

TRANSFORMING NOAA WATER PREDICTION



Informing Decisions for a Water-Prepared Nation

NWS National Climate Services Meeting

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Outline

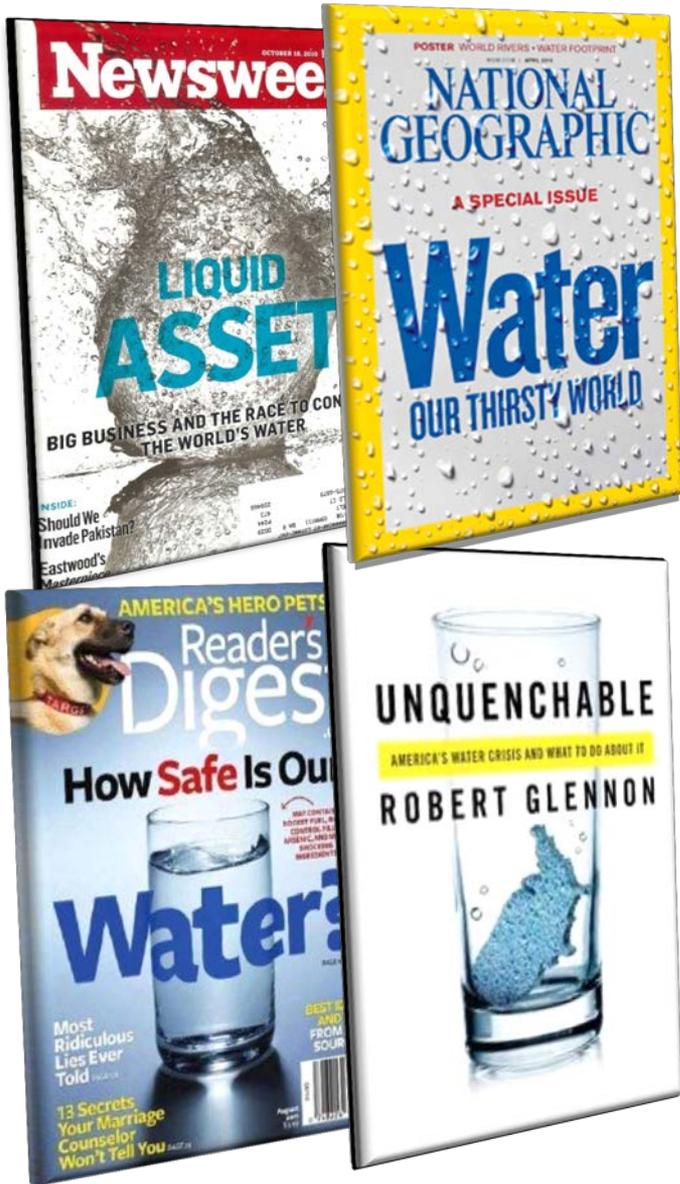
- Impetus for Change
- NWC Status and Plans
- Deep Dive into New Prediction Capabilities
- Partnering to Accelerate R2O
- Summary



TOO MUCH
TOO LITTLE
POOR QUALITY

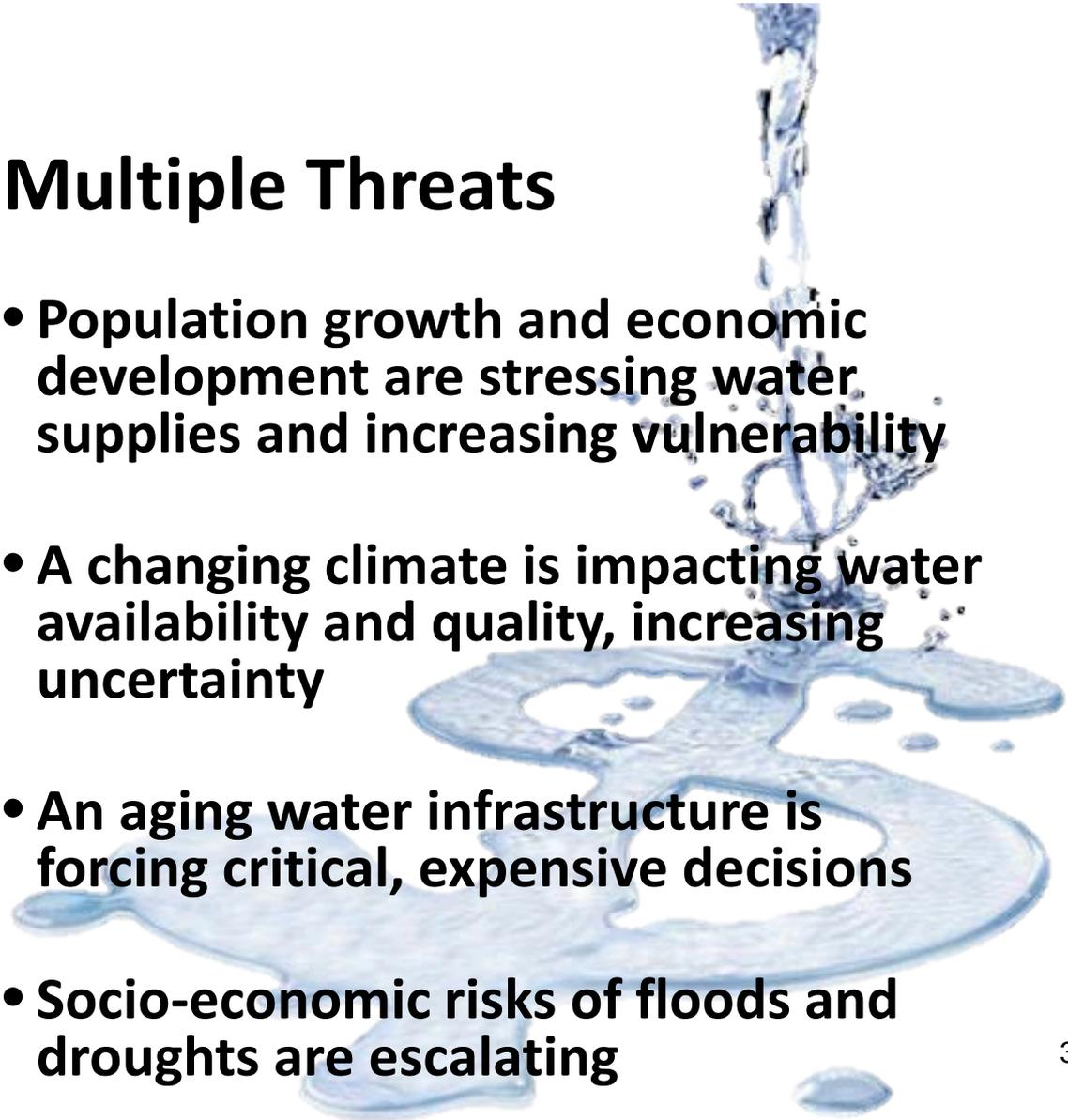
Impetus for Change

Growing Water Challenges



Multiple Threats

- Population growth and economic development are stressing water supplies and increasing vulnerability
- A changing climate is impacting water availability and quality, increasing uncertainty
- An aging water infrastructure is forcing critical, expensive decisions
- Socio-economic risks of floods and droughts are escalating



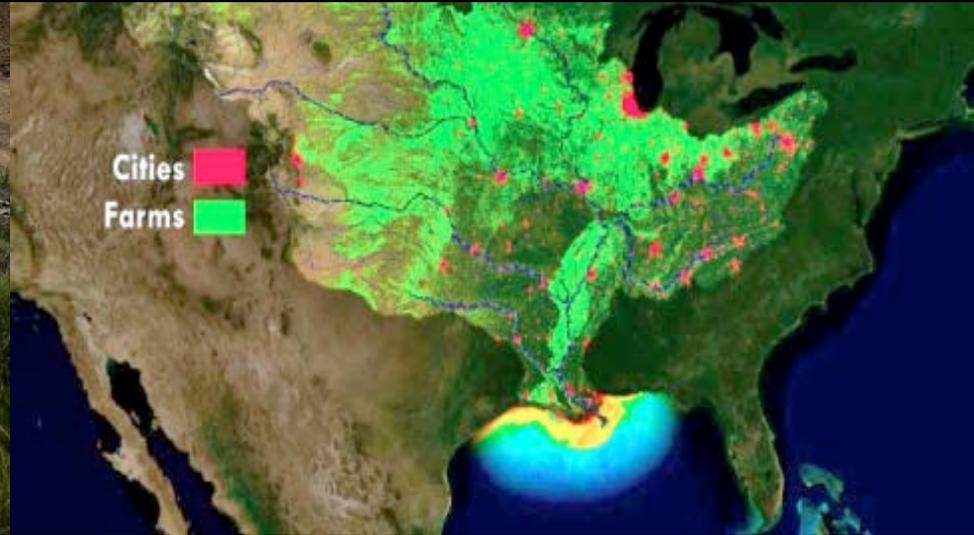
WATER EXTREMES



WATER SECURITY



WATER QUALITY



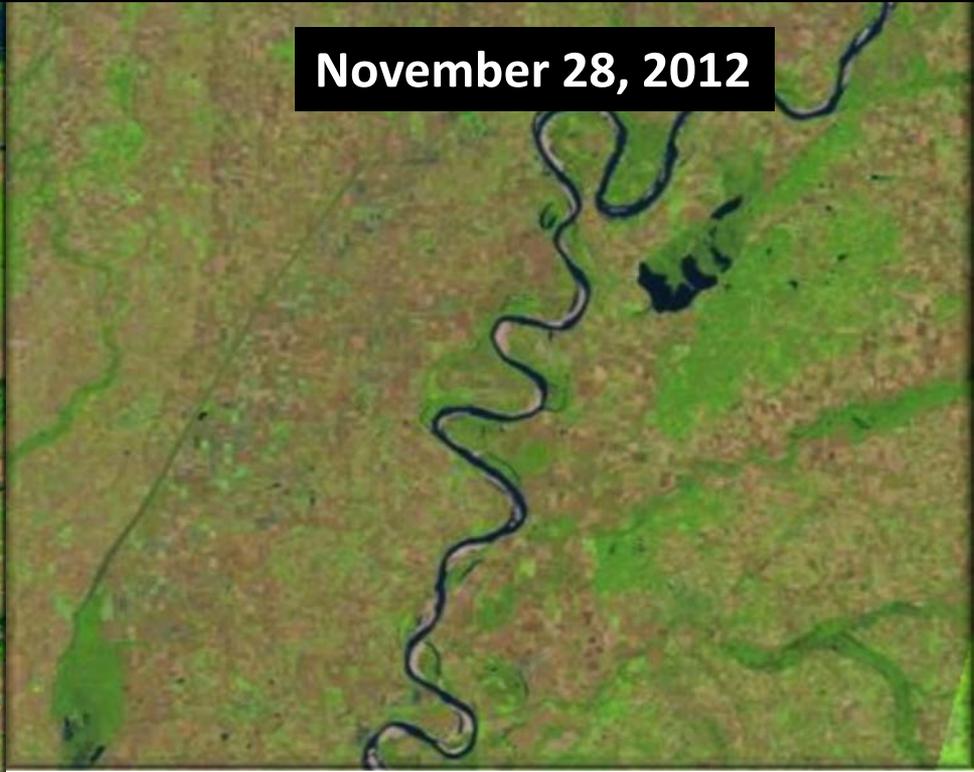
Interrelated Grand Challenges

Example of Grand Challenge: Mississippi River Above Memphis, TN

May, 10, 2011



November 28, 2012



National Academy of Sciences Report: *Weather Services for the Nation: Becoming Second to None*

Findings



Recommendations

NWS Modernization and Restructuring (MAR) did not directly address hydrologic prediction services

A significant gap exists between the state of hydrologic science today and current NWS hydrologic operations

The level of sophistication, representation of processes, and characterization of uncertainties in external research and operational communities outpace those used in NWS hydrology operations

NWS Hydrologic Forecasters are extensively *“in the forecast loop”*

Qualifications for hydrologist positions were not updated in the MAR to require degreed hydrologists

Lack of skill in modern computational programming, construction and use of new Earth System Models, current hydrologic data assimilation methodologies, and preparation and interpretation of meaningful ensemble predictions

Prioritize core capabilities - a MAR-like effort is needed to address long-standing and deep-seated issues in hydrology

Improve pathways for collaboration & accelerate R2O

Establish a hydrologic prediction testbed as part of the National Water Center

Implement a consistent framework for hydrologic prediction skill assessment

Transition RFC forecasters to “over the loop” enabling a shift in focus to model and product development, forecast interpretation, and decision support

Hydrologist staff require re-education and continual retraining to enable adoption of state-of-the-art prediction methodologies

Instill evolutionary culture

Add value to hydrologic forecasts through the use of more advanced models, data assimilation and employment of more sophisticated ensemble techniques

Stakeholder Priorities



Flooding



**Water
Quality**



**Water
Availability**



Drought



**Climate
Change**

Need integrated understanding of near- and long-term outlook and risks

Actionable Water Intelligence

High Resolution, Integrated Water Analyses, Predictions and Data

Transform information into intelligence by linking hydrologic, infrastructural, economic, demographic, environmental, and political data

National Water Center

Initial Operating Capacity: May 26, 2015



A catalyst to transform NOAA's water prediction program



Mission: Nationally Integrated Water Prediction

- Earth system modeling and geo-intelligence for water prediction
- Operations Center for water resources common operating picture
- Decision support services for spectrum of water stakeholders
- Proving ground to accelerate research to operations
- Interagency and Academia Collaboration



Transforming NOAA Water Prediction

| TODAY | THE FUTURE |
|---|--|
| Approximately 4000 forecast locations at points | Approximately 2,700,000 forecast stream reaches |
| Forecast river flow/stage, from summit to coastal zone | Forecast all hydrologic parameters which define the water budget, from summit-to-sea |
| Driven by large catchment “lumped” modeling | Driven by high/hyper resolution Earth System modeling (Built upon NCAR’s, community-based, ESMF-compliant, WRF-Hydro coupling architecture) |
| Forecaster “in the loop” – serial, basin to basin, modeling of flow through the river network | Forecaster “over the loop” – simultaneous modeling of the nation’s entire river network |
| Average basin size greater than 420 square miles | Average basin size ~1 square mile |
| 13 River Forecast Centers (RFCs) developing separate versions of the same regional model | 13 RFCs, NWC, academia, and federal partners developing/evolving same state-of-the-science national, community-based, model (working with NSF, CUASHI, and other Federal agencies to establish community development version of NWM) |
| RFC-generated river forecasts coordinated with Weather Forecast Offices (WFOs) to deliver Impact-based forecasts at selected points | National Water Model-based predictions coordinated among NWC, RFCs, and WFOs and linked with detailed local infrastructure data to communicate street level impacts |

For the hydrology community, the implementation of the NWM and the leap ahead capability it provides parallels the implementation of mesoscale atmospheric models in the 1970s (i.e., model resolution substantially greater than available observational network)

National Water Model (NWM)

IOC Experimental Output (FY16 Q4)

- **Hydrologic Output**

- River channel discharge and velocity at 2.7 million river reaches
- Reservoir inflow, outflow, elevation
- Surface water depth and subsurface flow (250 m CONUS+ grid)

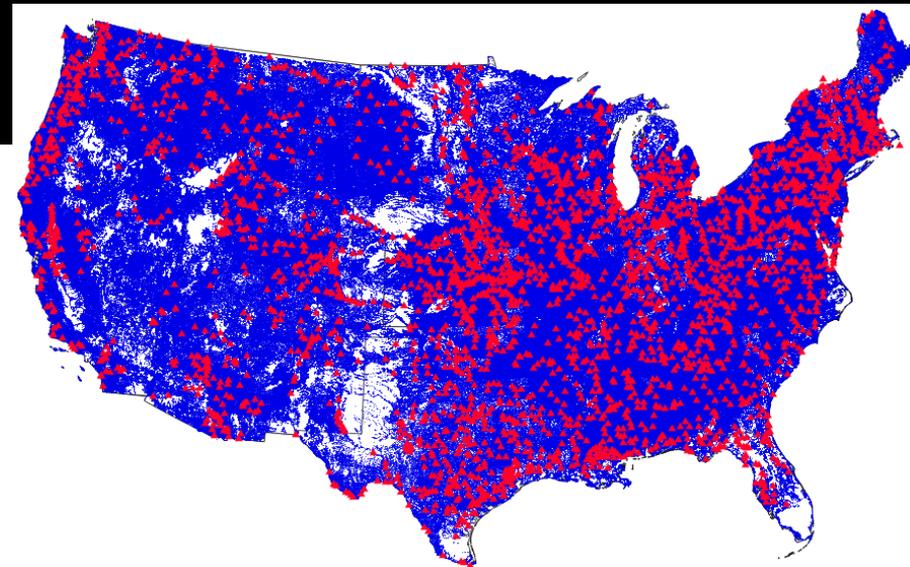
- **Land Surface Output**

- 1km CONUS+ grid
- Soil and snow pack states
- Energy and water fluxes

- **Direct-output and derived products** (e.g. stream flow anomalies)

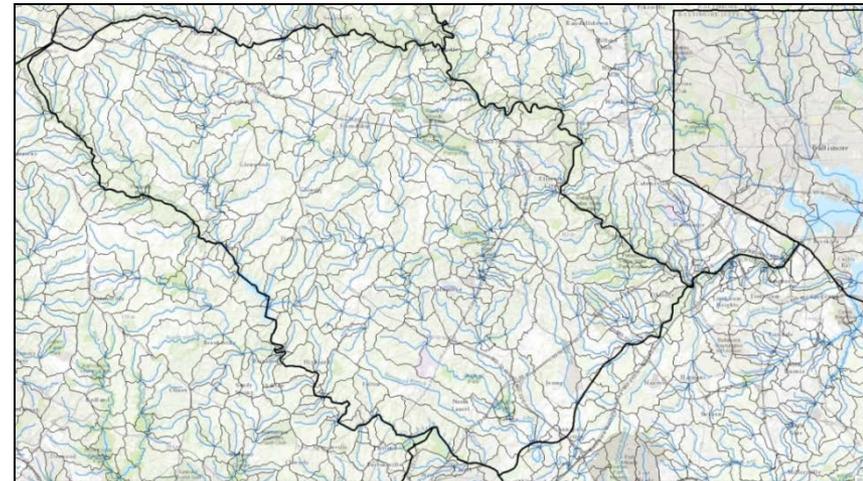
- **Three pronged dissemination strategy**

- Public-facing NWC website
- Data feed to River Forecast Centers
- NOMADS data service (NOAA National Operational Model Archive & Distribution System)



Current NWS AHPS locations (red)
NWM output locations (blue)

Howard County, Maryland (300k People)



Current River Forecast Locations: Zero
NWM Forecast Locations: 300+

NWM V1.0 Operational Configuration

Analysis &
Assimilation

Short-Range

Medium-Range

Long-Range

Cycling Frequency

Hourly

Hourly

Daily

Daily Ens (16 mem)

Forecast Duration

- 3 hrs

0-18 hours

0-10 days

0-30 days

Meteorological Forcing

MRMS blend/
HRRR/RAP bkgnd.

Downscaled
HRRR/RAP blend

Downscaled GFS

Downscaled &
bias-corrected CFS

Spatial Discretization & Routing

1km/250m/NHDPlus
Reach

1km/250m/NHDPlus
Reach

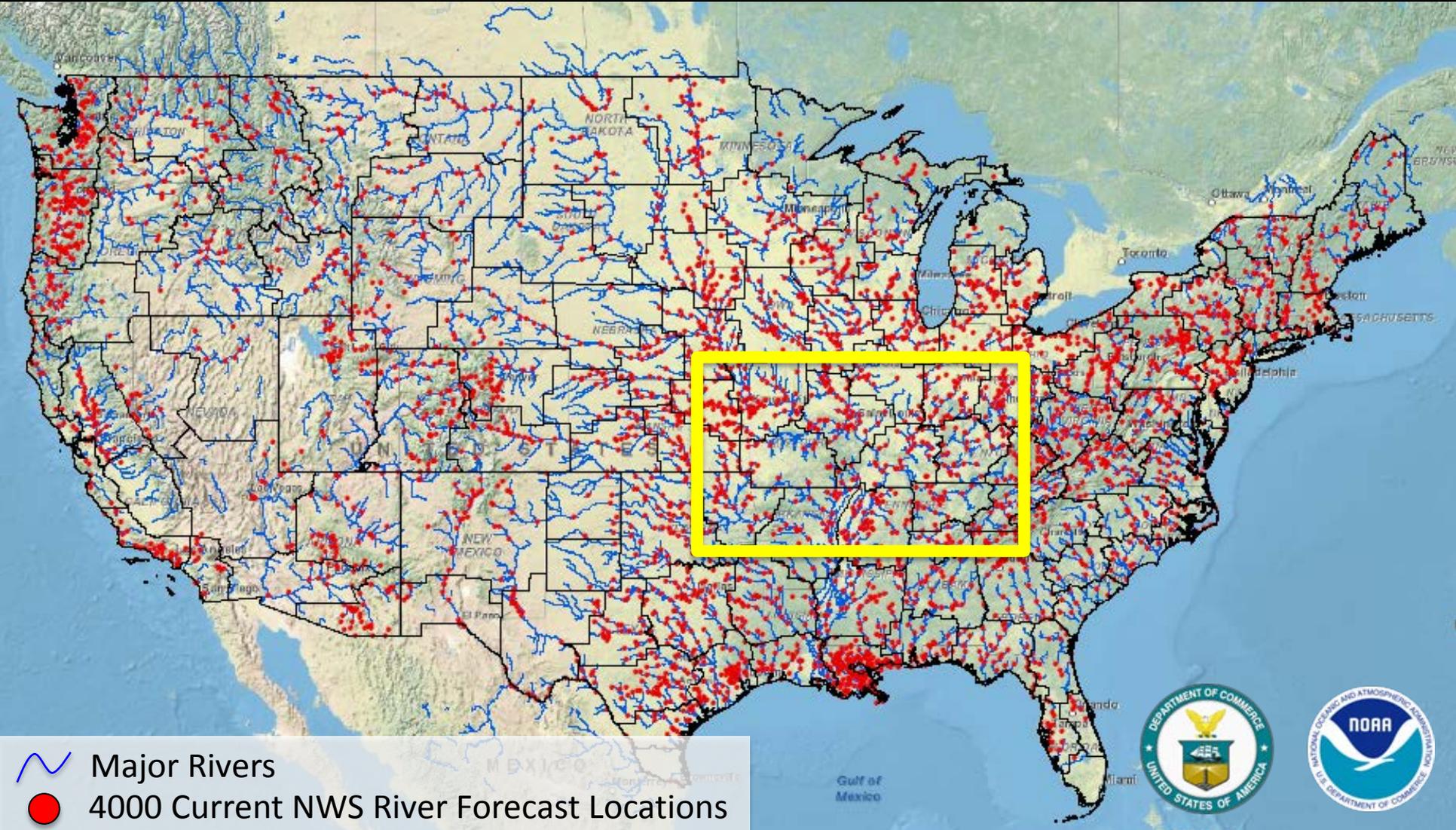
1km/250m/NHDPlus
Reach

1 km/NHDPlus Reach

Assimilation of 8k USGS Obs

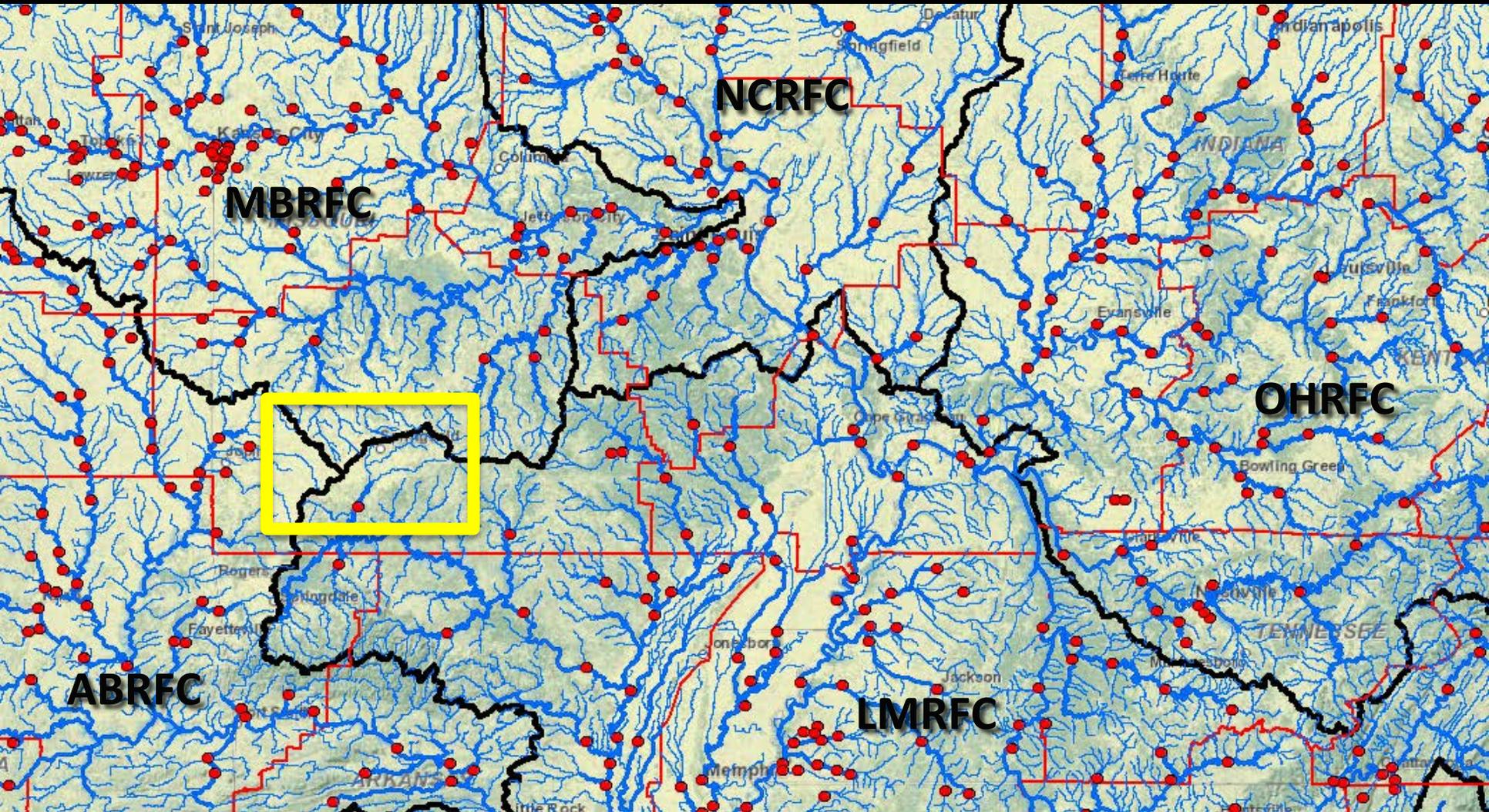
Reservoirs (1240 water bodies parameterized with level pool scheme)

Major Rivers and NWS Hydrologic Forecast Locations (Today)



River Forecast Centers, Major Rivers, and NWS Hydrologic Forecast Locations (Today)

Middle Mississippi River



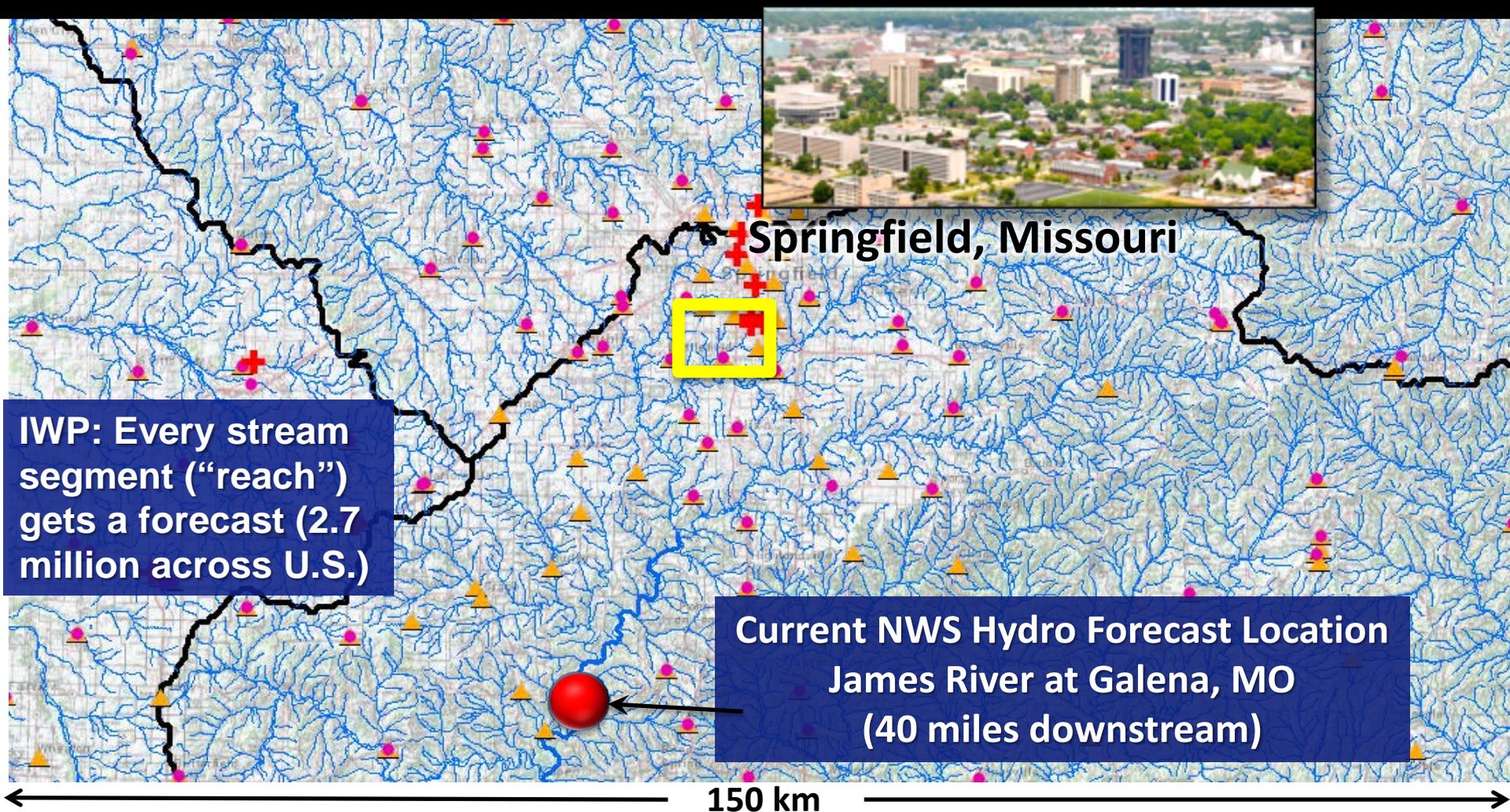
← 1000 km →

● Current NWS River Forecast Locations

Full Resolution National Hydrography Dataset NHD+

Forecasts for every stream reach (2.7 million across U.S.)

WATER PREDICTION + NATIONAL INFRASTRUCTURE = WATER INTELLIGENCE

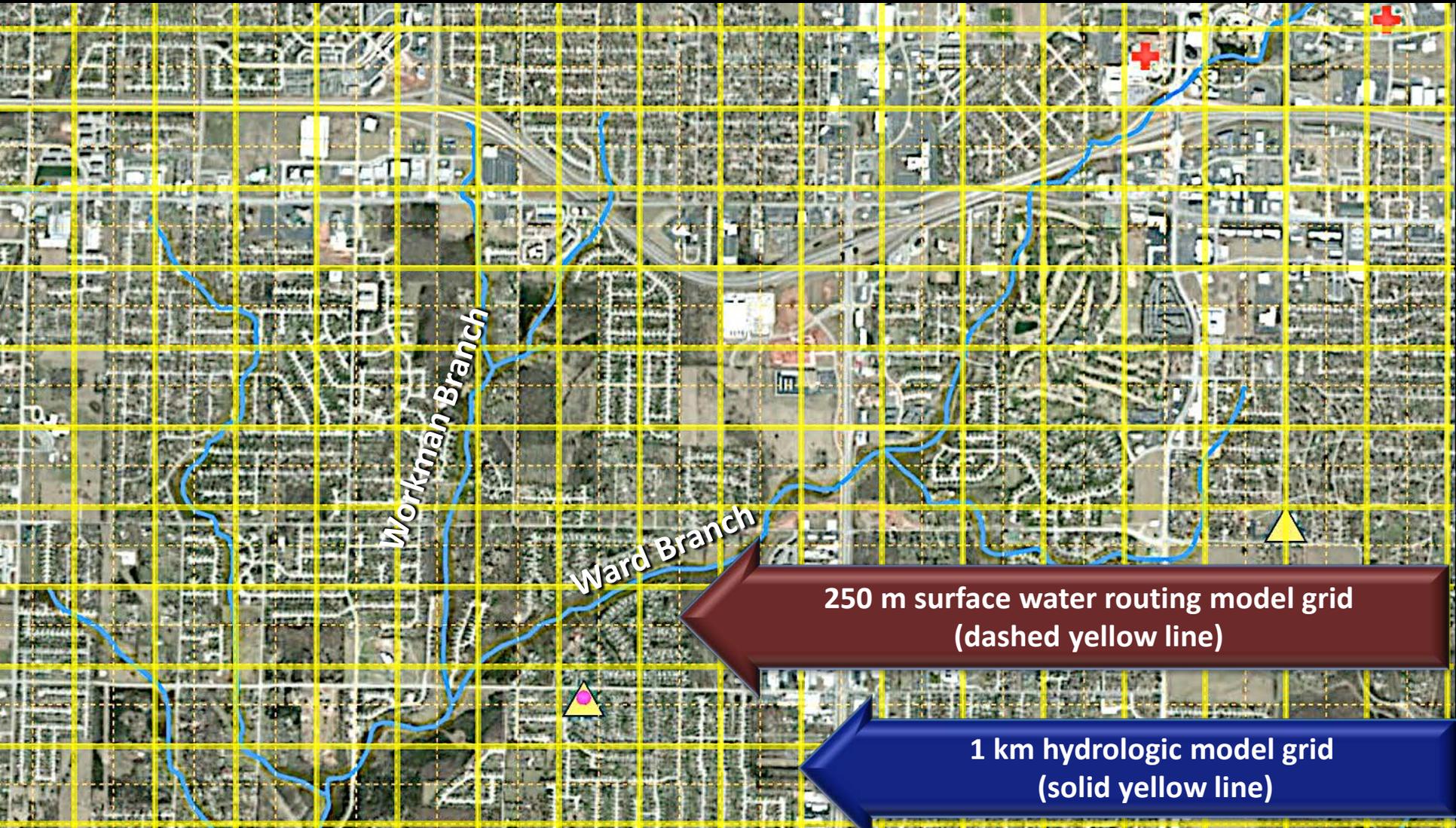


+ Hospitals ● EMS ▲ Fire

Infrastructure Data from National Geospatial Intelligence Agency

WATER PREDICTION + NATIONAL INFRASTRUCTURE

Hospitals, EMS & Fire Stations



250 m surface water routing model grid
(dashed yellow line)

1 km hydrologic model grid
(solid yellow line)

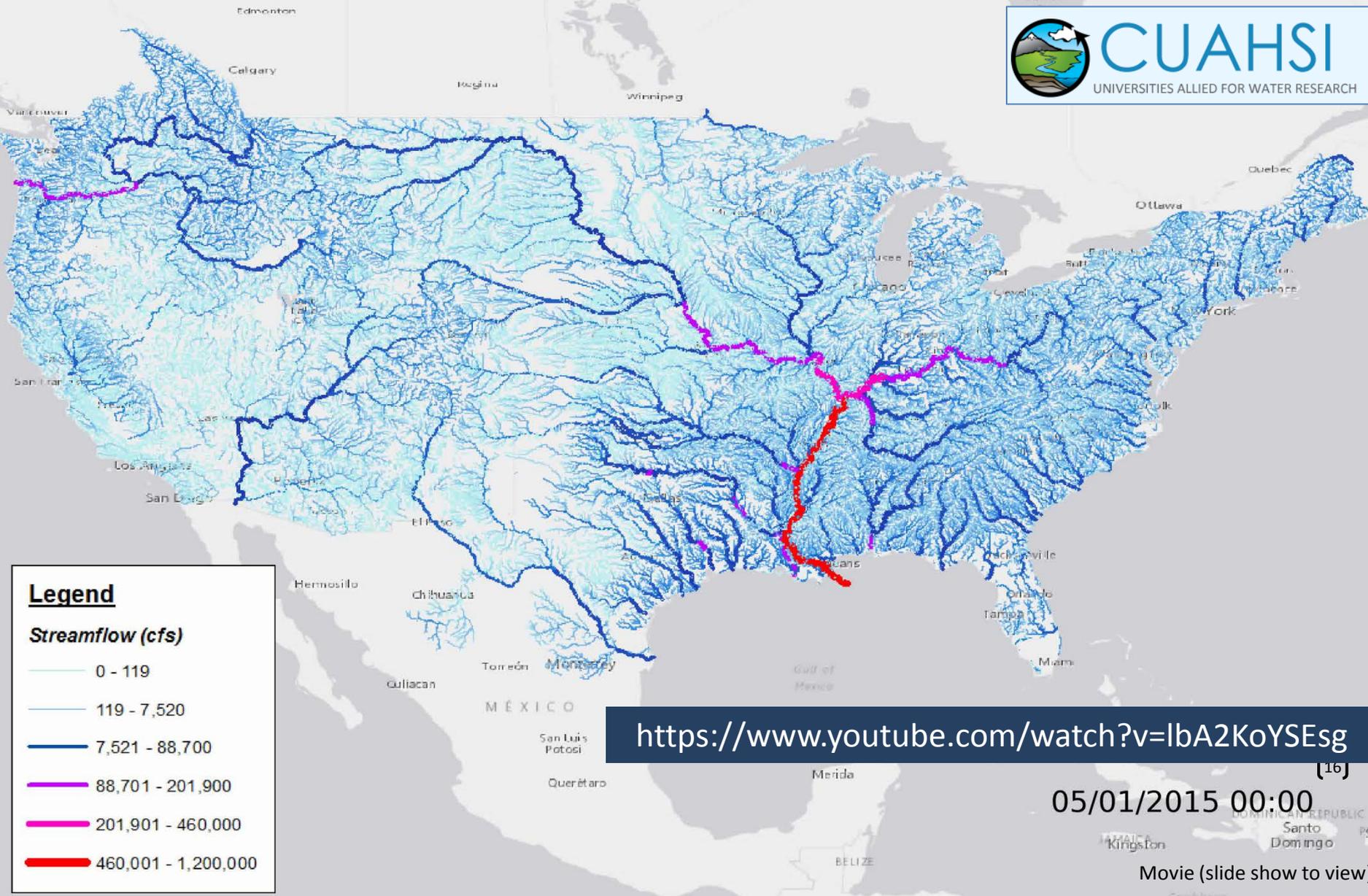
← Hospitals ● EMS ▲ Fire

11 miles

15



National Water Model



Legend

Streamflow (cfs)

- 0 - 119
- 119 - 7,520
- 7,521 - 88,700
- 88,701 - 201,900
- 201,901 - 460,000
- 460,001 - 1,200,000

<https://www.youtube.com/watch?v=lbA2KoYSEsg>

05/01/2015 00:00

Movie (slide show to view)

NWC Innovators Program

- Partnership between **NWS and the academic community** (Interagency Agreement between NSF and NOAA)
- Two Thematic Goals
 - Provide a **framework for collaboration** between the federal and academic communities that fosters innovation and creativity, and enables a pathway for that innovation to transition into operational water prediction
 - **Target emerging technologies** such as advanced water resources modeling capabilities, cutting edge data and interoperability services, or interdisciplinary techniques aligned with NOAA and the NWC's strategic Science and Service



National Flood Interoperability Experiment (NFIE)

(Sept 2014 to August 2015)

- First instance of the **NWC Innovators Program**
- Included a **Summer Institute** for 44 graduate students from 19 Universities at the National Water Center, June 1 to July 17, 2015 on the University of Alabama Campus and NWC
- Demonstrated ability to **simultaneously model the entire continental United States** river network at high spatial resolution, in near real-time for 2.7 million stream reaches
- A more elaborate version of this prototype is being made operation as the **National Water Model** in June 2016 at the National Water Center



Summary

- **NOAA's Water Services are Evolving**
 - Deliver comprehensive, integrated actionable water intelligence
 - Compliment current services with new information spanning Summit-to-Sea, Floods to Droughts, Treetops to Bedrock
- **Implementing State-of-the-Art Technical Approach**
 - Water prediction through state-of-the-science earth system modeling
 - Impact-based decision support services underpinned by geo-intelligence
- **Scale Change: Orders of Magnitude More Data**
 - Reach-based “Street Level” prediction
 - High Performance Computing
- **New Organization, Cornerstone Facility and Philosophy**
 - National Water Center
 - Collaborative, cross-NOAA, interagency, academic partnerships