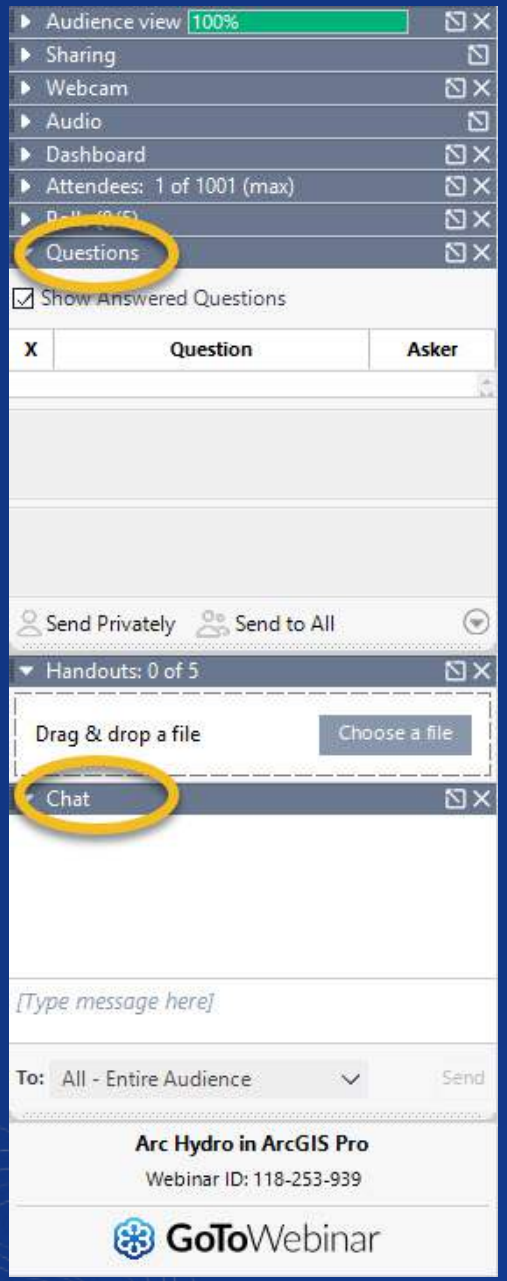
Arc Hydro in Action Webinar Series

2/25/21: Arc Hydro in ArcGIS Pro

3/11/21: **Arc Hydro: Flooding & Forecasting**

3/25/21: Arc Hydro: Hydrology & Hillslope

4/15/21: Arc Hydro: Support for Hydrologic and Hydraulic Modeling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Arc Hydro in ArcGIS Pro
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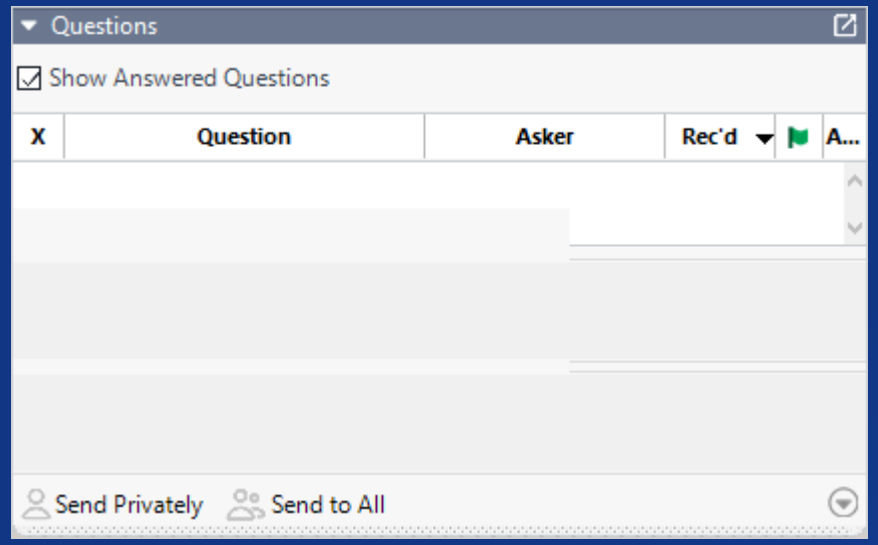
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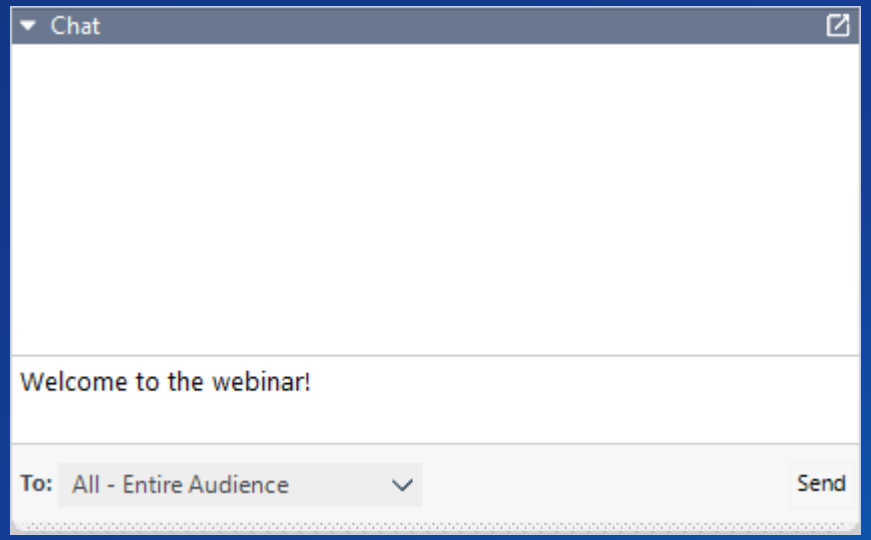

Chat
Welcome to the webinar!
To: All - Entire Audience
Send

Announcements

- First webinar recording

- Applied Meteorology Using ArcGIS (webinar series)

Polling Questions

Did you attend or watch the first webinar “Arc Hydro in ArcGIS Pro”?

- Yes
- No

What ArcGIS Software are you using?

- ArcGIS Pro
- ArcMap
- ArcGIS Online
- Not using ArcGIS/Esri

Arc Hydro: Flooding and Forecasting

Dean Djokic

2021 “Arc Hydro in Action” Webinar Series

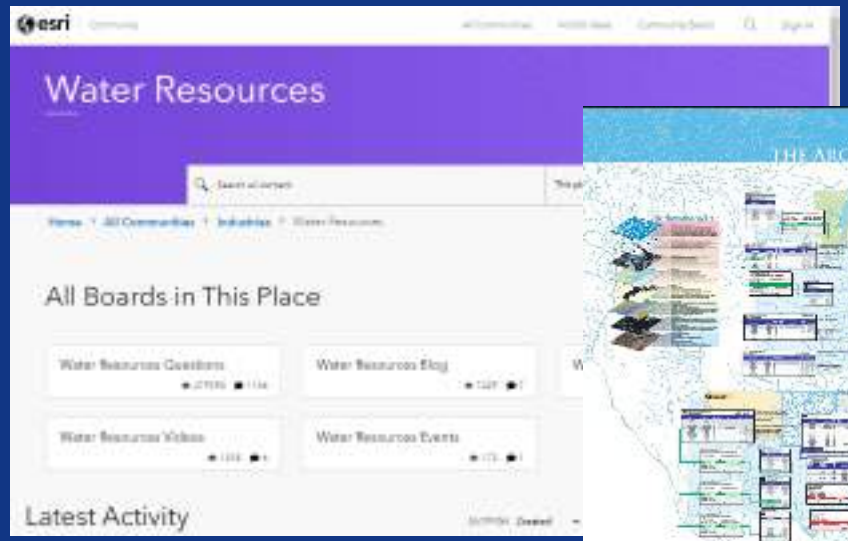
Webinar 2 Topics

- Quick review of Webinar #1
  - Quick overview of Arc Hydro
  - Data, data, data
- Floodplain delineation
- Flood forecasting integration
  - NWM
- Questions

Review of Webinar #1

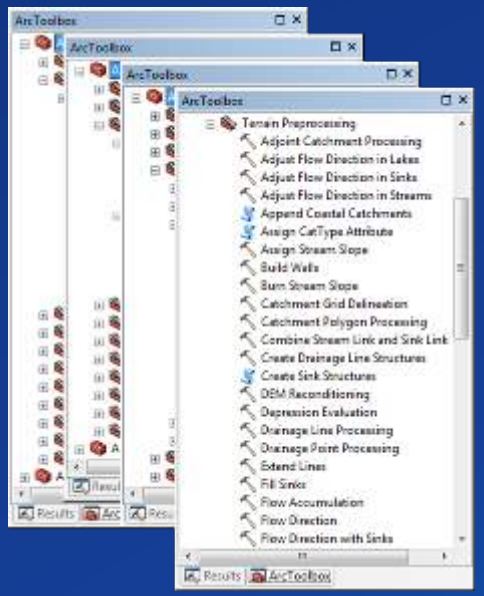
Arc Hydro: Vision

“Provide practical GIS framework for development of integrated analytical systems for water resources market.”

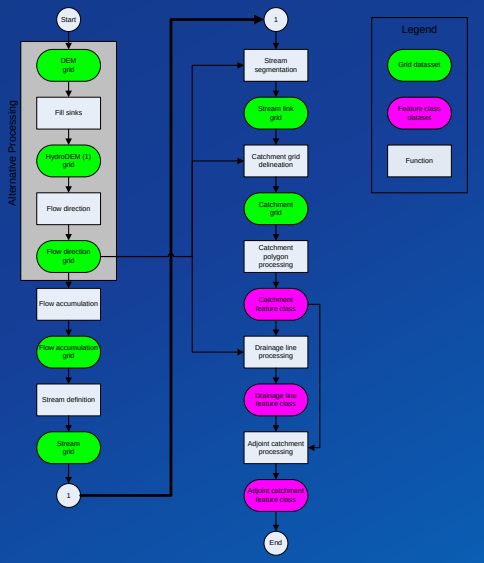


Community

Data Model



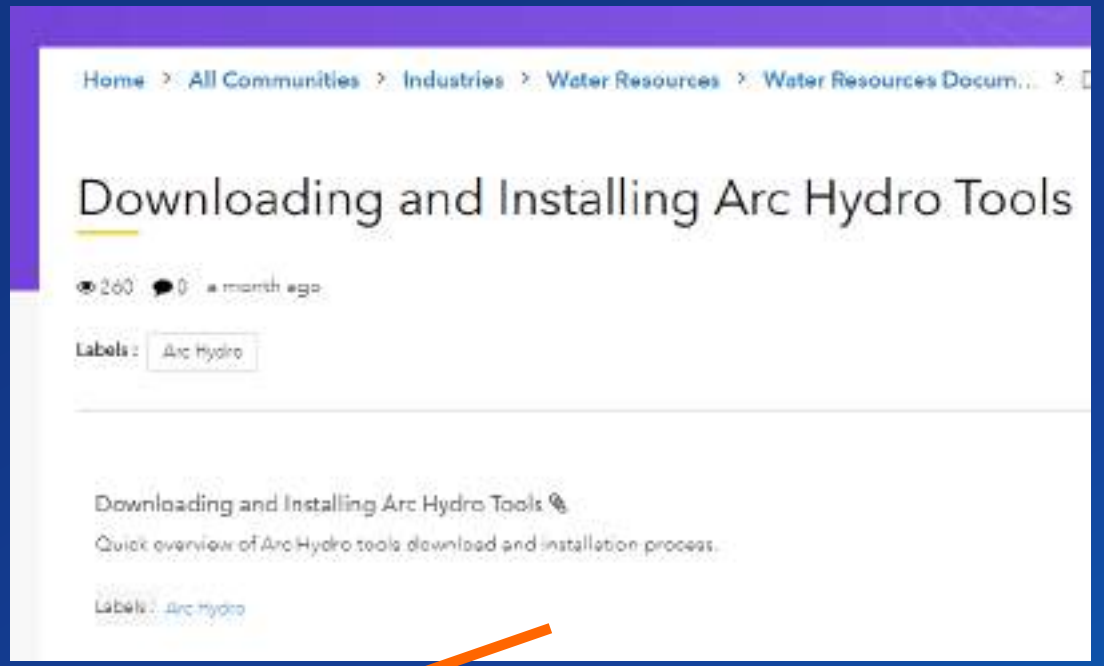
Tools



Workflows

Product \ Capability Summary

- “No fee” downloadable offerings:
  - Data model
  - Tools
  - Workflows
  - Documentation
  - Available now :
    - ArcMap tools - all versions up to 10.8
    - Pro tools - all versions up to 2.7
    - Web services in the Living Atlas



- Optional offerings:
  - Training (paid)
  - Consulting (paid)

- Average of 1000 views per month of the download page

Arc Hydro Tools Summary

Functionality Grouping

Foundation

Administration

- ID mgmt.
- QA
- Configuration

Terrain preprocessing

- Streams
- Sinks
- Flow patterns

Specific implementations

Living Atlas

- Watershed delineation
- Downstream tracing
- Floodplain delineation

Customer Specific

- Nebraska DNR
- USFS GRAIP-Lite
- Illinois DNR

Scientific model integration

- HEC-HMS
- HEC-RAS
- ICPR

General implementation domains

Watershed delineation

- Watershed
- Sub-watershed
- Batch processing

Watershed characterization

- Pollutant loads
- Impervious areas
- Runoff characteristics

Floodplain delineation

- Streams
- Lakes
- Forecast

Stormwater

- Built infrastructure
- Surface drainage
- Connectivity

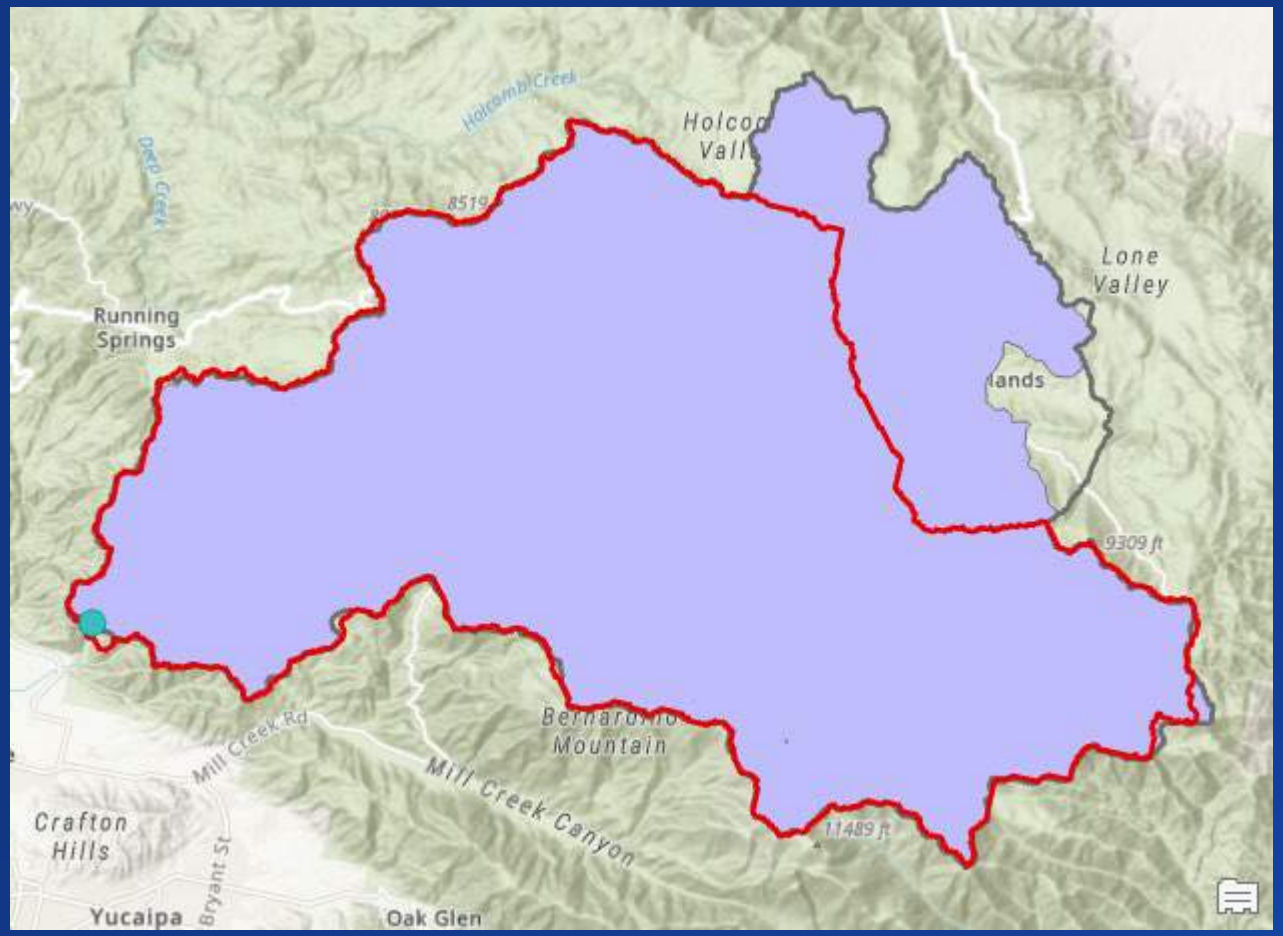
Arc Hydro “Required” Reading

- Arc Hydro - Project Development Best Practices (general)
- Arc Hydro - ArcGIS Pro Project Startup Best Practices (Pro)
- Arc Hydro - Overview of Terrain Preprocessing Workflows (workflow)
- Arc Hydro - HydroPeriod Tool (toolset / workflow)
- Arc Hydro - Wetland Identification Toolset (Pro / toolset / workflow)
- Arc Hydro - Stormwater Processing (toolset / workflow)
- Arc Hydro - Identifying and Managing Sinks (workflow)
- Arc Hydro - Support for Hydrologic Modeling (workflow)
- Arc Hydro - Calling Arc Hydro Tools in Python (developers)

Arc Hydro Demo Reflections

- 3 different ways of doing the same work (watershed delineation).
- 3 different datasets (10m, 30m, 90m).
- 3 (slightly) different results.
- Why !!!???

Arc Hydro Demo Reflections



10m – blue filled poly

30m – black outline poly

90m – red outline poly

Arc Hydro Demo Reflections

10m – blue filled poly

30m – black outline poly

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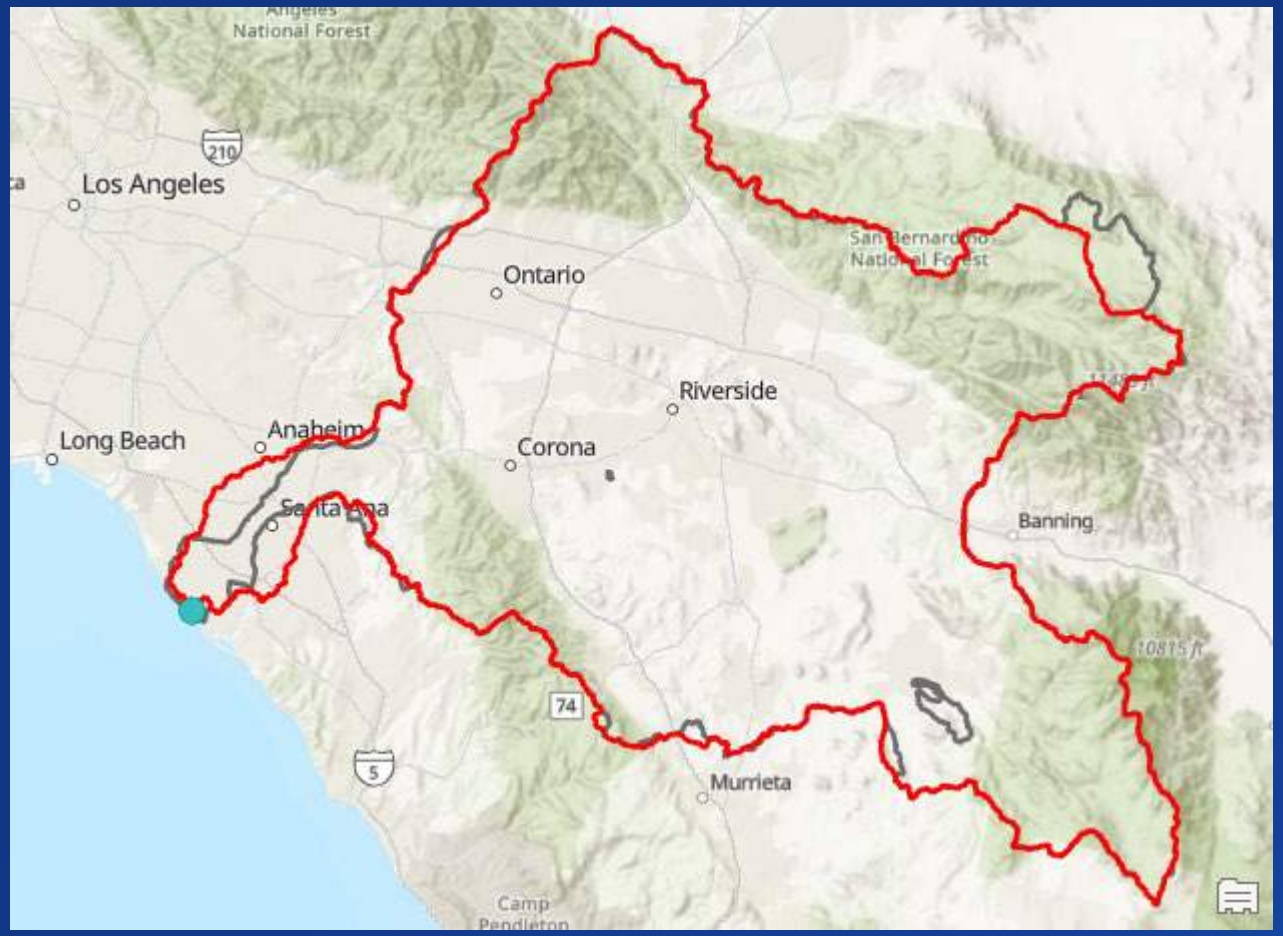
Arc Hydro Demo Reflections



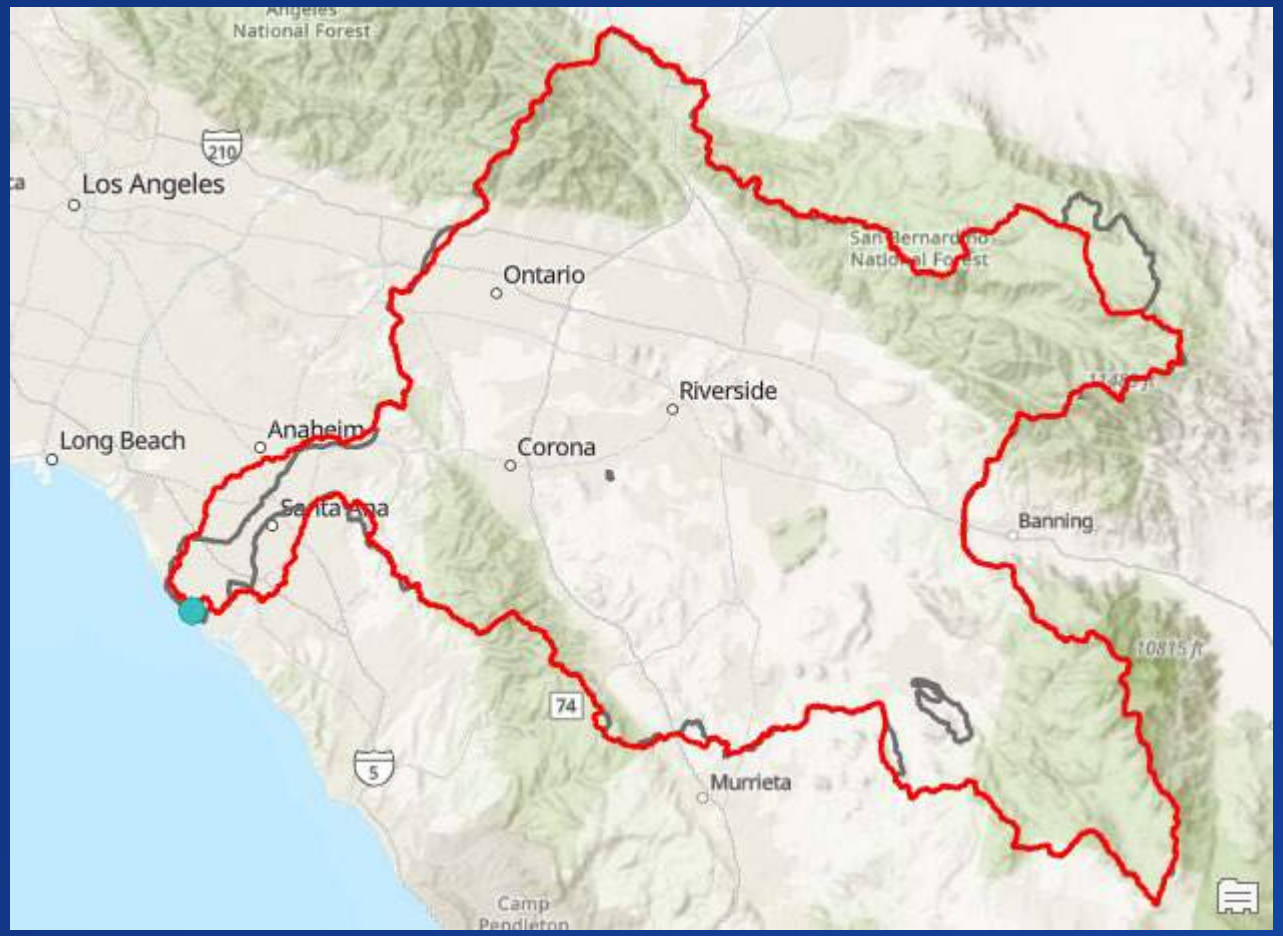
30m – black outline poly

90m – red outline poly

Quotes of the day/month/year/…

- “All models are wrong, but some are useful” (George Box ~1976)
- “Perfect is the enemy of the good” (Voltaire ~1770)
- “A fool with a tool is still a fool”
  - (reported by Ken Lanfear, USGS ret.)

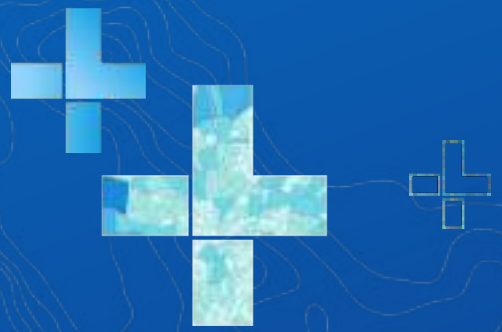
Arc Hydro Demo Reflections



30m – black outline poly

90m – red outline poly

Definitions



Flood Definitions

- “An overflow of water onto normally dry land” (NOAA)
- “A rising and overflowing of a body of water especially onto normally dry land” (Merriam-Webster Dictionary)
- “A general and temporary condition of partial or complete inundation of 2 or more acres of normally dry land area or of 2 or more properties (at least 1 of which is the policyholder's property)” (FEMA/NFIP)

Floodplain Definitions

- “To define a floodplain depends somewhat on the goals in mind. As a topographic category it is quite flat and lies adjacent to a stream; geomorphologically, it is a landform composed primarily of unconsolidated depositional material derived from sediments being transported by the related stream; hydrologically, it is best defined as a landform subject to periodic flooding by a parent stream. A combination of these [characteristics] perhaps comprises the essential criteria for defining the floodplain" (Schmudde, 1968).
- “Any land area susceptible to being inundated by flood waters from any source” (FEMA).

- “Our” definition of floodplain is really not related to “flood”. It is related to “water extent”.

Flood (flow) Forecasting Definitions

- **Forecast in general:**
  - **“To calculate or predict (some future event or condition) usually as a result of study and analysis of available pertinent data” (Merriam-Webster Dictionary)**

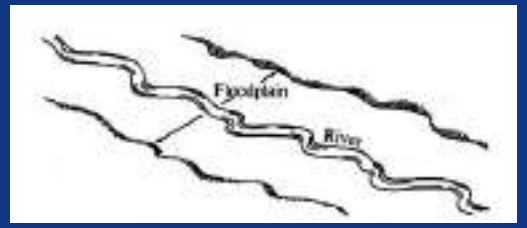
- **Flood forecast in particular:**
  - **“The use of forecasted precipitation and streamflow data in rainfall-runoff and streamflow routing models to forecast flow rates and water levels for periods ranging from a few hours to days ahead, depending on the size of the watershed or river basin.” (AMS)**

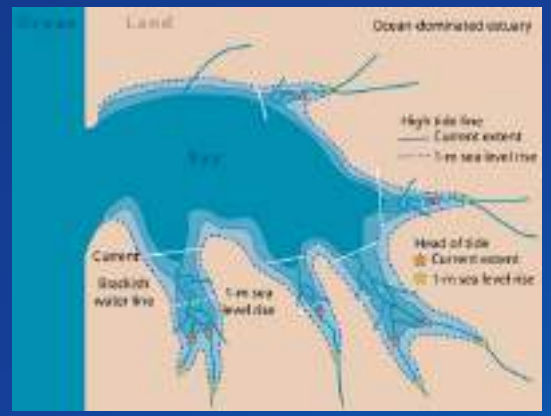
All About Context

- Need to put it all in the context of your specific work.
- Focus in this presentation is on general GIS tools and methods.

Floodplain delineation

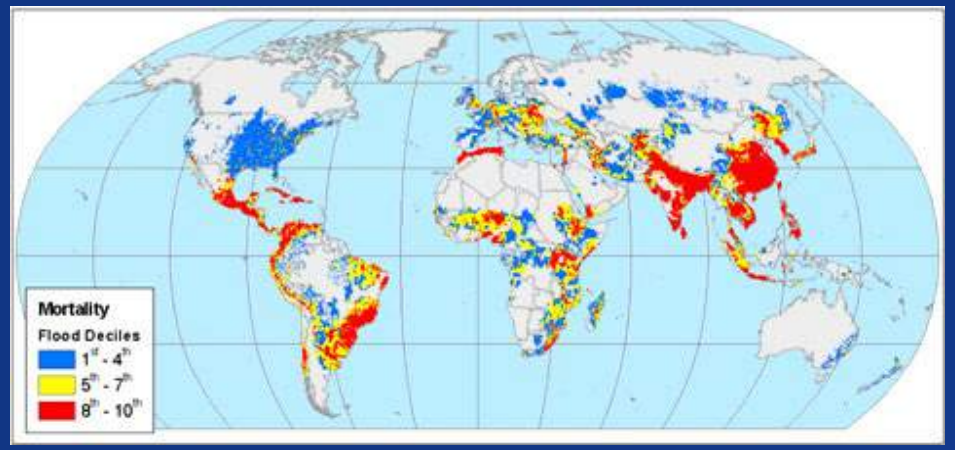
Floodplain Definitions





What's so Important About Floodplains

- **82% of the world's population lives in areas with high flood risk (UNDP, 2004).**

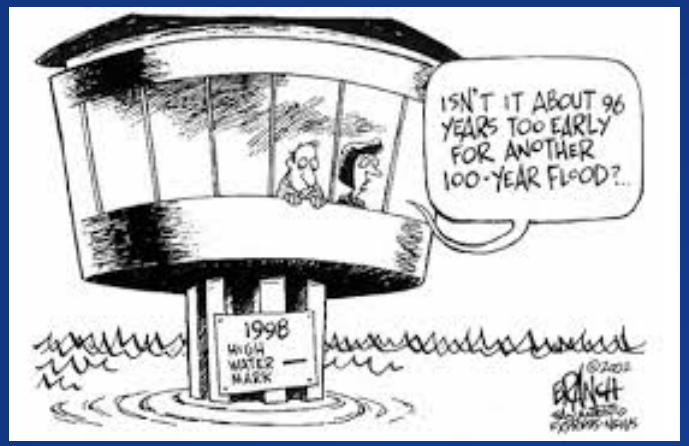


Mortality risk is expressed within a decile range with 10 being the most exposed (Decile 10 = est. 300 people/sq. km and decile 9 is around 150 people/sq. km). Source: Mark Pelling, Visions of Risk, UNDP / ISDR, 2004

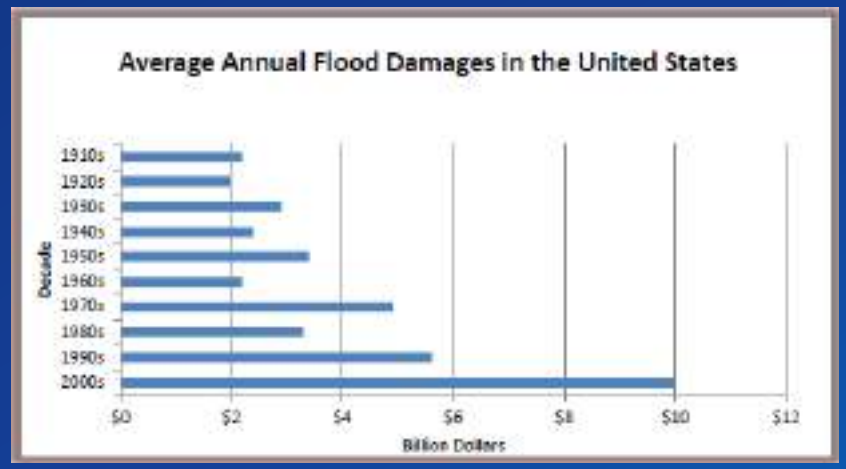
- **¾ of world population lives within coastal zone**
  - **USA – 16.5 million (5% population) within flood prone coast**
- **½ billion people live within flood prone deltas**

What's so Important About Floodplains

- Recurring
  - Lie, bigger lie, statistics



- Increase in % of aid from Feds due to hurricane/flooding (25% -> 70% since 2005)
  - Sandy (2nd most costly), Katrina (1st most costly) ~ $200B
  - 2017 ~ $200-300B (Harvey, Irma, Maria)

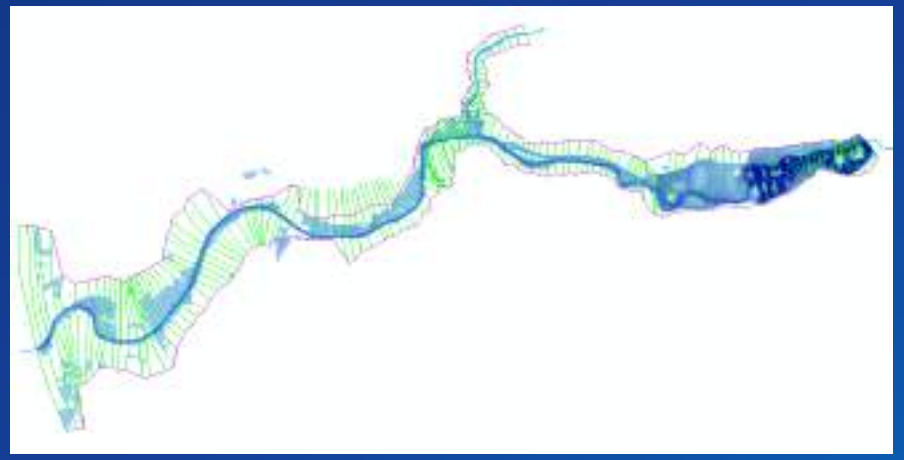


If We Know Where the Floodplain Is …

- Operations
  - Flood prevention (dam and levee operations)
  - Emergency management
  - Facility management
- Planning
  - Design
  - Insurance (not everywhere)
  - Emergency planning

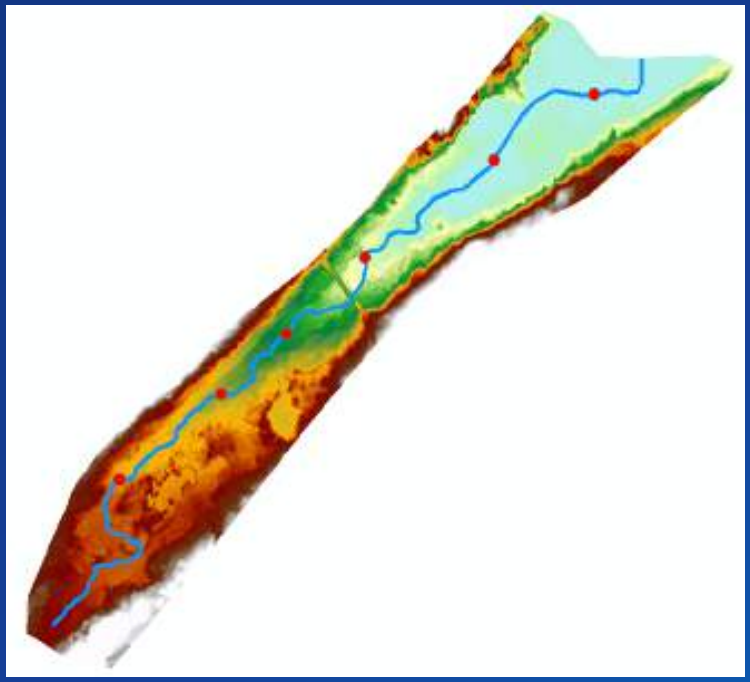
How to Get the Floodplain

- Observations
  - Water surface elevations and extents
- Modeling (H&H)
  - Precipitation-runoff
    - Real-time
    - Planning (design)
  - Need observations of forcing variables
    - Flows
    - Precipitation (rainfall, snow)
    - “Other” (temperature, soil moisture, E/T, …)



Floodplain Delineation Solutions Matrix

- Different levels of complexity are possible/needed to determine flood extents
- Simple, based on terrain and observations only:
  - “Flooding out” based on DEM, stream centerline, and point data
  - HAND approach (constant depth of flooding per reach)
- Complex, based on hydraulic modeling (using external hydraulic models):
  - 1D
  - 2D
  - Full or simplified equations (Navier-Stokes / Saint-Venant / …)



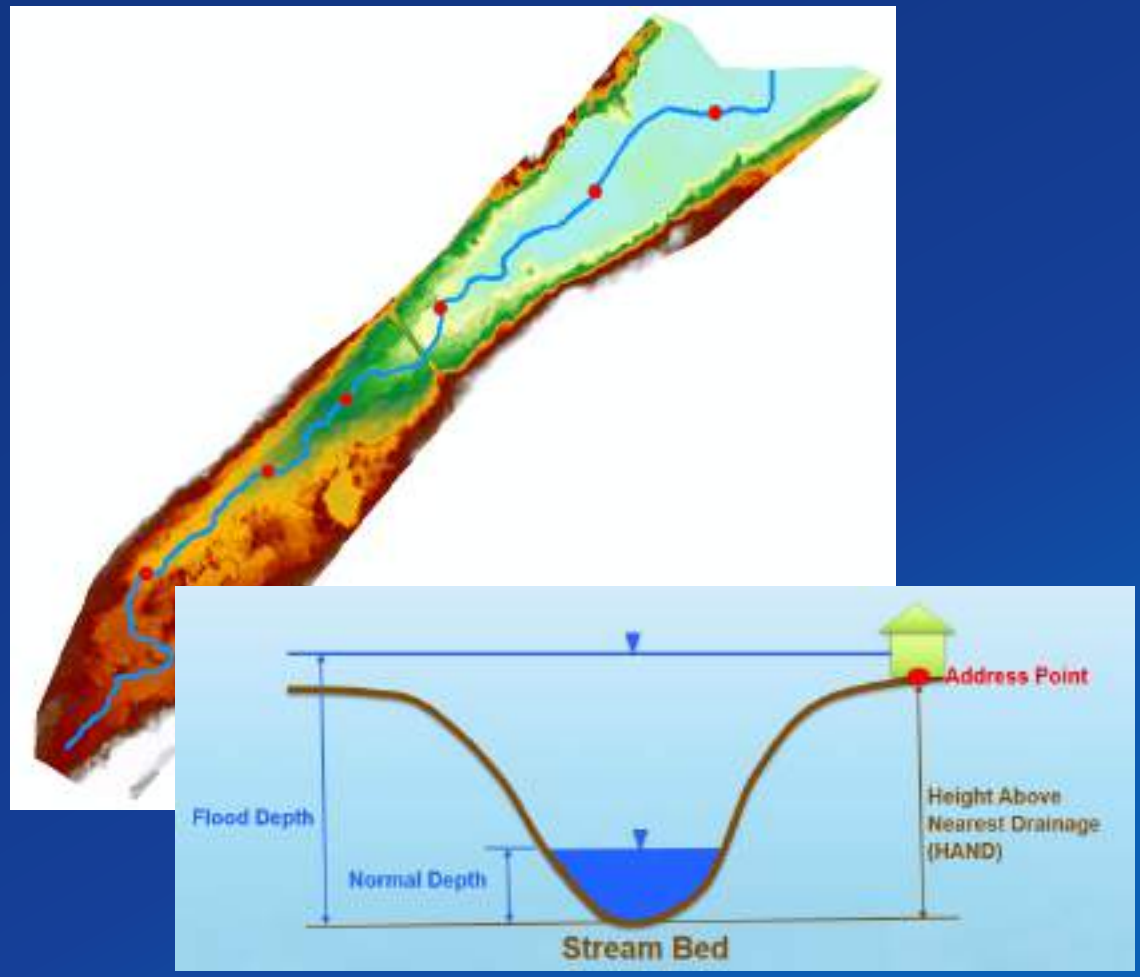
Polling Questions

Do you use hydraulic models for floodplain delineation?

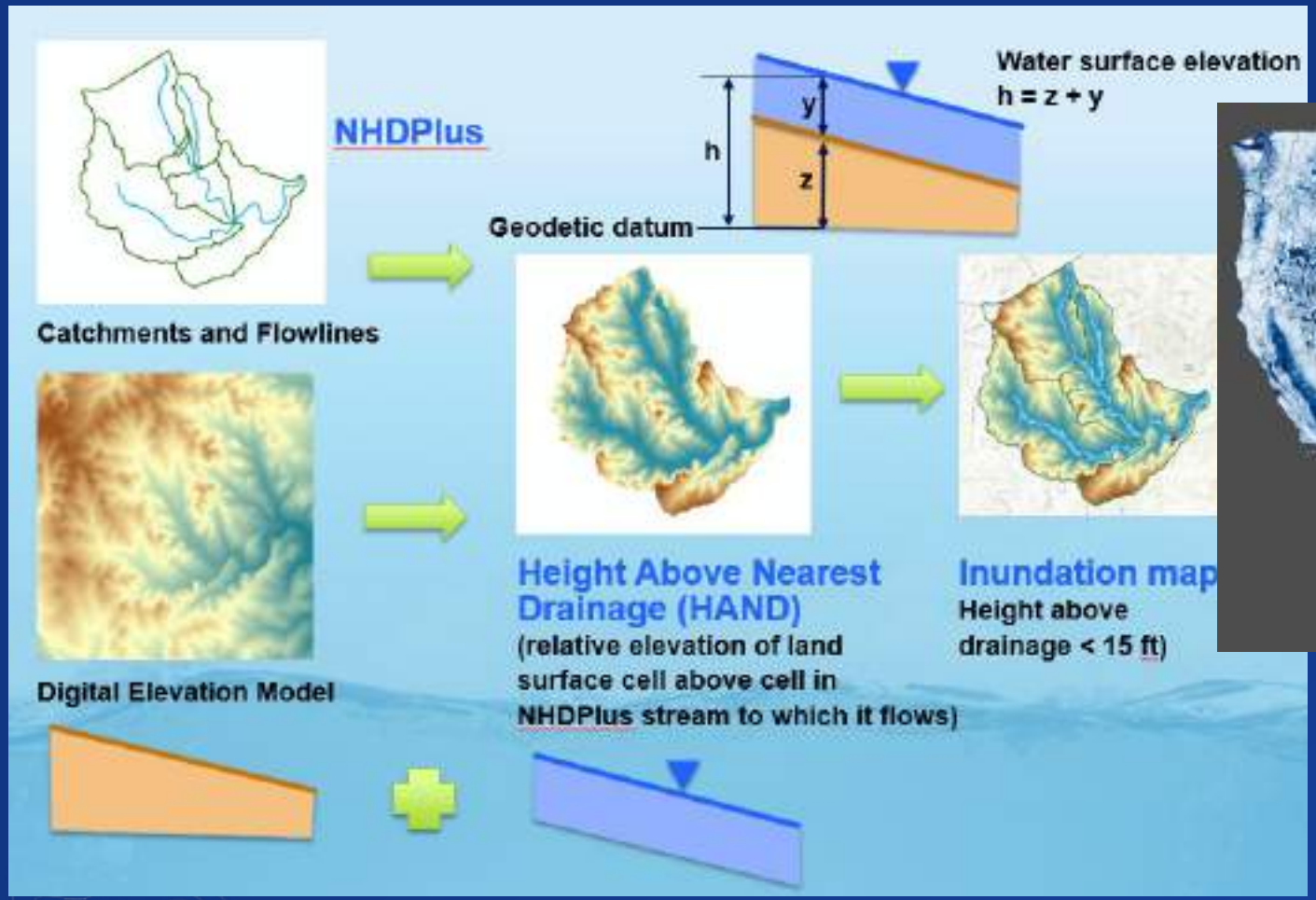
- Yes
- No

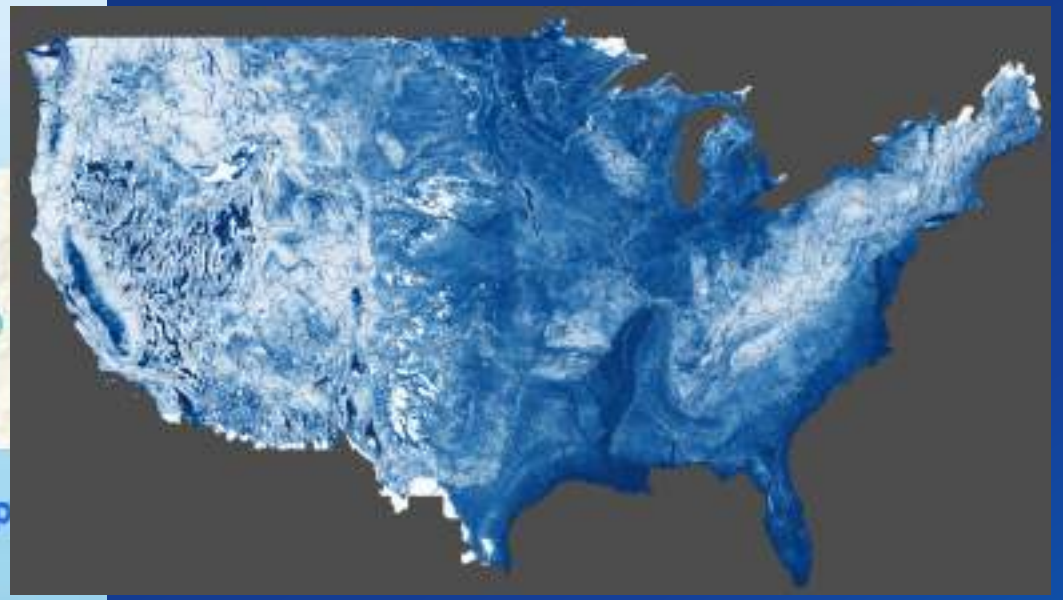
Floodplain Delineation Solutions Matrix - Simple

- HAND – Height Above Nearest Drainage
  - It measures relative elevation above stream bed.
- HAND approach for flood mapping is based on the assumption of constant depth of flooding per stream reach.



Flood Inundation Mapping – NHDPlus-HAND Method





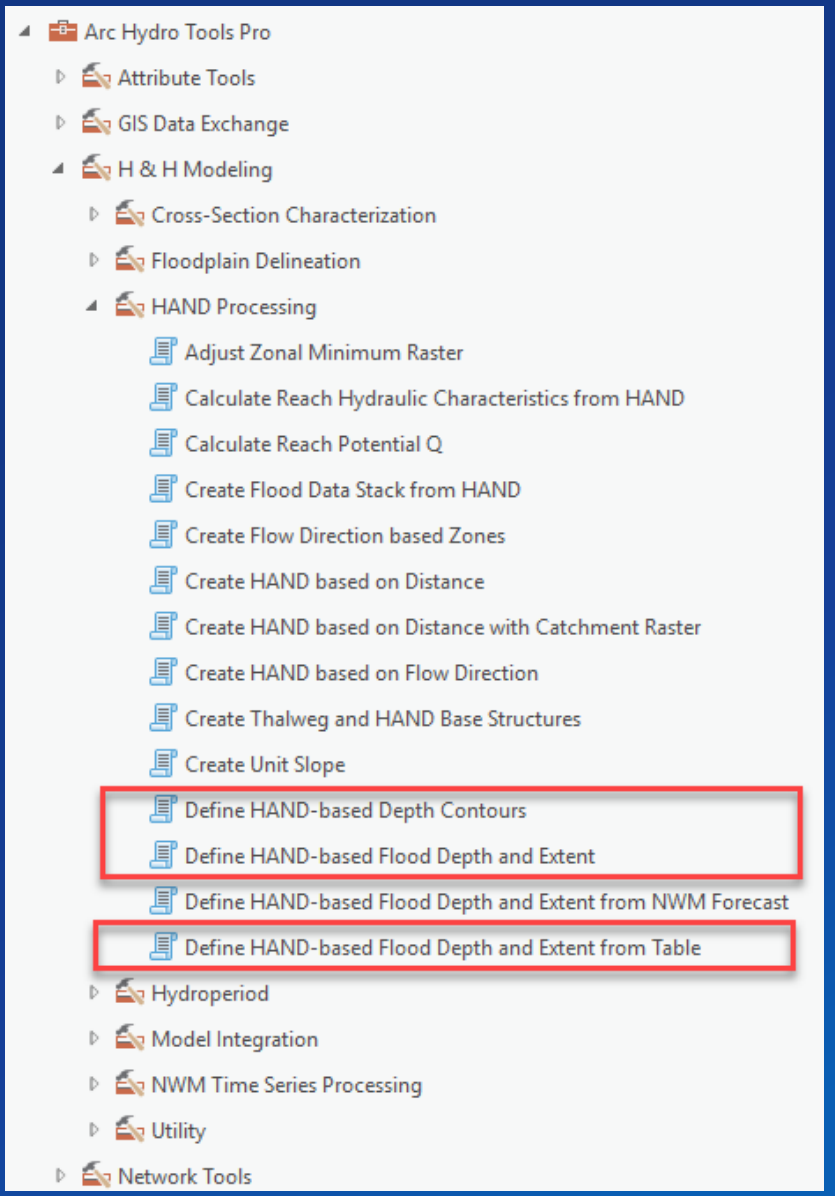
Source: Yan Liu, University of Illinois at Urbana-Champaign

David R. Maidment, UT Austin

https://cwe.engr.utexas.edu/researchpage/water-and-environmental-management/national-flood-interoperability-experiment/

Sample HAND Implementation Use Cases

- **DEM only:**
  - **Derive HAND**
  - **Use HAND for:**
    - **Flood extent and depth for specific depth of flooding over the whole AOI**
    - **Create flood “contours” indicating flood extents for incremental depth of flooding**
    - **Flood extent and depth for specific depth of flooding along each stream (need a table of depth per reach)**



Arc Hydro HAND Demo

Flood forecast integration

We need actionable water intelligence to provide better response

- Global to street scale

Fernando Salas, NWC

Envisioned solution can be adapted to the data and spatio-temporal needs of each client

- Applicable across spatial and temporal scales
- Leverage existing modeling components when present
  - H&H models
    - Global models (ECMWF – European Centre for Medium-Range Weather Forecasts)
    - National Water Model (US)
    - Local models (numerous implementations across the World) – ICPR4
  - “High resolution” terrain spatial data
  - Local impact data
- “Plug and play” approach

What is needed

- Forecast weather
- Forecast river flow
- Relate river flow to depth of water
- Delineate flood extent based on known depth of water
- Evaluate current impact of flood extent/depth
- Communicate flood risk to stakeholders in real time

System components

Rainfall
Runoff
Forecast

Multi-scale
Temporal
Map Service

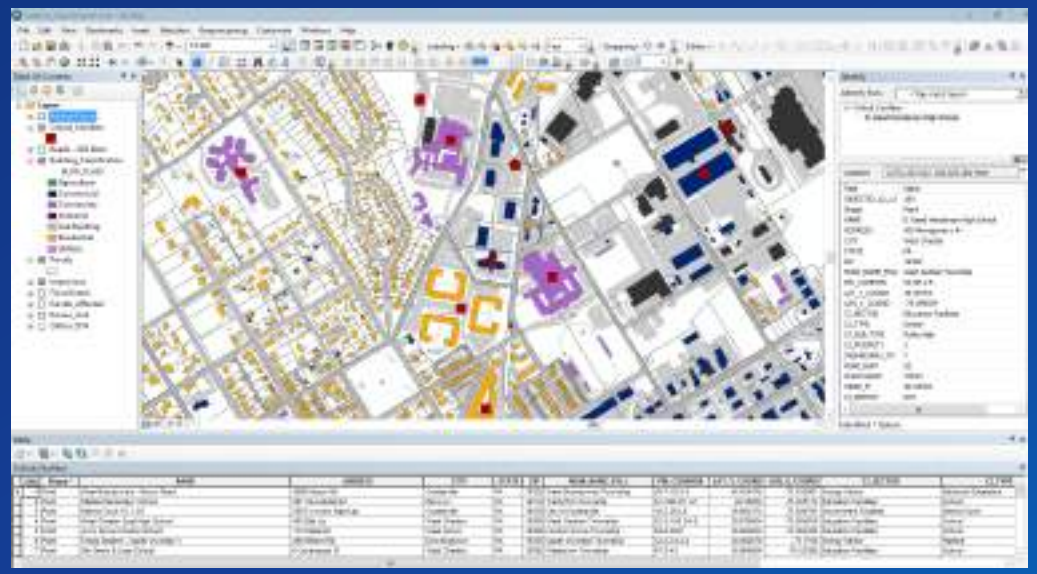
Web
Applications

Flood Impact Forecasting

WHEN:
National Water Model

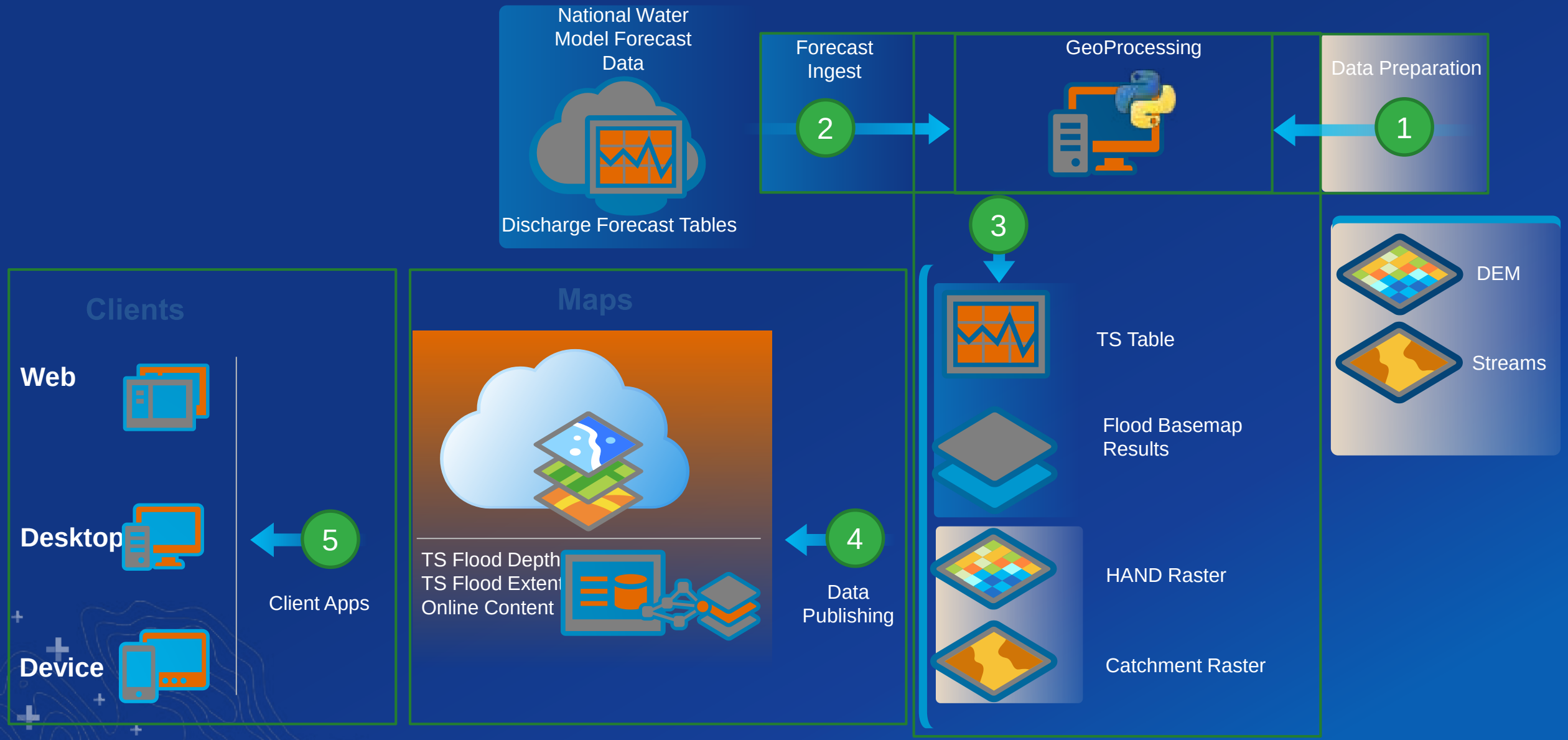
WHERE:
Arc Hydro Tools

WHO:
Local County GIS Data

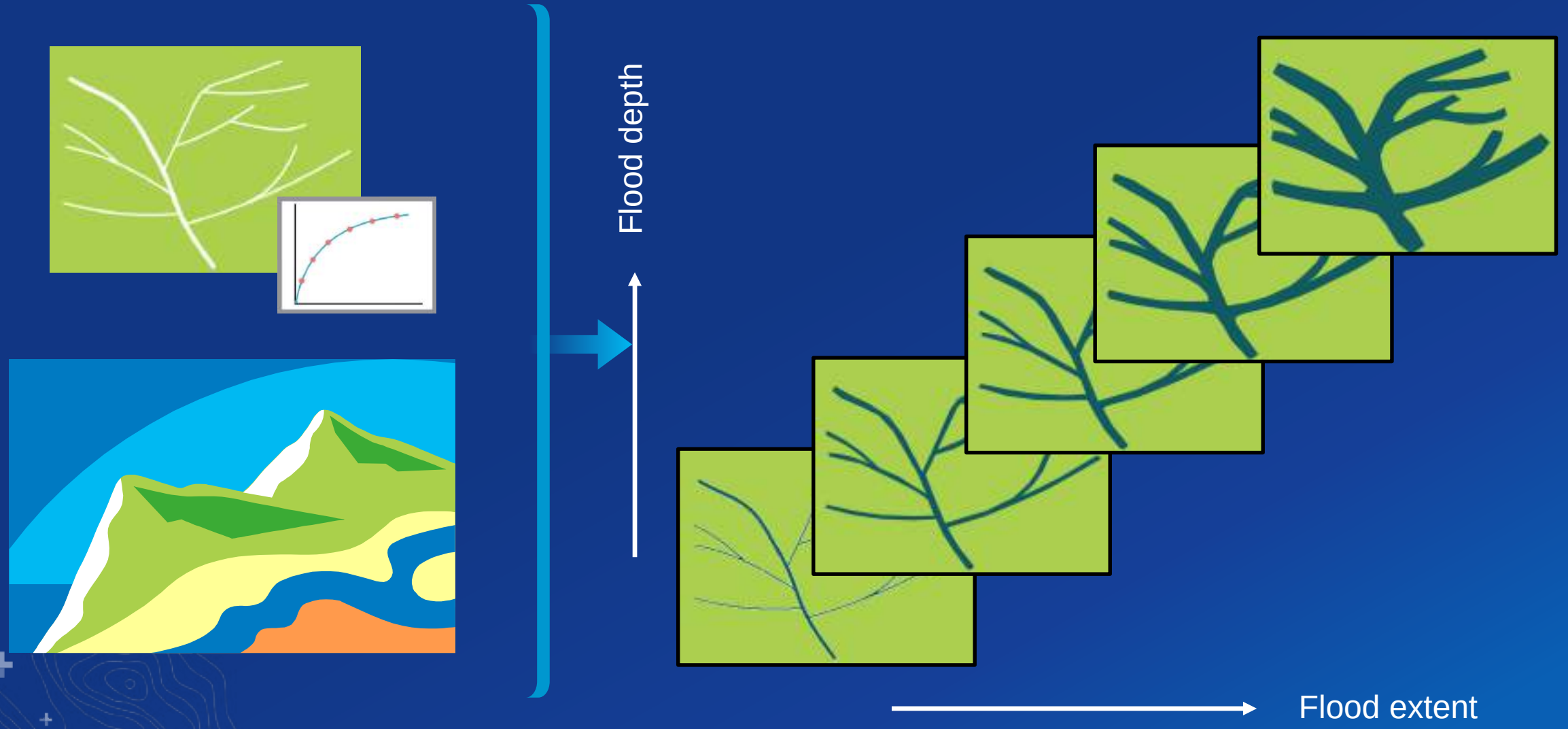


Dave Sekkes, Chester County EOC

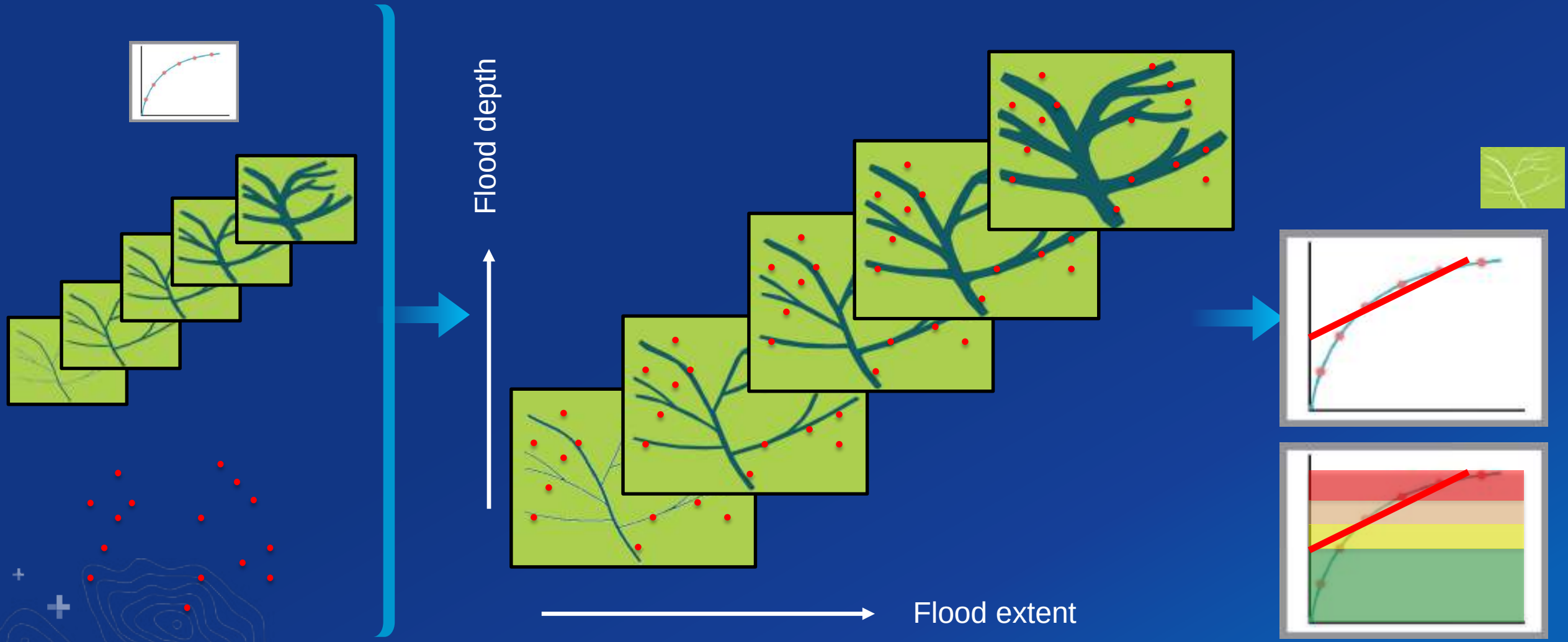
NWM Integration Concept Diagram (HAND approach)



Develop flood inundation dataset – geoenable runoff forecast



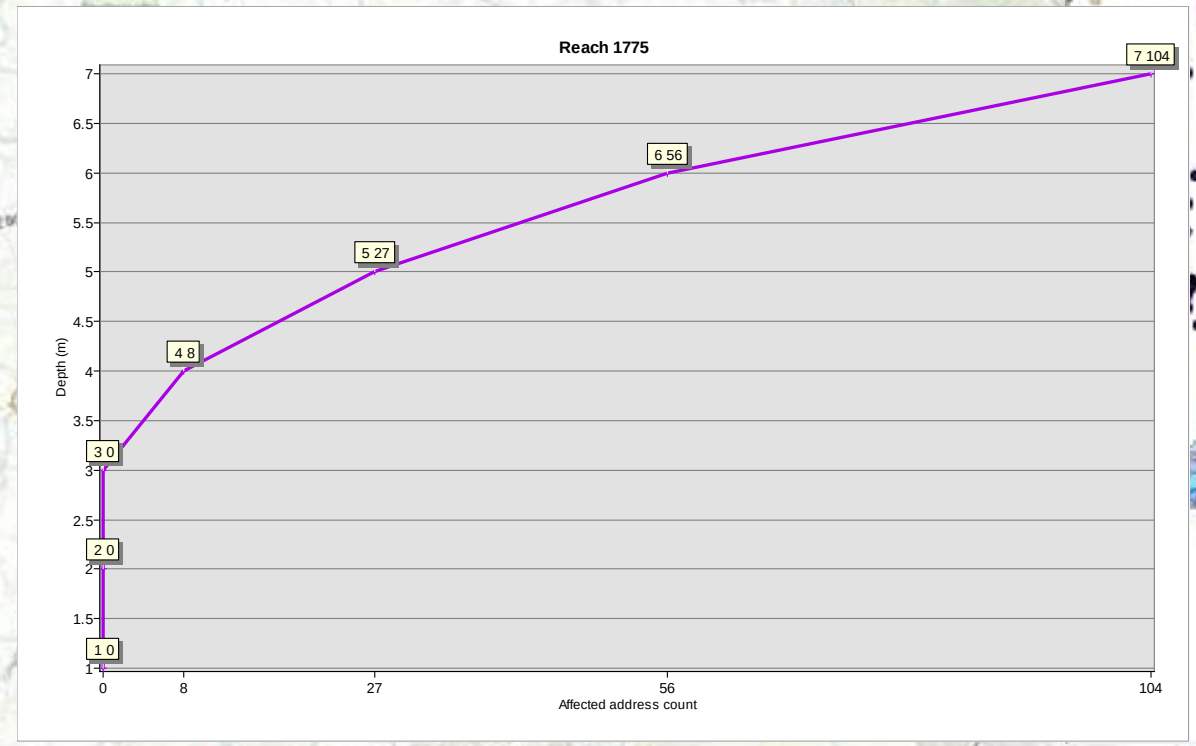
Develop flood impact dataset and rating curve



Geoenable runoff forecast

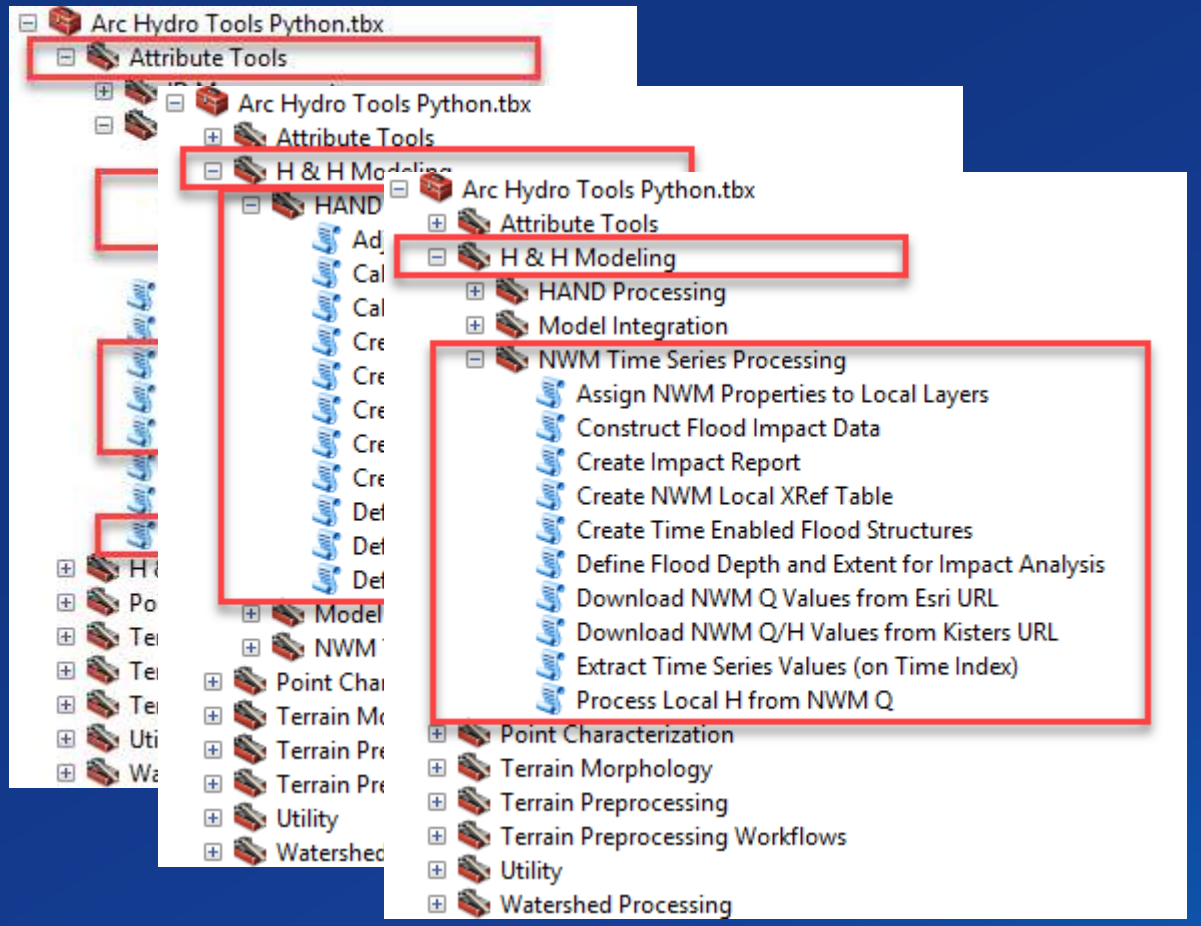
Relate stages to local topography and impact

- **Relating stage/water surface elevation to depth and extent of flooding and to affected addresses**



Flood analyses and visualization

- Tools
- Workflows
- Services
- Apps
- Areas:
  - Planning
  - Forecasting
  - Operations / response



Few Examples

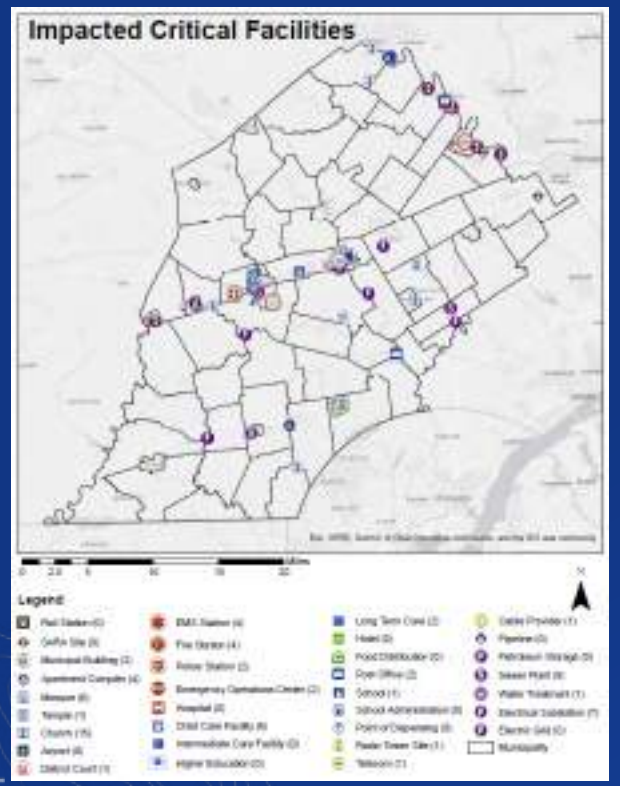
- Chester County (smaller area, detailed operational information)
- ECOWAS (continental scale, overview information)
- Pin2Flood (detailed, operational, first responder focus)

Chester County Project Overview

- User: Chester County (PA) Emergency Operations Center
- Goal: Operational flood forecasting and impact assessment application for EOC use
- Implementation components:
  - Data:
    - Forecast: NWM via Esri Living Atlas.
      - Short and aggregated mid-range forecasts
    - Topography/hydrography: Local DEM and hydrography
      - DEM at 1m.
    - Impact data:
      - Detailed population and critical infrastructure information provided by CC EOC.
  - Printed report and web application (OD app) for end user interaction.

WHO: Printable PDF Impact Report

- Include in Situation Reports
- Distributed to Local Emergency Managers and Key Partners



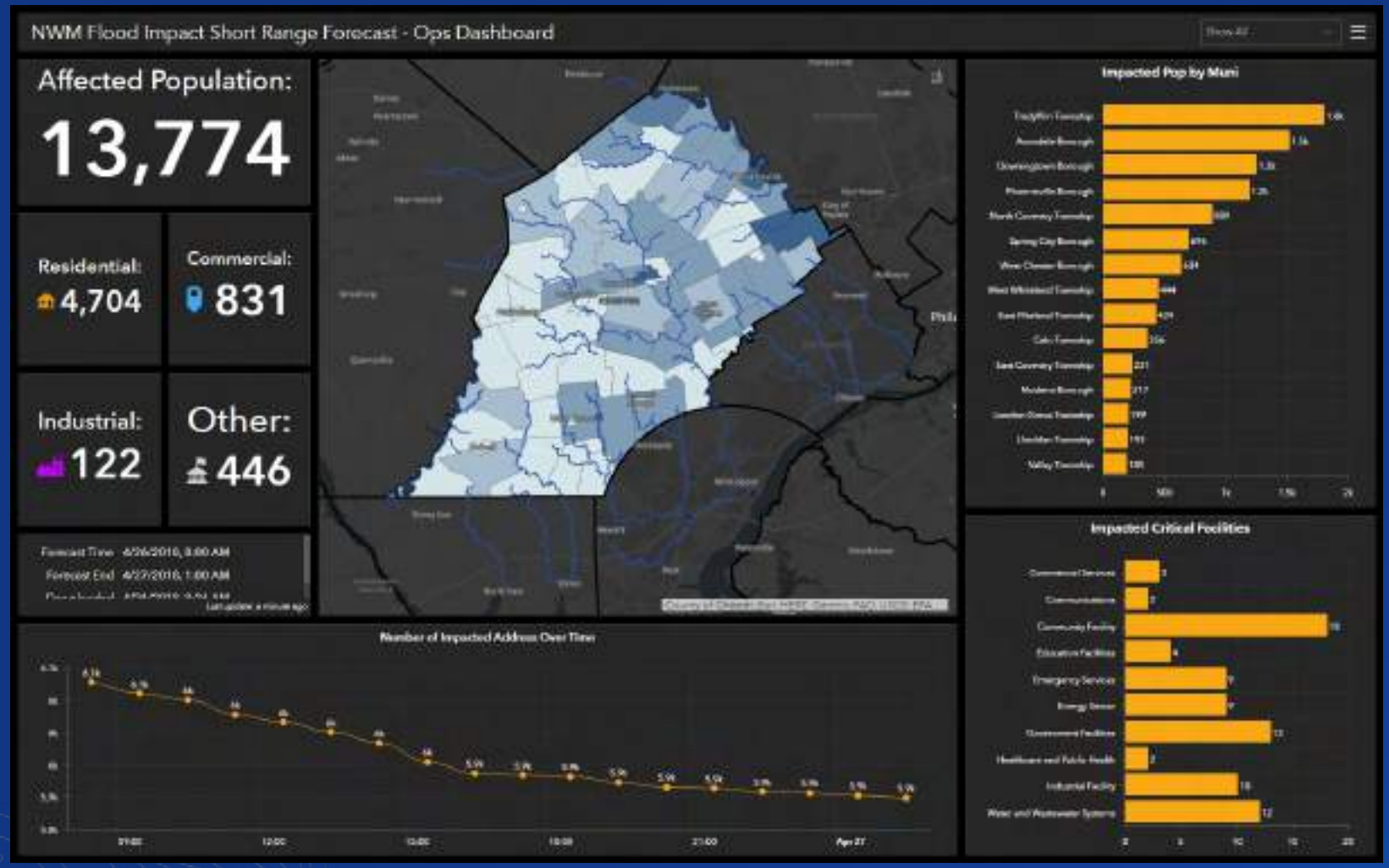
MUNICIPALITY	Downingtown Borough			18
CI SECTOR	Commercial Services			3
CI TYPE	Child Care Facility			2
Child Care Center	Teach And Learn Day School	85 W Lancaster Av	Downingtown	19335
CI SECTOR	Communications			3
CI TYPE	Telecom			2
Phone Exchange	Verizon Downingtown Co (PA210117)	201 Whitehall Av	Downingtown	19335
CI SECTOR	Community Facility			9
CI TYPE	Apartment Complex			2
Apartment Complex	Chestnut Village Apts	238 Chestnut St	Downingtown	19335
Apartment Complex	Downingtown Arms Apts	227 Whitehall Av	Downingtown	19335
CI TYPE	Church			4
Protestant	Downingtown Friends Meeting	800 E Lancaster Av	Downingtown	19335
Protestant	Hassan Evangelical Lutheran Church	40 W Lancaster Av	Downingtown	19335
Protestant	Mount Raymond Church	220 Manor Av	Downingtown	19335
Protestant	New Beginnings Fellowship	29 W Lancaster Av	Downingtown	19335
CI SECTOR	Education Facilities			3
CI TYPE	School			2
Private School	Regina Lucinis Academy	42 W Pennsylvania Av	Downingtown	19335
CI SECTOR	Emergency Services			3
CI TYPE	EMS Station			2
ALS/BLS	Rimpacs Ambulance	141 Wallace Av	Downingtown	19335
CI TYPE	Fire Station			2
Fire Station	Rimpacs FC	141 Wallace Av	Downingtown	19335
CI TYPE	Public Service			2
Municipal Police Station	Downingtown Boro PD	10 W Lancaster Av	Downingtown	19335
CI SECTOR	Energy Sector			1
CI TYPE	Electrical Substation			1
Electrical Substation	Downingtown - Jefferson Ave	128 Jefferson Av	Downingtown	19335

Municipality Impact

Municipality	Estimated Affected Population	Fire Station	EMS Station	Police Station	EOC	Solid Waste Facility	Wastewater Treatment Plant	Hospital	Long-Term Care Facility	School	Child Care Facility	Place of Worship	Apartment Complex
Avondale Borough	1,981												1
Downingtown Borough	1,893	1	1	1	1	1				1	1	4	1
East Bradford Township	85												
East Brandywine	87												
East Caln Township	34					1	1					1	
East Goshen Township	334								1		1	1	
East Whiteland Township	134												
Easttown Township	73												
Elk Township	18												
Elverson Borough	0												
Franklin Township	14												
Highland Township	13												
Honey Brook Township	10												
Honey Brook Borough	0												
Kennett Township	171												
Kennett Square Borough	75										1	2	
London Britain Township	17												

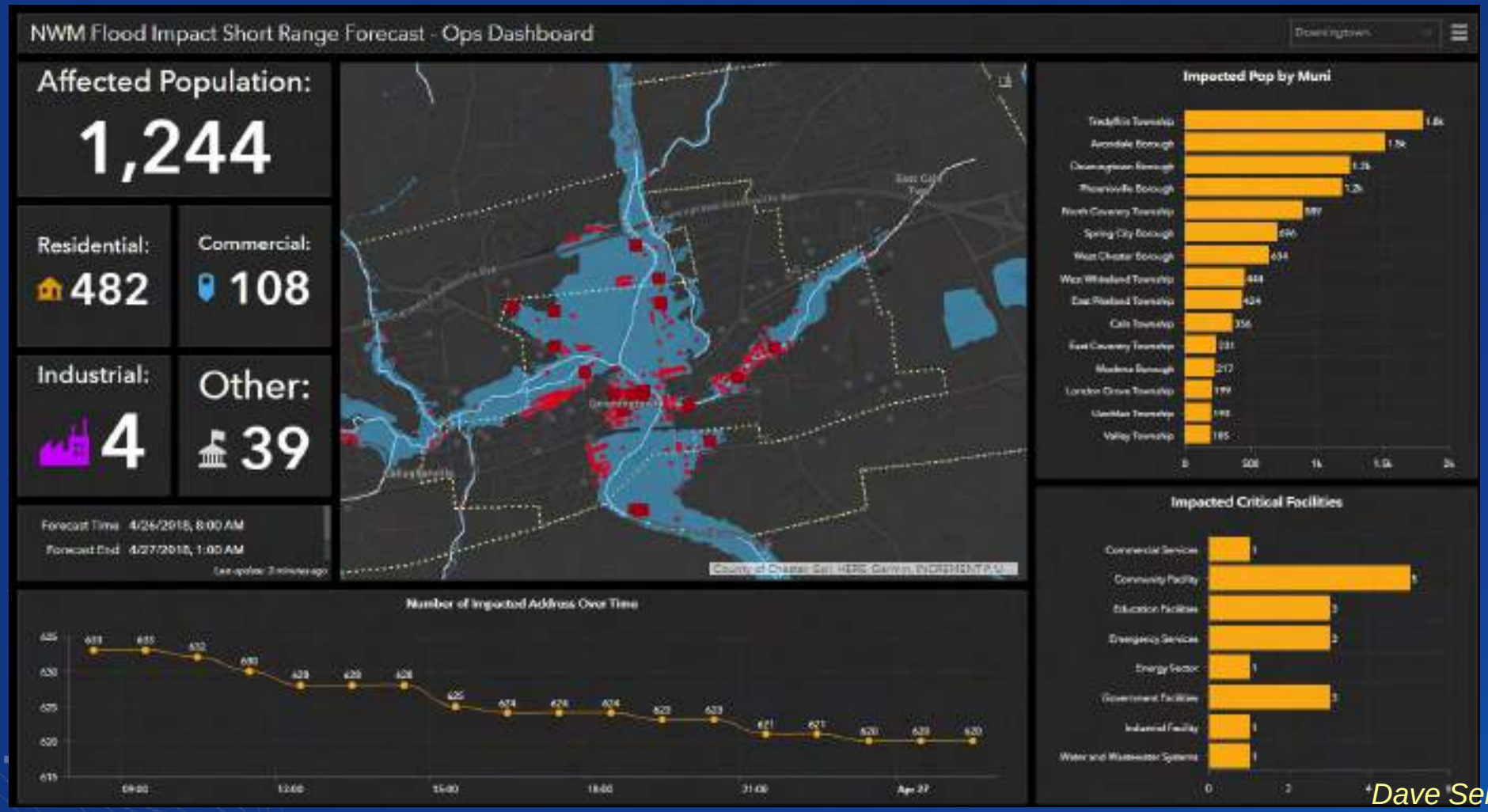
Dave Sekkes, Chester County EOC

WHO: Flood Impact Short Range Forecast Ops Dashboard



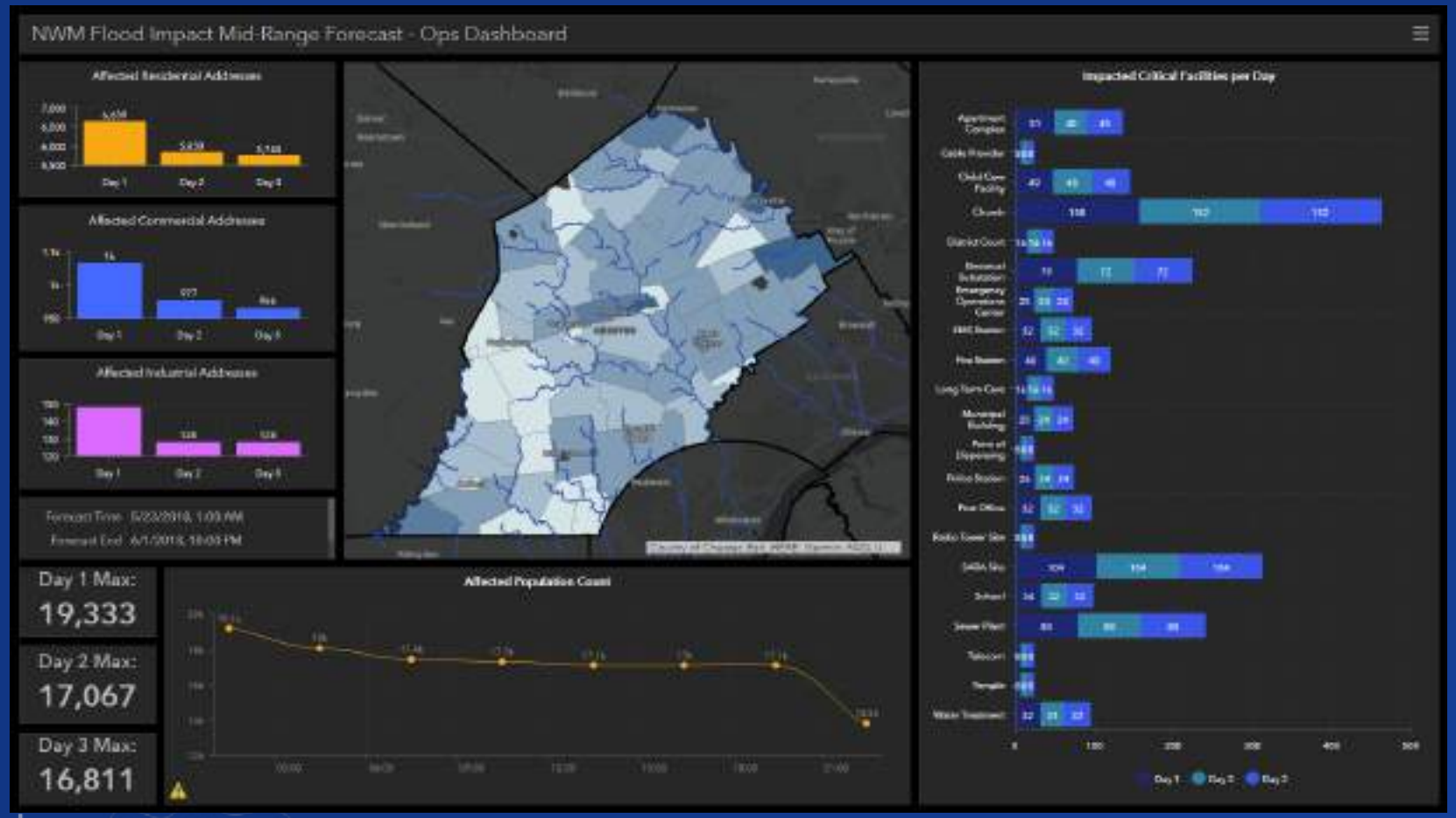
- Total Affected Population
- Count of Addresses affected by Type
- Timeline of the number of affected addresses within the next 24 hours
- Top 15 most impacted jurisdictions
- Impacted Critical Facilities count by sector

WHO: Flood Impact Short Range Forecast Ops Dashboard



Dave Sekkes, Chester County EOC

WHO: Flood Impact Mid-Range Forecast Ops Dashboard

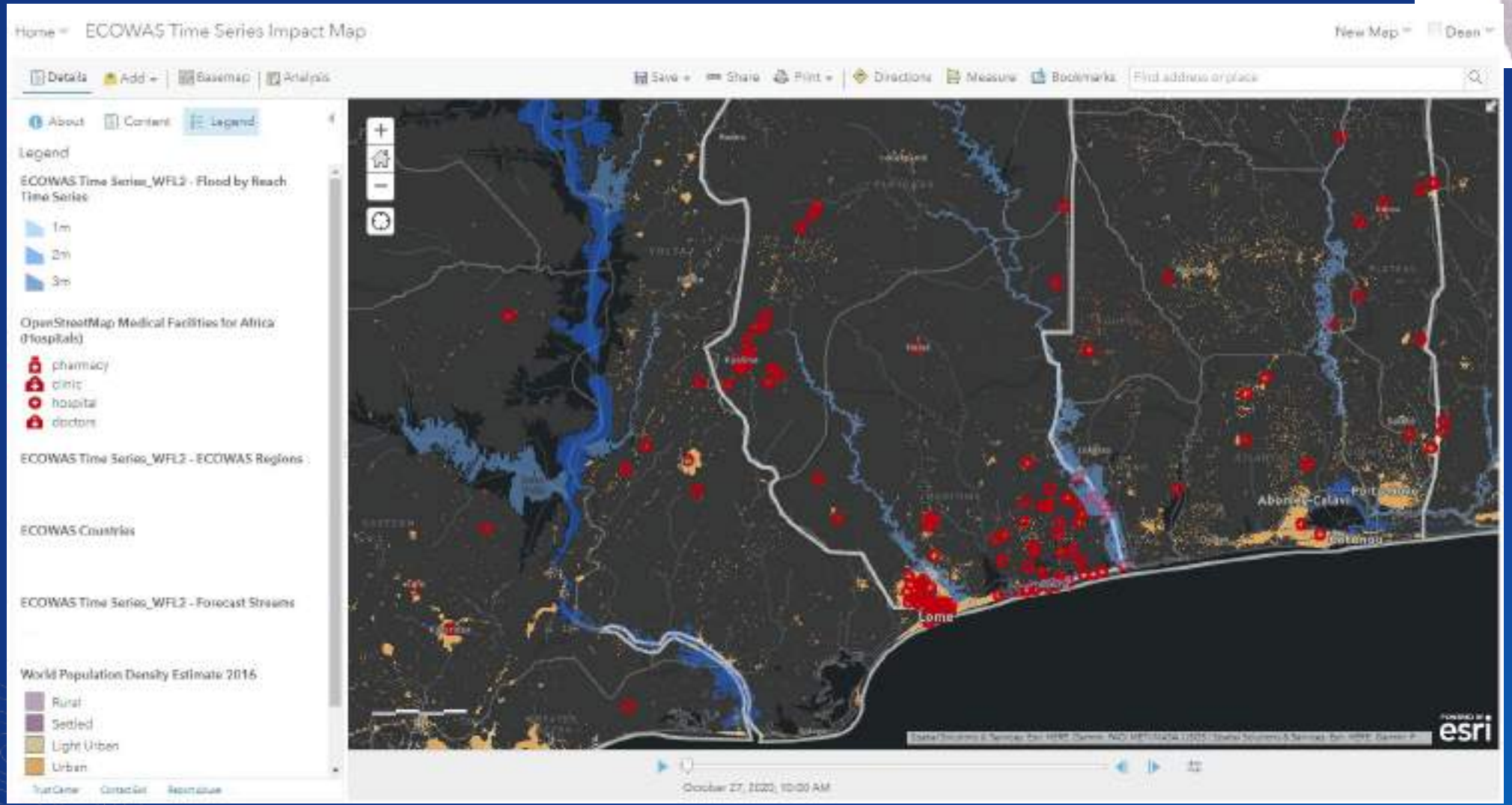


- Total Affected Population for the next 3 day
- Count of Addresses affected by Type for the next 3 days
- Timeline of the number of affected addresses within the next 3 days
- Impacted Critical Facilities count by type

ECOWAS Project Overview

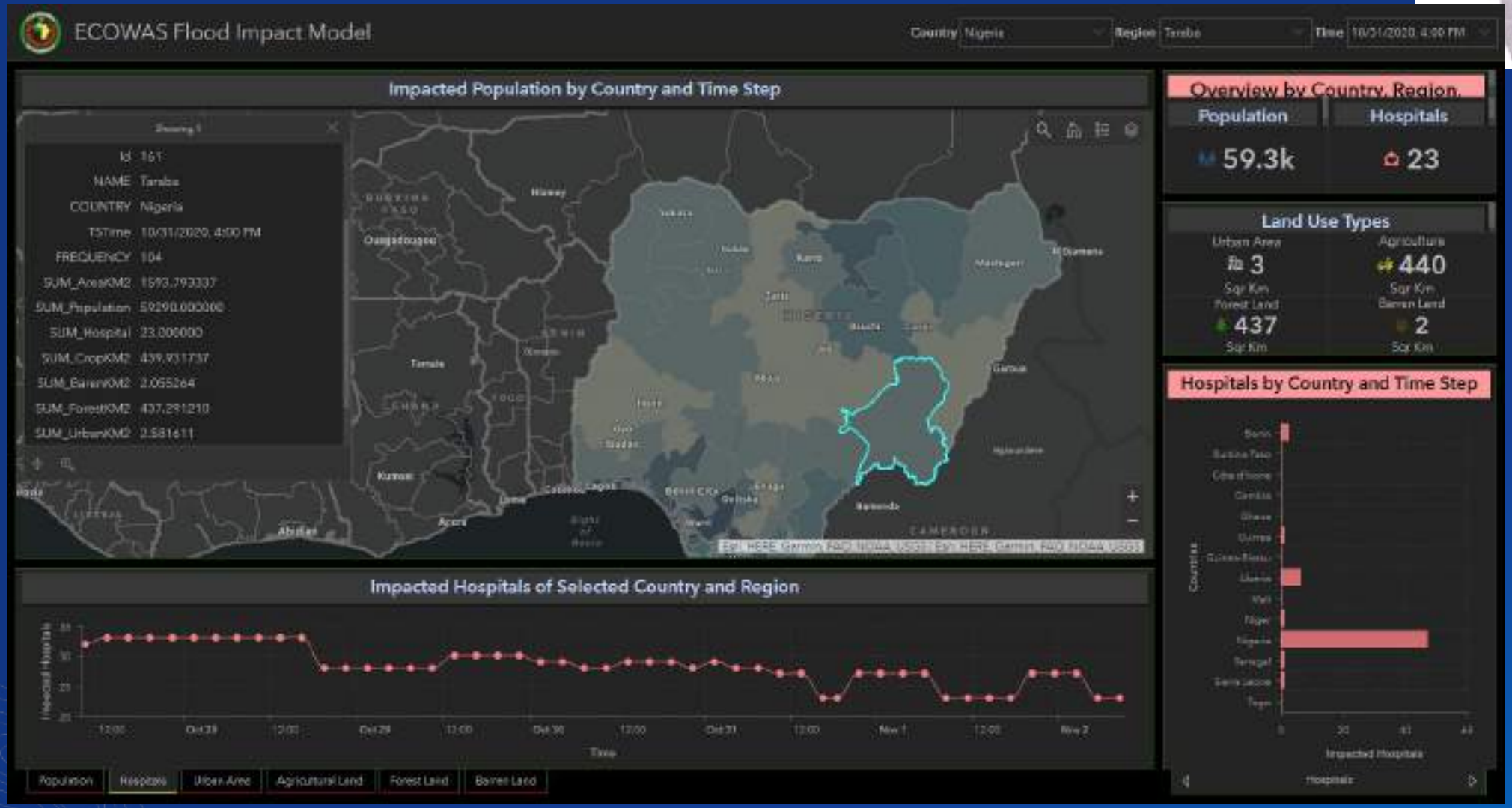
- User: Economic Community of West African States
- Goal: Flood sensitivity demonstration project based on readily available data and technology
- Implementation components:
  - Data:
    - Forecast: ECMWF via Esri Living Atlas (but not implemented operationally).
      - 6 day ahead with 3-hour interval
    - Topography/hydrography: HydroSHEDS/GeoGloWS
      - 15” DEM (~450m cell size).
    - Impact data:
      - Hospitals (OpenStreetMap), World population (Esri Living Atlas), Land cover 2018 (ESA CCI): crop, forest, urban, and baren classes
  - Web application (web map, OD app) for end user interaction.

ECOWAS Dynamic Web Map



ECOWAS Static Dashboard

ECOWAS Time-enabled Dashboard



Pin2Flood

- Developed in collaboration with the University of Texas at Austin and City of Austin Fire Department.
- Designed for first responders
- Prototype apps in the Living Atlas
  - Field app – basic, just observations captured in the field
  - EOC app – includes forecast component

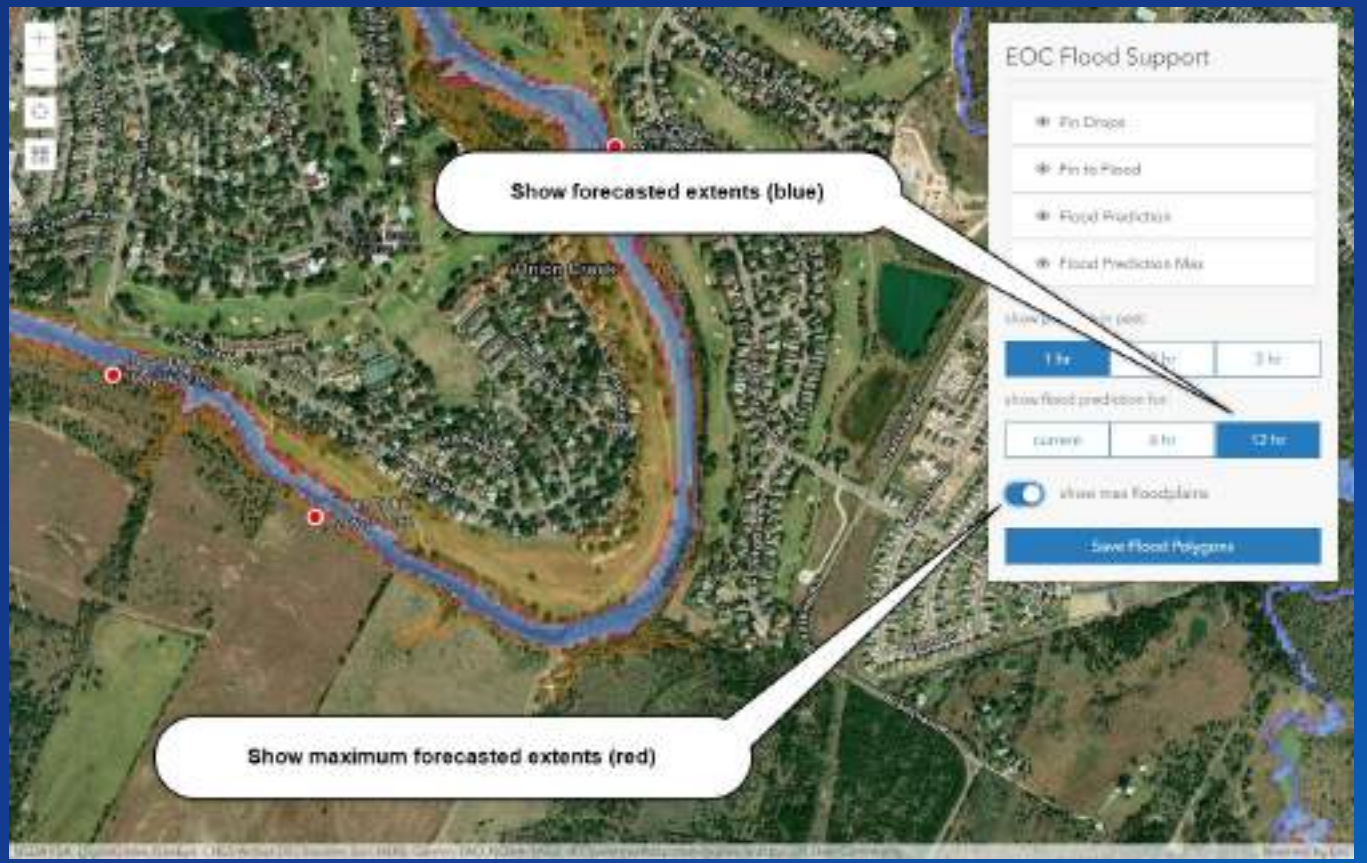
Pin2Flood field application (pin dropping)

- Click on the map to drop the pin.
- Save the pin if satisfied with its location.
- The flood extent “shows up”.
- Add more pins to get more flood extents.

https://livingatlas.arcgis.com/labs/flood/field/

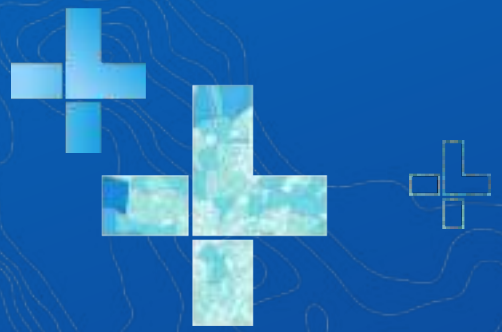
Pin2Flood EOC application

- As pins are dropped in the field, they “show up” in the EOC app (done without need for user intervention in the EOC app).
- App allows display of forecasted extents in addition to the pin-defined extents.



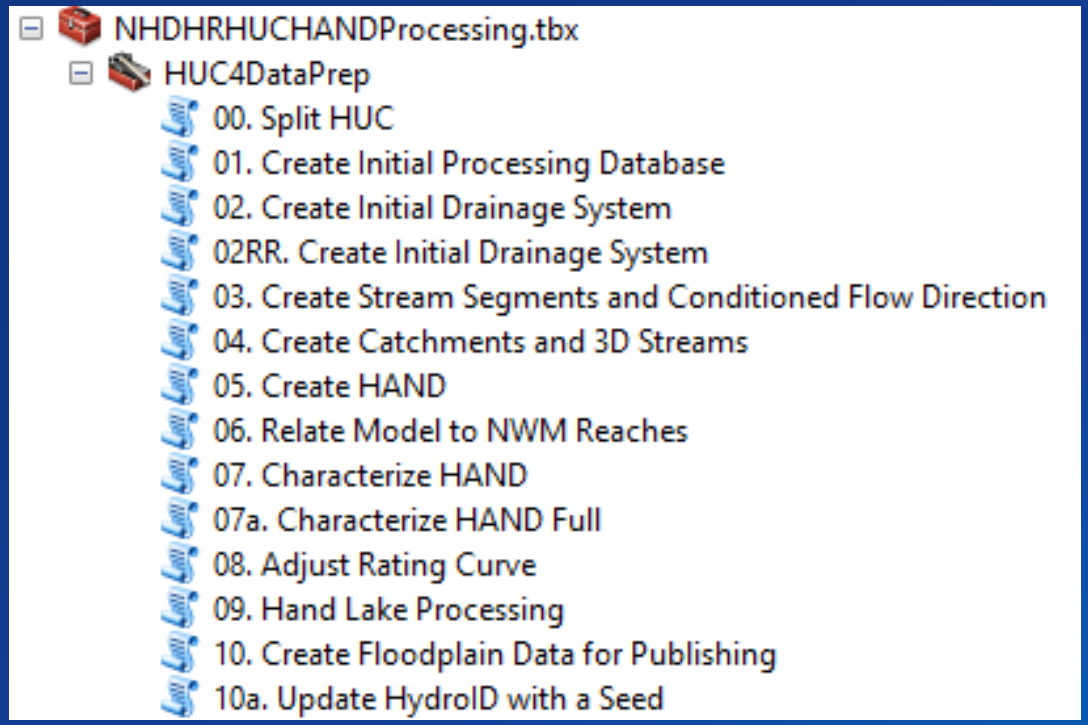
https://livingatlas.arcgis.com/labs/flood/eoc/

Final Thoughts



Advanced HAND/NWM Integration Processing Use Cases

- **Full processing workflows:**
  - **Custom toolbox to be rolled into Arc Hydro**
  - **NHDPlusHR Tools completed**
  - **Documentation work in progress**
- **Data:**
  - **NHDPlusHR**
  - **Local data (e.g. Lidar and high resolution hydrography)**
  - **NWM 1.2/2.0**



Terrain !!!

- Good terrain representation is important for any type of floodplain delineation.
- “Good” is a function of the type of modeling being made and type of terrain morphology (flatter terrains need higher accuracy).
- “Mapping the Zone”, National Research Council, 2009, National Academies Press, Washington, D.C., 122 pp.
- “Elevation Data for Floodplain Mapping”, National Research Council, 2007, National Academies Press, Washington, D.C., 152 pp.

LiDAR – Beauty and the Beast

- Beauty
  - High resolution and density
- Beast
  - Too much irrelevant data
  - What are we really measuring?
  - No explicit breaklines
  - Not hydro-conditioned
  - Processing “art”

All About Context

- Need to put it all in the context of your specific work.
- While methodology and many tools are “standard”, end-user requirements and data, specially on impact assessment, will drive the ultimate implementation.

“All models are wrong, but some are useful” (George Box ~1976)

“Perfect is the enemy of the good” (Voltaire ~1770)

“A fool with a tool is still a fool” (reported by Ken Lanfear, USGS ret.)

Arc Hydro in Action Webinar Series

2/25/21: **Arc Hydro in ArcGIS Pro**

3/11/21: **Arc Hydro: Flooding & Forecasting**

GIS as foundation for integrated floodplain analysis – from fieldwork to hydraulic modeling to flood impact analysis.

3/25/21: **Arc Hydro: Hydrology & Hillslope**

Hydrological processing workflows in GIS context.

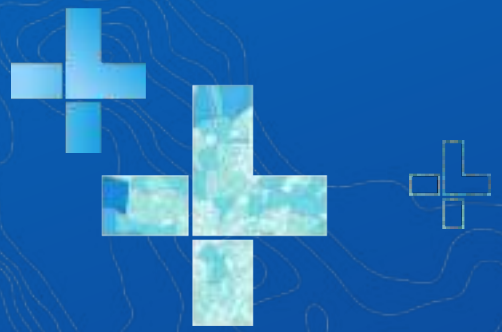
New hillslope analysis tools.

4/15/21: **Arc Hydro: Support for Hydrologic and Hydraulic Modeling**

GIS for integrated H&H modeling.

Why GIS is not just model pre- and post-processor.

Questions?



Getting involved

- Arc Hydro Web Page

- Water Resources Industry Web Page

- Arc Hydro Community
  - archydro@esri.com
  - ddjokic@esri.com