# Flood Inundation Mapping Training for NRPC/MRBAVT

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NWS Burlington
August 12, 2025

# Agenda

.01
The Importance of FIM

.02
FIM Overview

.03
FIM & IDSS

.04
Tools and Resources

# .01 The Importance of FIM

# Transforming the Way We Communicate Flood Impacts

- Enhancing the way flood forecasts and impacts are conveyed
- Strengthening efforts to protect lives and property

# IDSS: Then Versus Now

La Vita Bella Nursing Home during Harvey


Good Samaritan Society Evacuating during Ian

# Putting Water on a Map

# .02 FIM Overview

# The National Water Model (NWM)

- The National Water Model (NWM) is a continental-scale, operational hydrologic modeling system designed to enhance NOAA's forecasting capabilities.
- It provides high-resolution streamflow and hydrologic forecasts across the contiguous United States (CONUS), Hawaii, Puerto Rico, and portions of Alaska.
- Provides real-time and forecast data for flood forecasting, water resource management, and hydrologic modeling.
- Key outputs include streamflow predictions, inundation mapping, and flood forecasting.

# Implementation of NWS Flood Inundation Mapping Services

## Map Legend

10% Population served by **October 2023**.

30% Population served by **October 2024**.

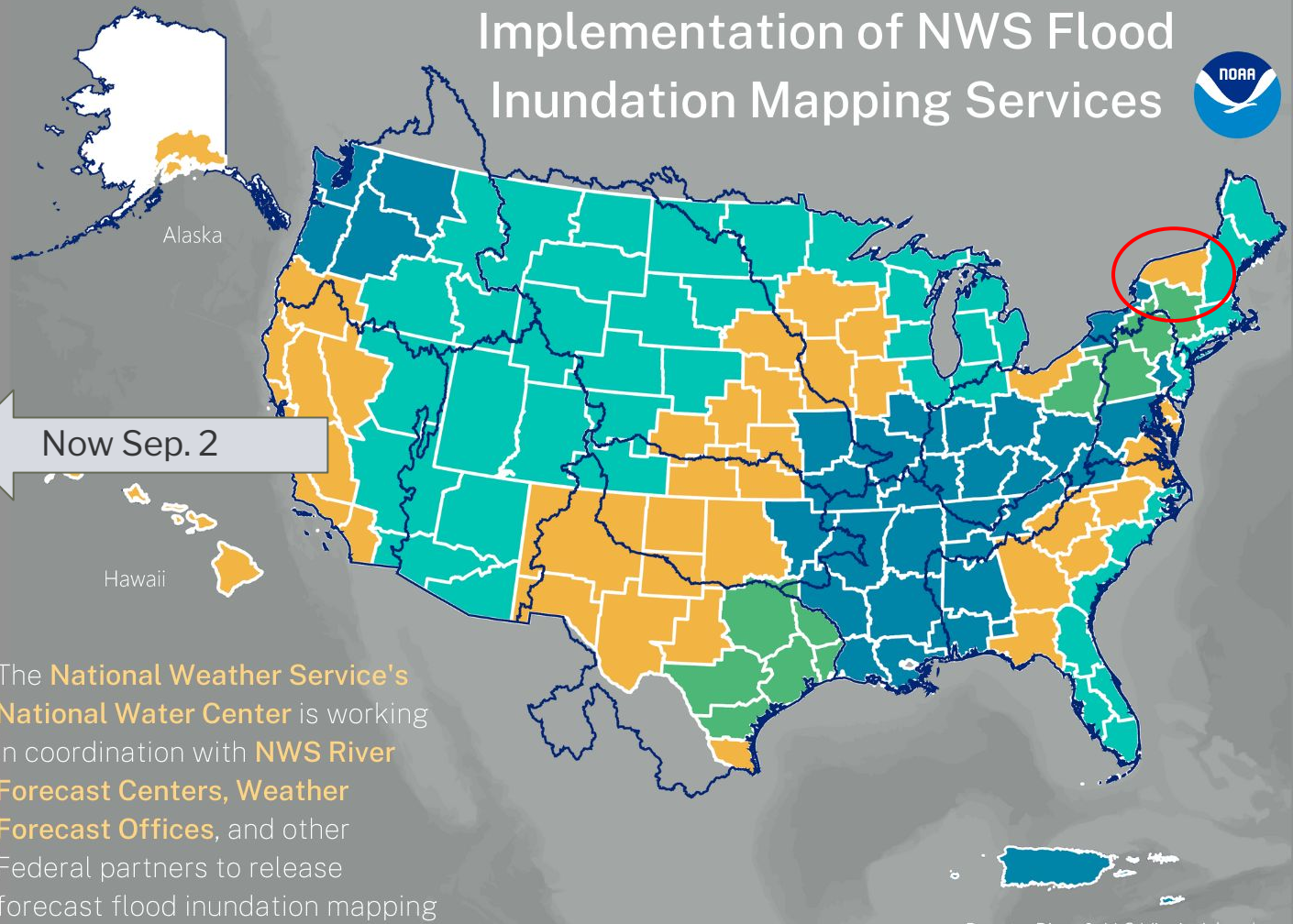
60% Population served by **October 2025**.

100% Population served by **October 2026**.

NWS County Warning Areas

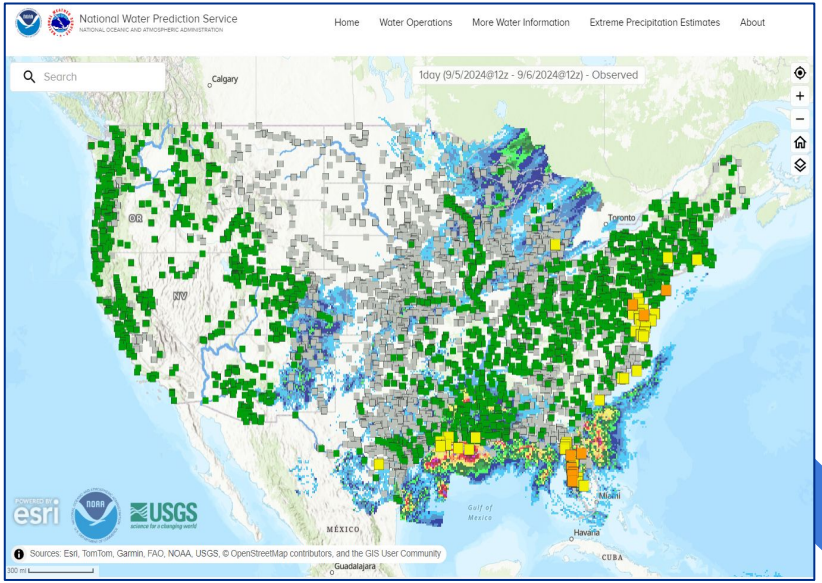
NWS River Forecast Center Boundaries

*100% is approximate. Does not include all parts of Alaska, American Samoa, and Guam. Implementation areas are subject to change.




The **National Weather Service's National Water Center** is working in coordination with **NWS River Forecast Centers, Weather Forecast Offices**, and other Federal partners to release forecast flood inundation mapping services to the Nation.

# Evolving Water Prediction Capabilities

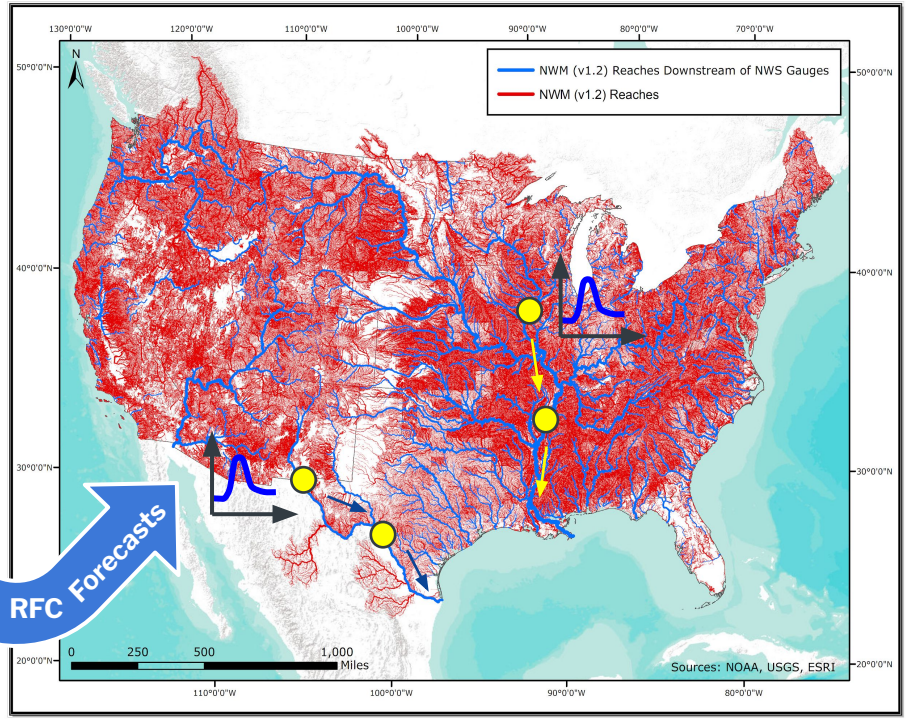



**~3,600 NWPS Forecast Points**

**RFC Forecast Models**

**FIM provided for ~ 110,000 river miles**

Extended RFC Forecasts



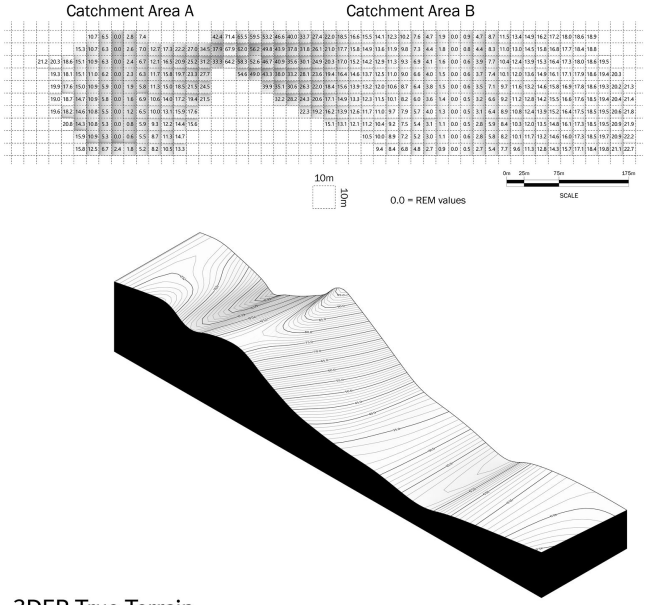

**~2.7M NWM Forecast Points**

**National Water Model (NWM)**

**FIM provided for ~ 3.4 million river miles**

# HAND Method

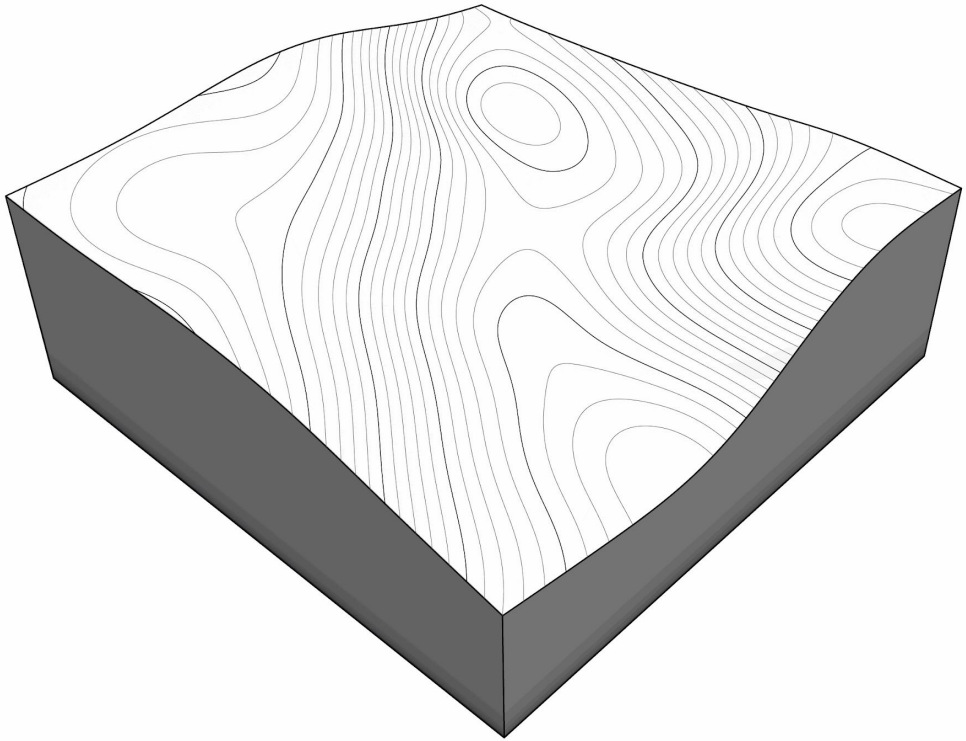
- HAND [Height Above Nearest Drainage] is the method by which water elevation in a stream or reach is applied to a grid representing the terrain to depict inundation extent. Primary inputs include:
  - Catchments
  - Reaches
  - DEMs [Digital Elevation Models]
- Hydroconditioning converts a DEM to an REM [Relative Elevation Model], relating the elevation of the terrain to the elevation of the channel thalweg [zero reference point]
- The HAND value of each REM grid cell indicates the water depth needed to inundate that cell
- "HAND"outs available on table




3DEP True Terrain

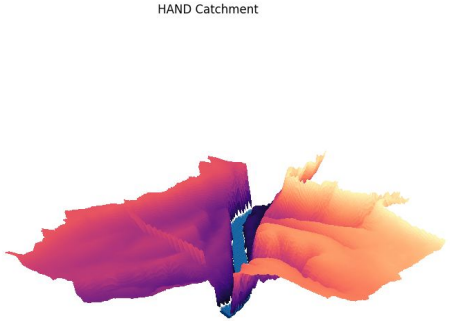
# HAND Method

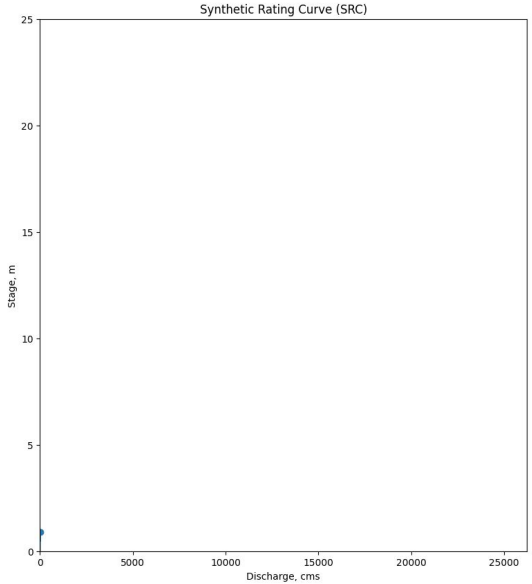
**DEM Representation of Earth's Surface**



# Synthetic Rating Curves

- Estimate water depth for flood mapping based on streamflow.
- Derived from HAND terrain, channel shape, and slope.
- Precomputed at 0.5 ft intervals for each reach.
- Do not update dynamically with changing river conditions.
- Used where traditional stage-discharge relationships are unavailable.



# HAND Advantages and Limitations

## ADVANTAGES

- Computational Efficiency
- Scalability
- Terrain Normalization
- Improved Flood Prediction
- Real-Time Integration
- Simplicity and Accessibility
- Consistency Across Different Regions
- Flexibility for Various Applications

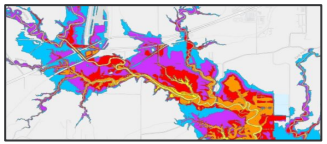
## LIMITATIONS

- Resolution Dependency
- Missing bathymetry
- Exclusion of Hydraulic Structures
- Assumptions in SRCs
- Backwater effects
- Catchment Boundaries**
- Waterbody Inundation

# NWS FIM Capabilities - Available since September 2023

**Static**

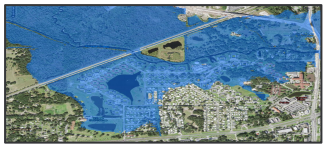
**Partner FIM Libraries (Partner FIM)** ~ 200 RFC forecast locations. Shows the flood extent & depth based on a river crest of X feet. This is a hydraulic-based FIM which can be used with high confidence.



**NWS Flood Categorical HAND FIM Libraries (CatFIM)** ~3,000 RFC forecast locations. Maps derived from 10m Height Above Nearest Drainage (HAND) solution.

**Dynamic**

**Forecast National Water Model Flood Maps (NWM 5-Day Max Forecast)** along NHDPlus reach locations. Maps derived from NWM forecast and 10-meter Height Above Nearest Drainage (HAND) solution.



**Forecast River Forecast Center Flood Maps (RFC 5-Day Max Forecast)** downstream of ~ 3,600 RFC forecast locations. Maps derived from RFC forecast and 10-meter Height Above Nearest Drainage (HAND) solution.

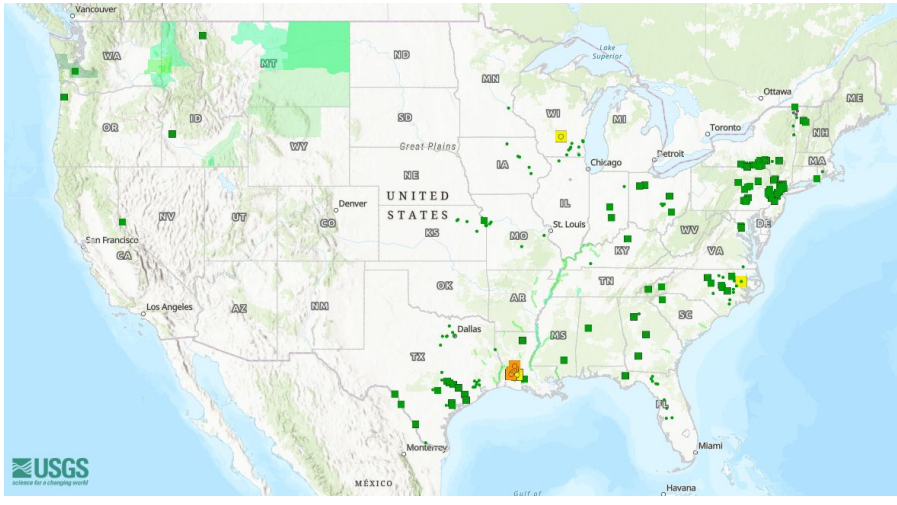
**National Water Model Latest Analysis Flood Maps** - utilizing observed rain and stream data to depict current flood extent. Maps derived from 10-meter Height Above Nearest Drainage (HAND) solution.

| Coverages |
| --- |
| < 1,000 miles |
| ~ 30,000 miles |
| ~ 3.4M miles |
| ~ 110k miles |
| ~ 3.4M miles |

# Static FIM

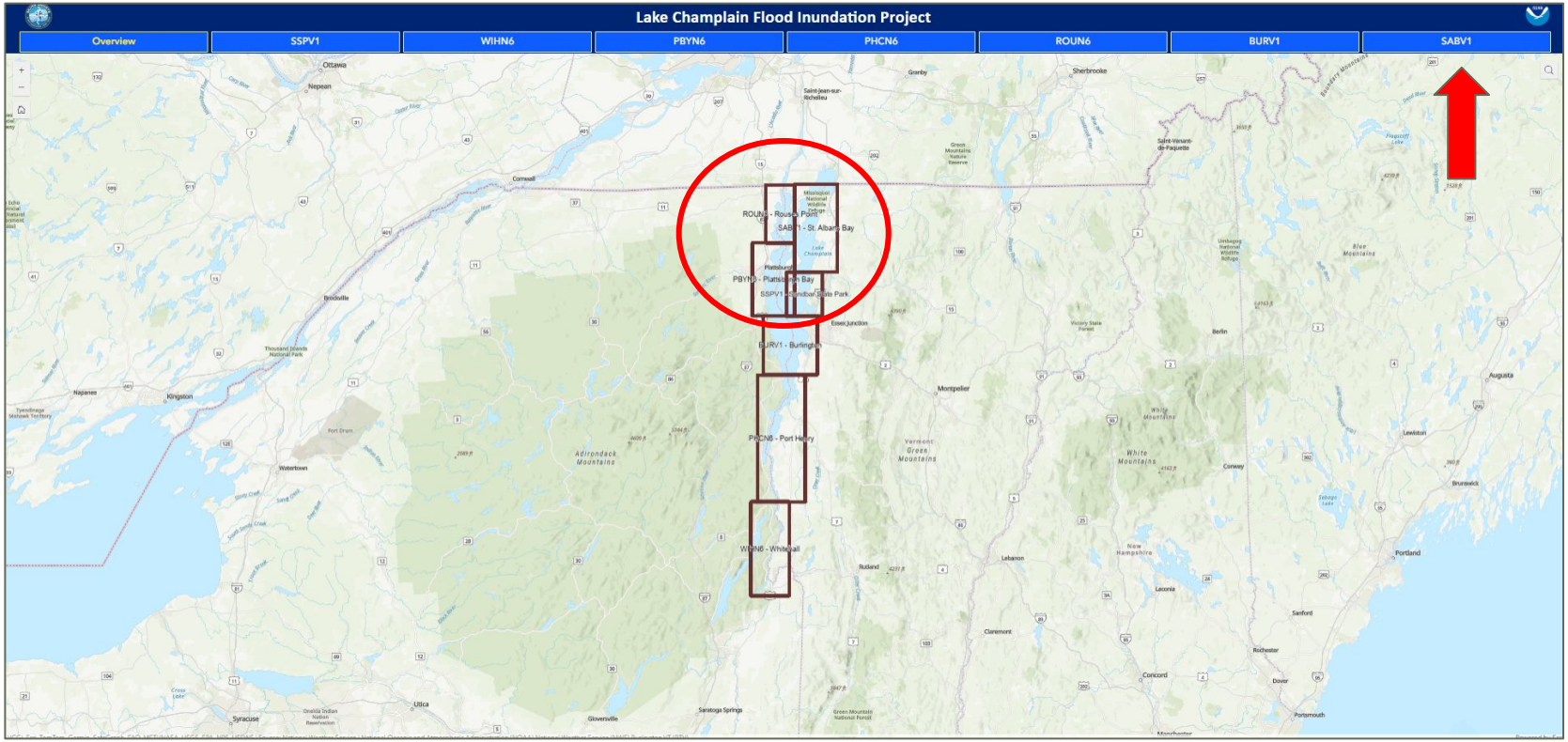
# Partner FIM - STATIC

- Partner FIM is the highest quality static FIM, using engineering-grade modeling.
- Includes depth information, often unavailable in other FIM.
- Forecast locations are carefully selected based on flood impacts and data accuracy.
- Validates Dynamic FIM as a quality assurance tool.
- Coverage is limited to approximately 200 RFC locations
    - https://water.noaa.gov/about/partner-fim-locations
- NWM FIM fills gaps where Partner FIM is unavailable.
- 9 Partner FIM sites in our area, including Montpelier, Waterbury and 7 sites on Lake Champlain.



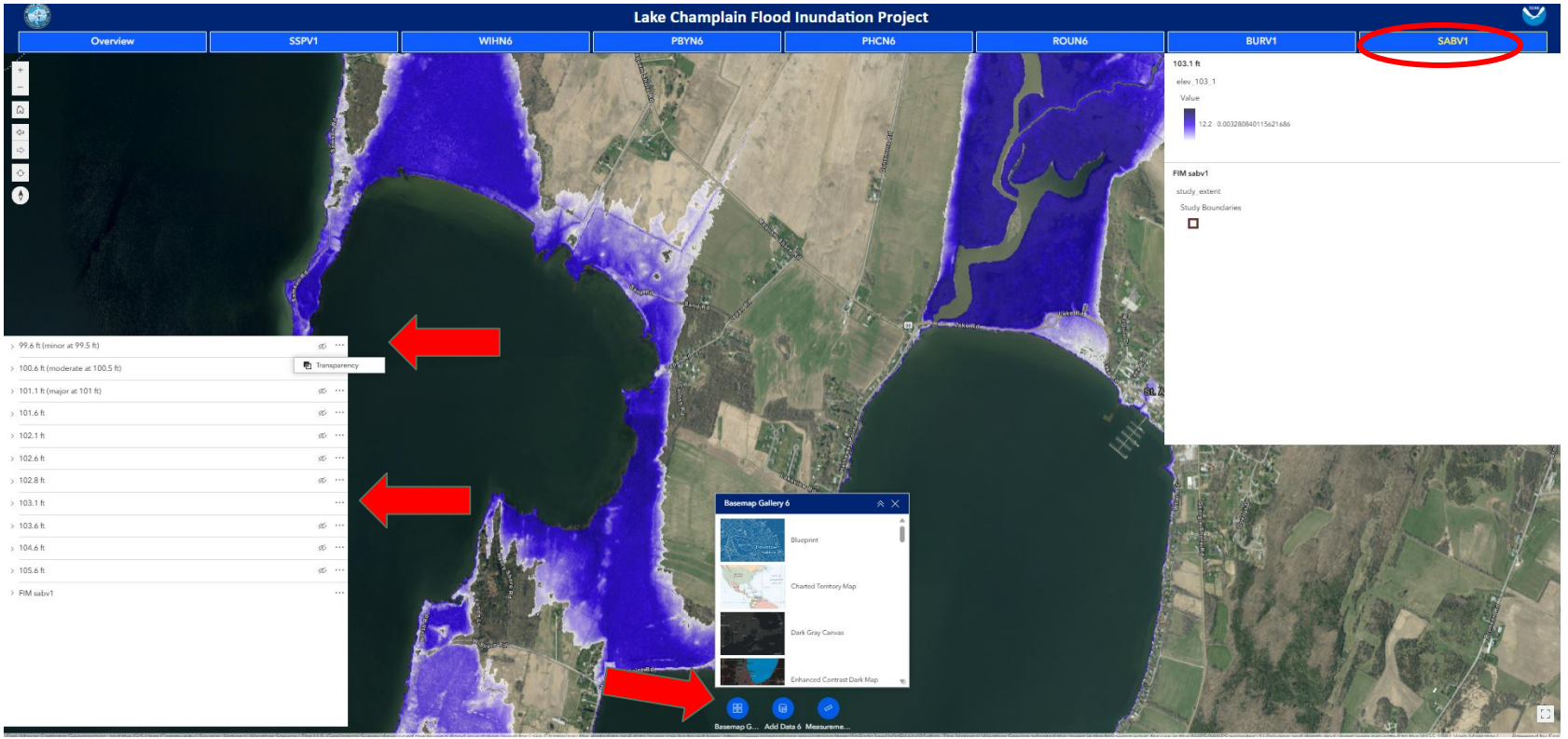

# Partner FIM - STATIC

4 Sites cover portions of NRPC area on Lake Champlain (Rouses Pt., Plattsburgh Bay, Sandar St. Park & St. Albans Bay)



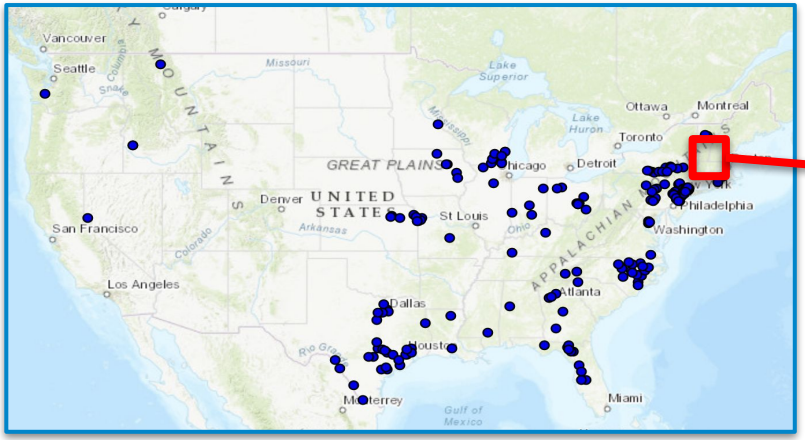
# Partner FIM - STATIC

## Lake Champlain @ St. Albans Bay

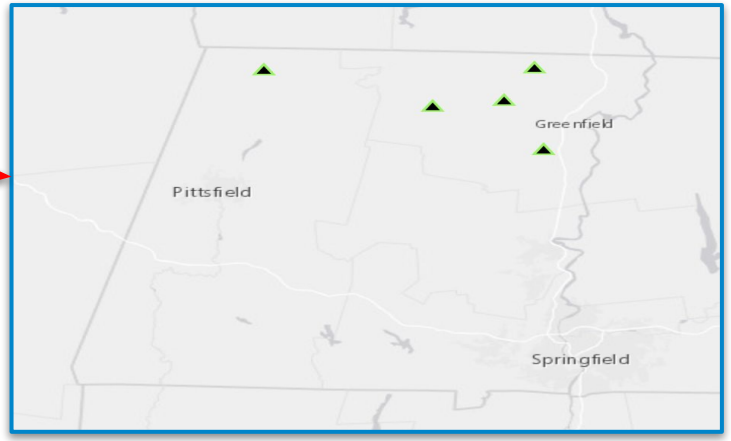


# External FIMs - STATIC

- External FIMs are separate from Partner FIM and serve different purposes.
- These libraries are developed and maintained by the originating agency
- These libraries are **not** hosted on NWPS and are typically only available on the originating agency's website.
- The focus is on understanding and communicating NWPS-hosted FIM, as external ones vary in methodology and availability.



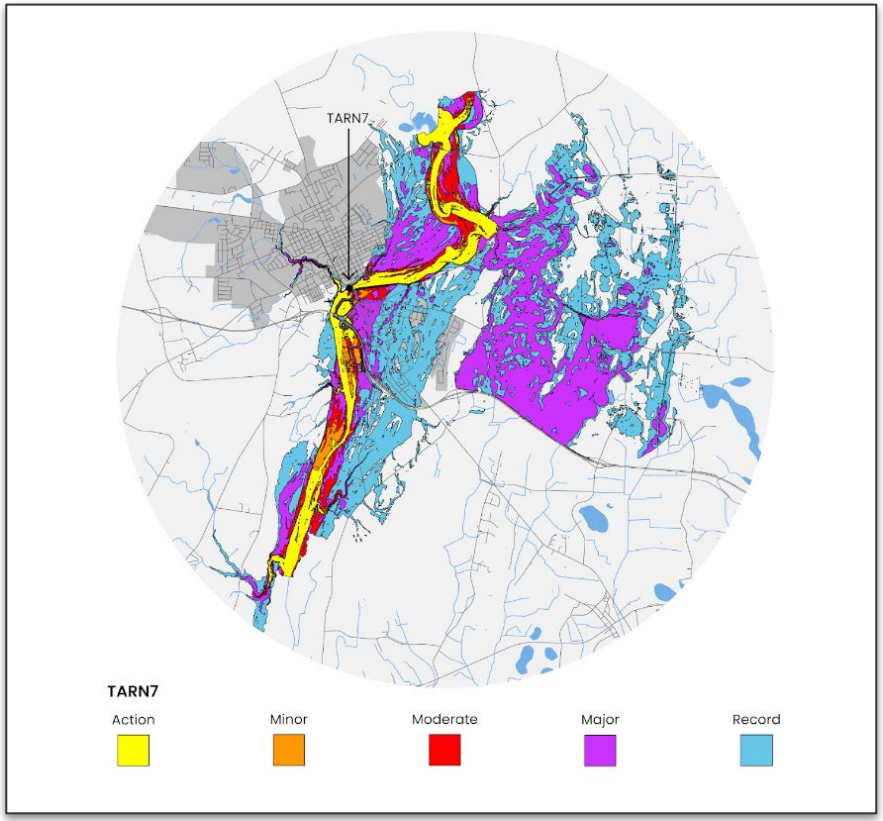

NWPS Partner FIM Locations.




Example of External FIM locations - hosted by the USGS on their website. These are not hosted on NWPS as shown in the red box.

# Categorical Stage-Based FIM - STATIC

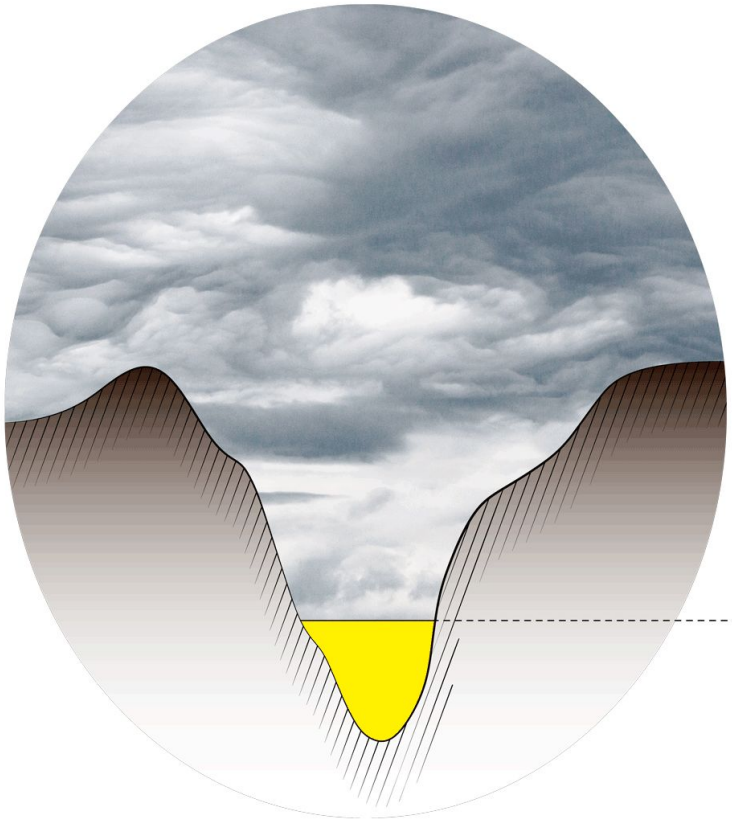
- Static inundation extent mapping library produced at ***select official forecast point locations.***
- Available at 1-foot increments, including the official NWS flood stage category thresholds (Action, Minor, Moderate, Major, and Record).
- An invaluable tool for emergency planning and informing best practices for anticipation of potential future flood events.
- Limitation: only available at select sites. Will be available for Missisquoi R. @ E. Berkshire. Perhaps at Swanton in the future*.
- Availability at forecast points on NWPS determined by local NWS office. Still available on NWS GIS Viewer or through REST services



# Categorical FIM - STATIC

## Stage-Based CatFIM example from Texas on NWPS

# CatFIM Stages



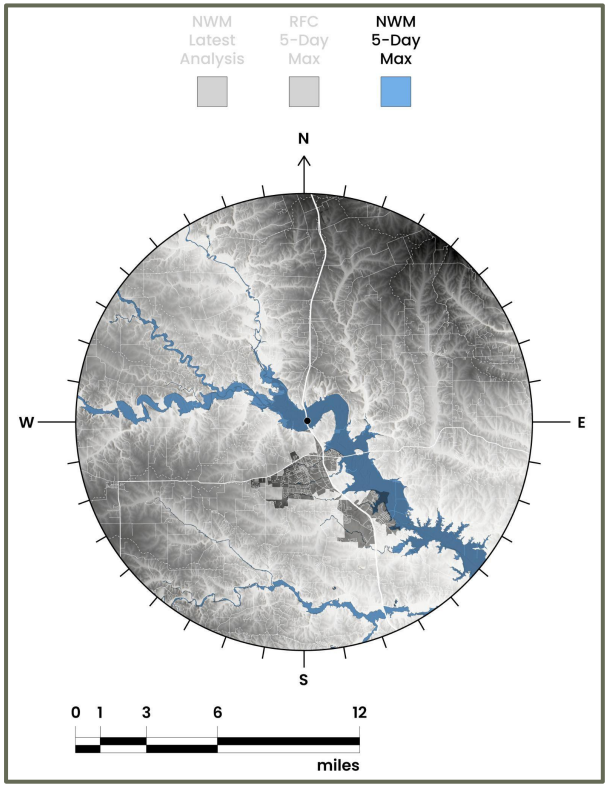
**Action Stage**

The stage which, when reached by a rising stream, represents the level where the NWS or a partner/user needs to take some type of mitigation action in preparation for possible significant hydrologic activity. The appropriate action is usually defined in a weather forecast office [WFO] hydrologic services manual

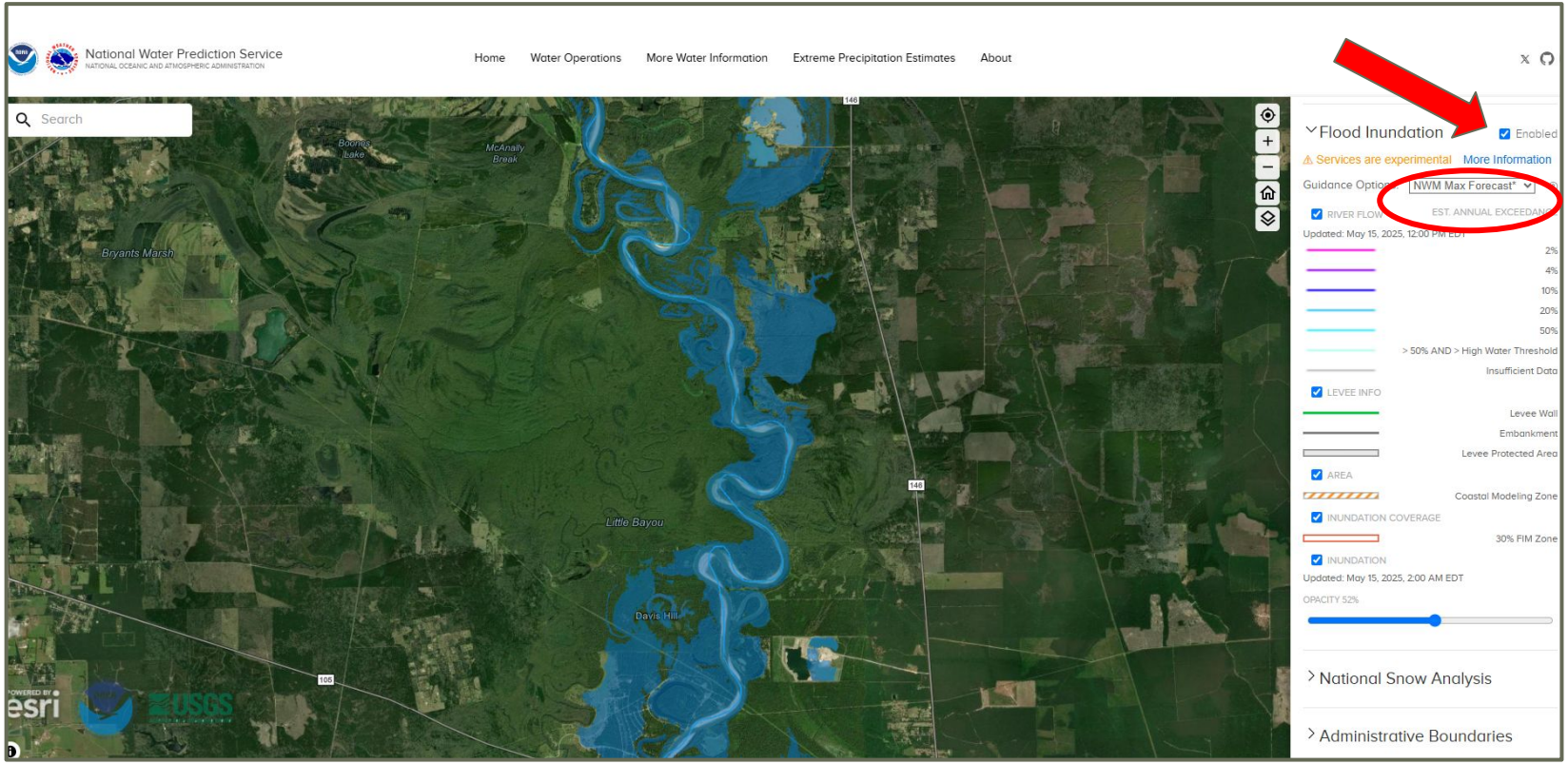
# Dynamic FIM

# NWM 5-Day Max Forecast FIM - DYNAMIC

- Depicts inundation extent of the peak National Water Model (NWM) streamflow forecast over the next five days where NWM is producing flows that meet or exceed high water threshold for a given river reach
- Based on the National Blend of Models rainfall forecast
- High water thresholds vary by region (Similar water-year runoff efficiency variability, *https://pubs.usgs.gov/publication/70173952*)
- Limitation: Quality Control (QC) limitation exists because no forecaster is involved in decision-making process regarding forecast

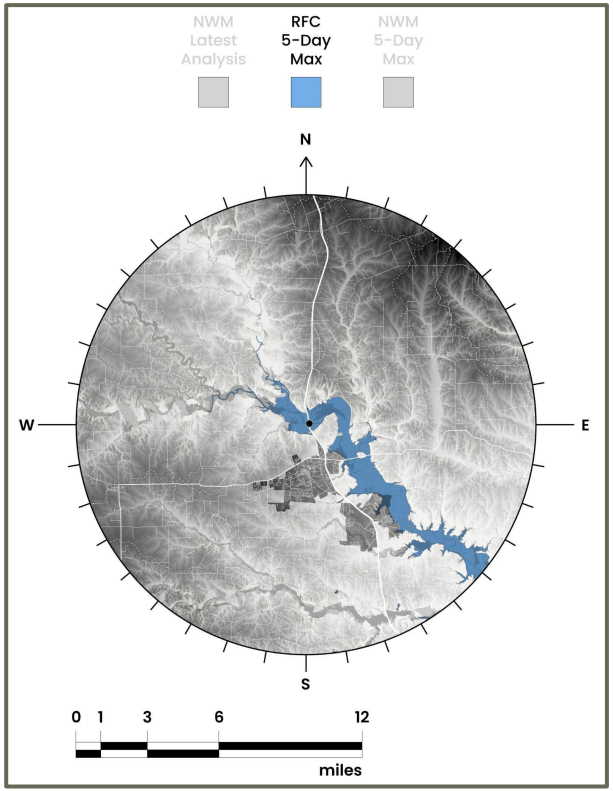


# NWM 5-Day Max Forecast FIM - DYNAMIC

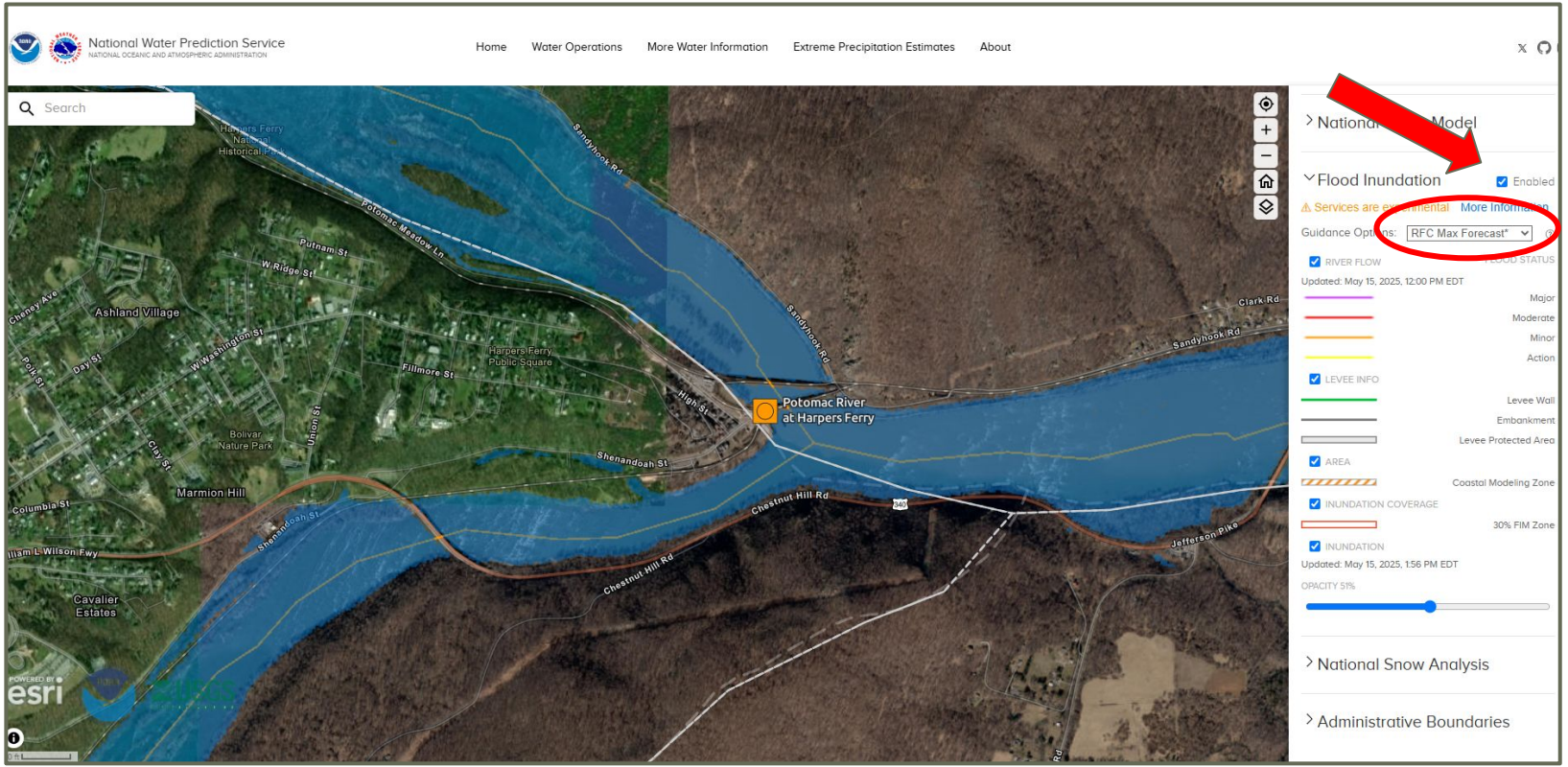


# RFC 5-Day Max Inundation Forecast FIM - DYNAMIC

- Depicts maximum inundation extent over the next five days derived from the official River Forecast Center (RFC) forecast
- Maximum streamflows are available downstream of RFC forecast points whose forecast reaches Action-Stage or higher flow threshold categories.
- Limitation: only available downstream of NWPS forecast points

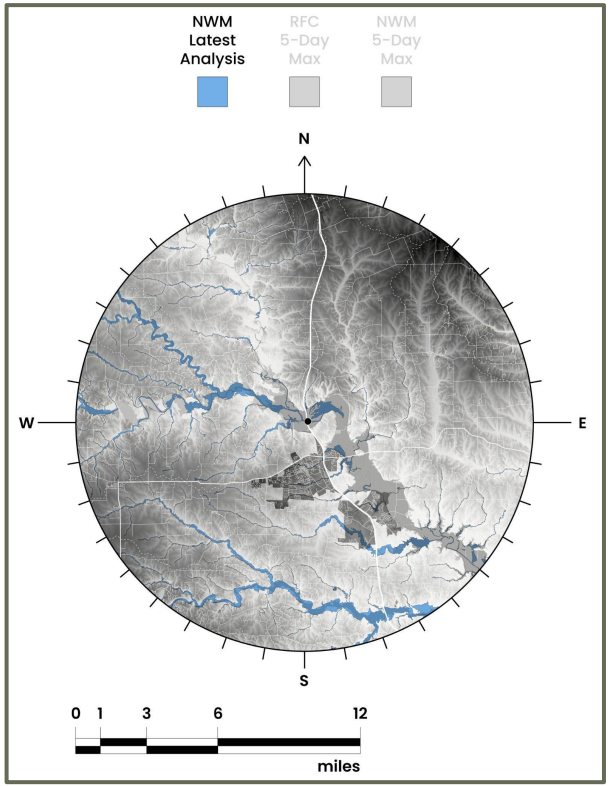


# RFC 5-Day Max Inundation Forecast FIM - DYNAMIC

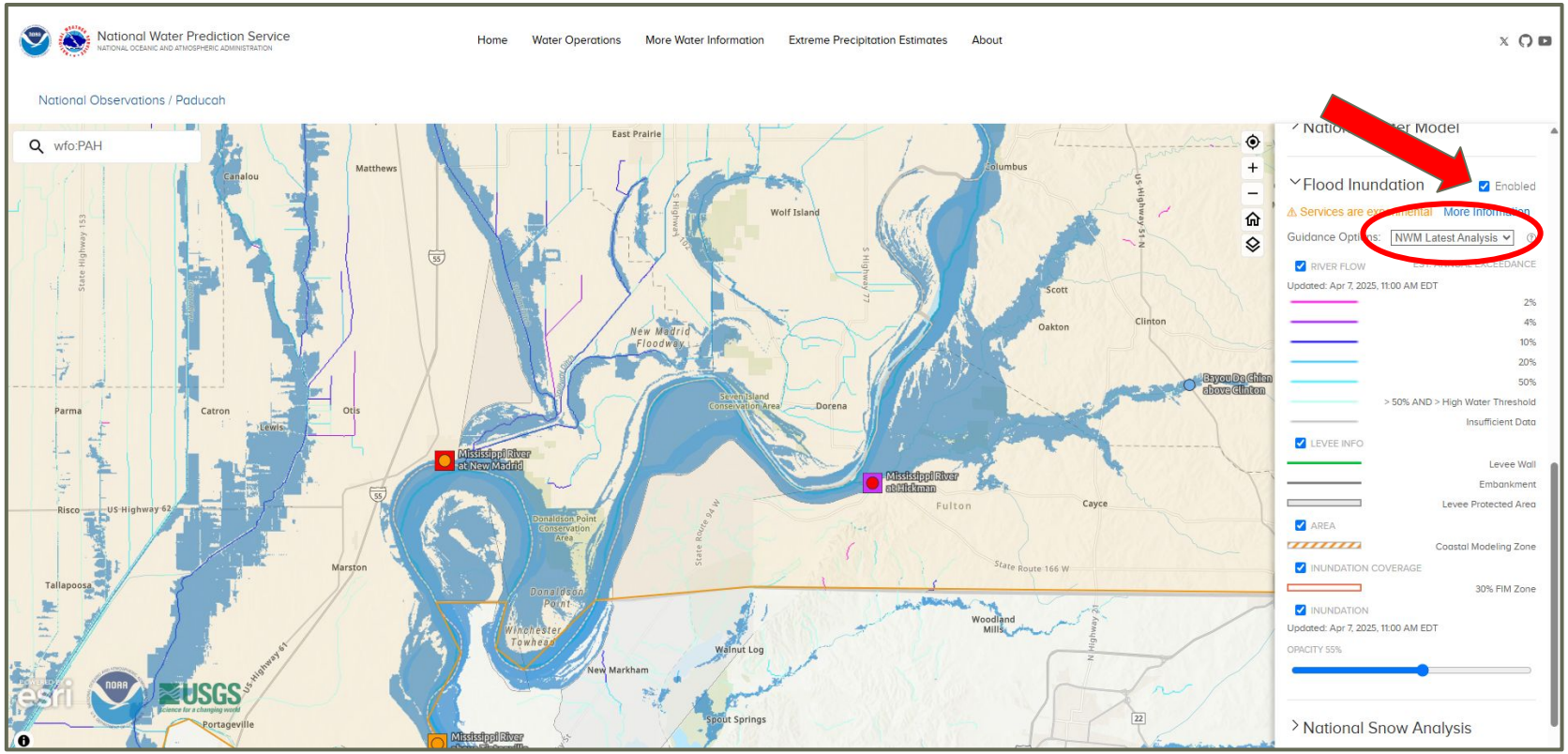


# NWM Latest Analysis FIM - DYNAMIC

- Depicts closest reasonable inundation extent at the current time for locations exceeding the high water threshold.
- High water threshold varies by region.
- Due to data gathering, Latest Analysis FIM for a given hour becomes available 55 minutes after that hour.
- Limitation: reliability decreases in ungauged areas (or other data voids) where analysis cannot be tuned to observed information. Think radar data holes/beam blockage-poor precipitation estimates



# NWM Latest Analysis FIM - DYNAMIC



# Strengths of NWM and RFC FIM

- Visualize flood forecasts and impacts for every river across the nation (including portions of Alaska, Hawaii, Puerto Rico, and the Virgin Islands)
- Creating a common picture of the river/stream flood threat in a given area
- Improve ability to target areas and preposition resources (regional, not local)
- Large scale regional response and reaction
    - National, Regional, and County Partners

***"Had I have had this tool in 2011, we would have had a larger evacuation area established earlier, would have moved emergency assets out of the flood zone, pre-positioned support resources and been able to provide better information to the residents of the affected area."***

***- County Emergency Manager***

# Limitations of NWM and RFC FIM

- Extent Only
  - Number 1 question about flooding after “where?” is “how deep?” Depth is not currently part of Water Center Flood Mapping
- Limited to 10-meter Digital Elevation Model
  - Can’t see small physical features and their impact on FIM extent such as small ridges, bridges, or unofficial levees
- Simplified Physics
  - Equations describing the physics are simpler with more assumptions as compared to Hydraulic Models like HECRAS
  - Height Above Nearest Drainage (HAND) technique limitations

# Limitations of NWM and RFC FIM

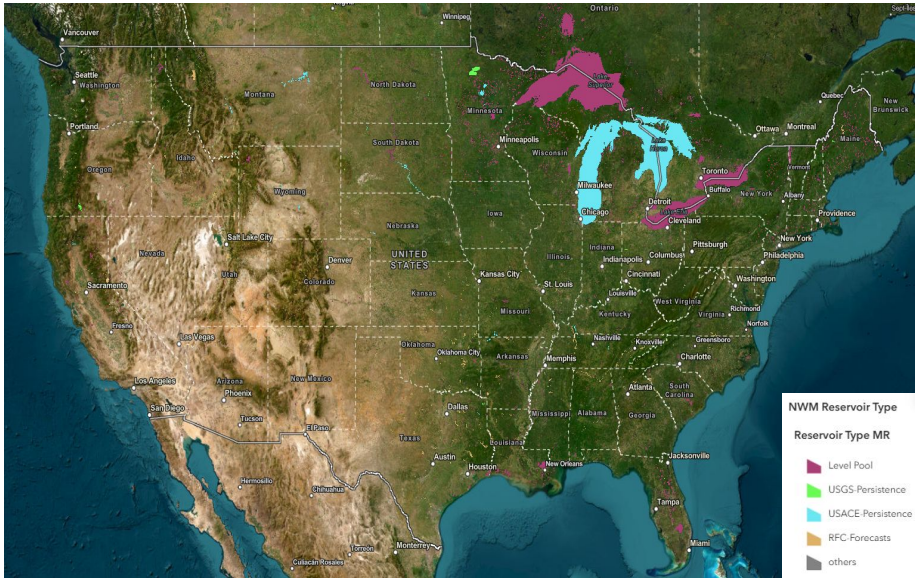
- NWM Versions limited by Quantitative Precipitation Forecast (QPF) Input
  - The rainfall creating the flow is based on the National Blend of Models
  - Can't adjust or manipulate the forecast rainfall going into the model

- NWM Versions flow has no human influence for the forecast
  - Similar to being unable to adjust the rainfall, NWM version has no ability to adjust the flow generating the map

- Coastal use is limited
  - Current FIM capabilities are only able to address freshwater flooding
  - *Total Water Level FIM derived from a coastal coupled NWM approach is under development*

# Reservoir Impacts on FIM

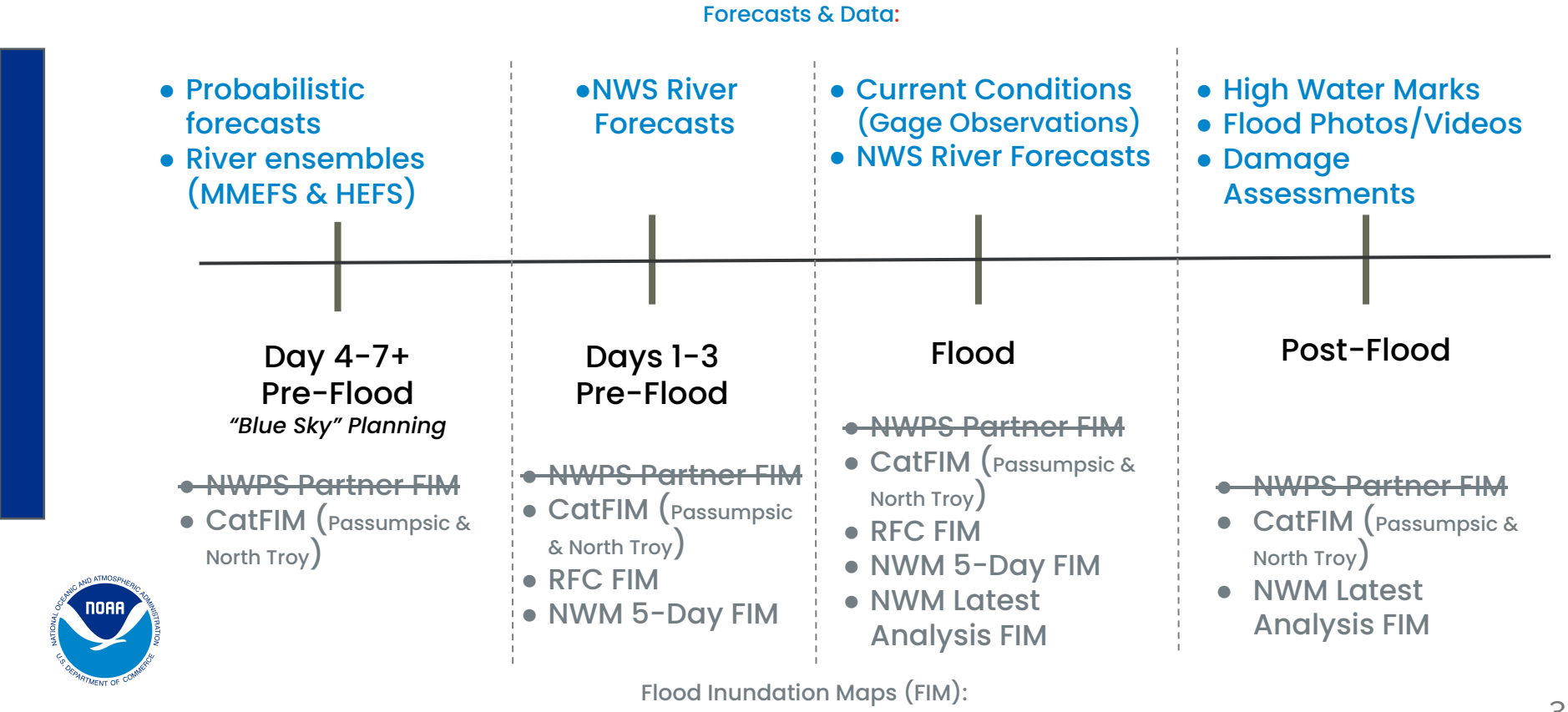
- Reservoir operations and outflows impact NWM streamflow accuracy and, as a result, the resulting FIM. Flows could change if there has been significant impact
- Several thousand reservoirs represented in NWM in one of three methods:
  - Level Pool
  - Persistence
  - RFC Forecast informed



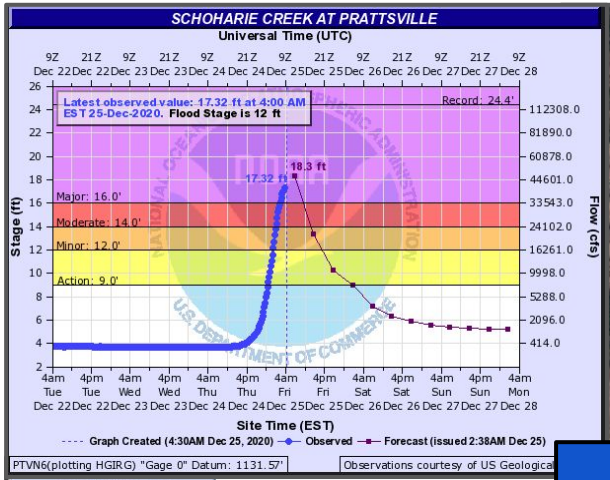

An interactive map of these reservoir types is available in the "Using the National Water Model Within NWPS" storymap: https://storymaps.arcgis.com/stories/c4964f08ffcf4d9286bd1fd545ddfbab

# .03 FIM and IDSS

# FIM Use Before, During, and After a Flood Event

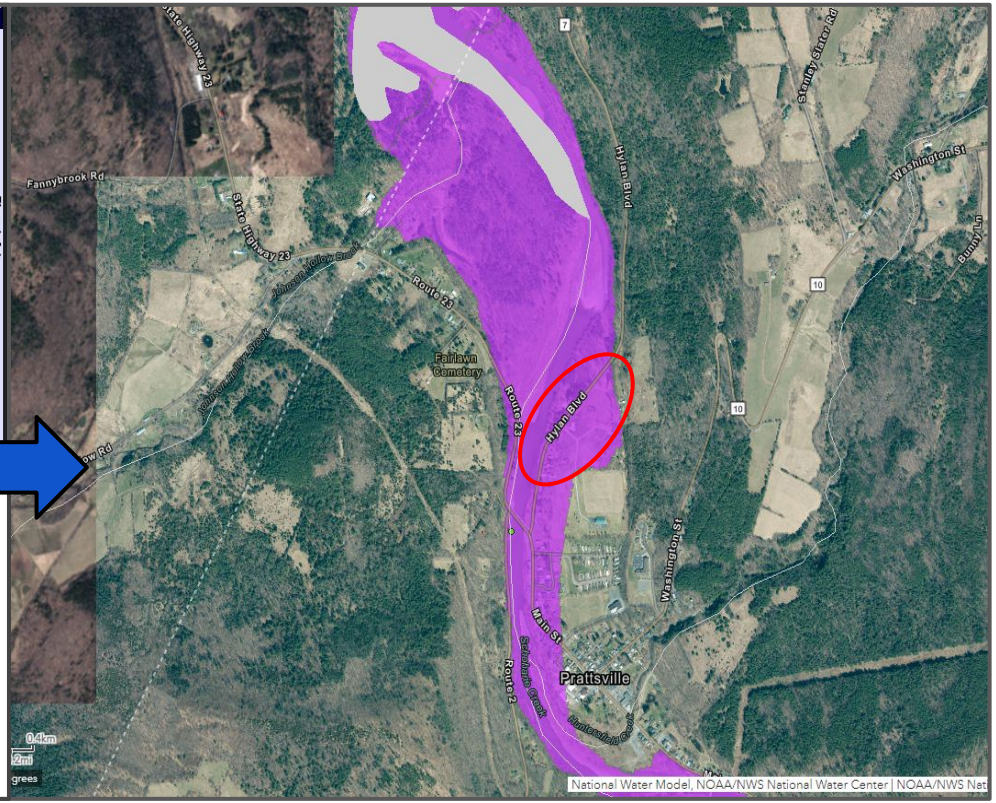


# Visualizing FIM - Putting Water on a Map




If you notice any errors in the below information, please contact our Webmaster

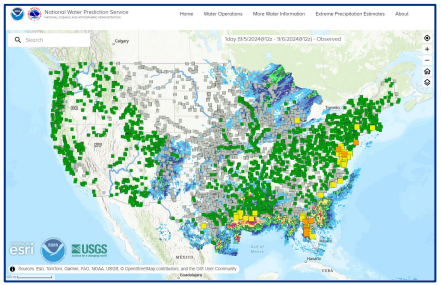
| | |
|---|---|
| 24.38 | Record level from Tropical Storm Irene in August 2011. |
| 19 | Lower portion of village inundated with three feet of water. |
| 18 | Substantial damage with two to three feet of water on properties in the village along the river. |
| 16 | Major flood stage. Water overflows onto County Route 7 north of Route 23. |
| 14 | Moderate flood stage. Water overflows onto Main Street or NY State Route 23. |
| 13 | Minor flooding of basements. |
| 12 | Minor flood stage. The river overflows into lowlands. |
| 11 | The river is close to bankfull. |
| 9 | Action stage. The river is about two thirds bankfull. |



# FIM Impact-Based Decision Support Services

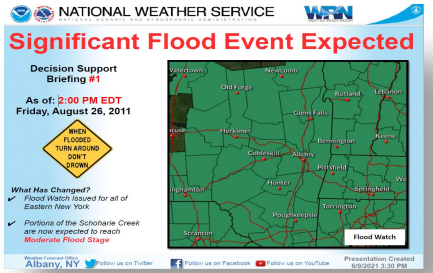
**Increasing direct interaction with core partners based on various scenarios and needs**

## Public Services



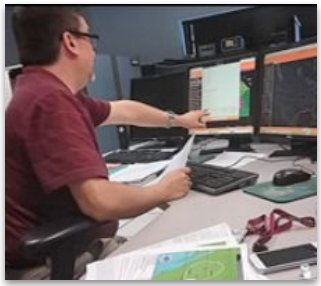
NWPS, National Viewer, providing visualizations and FIM for the partners to ingest into their system (i.e. REST services via HydroVis).

## Baseline IDSS



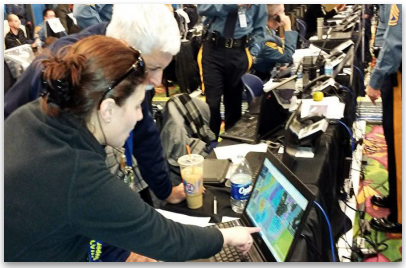

Providing graphics, email packages, webinars, NWSChat, etc. to all core partners to convey general impacts.

## Targeted IDSS



Providing targeted graphics, email packages, webinars, etc. to core partners to convey specific impacts based on their specific needs and thresholds.

## Integrated IDSS



Providing onsite, integrated support within a core partner's operations with detailed impact information tailored to the partner's needs and thresholds.

# Homes north of the river near Elmwood Ave

***Disclaimer: These experimental maps represent the NWS' best approximation of inundation extent based upon modeled river discharge.***

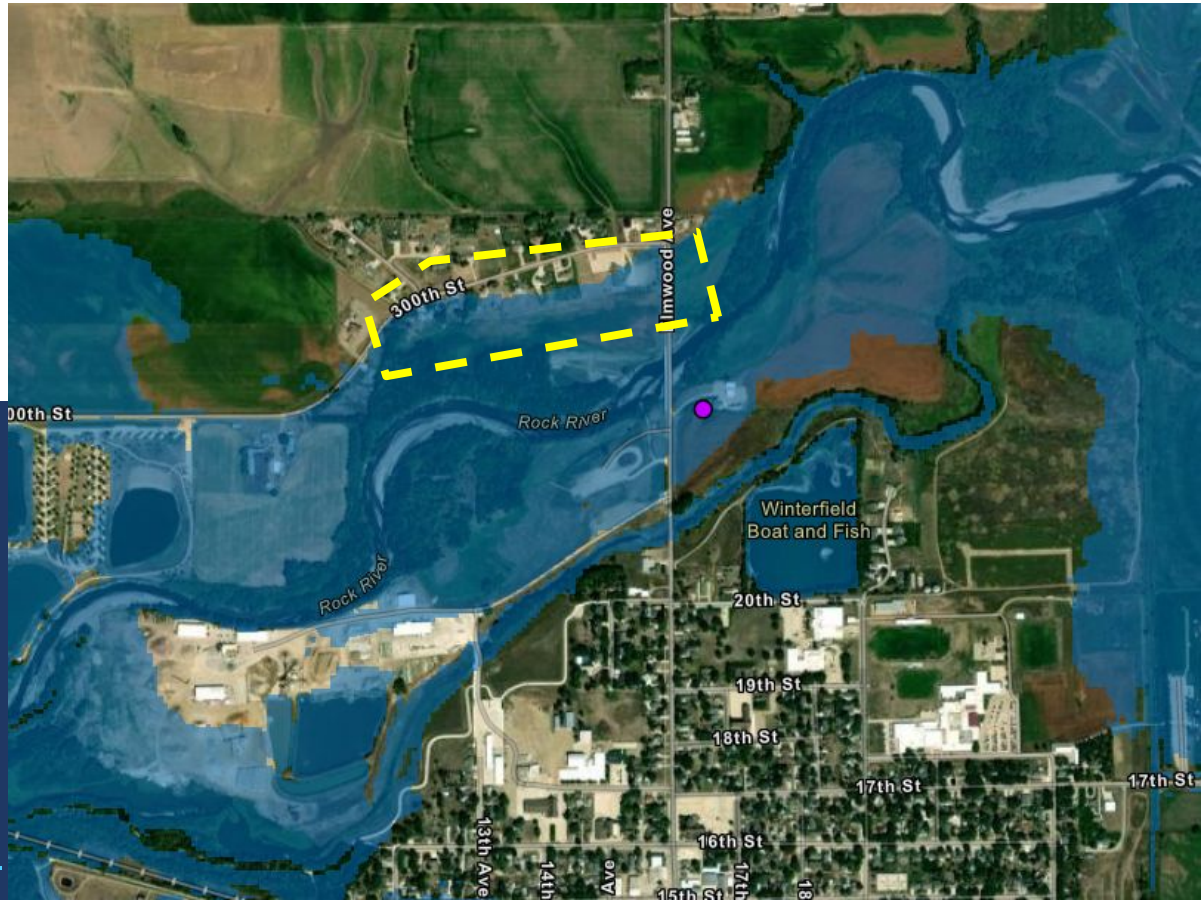
## *Rock River*
## *Rock Valley, IA (RKVI4)*

Forecast Crest Height: **21.0 Feet**
FIM Source: **NWC RFC R&R**
FIM Type: **Dynamic (Depth NOT Included)**
FIM Creation Time: **06/21/24 @ 7:00 am**

## Impacts:

**Water reaches the backyards of some houses north of the river and west of Elmwood Ave in Rock Valley and some outbuildings are flooded at 18 feet.**

Link: *https://water.noaa.gov/gauges/rkvi4*



# Record Flooding Forecast in Asheville, NC

Friday, September 27, 2024
12:45 AM EDT

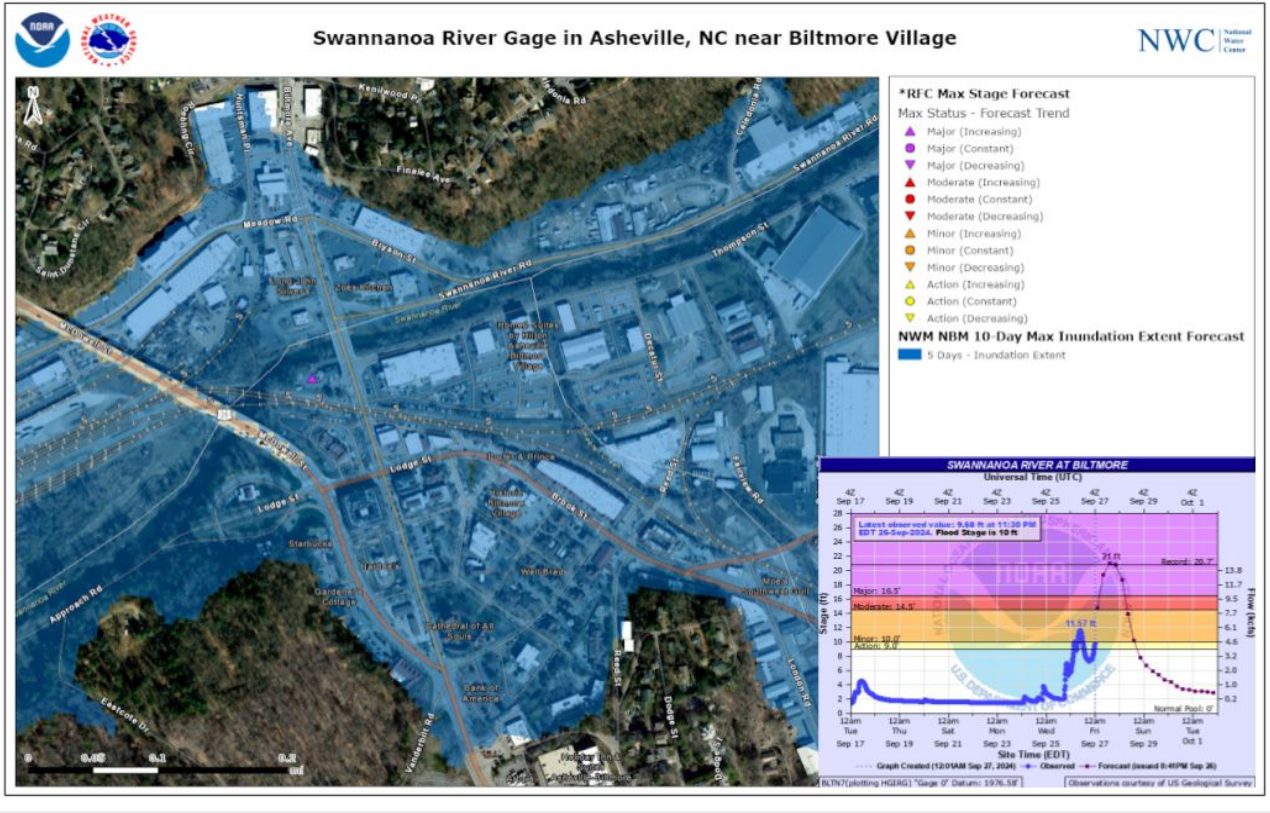
## Life Threatening Flooding Possible

## Key Messages

- Record flooding is forecast along the Swannanoa River
- Life threatening flooding may be possible
- Flood inundation mapping suggests widespread flooding in the Biltmore Village area of Asheville (shown in blue in the image on the right)
- To escape rising water, take the shortest path to higher ground.

## Timing

- Flooding is ongoing and expected to crest Friday evening at record stage



# .04 Tools and Resources

# FIM & NWM Visualizations Experimental Services

**FIM Services available for NRPC jurisdictional area in Sep. 2025**

- **Categorical Stage-Based FIM (Missisquoi @ E. Berkshire & Swanton* during high water)**
- **Partner FIM (4 Lake Champlain sites, always)**
- **NWM Latest Analysis FIM (all areas, during high water)**
- **RFC 5-Day Max Extent FIM (Missisquoi @ E. Berkshire and Swanton, during high water)**
- **NWM 5-Day Max Extent FIM (all areas, during high water)**

**Non-FIM NWM Services available nationwide**

- High Water & Peak Flow Arrival Time, Max High Flow Magnitude Forecast, & High Water Probability Forecasts
- Rapid Onset Flooding Probability Forecasts
- Services available for ingest into your local GIS systems

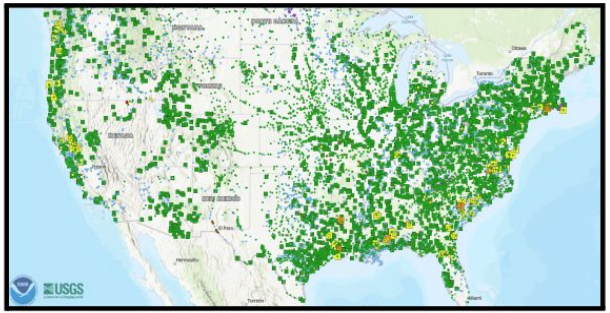
**Visualizations available on NWPS & the NWS GIS Viewer**

- **NWPS** (https://water.noaa.gov) *Includes FIM services, CATFIM in 30% area, RFC & NWM forecast hydrographs, and a few NWM non-FIM visualizations* ***(60% area, including NVDA areas in Sep. 2025)***
- **NWS GIS Viewer** (https://viewer.weather.noaa.gov/water) *Includes FIM services and all Non-FIM NWM services*

**Public Handbook:**

**National Water Center Visualization Services**

Version 2.3




Last updated: April 19, 2024

*Preliminary - Subject to Change

OWP OFFICE OF WATER PREDICTION

https://www.weather.gov/owp/operations

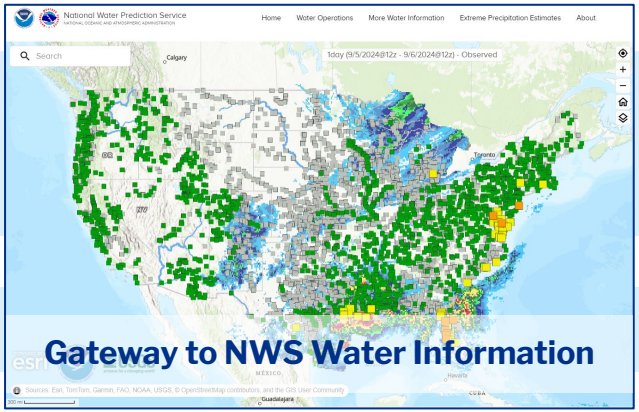
# FIM Dissemination Endpoints

## HydroVIS Enterprise GIS

https://maps.water.noaa.gov/server/rest/services
https://maps.water.noaa.gov/image/rest/services

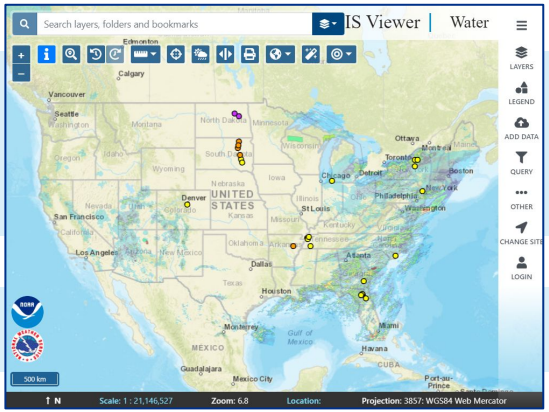

## National Water Prediction Service

https://water.noaa.gov



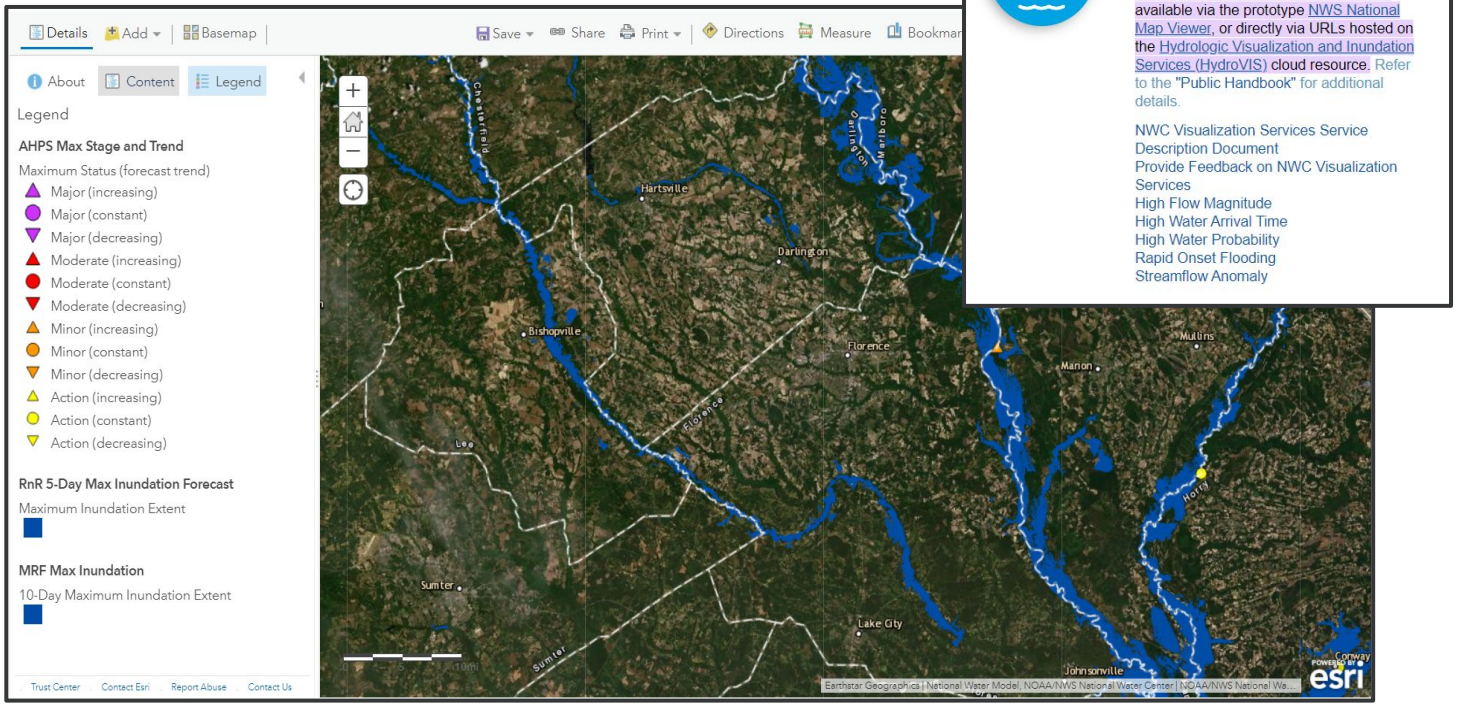

## NWS National GIS Viewer

https://viewer.weather.noaa.gov/water



# Access to FIMs

## *Via REST Services*




**NWC Visualization Services**

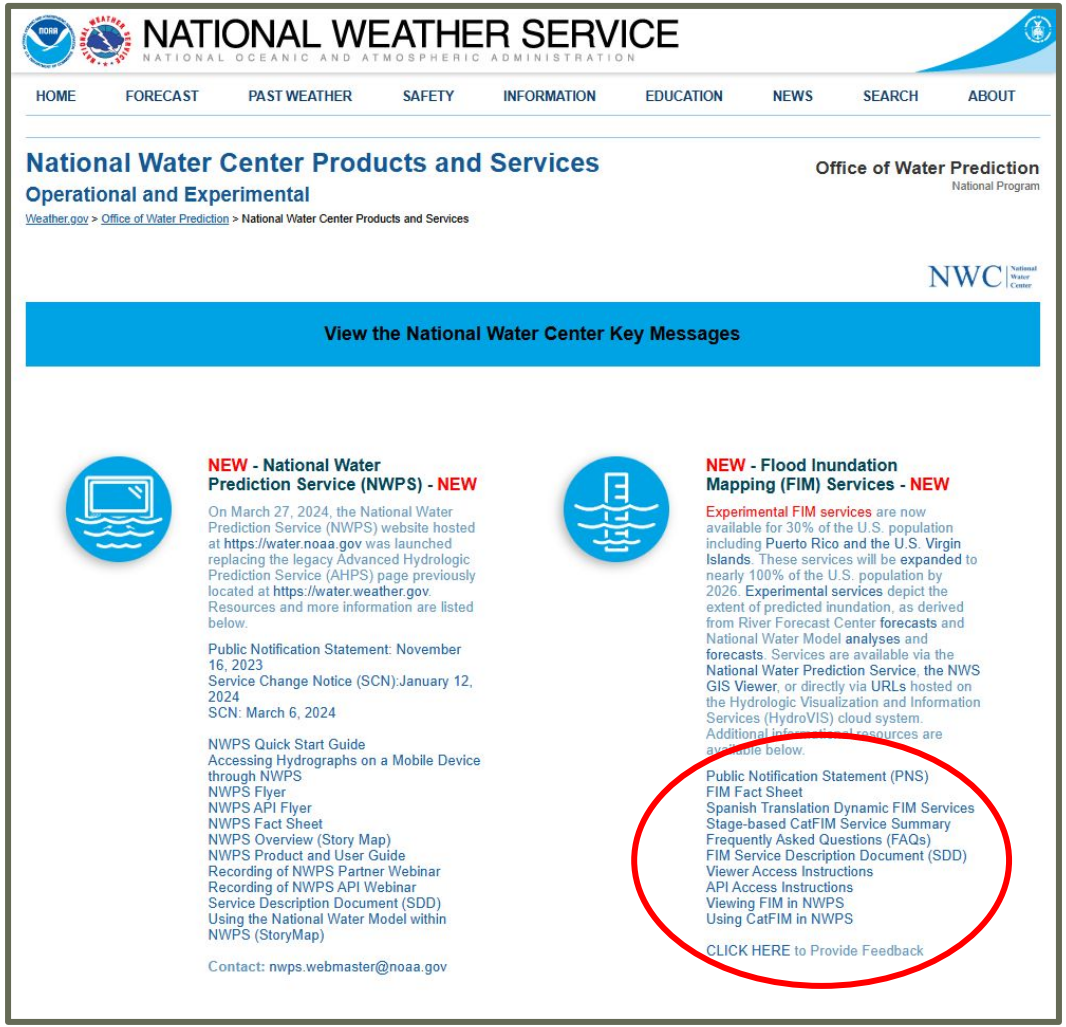
Experimental geospatial services depicting forecasts from the River Forecast Centers and the National Water Model. Services available via the prototype NWS National Map Viewer, or directly via URLs hosted on the Hydrologic Visualization and Inundation Services (HydroVIS) cloud resource. Refer to the "Public Handbook" for additional details.

NWC Visualization Services Service Description Document
Provide Feedback on NWC Visualization Services
High Flow Magnitude
High Water Arrival Time
High Water Probability
Rapid Onset Flooding
Streamflow Anomaly

Linked here:
https://www.weather.gov/gis/cloudgiswebservices

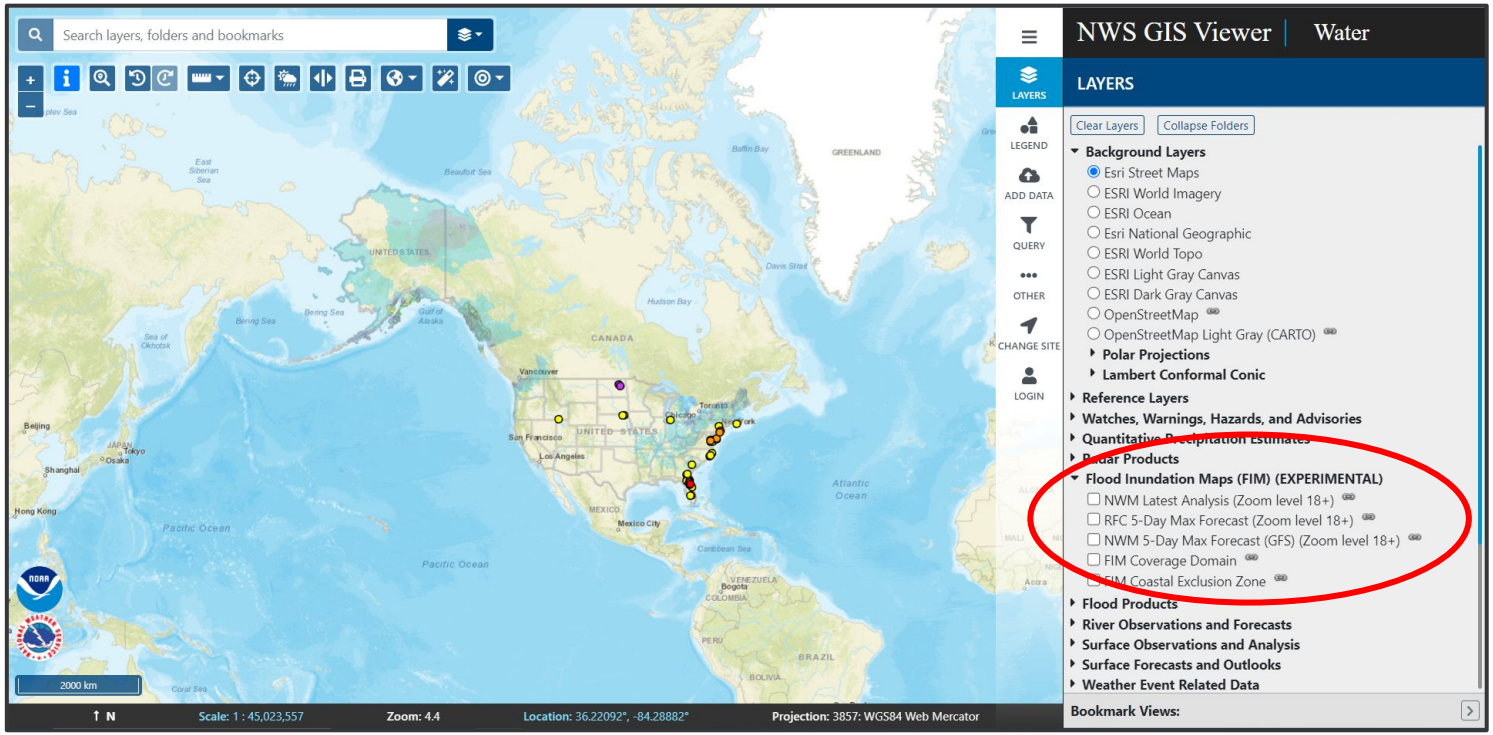
# Access to FIM FAQs

Linked here:
https://www.weather.gov/owp/operations



# Access to FIMs

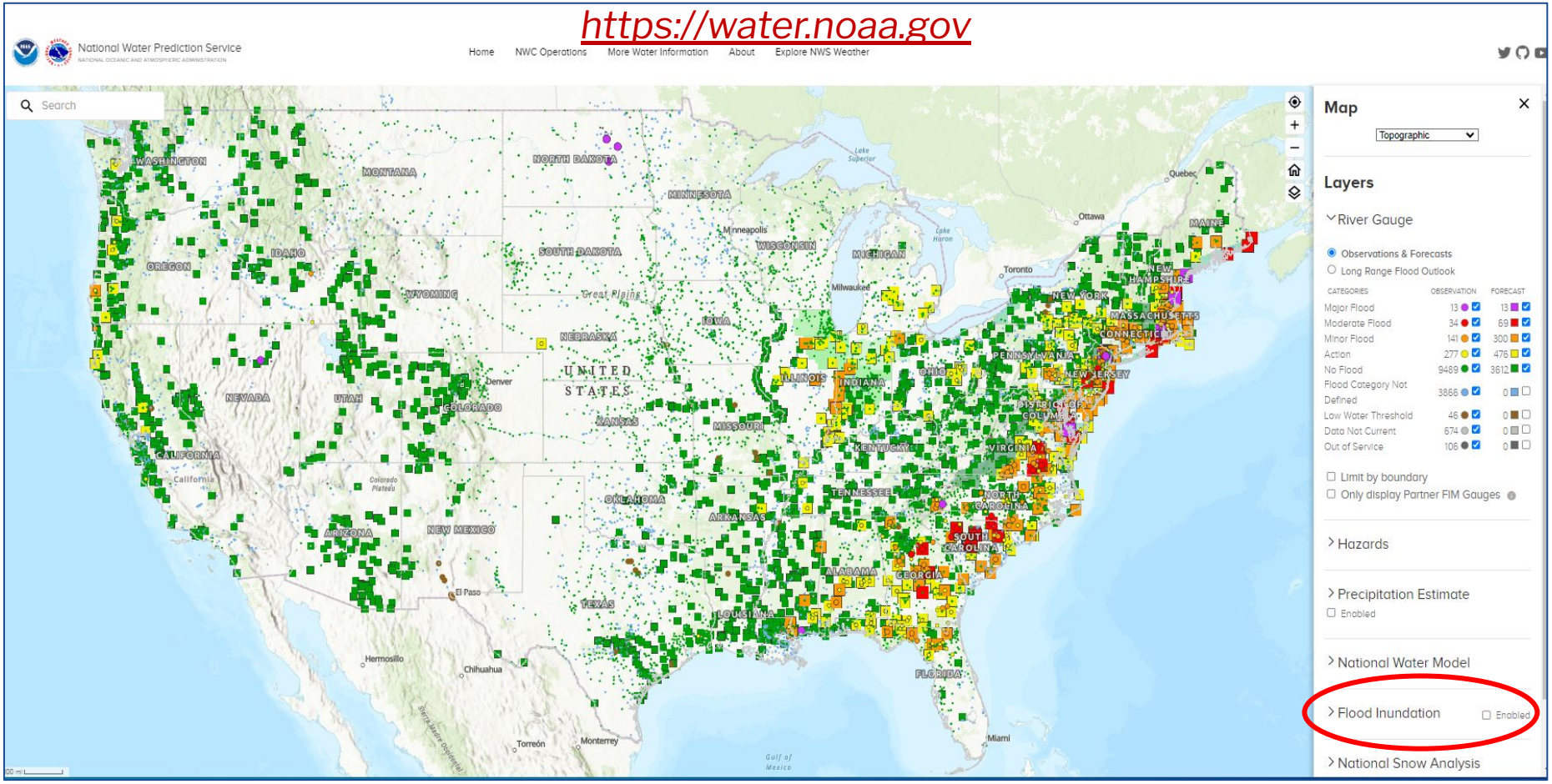
## *Via National Viewer*




https://viewer.weather.noaa.gov/water

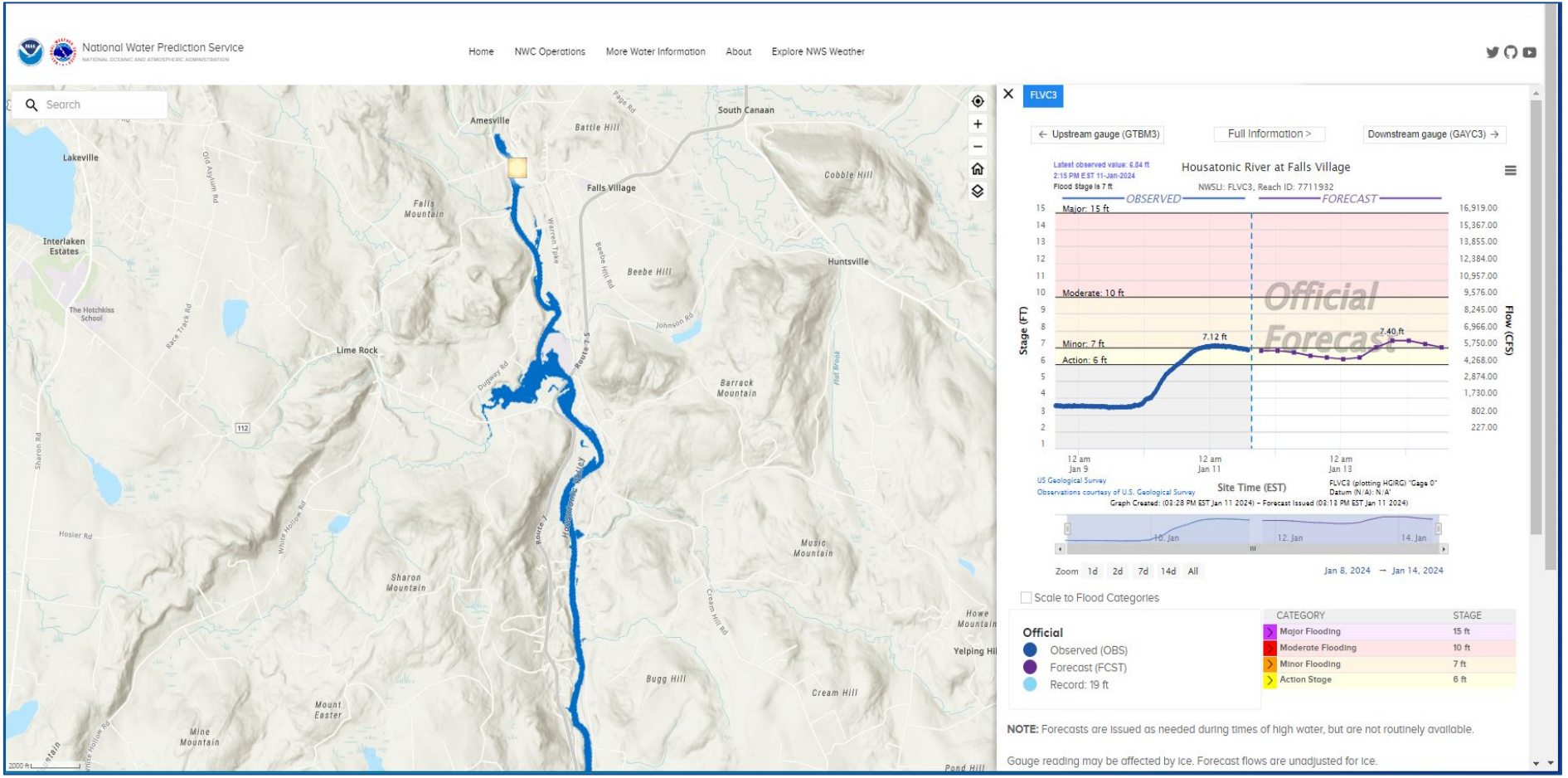
# Access to FIMs *Via NWPS*

https://water.noaa.gov



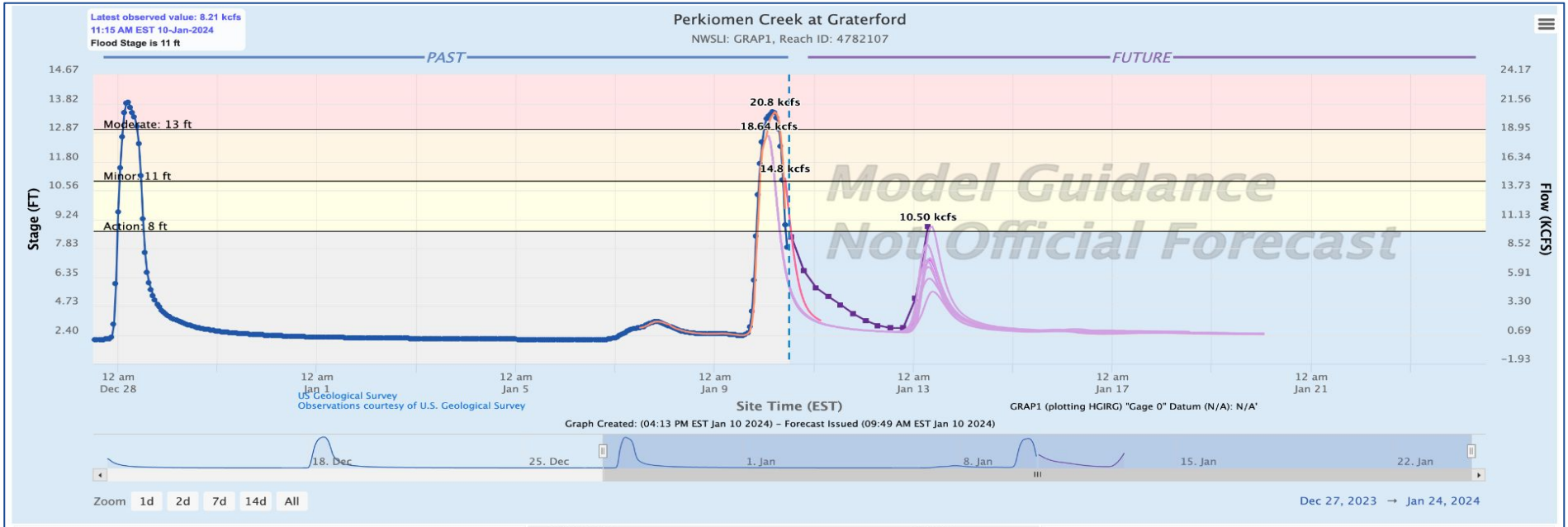
# National Water Prediction Service (NWPS)

*Linking RFC Forecasts and RFC FIM Services*



# National Water Prediction Service (NWPS)

## *NWM Guidance at Point Locations*




**Official**
- Observed (OBS)
- Forecast (FCST)

| CATEGORY | STAGE |
|---|---|
| Major Flooding | 16 ft |
| Moderate Flooding | 13 ft |
| Minor Flooding | 11 ft |
| Action Stage | 8 ft |

**National Water Model**
- Analysis (ANA)
- Medium Range Blend (MRB)
- Short Range (SR)

**Medium Range Ensembles**
- Medium Range Ensemble Mean (MRM)
- Medium Range Ensemble 1 (MR 1)
- Medium Range Ensemble 2 (MR 2)
- Medium Range Ensemble 3 (MR 3)
- Medium Range Ensemble 4 (MR 4)

Example of NWM Guidance for Perkiomen Creek, January 10th, 2024

# Questions?
# Comments?

Thank You!

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