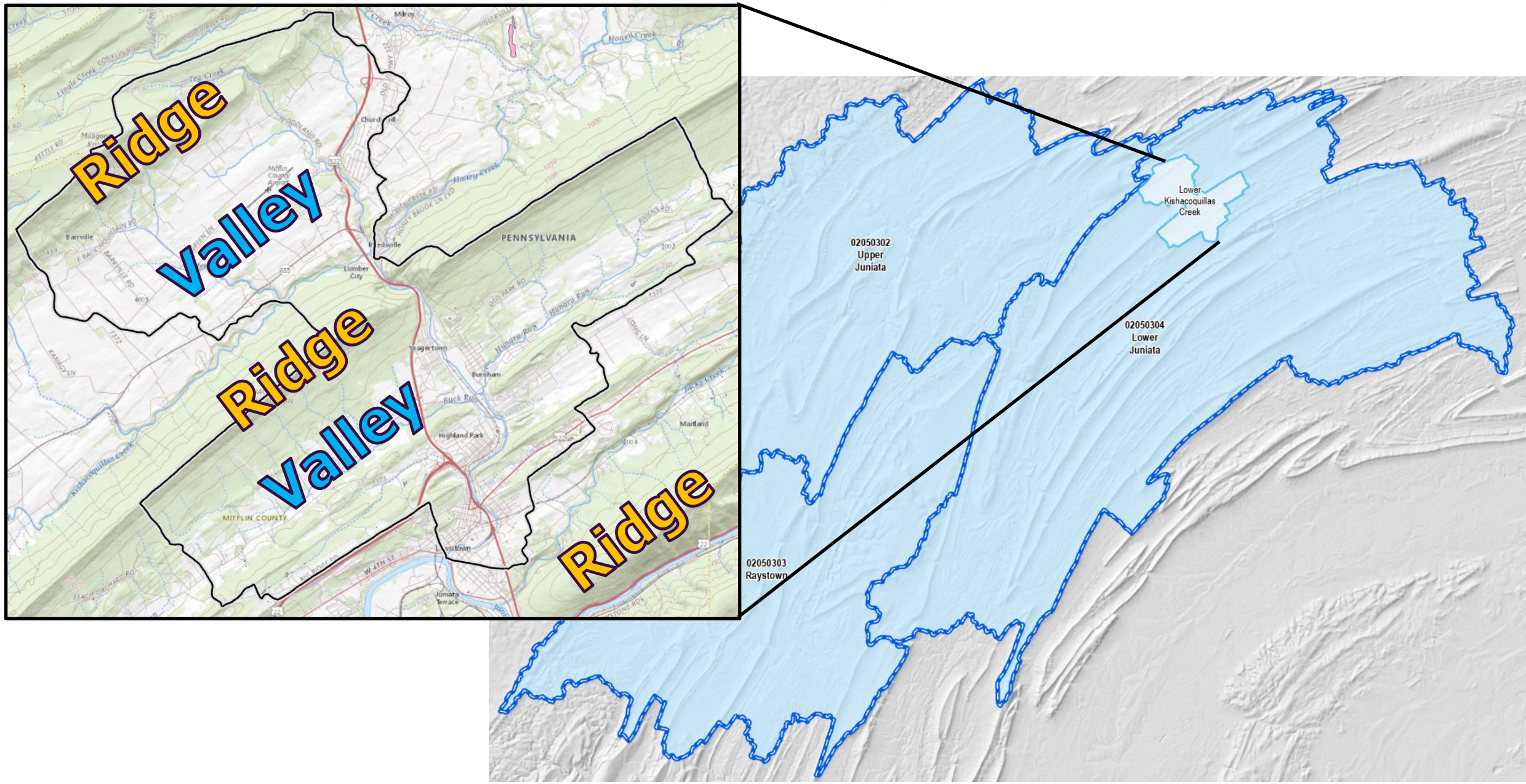
  - USGS inspects data deliveries and provides feedback in the form of a report
  - This process keeps going until the data meet USGS specs
- Data delivered to project partner – **August 2023**



Raystown PA pilot project – Valley and Ridge province



Raystown PA pilot project – Valley and Ridge province



Raystown PA pilot project – Valley and Ridge province

- Sandstone/shale ridges (pink)
- Carbonate valleys (purple)
  - Surface depressions
  - Sinkholes
  - Caves

The most important aquifers in the Valley and Ridge province are northeast- to east-trending carbonate rocks. Undifferentiated sedimentary-rock aquifers that consist mostly of sandstone and yield moderate volumes of water separate the bodies of carbonate rocks. Coal-bearing beds are prominant in parts of Pennsylvania and in a local area of southeast Virginia.

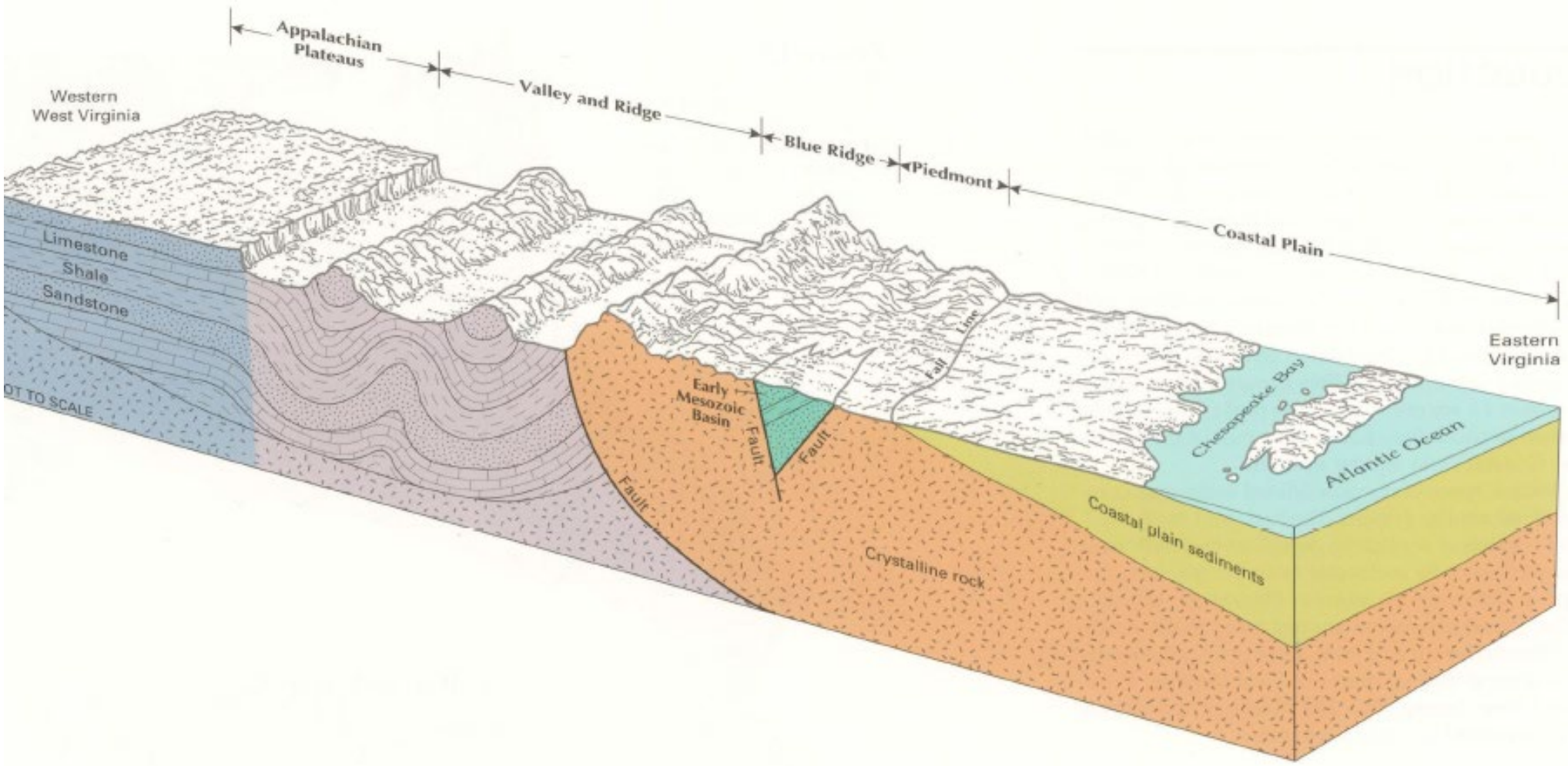
EXPLANATION

Valley and Ridge aquifers

- Carbonate-rock aquifers
- Undifferentiated sedimentary-rock aquifers

Raystown PA pilot project – Valley and Ridge province

- Sandstone/shale ridges (dots/dahes)
- Carbonate valleys (blocks)
  - Surface depressions
  - Sinkholes
  - Caves



Raystown PA pilot project – Valley and Ridge province

- Sandstone/shale ridges (pink)
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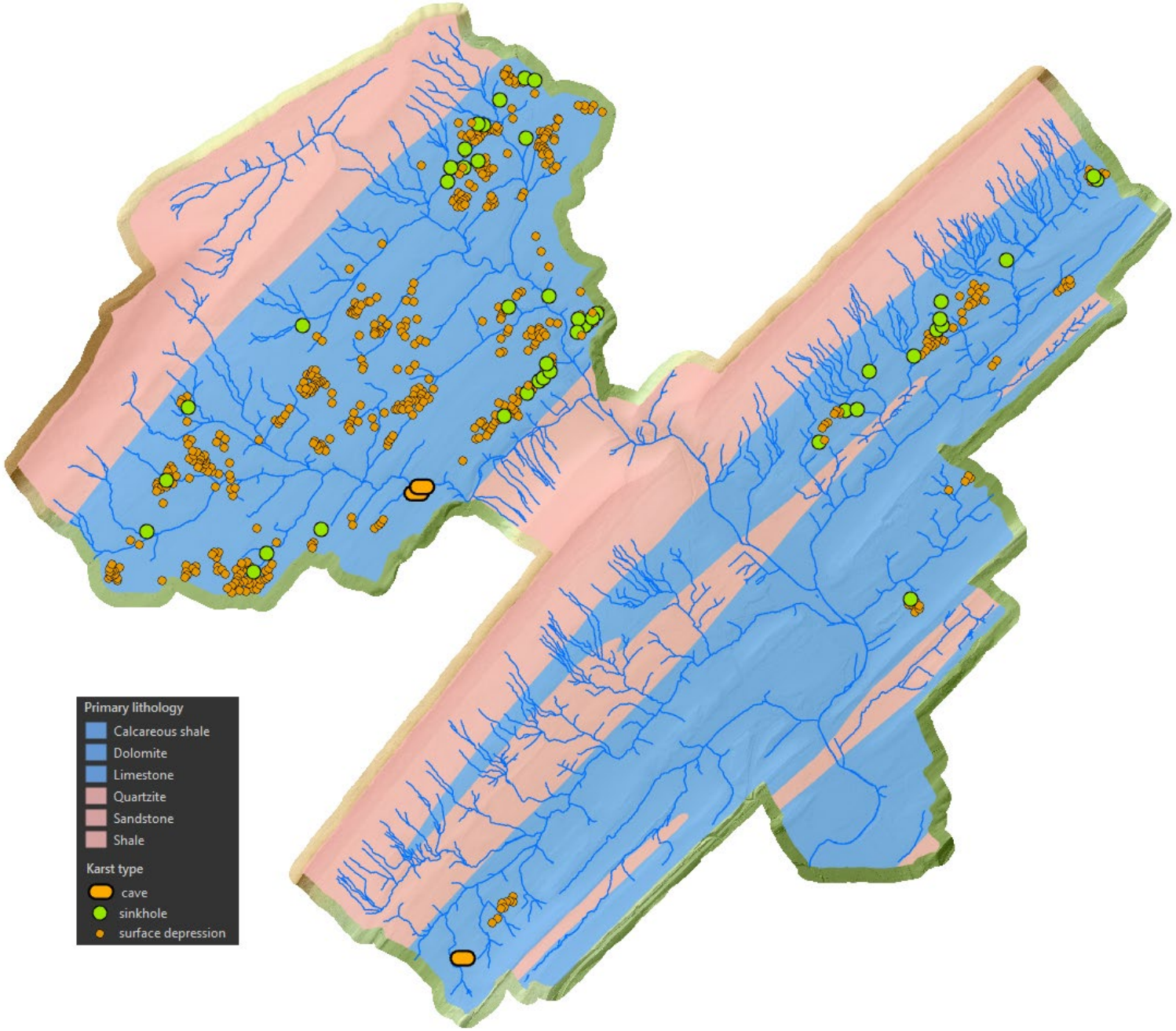
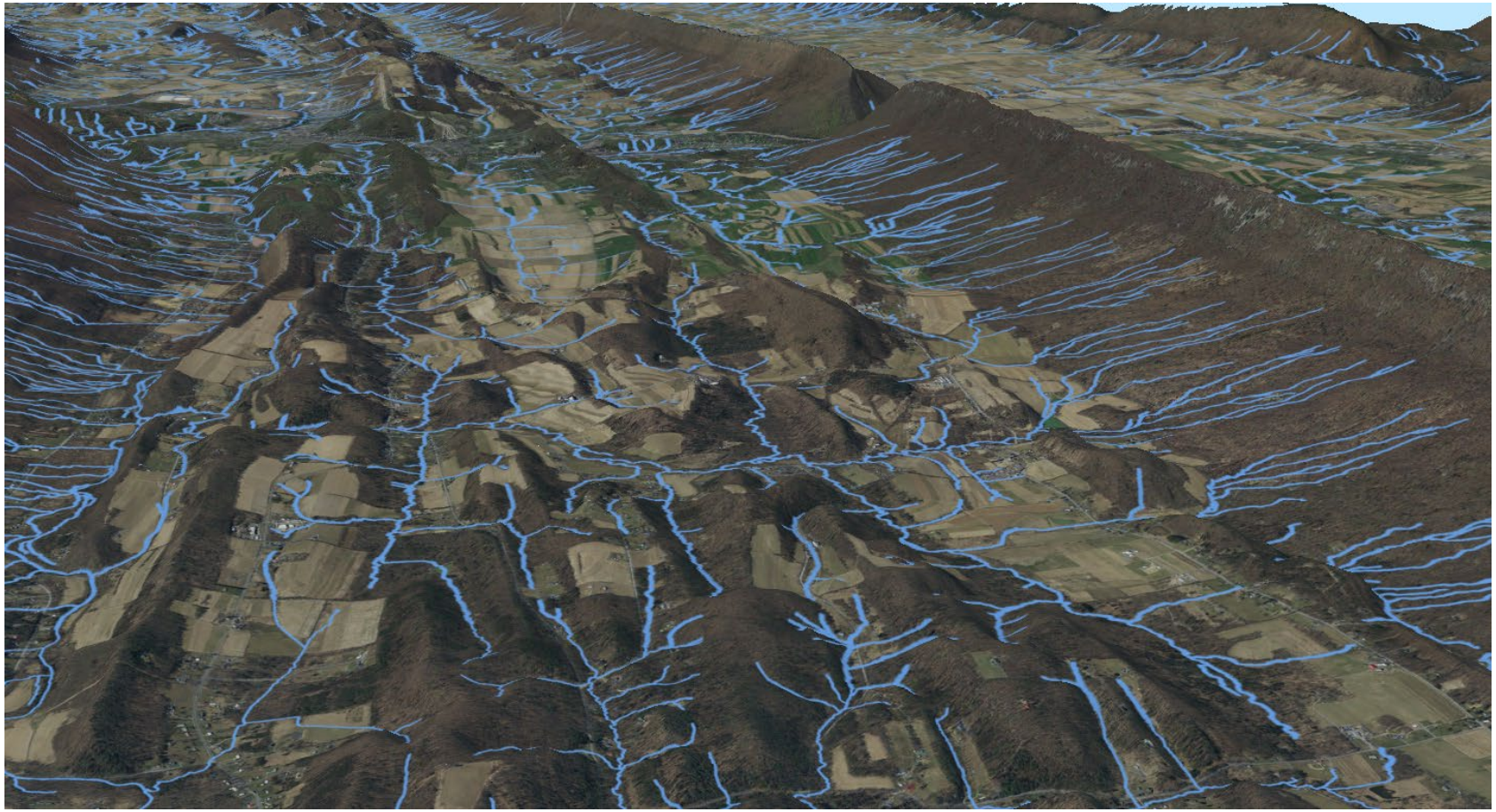


3D Hydrography Program Benefits

- accurate alignment of surface water features with 3DEP data
- uniform updates
- simplified data model
- national consistency of data quality and interoperability with NOAA-NWM and Canada
- better accounting of the hydrologic cycle through connections to groundwater, US FWS National Wetlands Inventory, and engineered hydrography
- will support and provide the geospatial underpinning for the Internet of Water



3DNTM Development Tracks

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Design and implement next generation of integrated data

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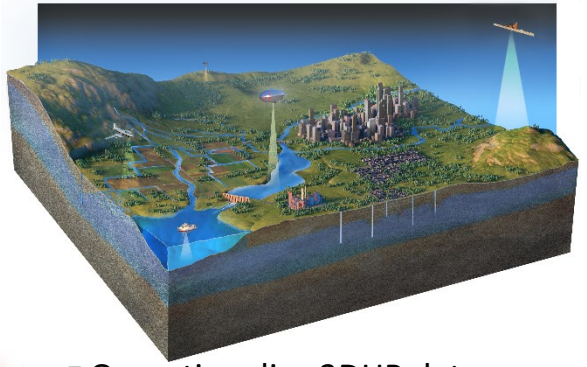
USGS science for a changing world

3DNTM Call for Action Part 1: 3D Hydrography Program

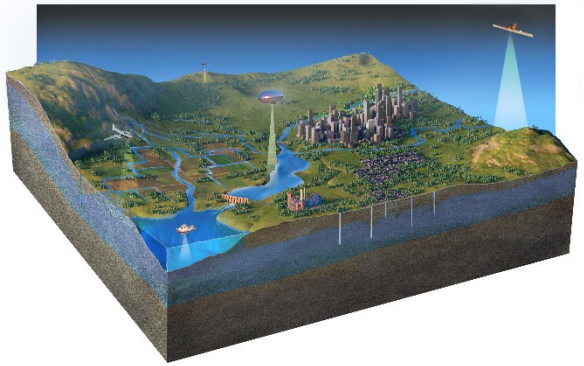


- Operationalize 3DHP data derived from elevation
- Connections to groundwater, engineered hydrography, wetlands
- 3DHP Infostructure

Will be published soon as a fact sheet

USGS science for a changing world

3DNTM Call for Action Part 2: Next Generation of the 3DEP



- Elevation data collected at new quality levels and frequencies
- Operationalize inland bathymetry
- Enable monitoring and change detection

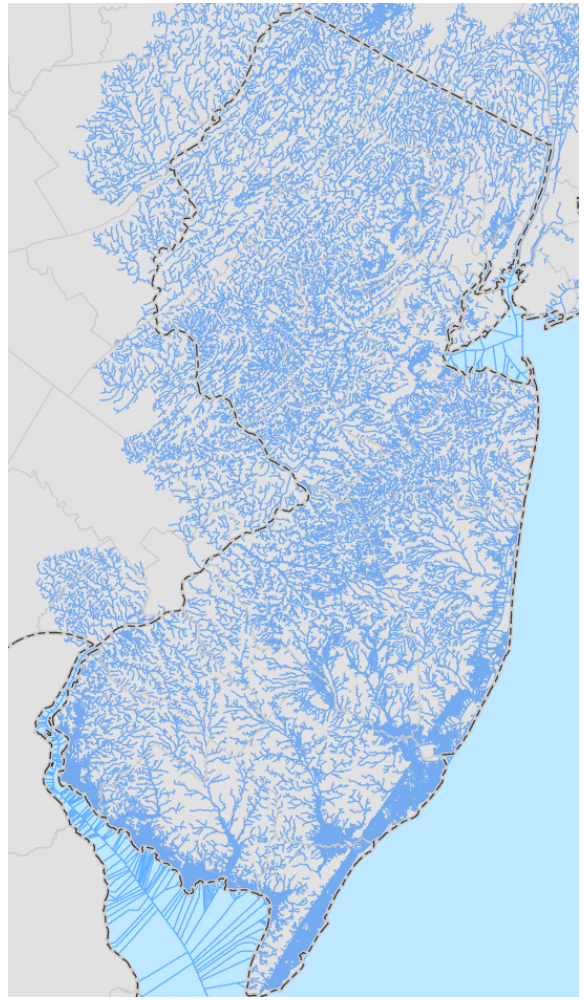
Fact sheet review in progress

Design and implement next generation of integrated data

Transitioning from NHDPlus HR to the 3D Hydrography Program (3DHP)

Retiring the legacy NHD

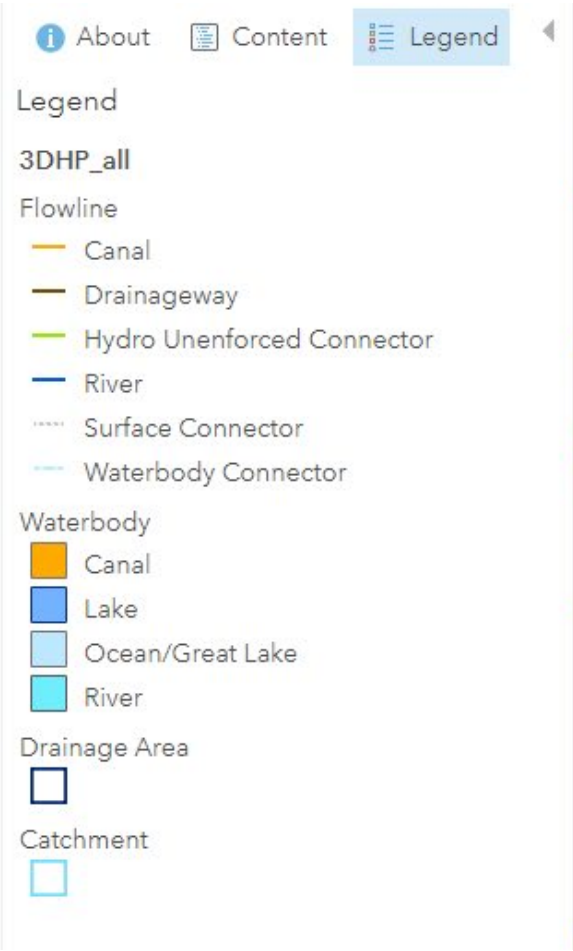
Action
Close Markup submissions
Complete Markups
Close external NHD editing
Publish final NHD
Complete updates to NHDPlus HR
Publish NHDPlus HR (Nat'l V2)
Close external WBD editing
Publish final WBD

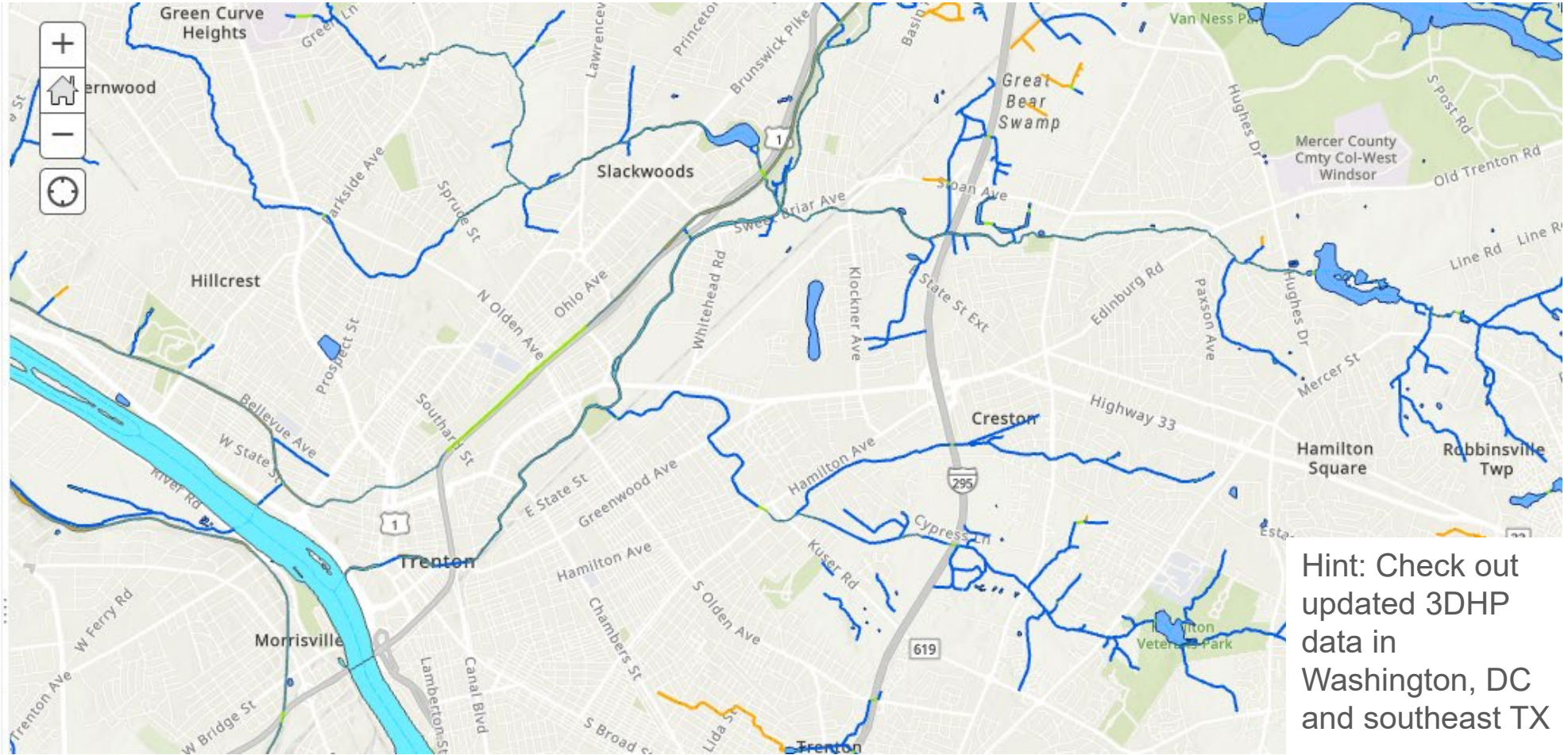


Design and implement next generation of integrated data

Launching the 3DHP Web Service

- https://hydro.nationalmap.gov/arcgis/rest/services/3DHP_all/MapServer
- Displays NHDPlus HR where 3DHP data don't exist yet



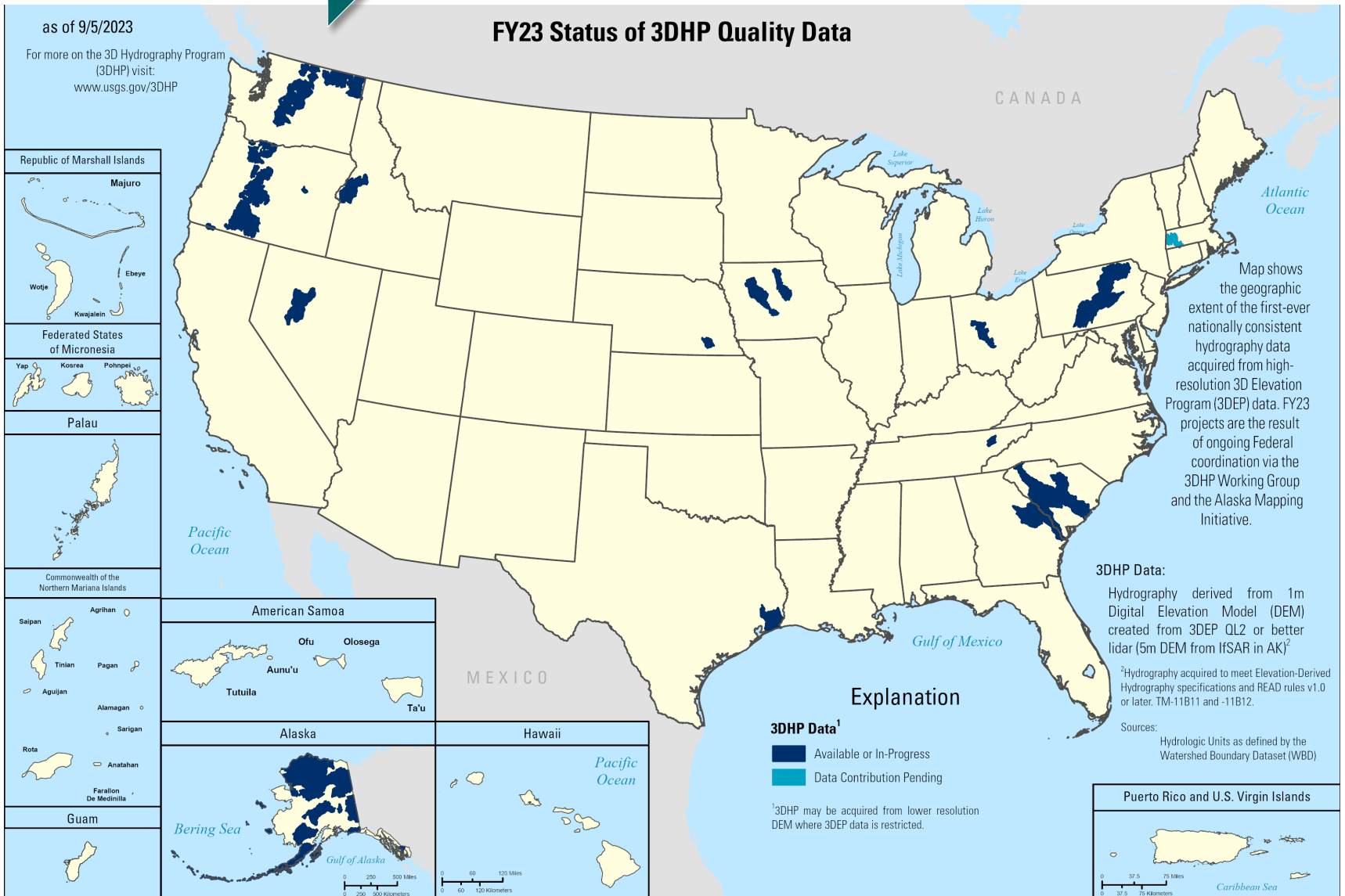


Hint: Check out updated 3DHP data in Washington, DC and southeast TX

Design and implement next generation of integrated data

3D Hydrography Program (3DHP)

Operationalizing deriving hydrography from lidar

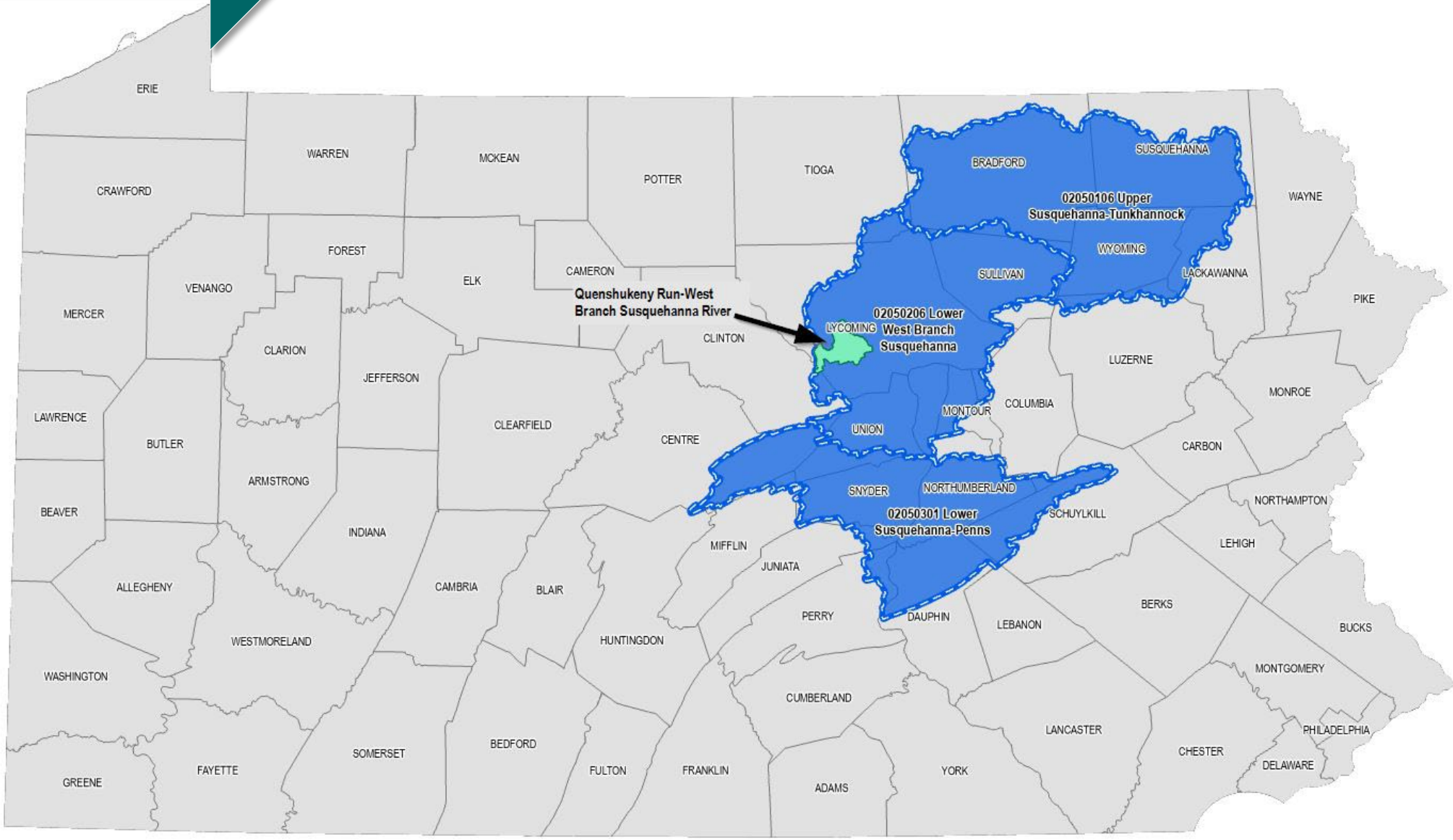


Design and implement next generation of integrated data

3D Hydrography Program (3DHP)

Operationalizing deriving hydrography from lidar

- New project funded by PA NRCS
- Northeast Susquehanna
- 3 HUC8s



Design and implement next generation of integrated data

3D Hydrography Program (3DHP)

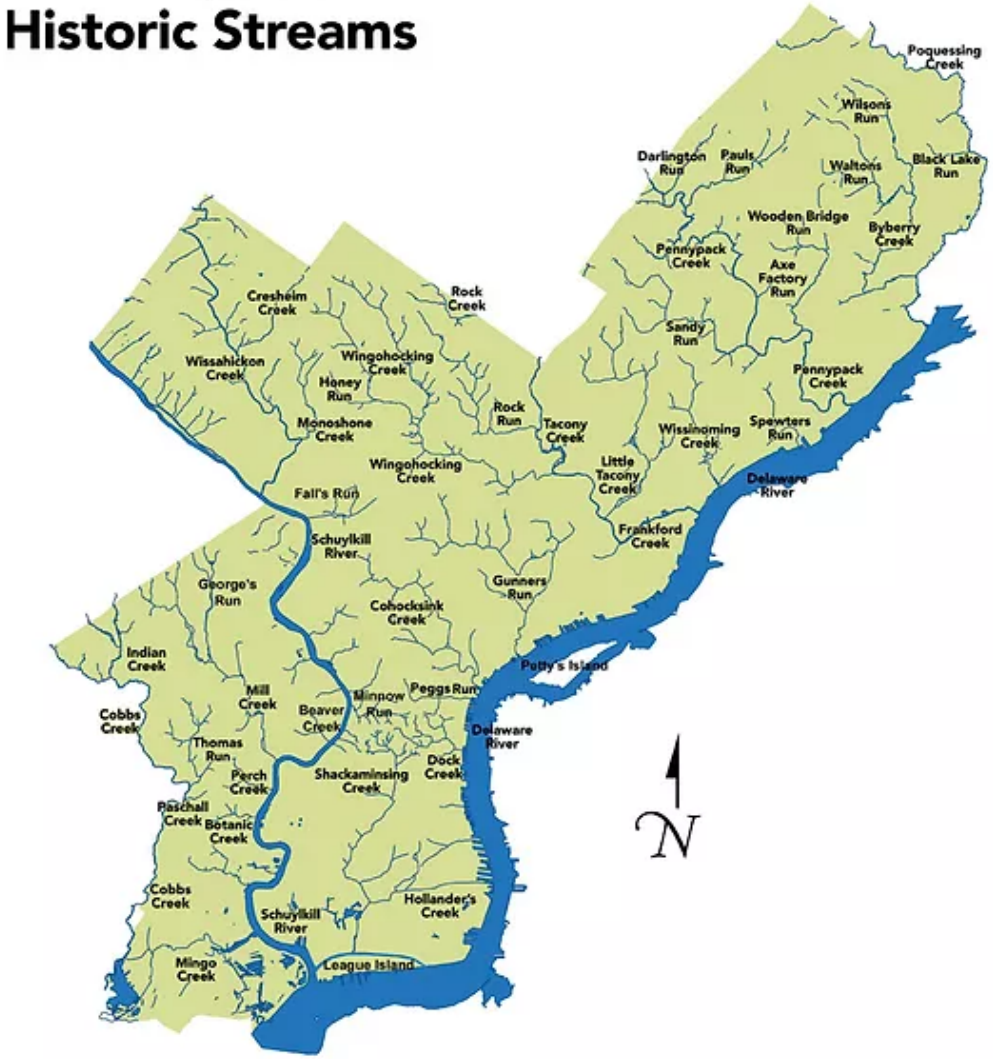
Enable better accounting of the hydrologic cycle by adding engineered hydrologic systems

A look at “hydrographic deserts” in the NHDPlus HR dataset

Design and implement next generation of integrated data

3D Hydrography Program (3DHP)

Enable better accounting of the hydrologic cycle by adding engineered hydrologic systems



http://www.phillyh2o.org/backpages/Maps/A_HistoricStreams.jpg

https://www.inquirer.com/science/climate/delaware-schuylkill-river-combined-sewer-stormwater-sewage-climate-change-20190913.html

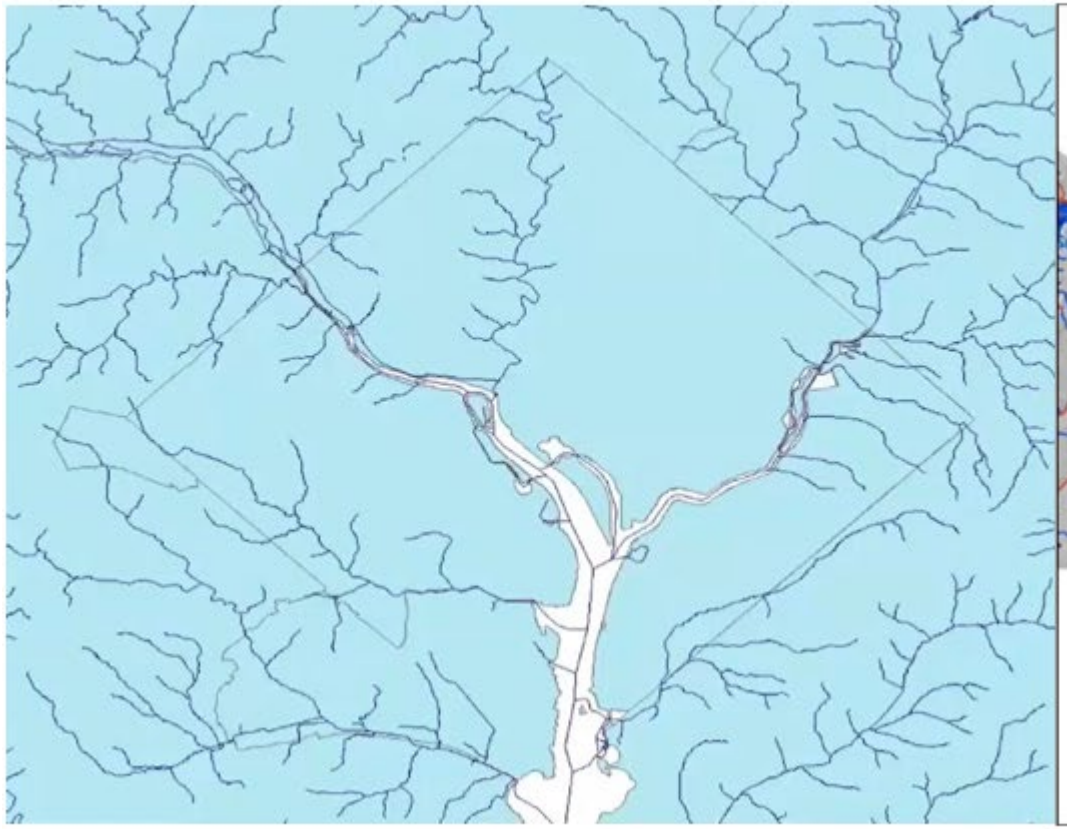
Design and implement next generation of integrated data

3D Hydrography Program (3DHP)

Enable better accounting of the hydrologic cycle by adding engineered hydrologic systems

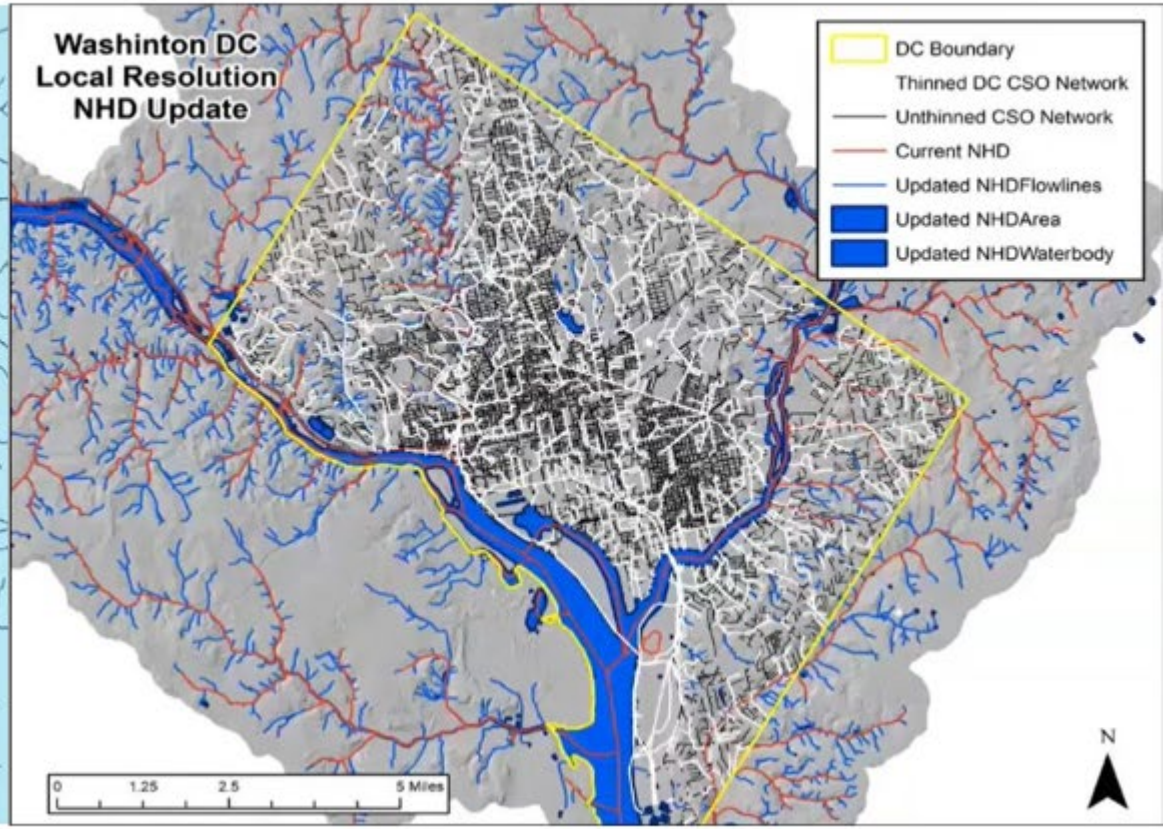
Engineered hydrologic systems in Washington, DC

Before



Urban hydrographic data gap

After

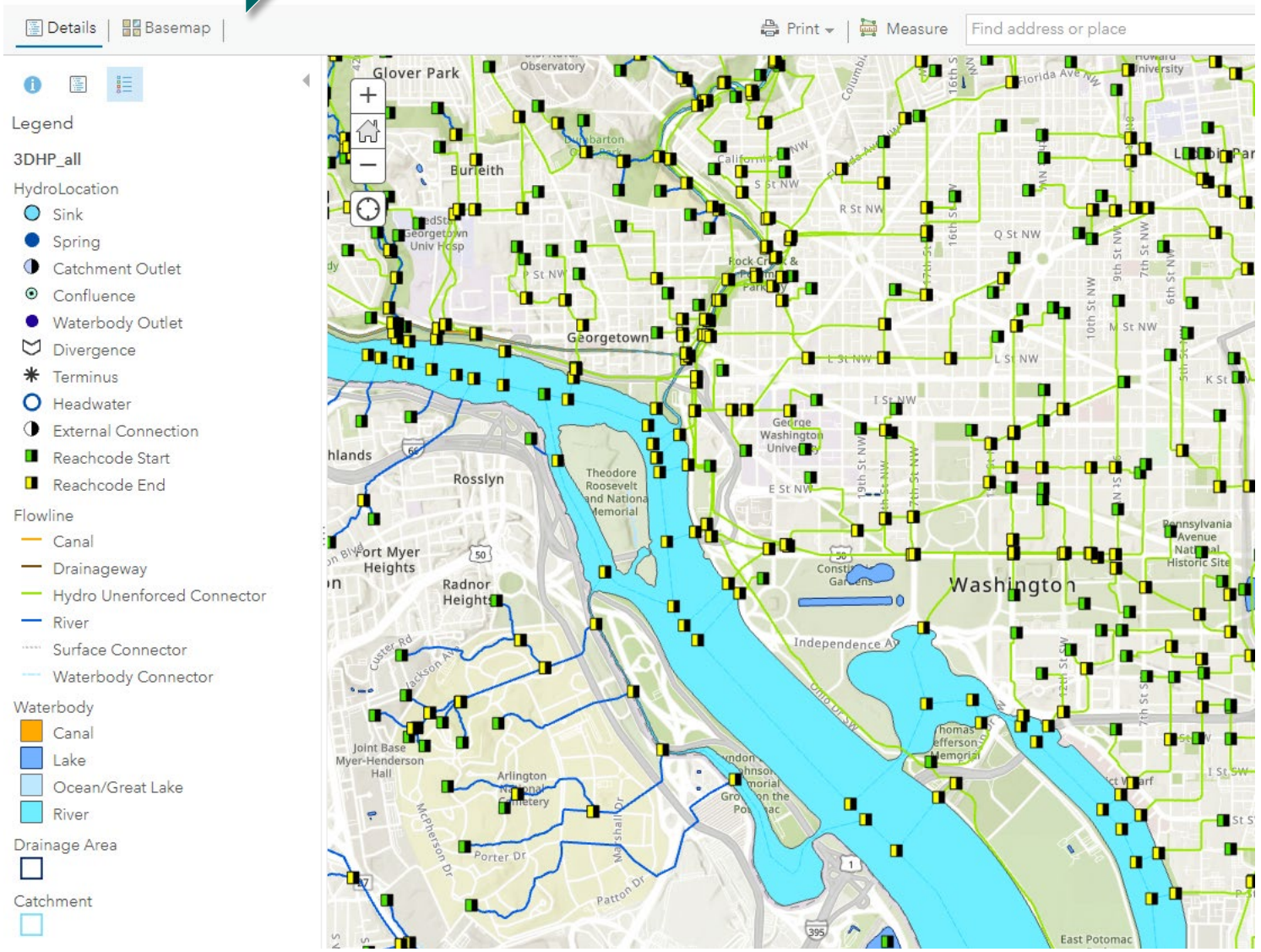


Stormwater drainage infrastructure data included

Design and implement next generation of integrated data

3D Hydrography Program (3DHP)

Enable better accounting of the hydrologic cycle by adding engineered hydrologic systems

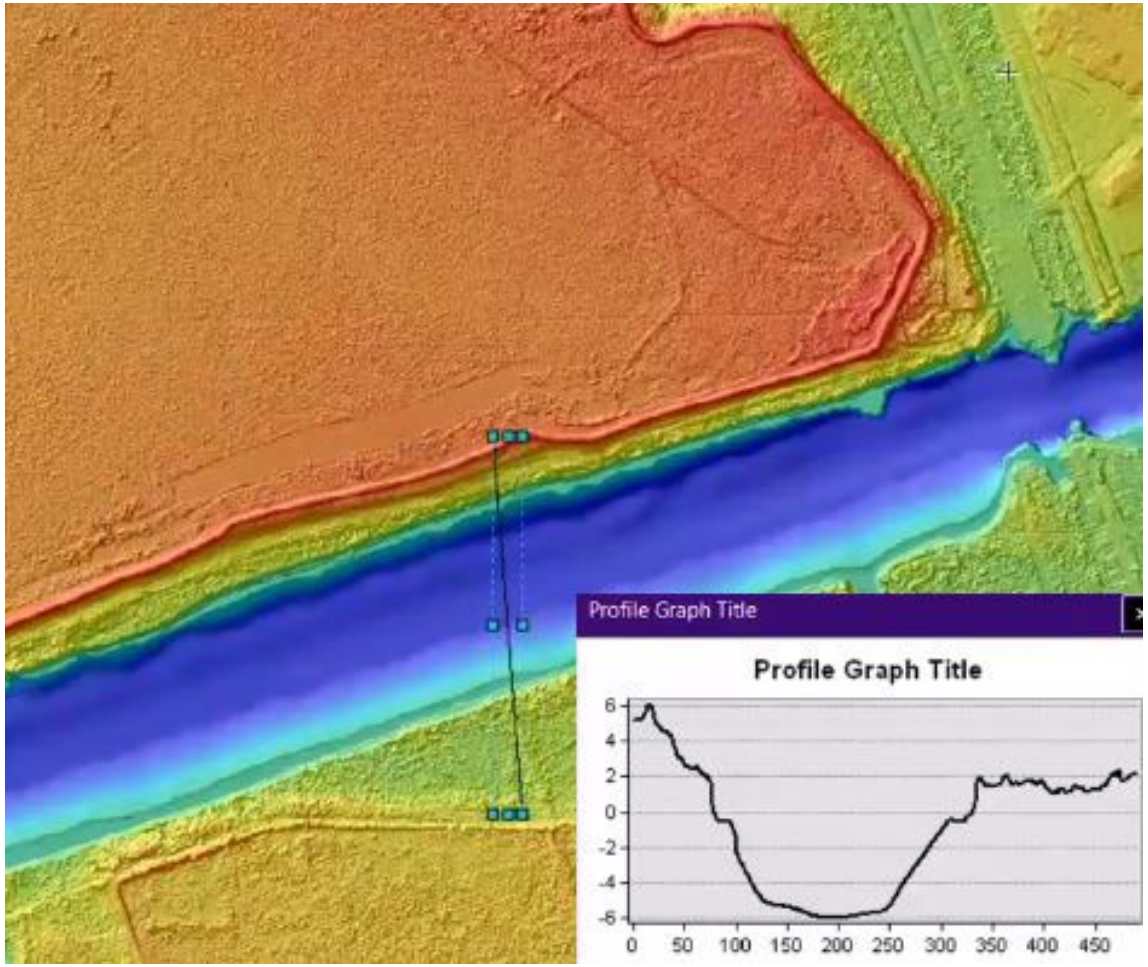


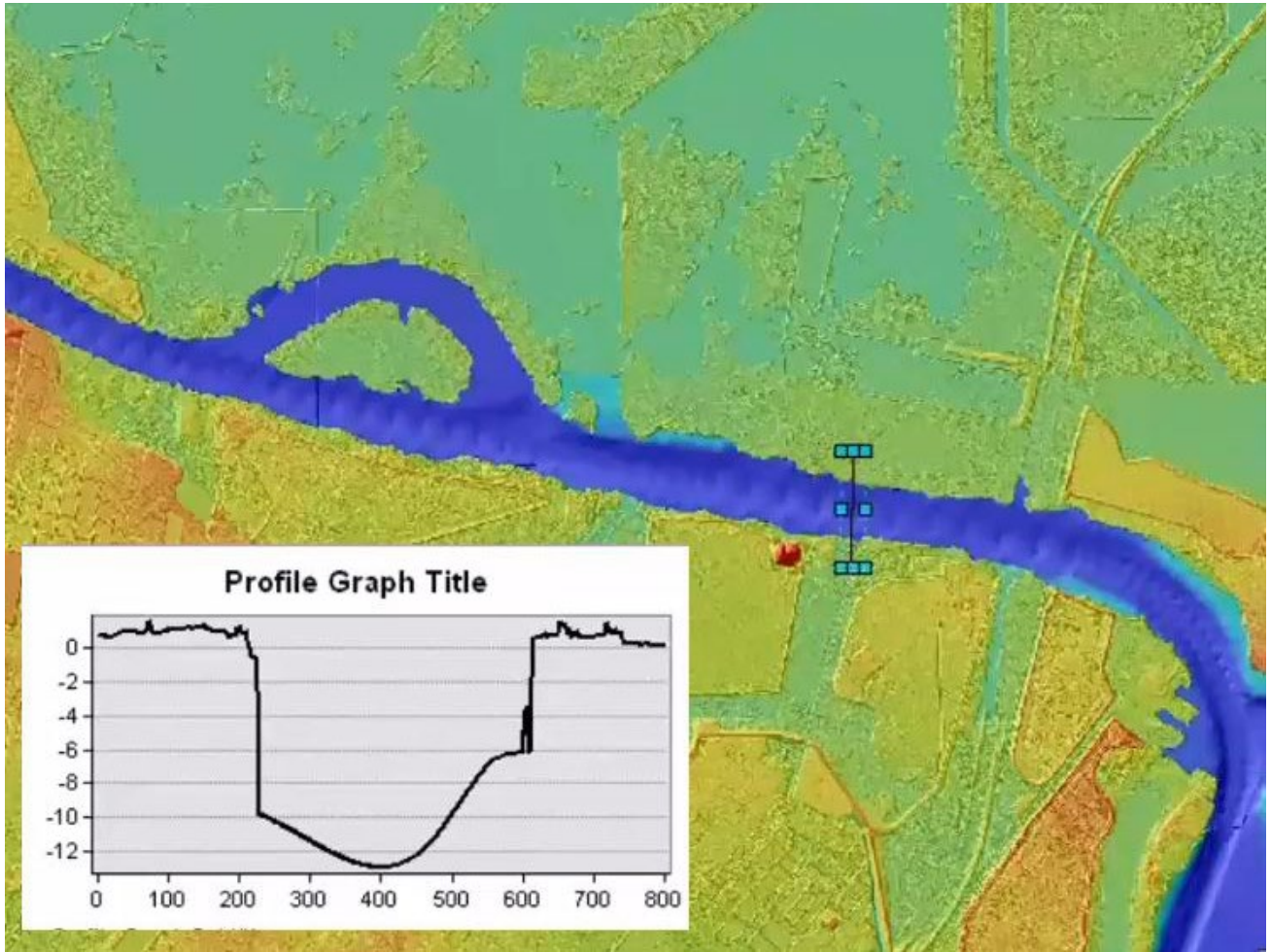
Design and implement next generation of integrated data

Next generation of the 3DEP

Operationalize inland bathymetry

Topobathymetry integrated with 3DEP topographic lidar to create a continuous surface





Design and implement next generation of integrated data

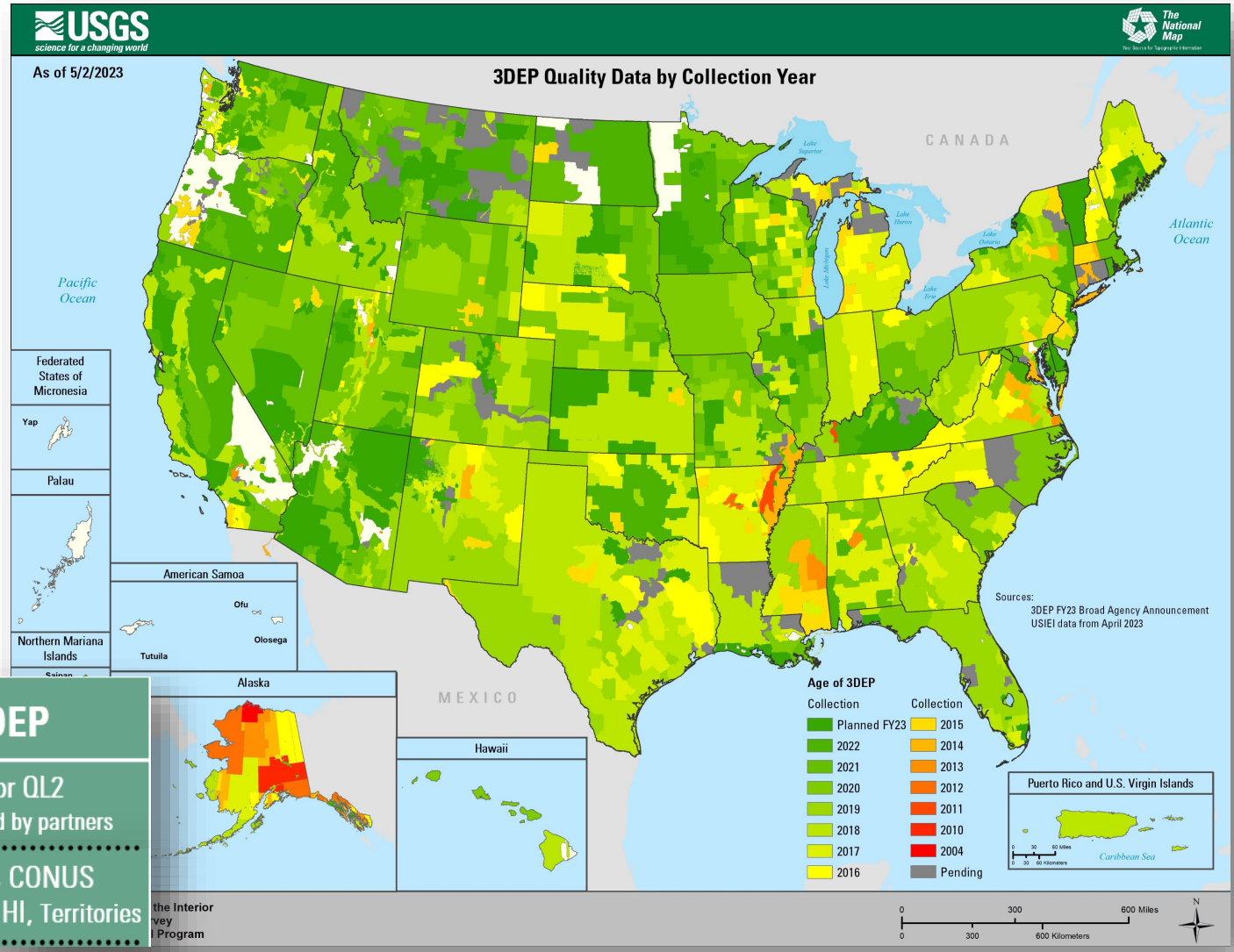
Next generation of the 3DEP

Transition to the next generation of data

Partnership priorities:

- Prioritize partnerships where there is no baseline coverage
  - USGS continues partnering on QL2 data
  - Applicants can submit projects for the acquisition of higher quality (QL1 or better) data as a buy up
- Where 3DEP baseline data exist – allow for new coverage
  - USGS partners on QL1 or QL2 data as submitted by the partner for areas where data are <u>5 years old or more</u>
  - Applicants can submit projects for the acquisition of higher quality (QL0) data as a buy up

	3DEP Baseline	Next gen 3DEP
Target Quality Level	QL2 / QL5 in AK ★★☆	★★★ QL1 or QL2 as proposed by partners
Update frequency	8 years	5 years CONUS 8 years AK, HI, Territories



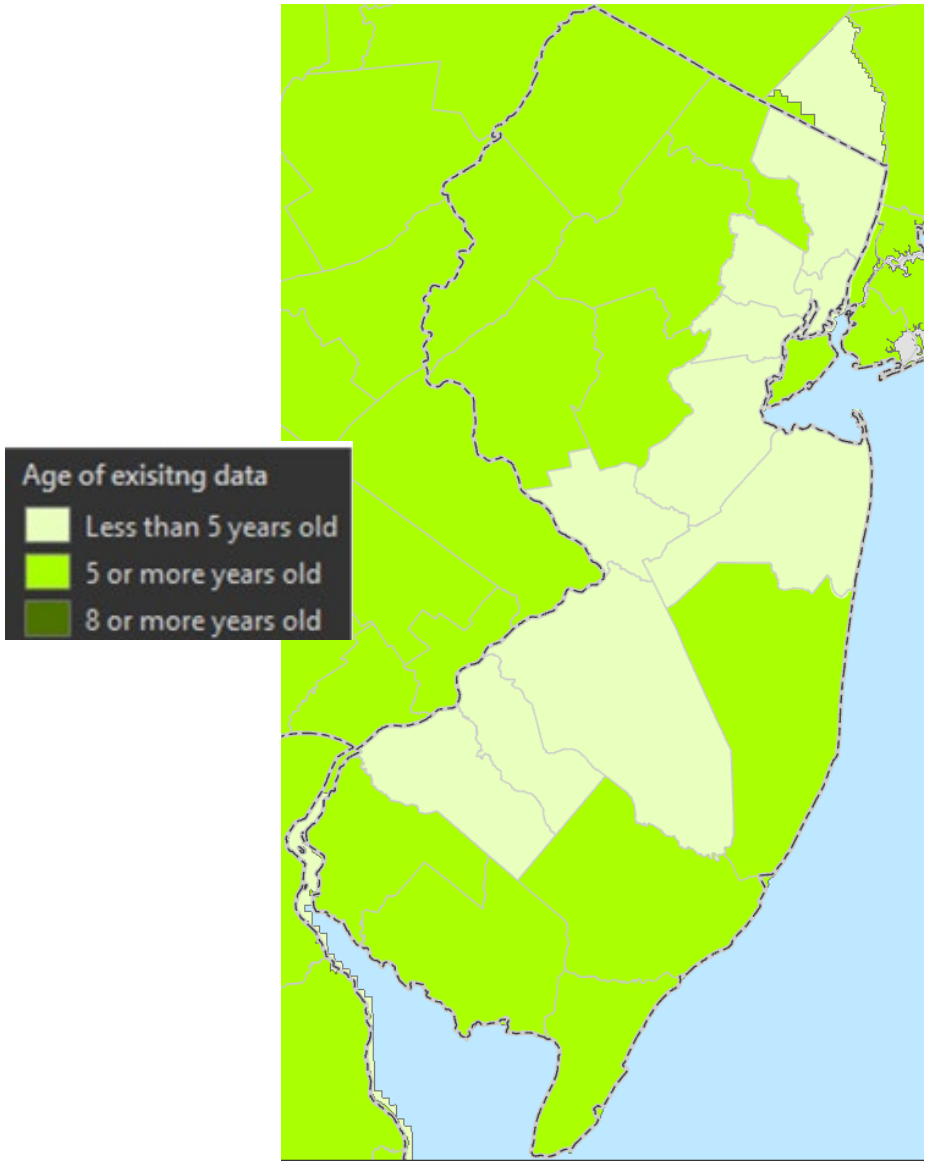
Design and implement next generation of integrated data

Next generation of the 3DEP

Transition to the next generation of data

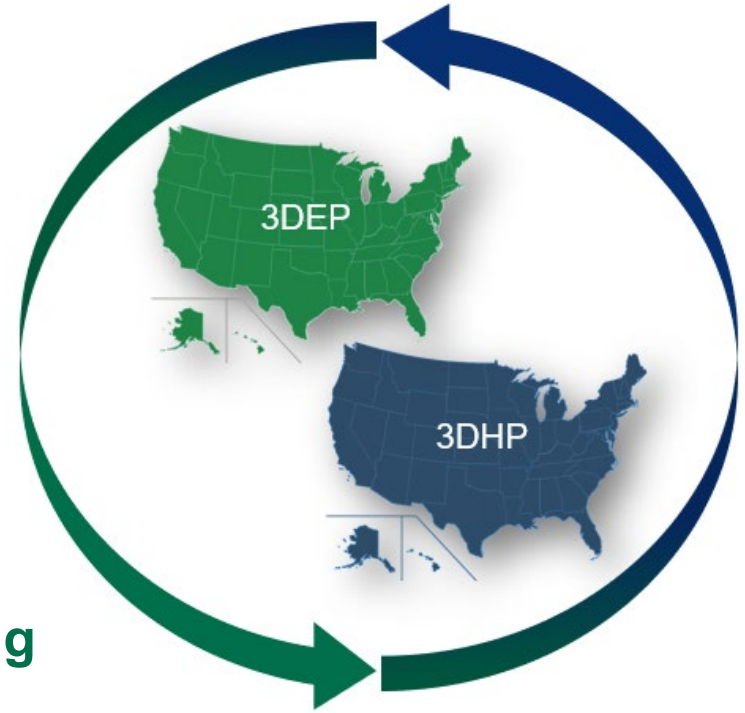
Age of existing 3DEP data in NJ by the end of 2024

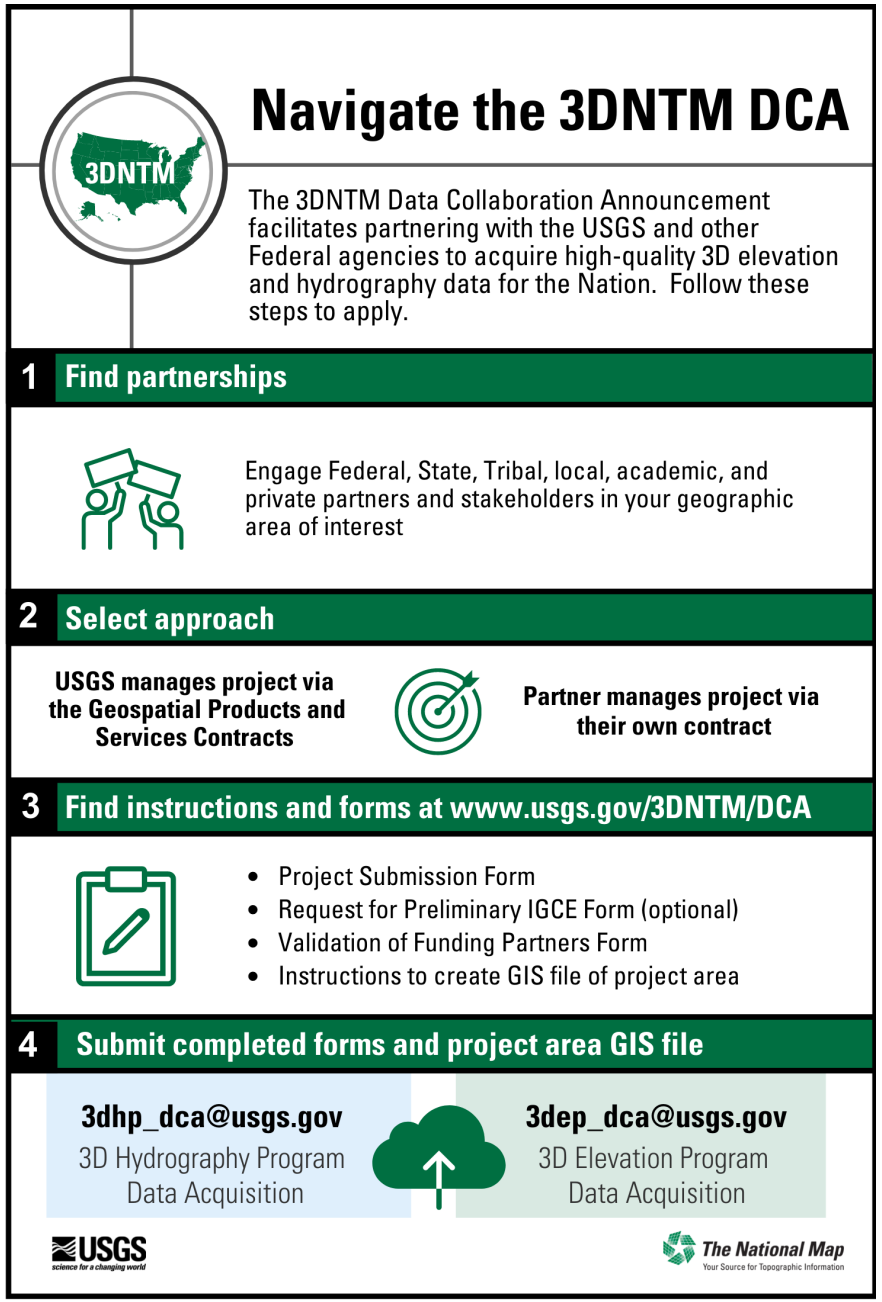
- Projects less than 5 years old
  - NJ Northeast 6 County
  - NJ 4 County



FY24 3DNTM Data Collaboration Announcement

- Moving from the Broad Agency Announcement (BAA) to the Data Collaboration Announcement (DCA)
- Facilitates partnerships for elevation (3DEP) and hydrography (3DHP) data acquisitions separately
- Initial deadline for project submissions was October 20, 2023
- 3DEP proposal selections being made now; 3DHP proposals won't be selected until FY24 budget is passed
- See webpage for more information: www.usgs.gov/3DNTM/DCA

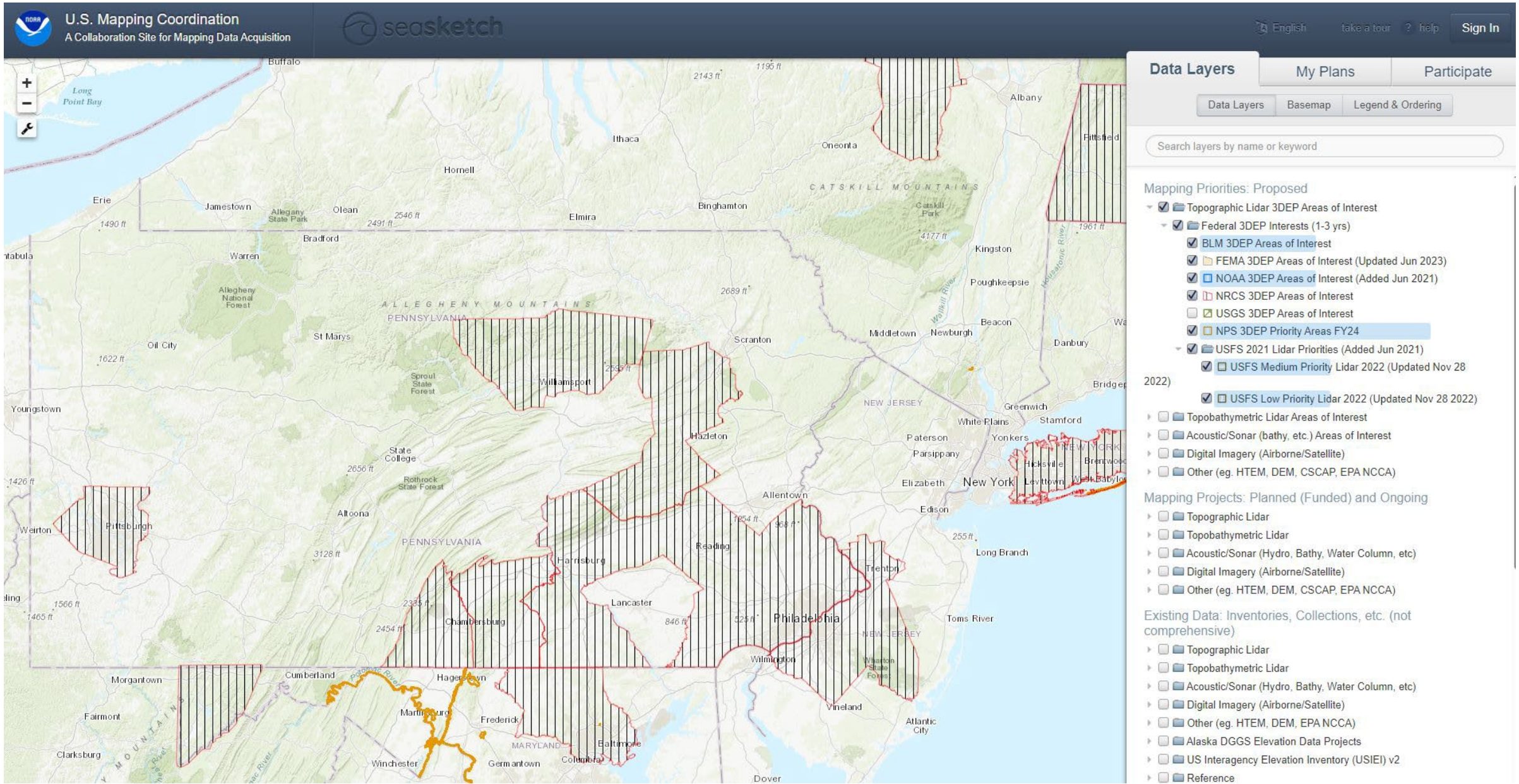




FY24 3DNTM Data Collaboration Announcement

Use SeaSketch to find project partners for 3DEP:

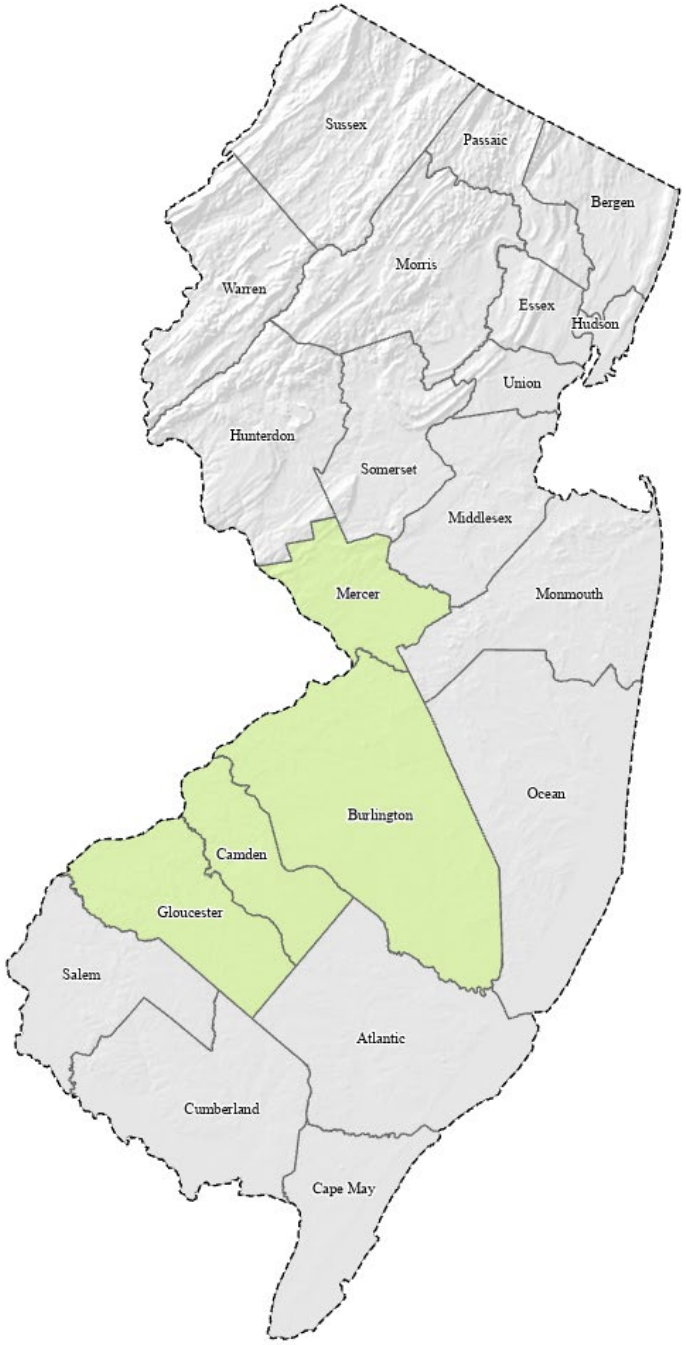
https://legacy.seasketch.org/#projecthomepage/5272840f6ec5f42d210016e4



FY24 3DNTM Data Collaboration Announcement

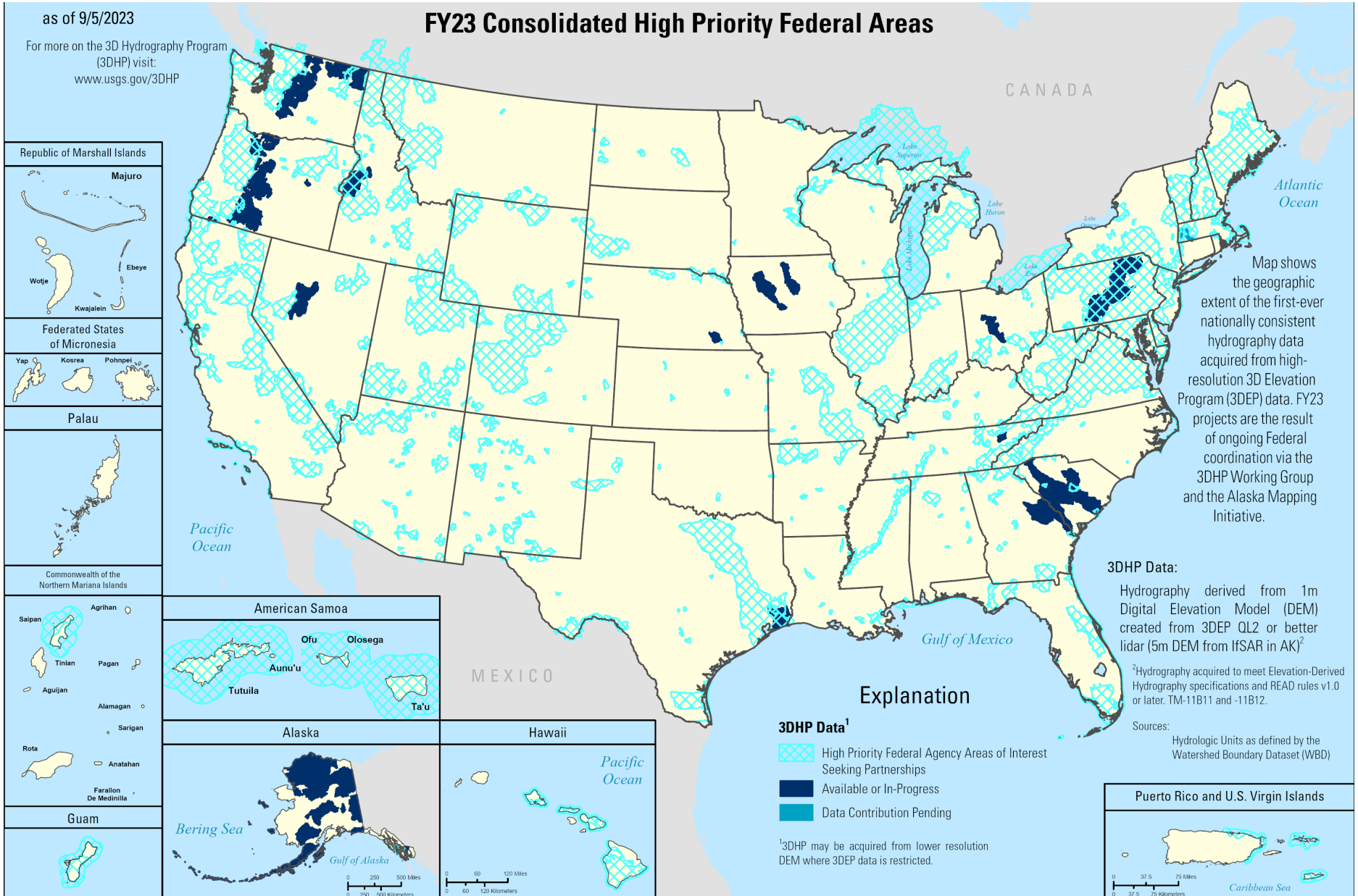
NJ 4 County DCA proposal is being awarded

- Quality level 1
- Tide coordination
- Machine generated contours
- Machine generated building footprints
- Independent QA/QC of 3DEP standard products and deliverables

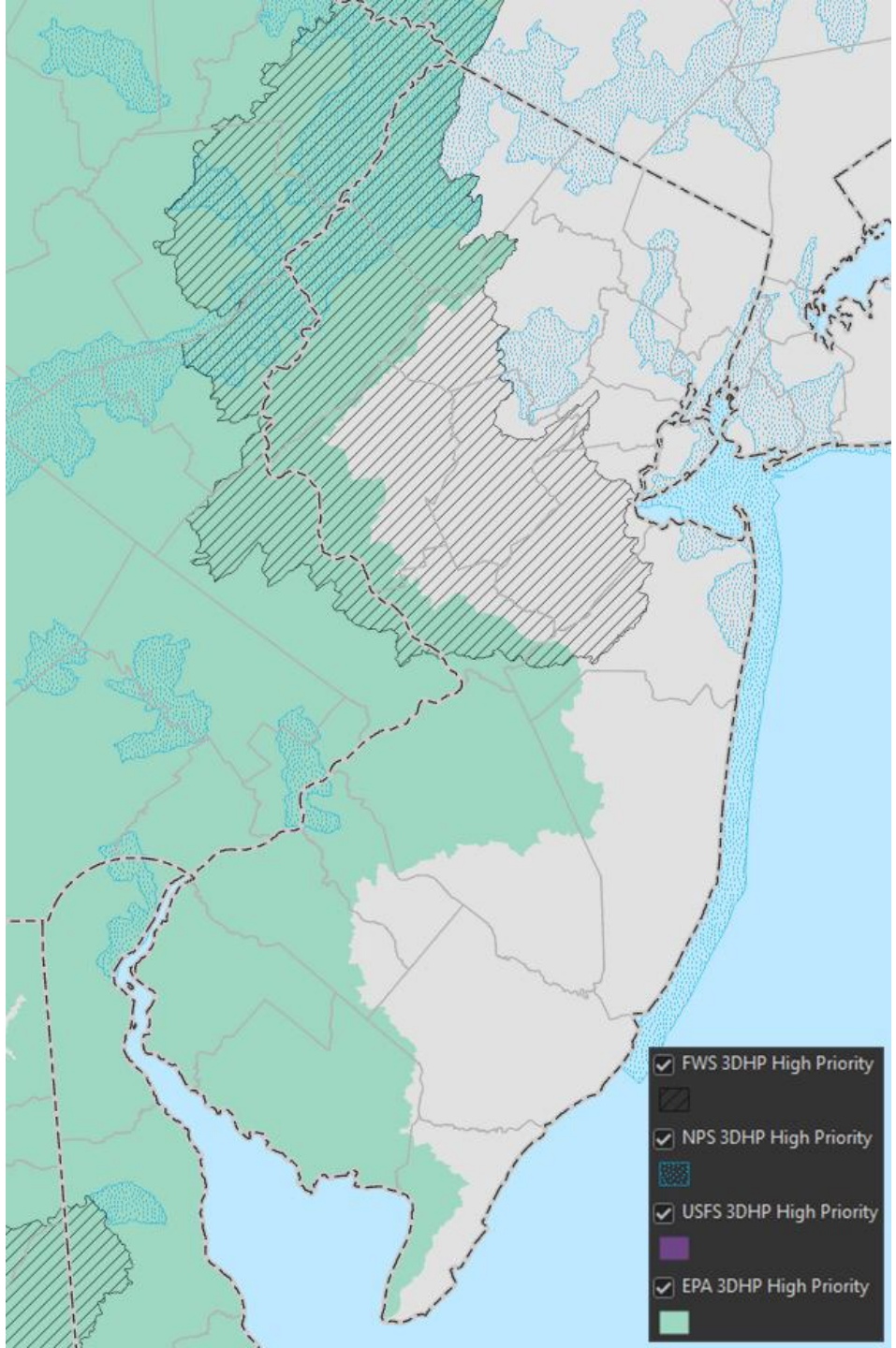


FY24 3DNTM Data Collaboration Announcement

Contact 3dhp_dca@usgs.gov to get contact info for project partners that have indicated high priority 3DHP areas



3DHP federal priorities in NJ



3D Hydrography Program (3DHP) – one HU8 at a time

- Hydrologic units (HUs) are basically watersheds – the smaller the number, the larger the watershed
- 3DHP is prioritizing processing by 8-digit HU (HU8) rather than by county

Water doesn't respect political boundaries

Name	Level	Digits
Region	1	2
Subregion	2	4
Basin	3	6
Subbasin	4	8
Watershed	5	10
Subwatershed	6	12

3DHP Data Collaboration Announcement – HU8

- NJ includes portions of 12 HU8s

- 4 of these are entirely within the state:
  - Raritan,
  - Mullica-Toms,
  - Cohansey-Maurice,
  - Great Egg Harbor

3DHP Data Collaboration Announcement – HU10

- NJ includes portions of 60 HU10s
- 27 of these are entirely within the state

3DNTM Development Tracks

Topography is defined by elevation and hydrography; elevation shapes hydrography, and hydrography shapes elevation. To support a broad range of applications, the **3D National Topography Model** integrates USGS elevation and hydrography datasets to model the Nation's topography in 3D.

The National Map
Your Source for Topographic Information

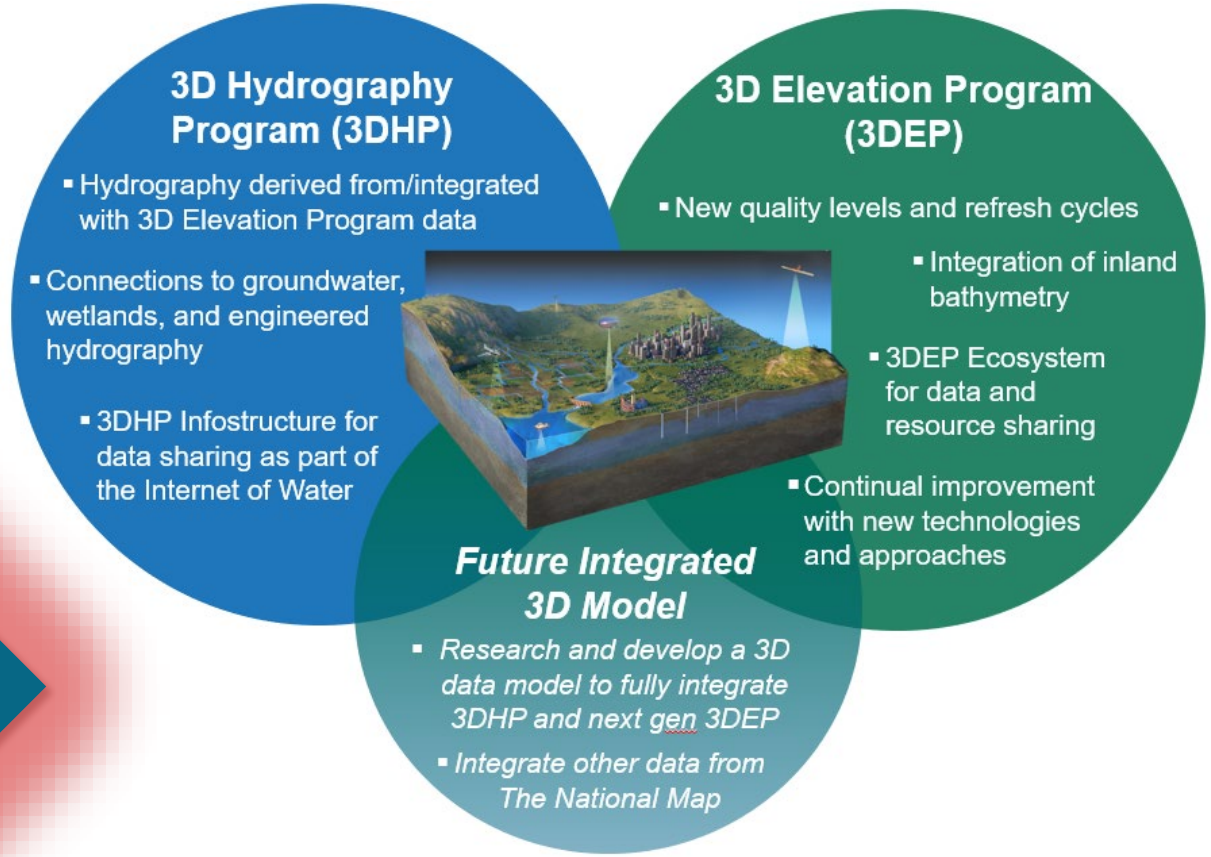
Complete nationwide elevation and hydrography baseline datasets

Pilot integration of hydrography and elevation

Design and implement next generation of integrated data

Research and develop 3D data model

- Research and develop a 3D data model to fully integrate 3DHP and 3DEP
- Integrate other data from The National Map
- Perform research activities like uncertainty and change detection



Lidar point cloud in Atlantic City, NJ