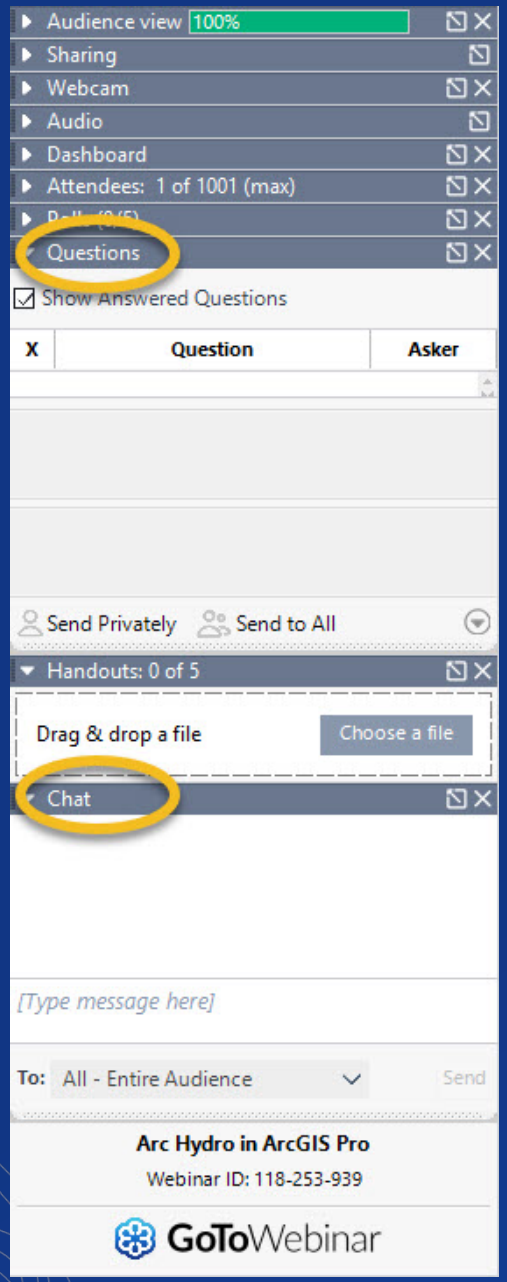
# Arc Hydro in Action Webinar Series

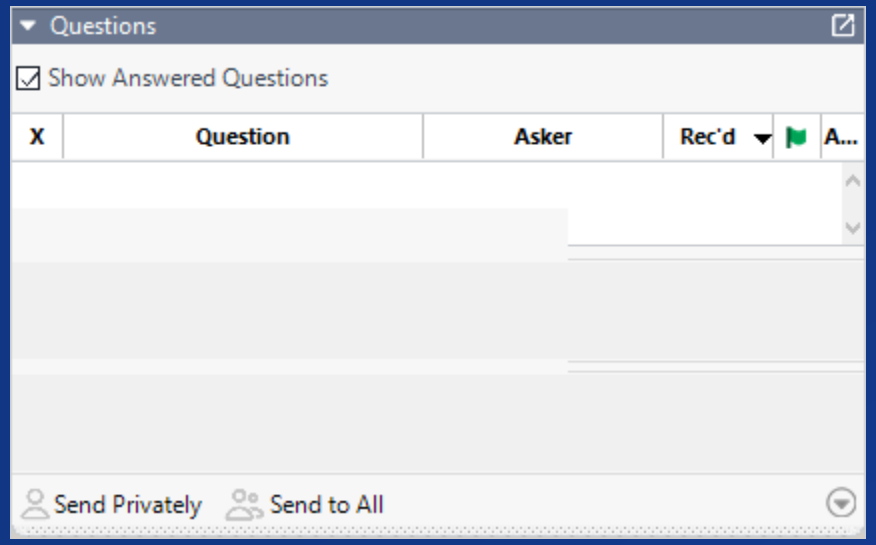
2/25/21: **Arc Hydro in ArcGIS Pro**

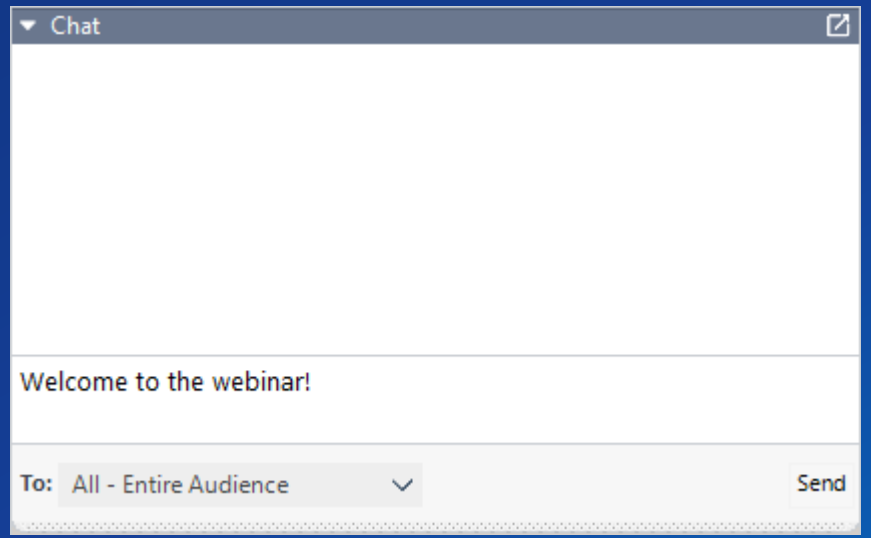
3/11/21: Arc Hydro: Flooding & Forecasting

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

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


Audience view 100%
Sharing
Webcam
Audio
Dashboard
Attendees: 1 of 1001 (max)
Questions
Show Answered Questions
X
Question
Asker
Send Privately
Send to All
Handouts: 0 of 5
Drag & drop a file
Choose a file
Chat
[Type message here]
To: All - Entire Audience
Send
Arc Hydro in ArcGIS Pro
Webinar ID: 118-253-939
GoToWebinar


Questions
Show Answered Questions
X
Question
Asker
Rec'd
A...
Send Privately
Send to All


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

# Arc Hydro in ArcGIS Pro

Dean Djokic

2021 “Arc Hydro in Action” Webinar Series

# Polling Questions

**Who are you?**

- Data developer
- Application developer
- Scientist/engineer

**What is your common GIS software usage?**

- Only Desktop
- Mostly Desktop and some ArcGIS Online
- Half Desktop Half ArcGIS Online
- Only ArcGIS Online / Web apps

# Polling Questions

**Who are you?**

- Data developer = 11%
- Application developer = 4%
- Scientist/engineer = 85%

**What is your common GIS software usage?**

- Only Desktop = 35%
- Mostly Desktop and some ArcGIS Online = 46%
- Half Desktop Half ArcGIS Online = 16%
- Only ArcGIS Online / Web apps = 2%

# The Arc Hydro Team (PS)

**Christine**
2000

**Zichuan**
1996

**Gina**
2019

**Ezra**
2020

**Dean**
1995

# Hydro at Esri

Christa Campbell

Mariah Salazar

Caitlin Scopel

Gonzalo Espinoza




Steve Kopp

Nawajish Noman

*…and many others*

# Webinar 1 Topics

- Definitions
- Review of core hydro tools
  - Difference between “hydro” and “Arc Hydro”
- What is Arc Hydro?
- Data, data, data
- Questions

# Polling Questions

**How often do you use ArcGIS?**

- Daily
- Weekly
- Rarely

**What version of ArcGIS desktop product are you using?**

- ArcMap
- ArcGIS Pro
- None (ArcGIS Online users)
- Not using Esri products

# Polling Questions

**How often do you use ArcGIS?**

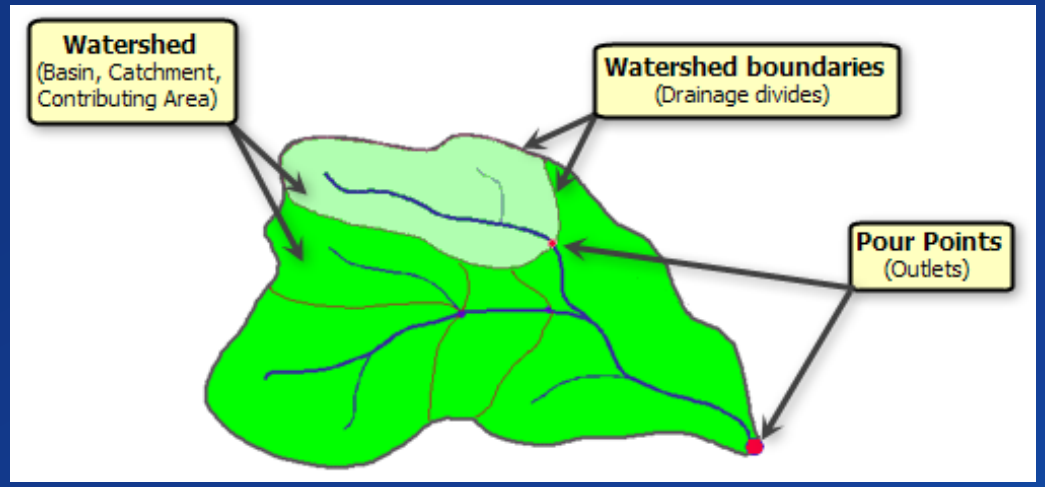
- Daily = 51%
- Weekly = 33%
- Rarely = 16%

**What version of ArcGIS desktop product are you using?**

- ArcMap = 54%
- ArcGIS Pro = 42%
- None (ArcGIS Online users) = 3%
- Not using Esri products = 1%

# Definitions: Hydro Analysis in ArcGIS

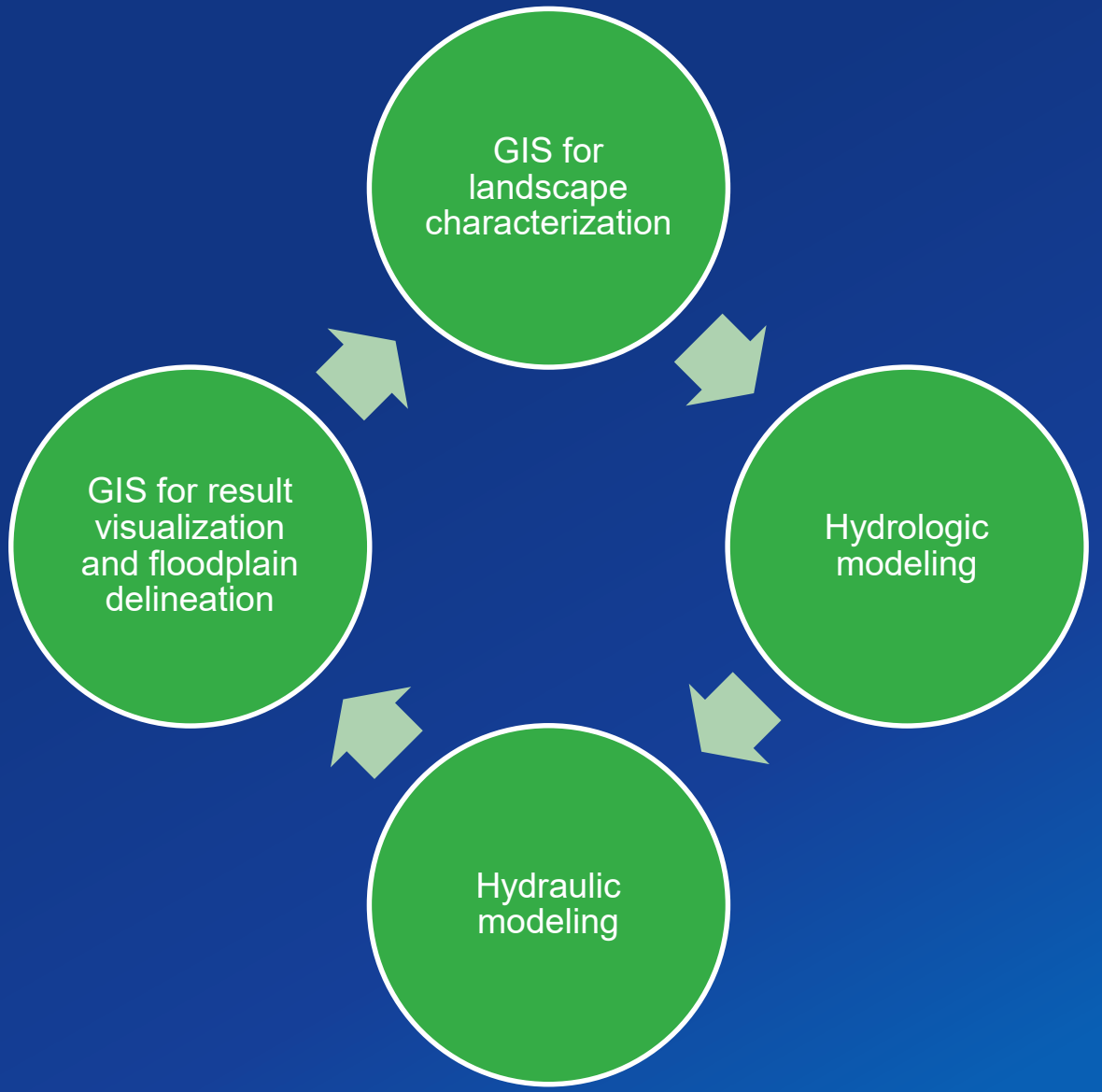
- Hydro Analysis in ArcGIS is used to model the flow of water across a surface.
- What are the primary objectives of hydro analysis in a GIS?
  - Extract hydro information and drainage system characteristics from a digital elevation model and supporting layers.
  - To know where the water comes from, and where it is flowing to.




*Hydro – to cover both hydrologic and hydraulic analyses (H&H)*

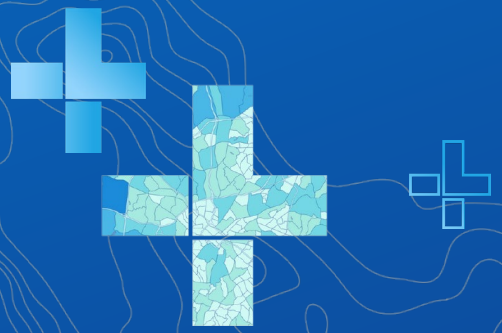
# GIS for Hydro Modeling “Cycle”

- **GIS** is used for landscape characterization and model parametrization.
- **Hydrology and Hydraulics** (H&H) is used for determination of flows, depths and velocities.
- **GIS** is used for result postprocessing and visualization.
- GIS and H&H modeling are closely connected as one impacts the other



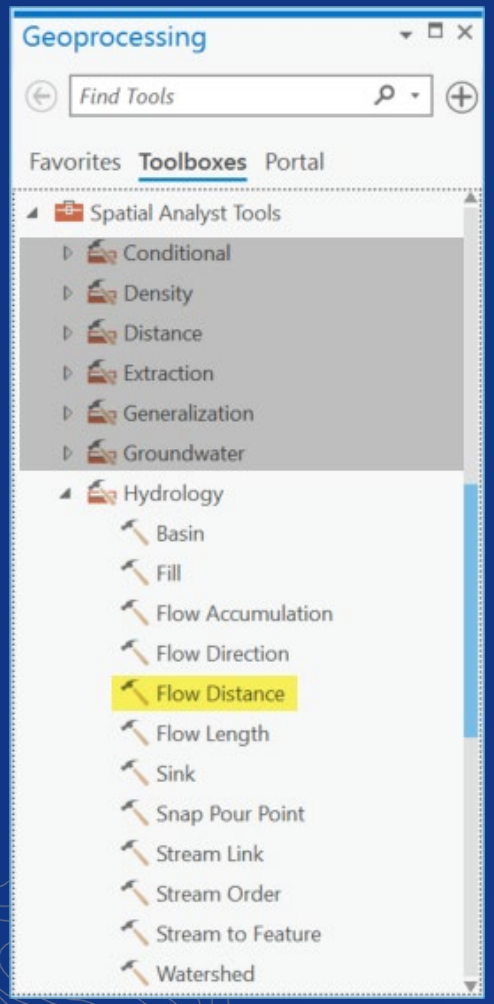

*… and many arrows in between*

# Review of Core Hydro Tools

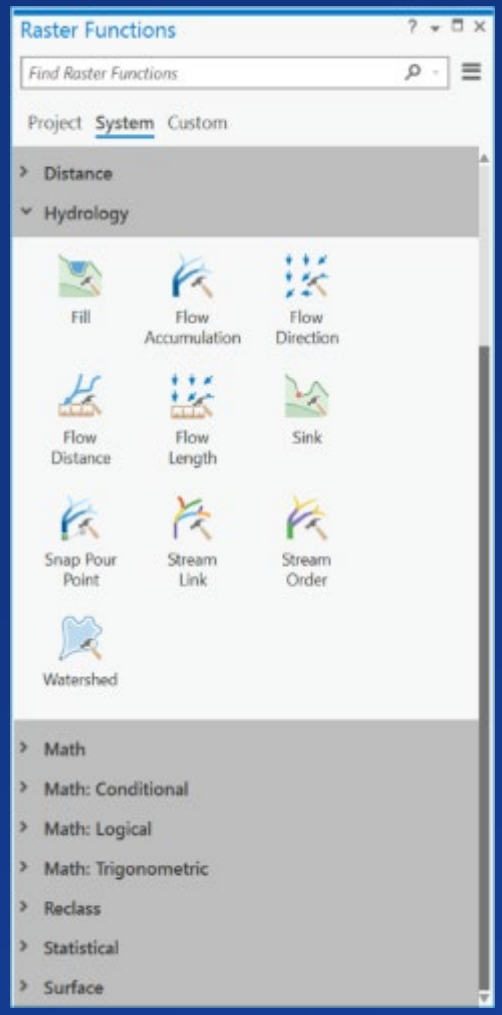


# Hydrology Tools

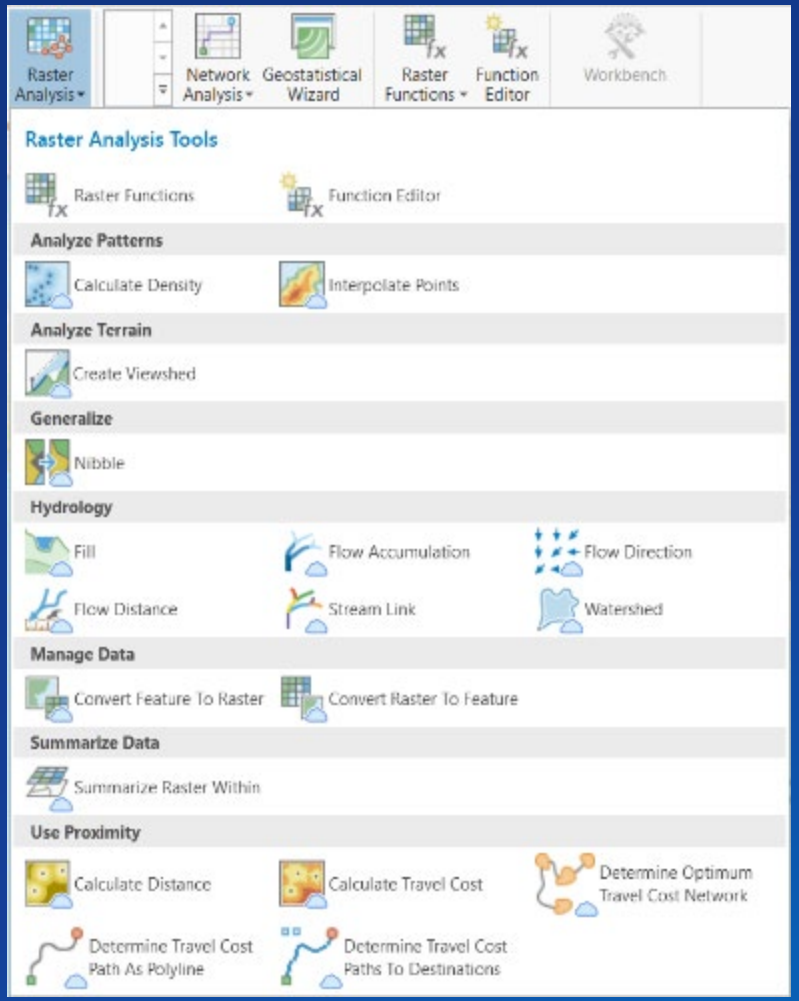
## ArcMap / ArcGIS Pro




## ArcGIS Pro




## ArcGIS Image Server

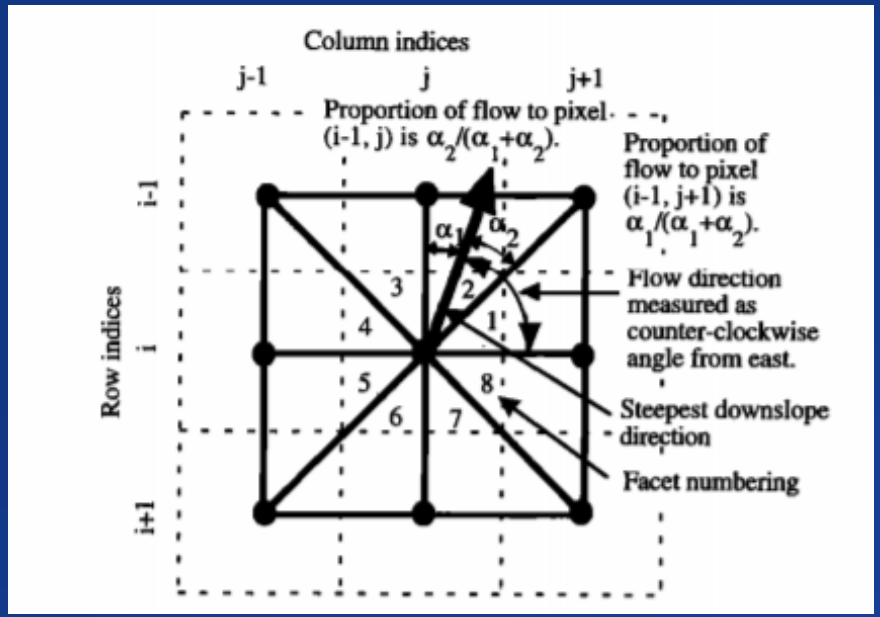


# Flow Direction: D-Infinity

**Creates flow direction as the steepest downward slope on eight triangular facets formed in a 3x3 cell window centered on the cell of interest.**

PPF enabled

- **D-Infinity best for modeling distributed hydrologic processes, such as runoff generation or erosion.**




D-Infinity Method

Steepest downslope direction

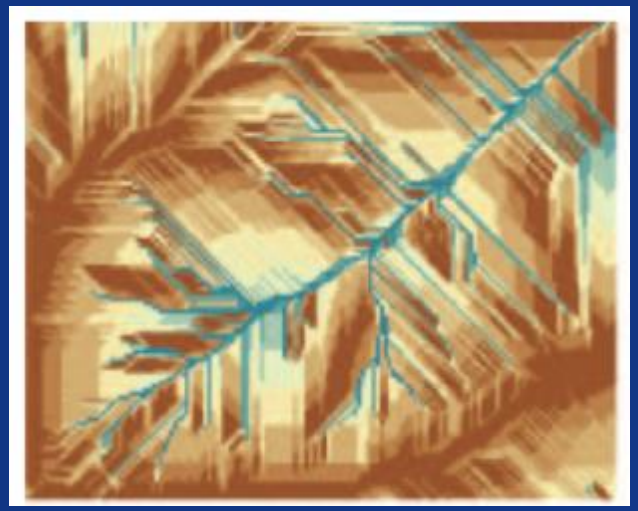
**Divergent flow**: flow proportioned up to two downstream neighbors


Tarboton, D. G., (1997), "A New Method for the Determination of Flow Directions and Contributing Areas in Grid Digital Elevation Models," Water Resources Research, 33(2): 309-319.

# Flow Direction: Multiple Flow Direction (MFD)

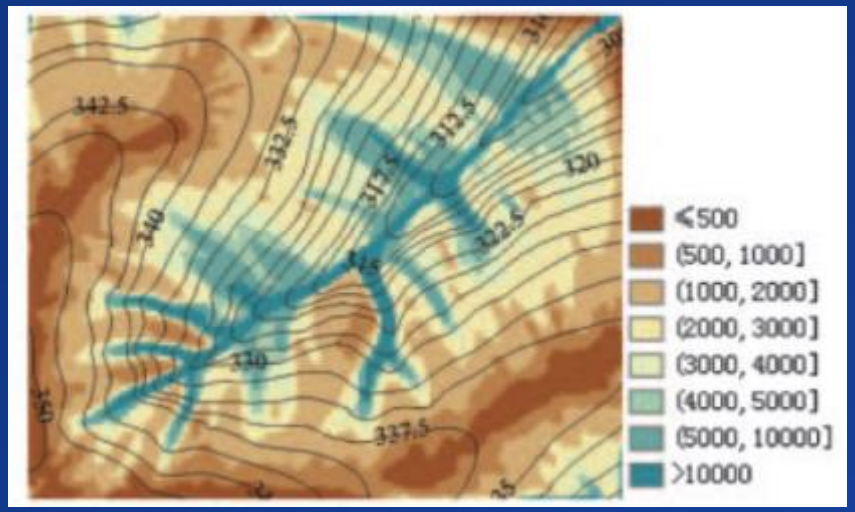
PPF enabled

- Better flow accumulation maps in low-relief areas
- Flow partitioning is adaptive to local terrain conditions.

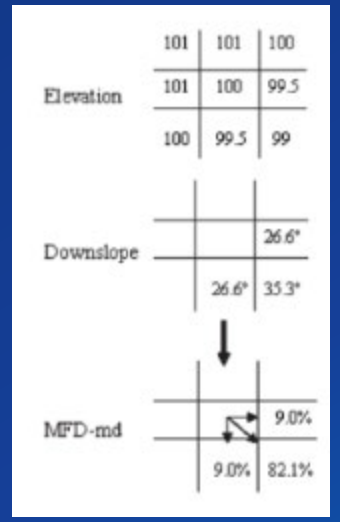


D8 Flow Accumulations

VS




MFD Flow Accumulations



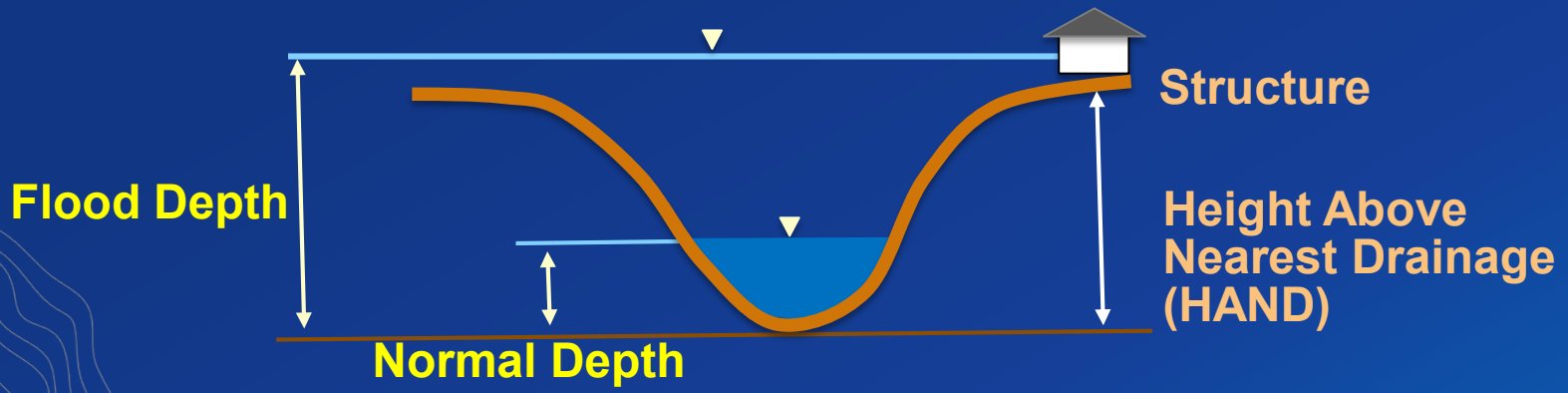

Flow proportioned to all downstream neighbor(s)

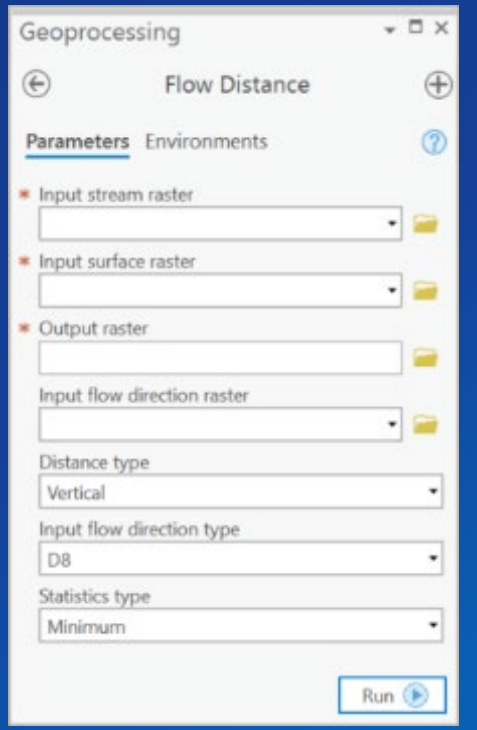
Qin, C., Zhu, A. X., Pei, T., Li, B., Zhou, C., & Yang, L. 2007. "An adaptive approach to selecting a flow partition exponent for a multiple flow direction algorithm." International Journal of Geographical Information Science 21(4): 443-458.

# Flow Distance

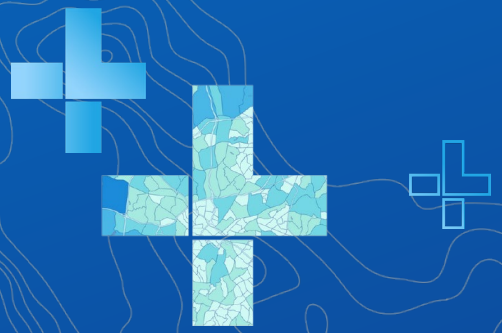
PPF enabled

- Compute vertical/horizontal downslope distance to streams over single or multiple flow paths.
- Supports D8, D-Infinity and MFD algorithms for computing flow distance.
- In case of multiple flow paths, minimum, weighted mean, or maximum flow distance can be computed.
- Used in computation of Height Above Nearest Drainage (HAND). Flooding occurs when water depth is greater than HAND.



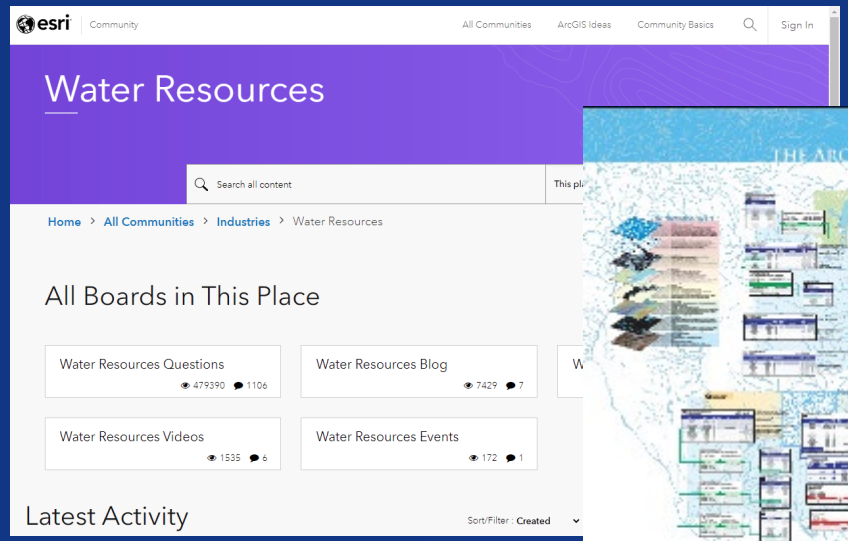



# What is Arc Hydro?

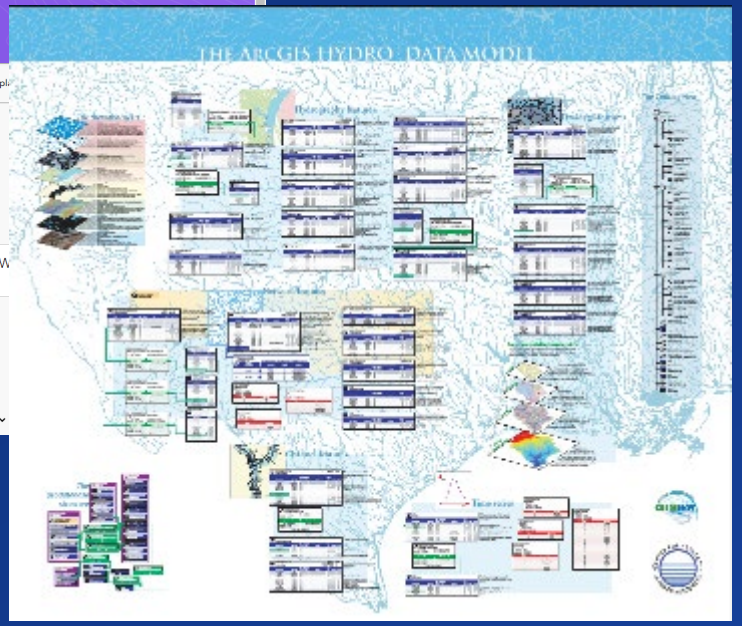


# Vision

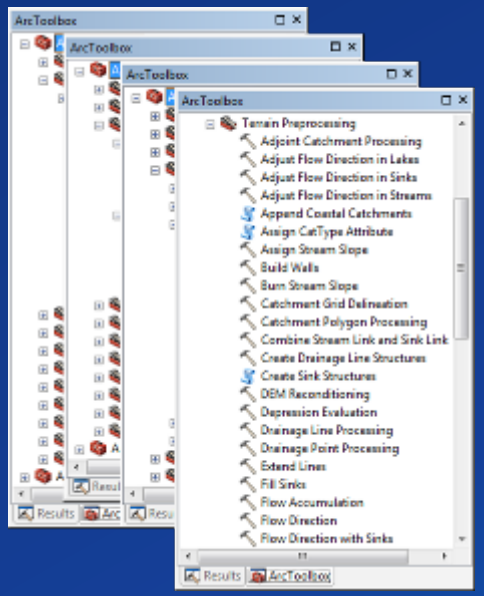
**“Provide practical GIS framework for development of integrated analytical systems for water resources market.”**



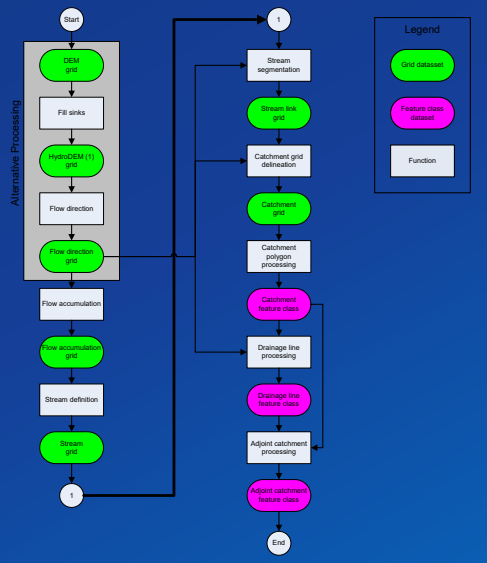

**Community**




**Data Model**




**Tools**




**Workflows**

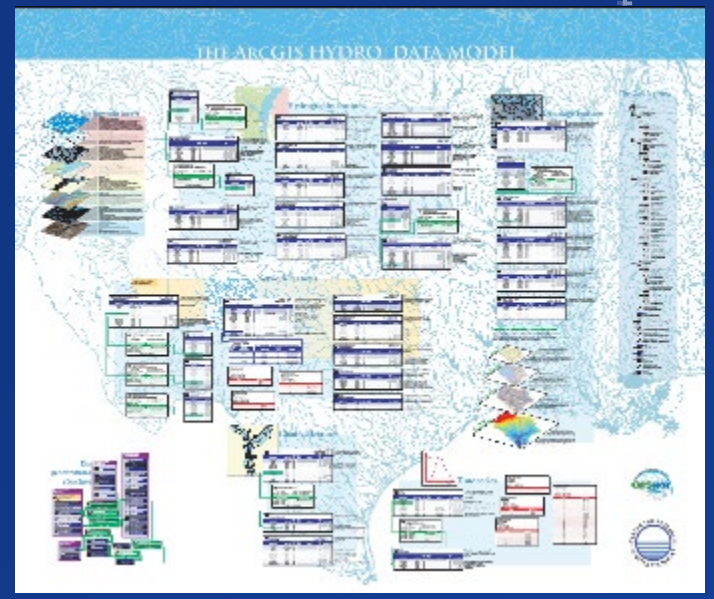
# What Arc Hydro is NOT

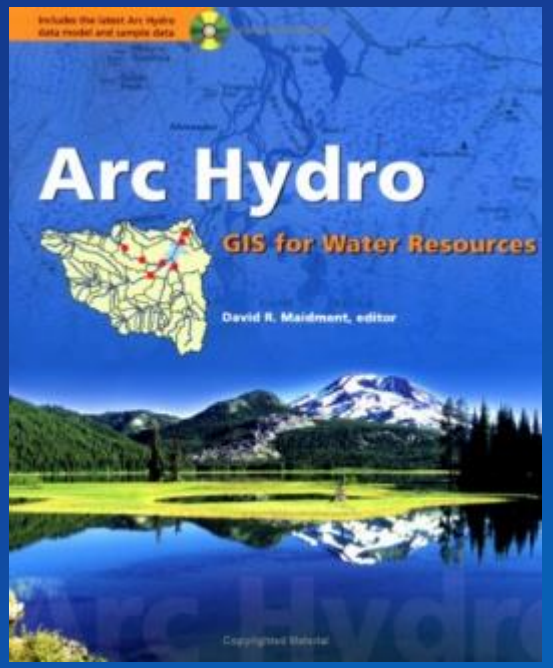
- Data
  - But can be used to develop hydro data
- H&H model
  - But can be used to support various H&H models
- Solution to a specific hydro problem
  - But can be used to develop specific hydro solutions
- Black-box
  - But also not free for all – remember “analytical system” – needs some rigor

# Brief History

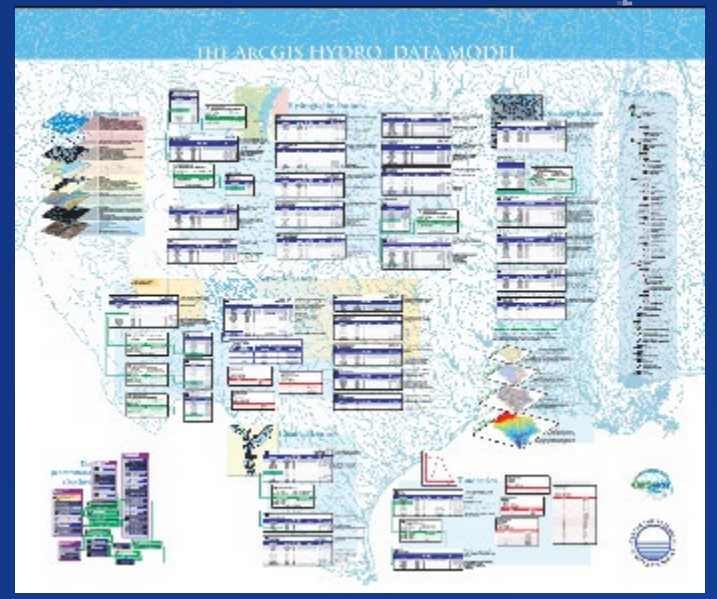
**1999 – 2002**

- Project to demonstrate geodatabase capabilities in water resources.
- Worked with Dr. David Maidment at the University of Texas.
- Focused on the Arc Hydro Data Model.
- Released in 2002 as a data model, a toolset, and an Esri Press book (Arc Hydro).
  - Initial set of ~ 30 tools (8.3) developed by Esri (PS) as a complement to the data model.



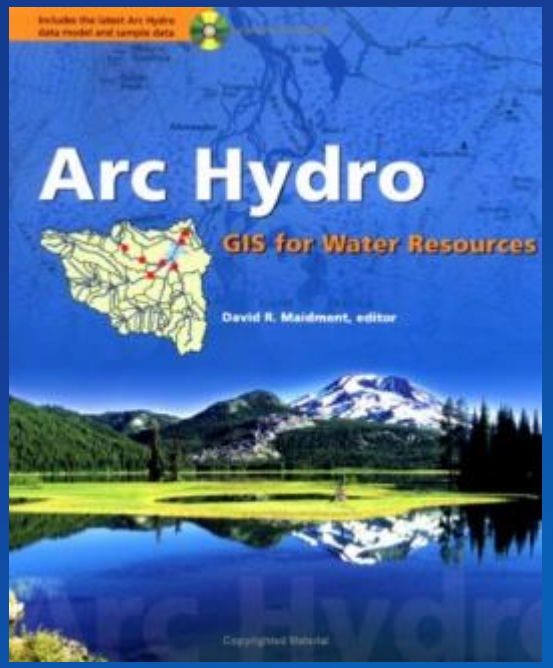



# Brief History



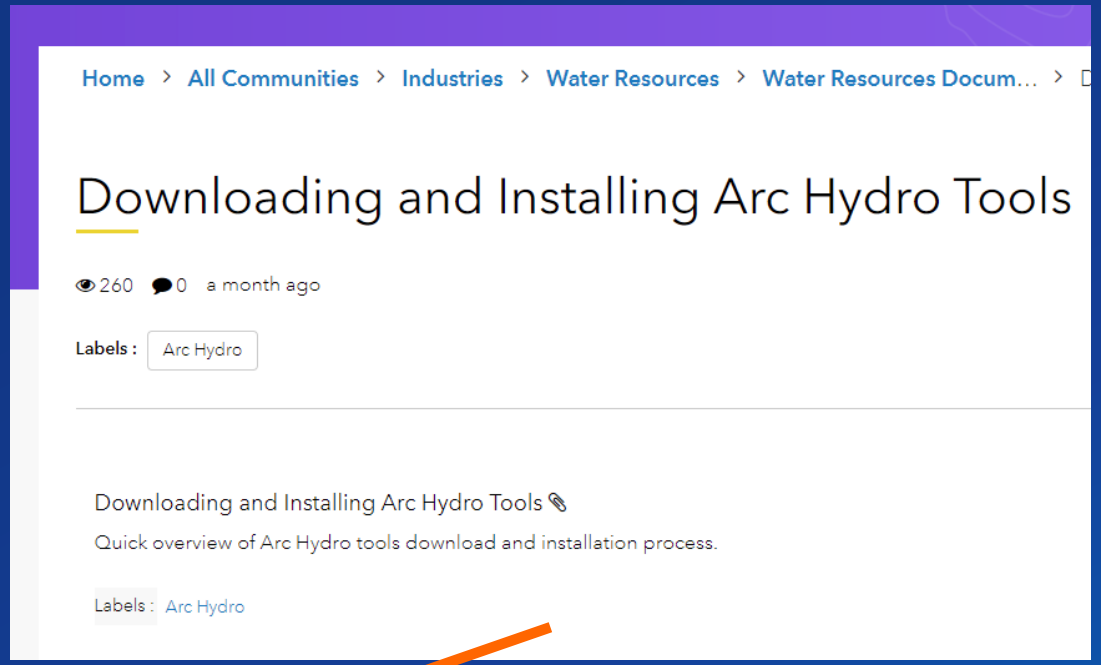

**Since 2003:**

- **Arc Hydro Groundwater**
  - Added in 2007.
  - Collaboration with Aquaveo and published Esri Press book (Arc Hydro Groundwater, 2011).
  - Aquaveo provides extensions (fee) and support
- **Arc Hydro tool development through projects.**
  - This added ~300+ tools over the years.
- **Tool maintenance** (version updates, move to Pro, etc.).
- **User support** (Web pages, GeoNet, response to emails, etc.).
  - **https://community.esri.com/community/gis/solutions/arc-hydro**
- **Training classes** (managed as standard Esri training and are delivered by PS).

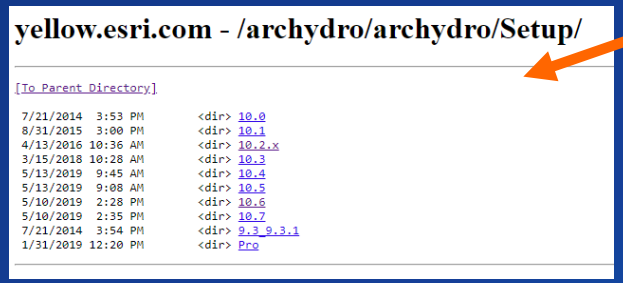


# Product \ Capability Summary

- “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 Adoption Over the Past 15+ Years

- Arc Hydro: ~ 1,000 views/downloads per month
- Projects: ~ 100 projects for Arc Hydro-related work
- Training: over 1,600 customers reached through ~120 Arc Hydro and H&H classes delivered on 4 continents

# Arc Hydro Users

- Fed / State / Local Government
  - USGS, FEMA, NWS, EPA, FS, …
- Water Management Districts
  - SWFWMD, SJRWMD, SFWMD, …
- Defense / Intelligence
- Private consultants
  - Engineering companies
  - Hydro professionals
- Anyone involved in water resources / environmental activities

# Arc Hydro Applicability Matrix

| Industry \ AH | Watershed delineation and character. | Stormwater | Wetlands | Hydrology | Hydraulics | Flood |
|---|---|---|---|---|---|---|
| Transportation | | | X | X | X | X |
| Insurance | | | | | | X |
| AEC | X | X | X | X | X | X |
| Facilities management | | X | | | | X |
| Local/state government | X | X | X | X | X | X |
| Mining | | X | | X | | X |
| Defense | | X | | X | X | X |
| Environmental | X | X | X | X | X | X |
| Emergency response / public safety | | | | X | X | X |
| Agriculture | X | | X | | | |
| | | | | | | |

*And many more …*

# Polling Question

**How much Arc Hydro experience do you have?**

- None
- 1 year
- 5 year
- 10 year
- “Forever“

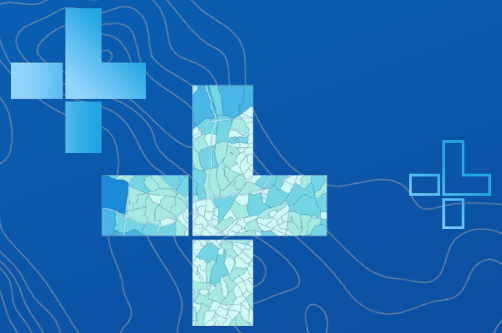
# Polling Question

**How much Arc Hydro experience do you have?**

- None = 60%
- 1 year = 25%
- 5 year = 6%
- 10 year = 5%
- “Forever“ = 2%

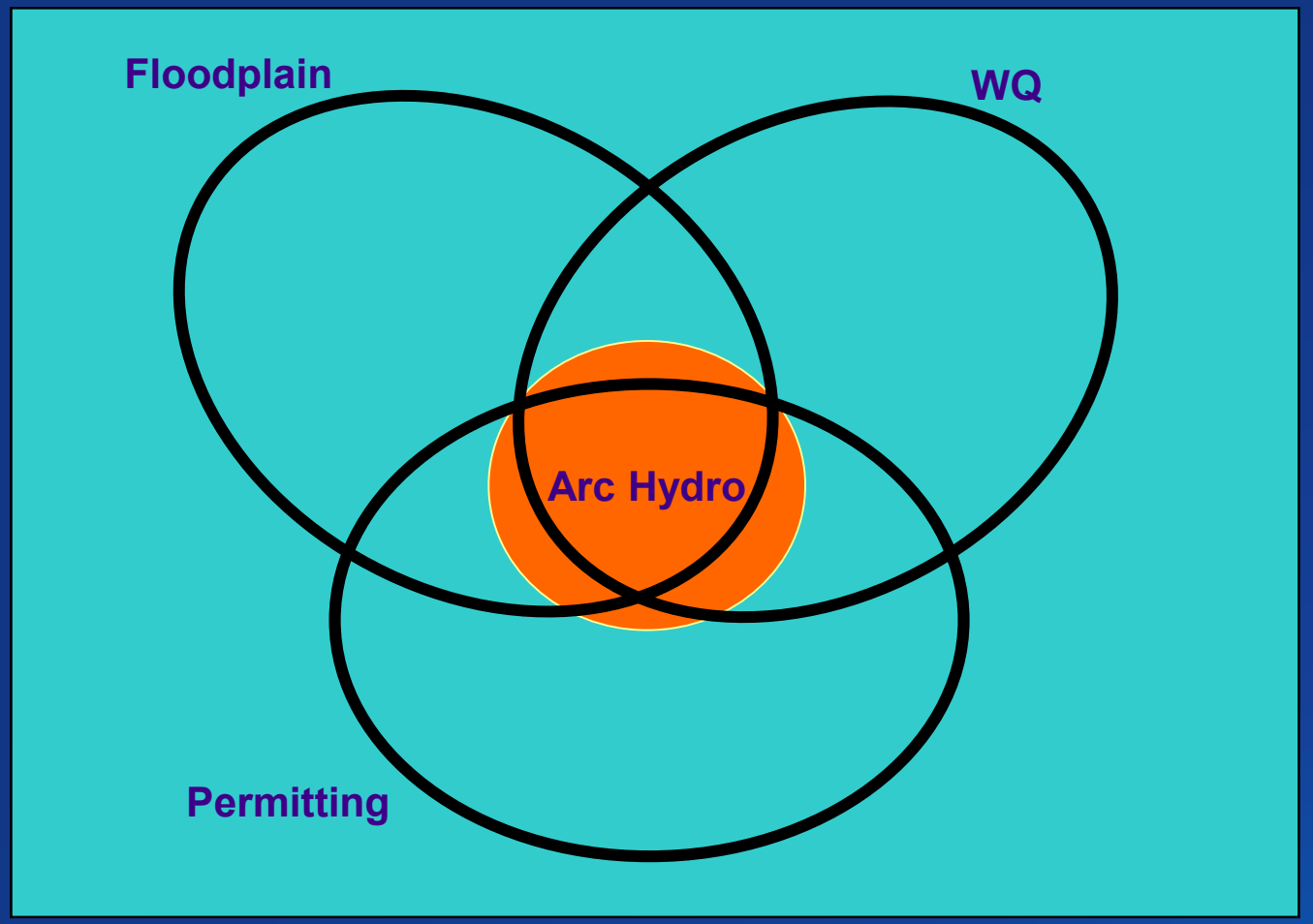
# Arc Hydro Data Model and Tools Foundation

Drainage System Example



# Arc Hydro Data Model and Tool Development General Approach

**Water Resources**



# 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

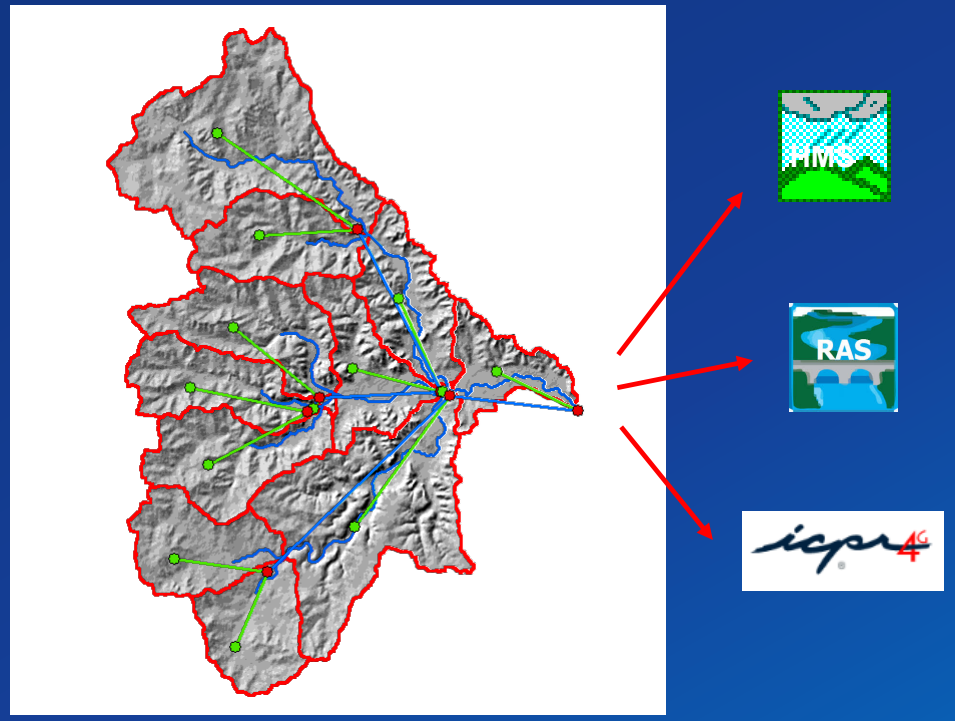
# Arc Hydro “Required” Reading

- 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 Tools Key Concepts

- Build foundation for analytical capabilities
  - Start with landscape (e.g. terrain)
  - Identify drainage patterns
  - Define necessary characteristics
  - Define node-link representation
  - Support scientific/engineering models (I/O)

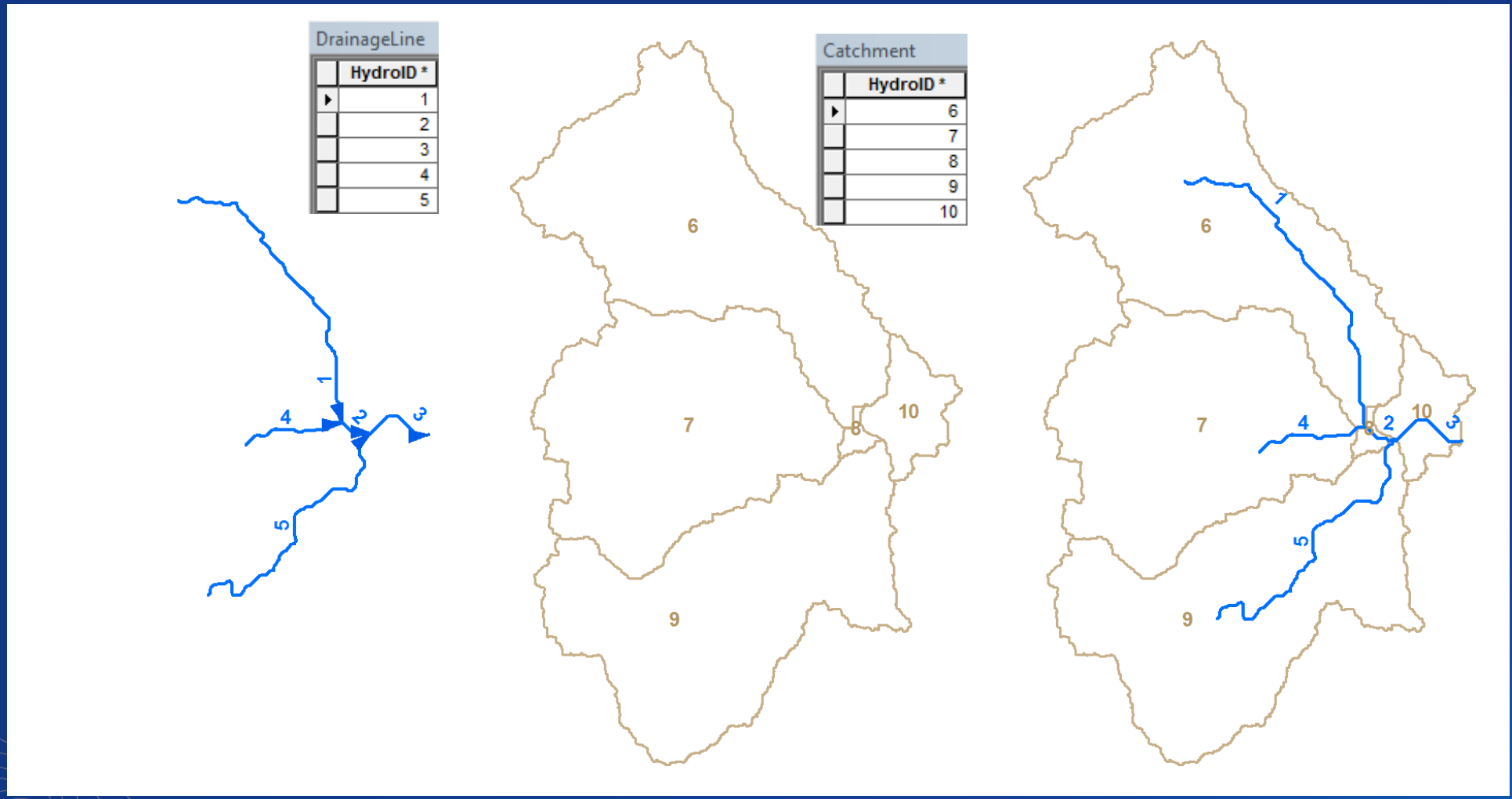
  - While maintaining spatial and referential integrity (collocation, IDs, vector/raster references, remove redundancy in processing, …)



# Arc Hydro Data Model Foundation

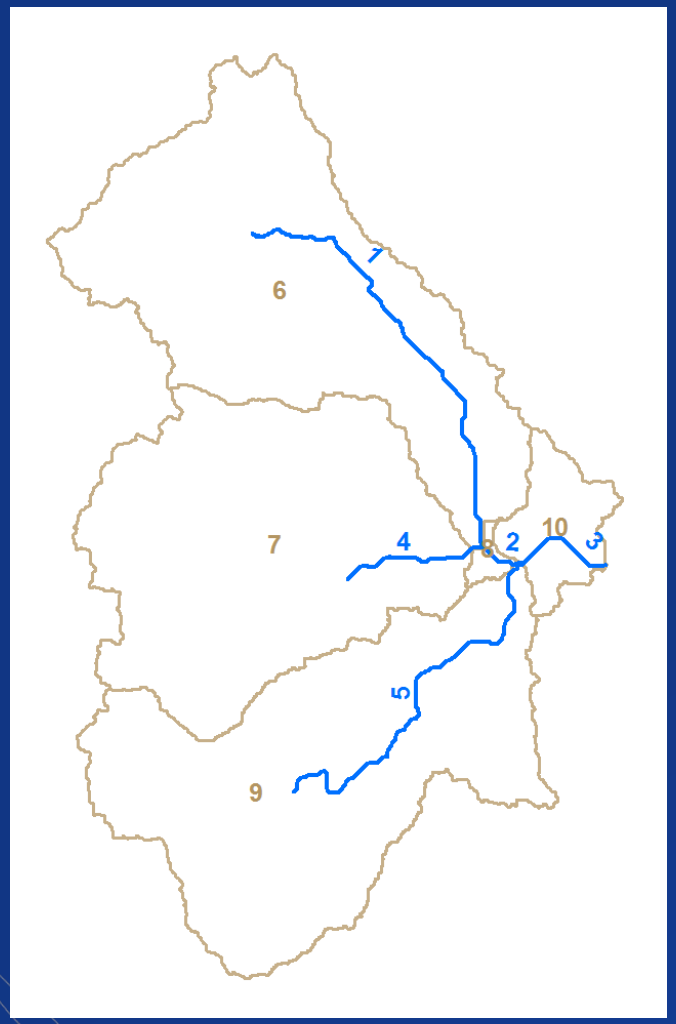
- **Unique identifier:**
  - HydroID – a unique integer identifier for every feature within a geodatabase
  - An internal identifier whose value is used for establishing the relationships within the Arc Hydro data model (HydroID, DrainID, NextDownID, JunctionID, …)
  - Use HydroCode (can be string) to store identifiers for external databases (e.g. ReachCode)
- **Linking Drainage System Elements:**
  - Use HydroID -> NextDownID -> DrainID -> JunctionID attribute relationship for vector data.
  - Use HydroID -> GridID for vector to raster data relationship.
- **Tracing:**
  - Trace or geometric networks
  - By attribute (from/to node or NextDownId)

# Drainage Lines and Catchments (1)




Basic HydroID assignment

# Drainage Lines and Catchments (2)




DrainageLine

| HydroID * | NextDownID | DrainID |
|---|---|---|
| 1 | 2 | 6 |
| 2 | 3 | 8 |
| 3 | -1 | 10 |
| 4 | 2 | 7 |
| 5 | 3 | 9 |

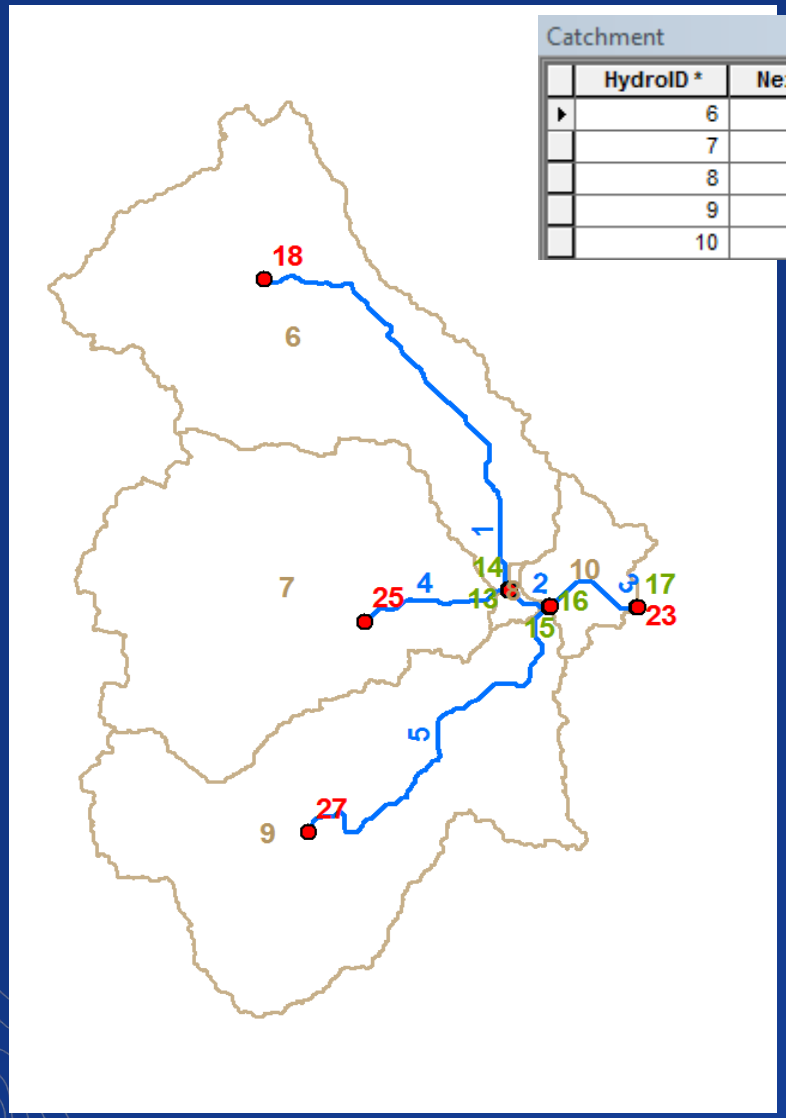
Catchment

| HydroID * | NextDownID * |
|---|---|
| 6 | 8 |
| 7 | 8 |
| 8 | 10 |
| 9 | 10 |
| 10 | -1 |

**NextDownID – connection within FC**

**DrainID – connection across FCs**

# All Together Now!




Catchment

| HydroID * | NextDownID * | JunctionID * |
|---|---|---|
| 6 | 8 | 19 |
| 7 | 8 | 19 |
| 8 | 10 | 21 |
| 9 | 10 | 21 |
| 10 | -1 | 23 |

DrainageLine

| HydroID * | NextDownID | DrainID |
|---|---|---|
| 1 | 2 | 6 |
| 2 | 3 | 8 |
| 3 | -1 | 10 |
| 4 | 2 | 7 |
| 5 | 3 | 9 |

DrainagePoint

| HYDROID | DrainID | JunctionID |
|---|---|---|
| 13 | 6 | 19 |
| 14 | 7 | 19 |
| 15 | 8 | 21 |
| 16 | 9 | 21 |
| 17 | 10 | 23 |

HydroJunction

| HydroID * | NextDownID |
|---|---|
| 18 | 19 |
| 19 | 21 |
| 21 | 23 |
| 23 | -1 |
| 25 | 19 |
| 27 | 21 |

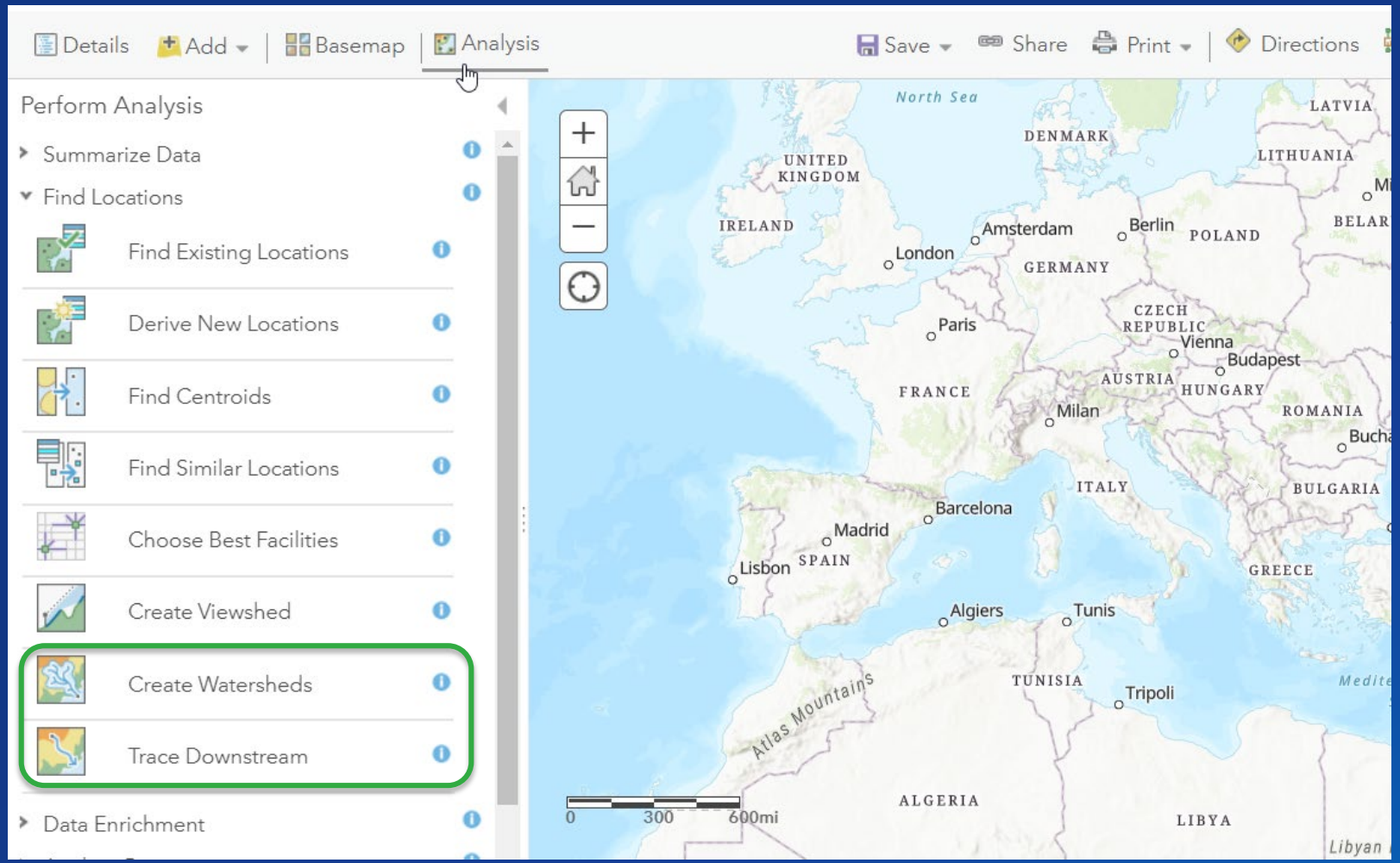
**And together with geometric/trace network - that makes the Arc Hydro drainage system!**

# Arc Hydro Demo

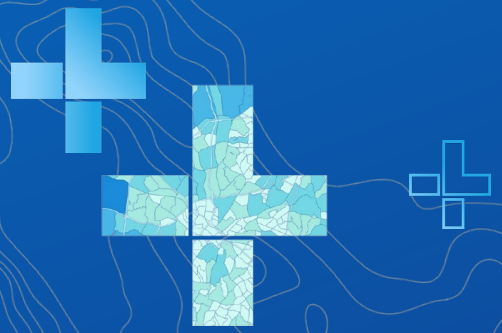

# Ready-to-use services on ArcGIS Online: Create Watershed & Trace Downstream

# How to Use the Analysis Services

## In ArcGIS Online



# “Good Data”: A Reality Check

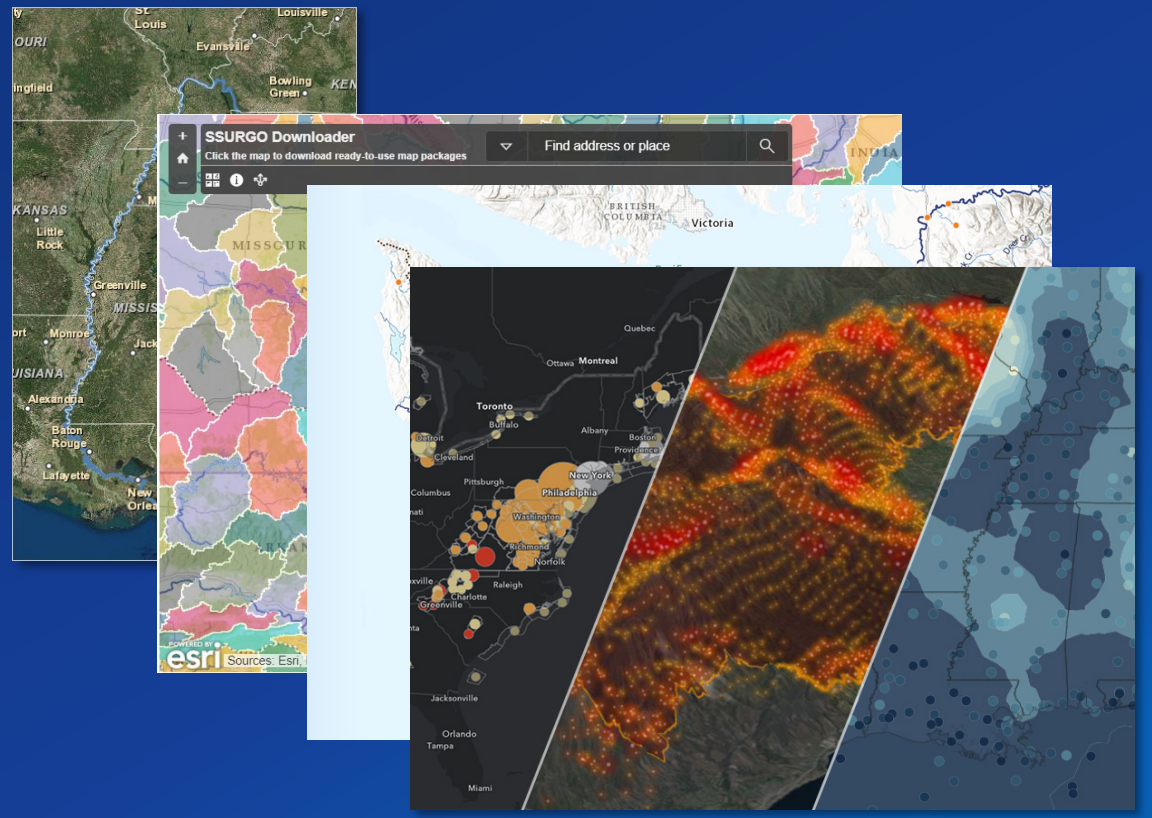


# GIS Data for Hydrologic and Hydraulic Modeling

- “Landscape” data
  - Digital elevation
  - Hydrography
  - Land use
  - Soils
  - …
- “Hydro” data
  - Flow measurements
  - Precipitation
  - Water quality
  - Weather/climate variables – wind, evaporation, …
  - …

# GIS Data for Hydrologic and Hydraulic Modeling

- Esri's Living Atlas of the World
  - Global hydro geoprocessing services (watershed delineation and downstream trace)
  - Soils data (SSURGO 2019 update)
  - Stream gage data
  - Live feeds on multiple variables
    - USA Weather Watches and Warnings
    - Current weather and wind station data
    - …



# GIS Data for Hydrologic and Hydraulic Modeling

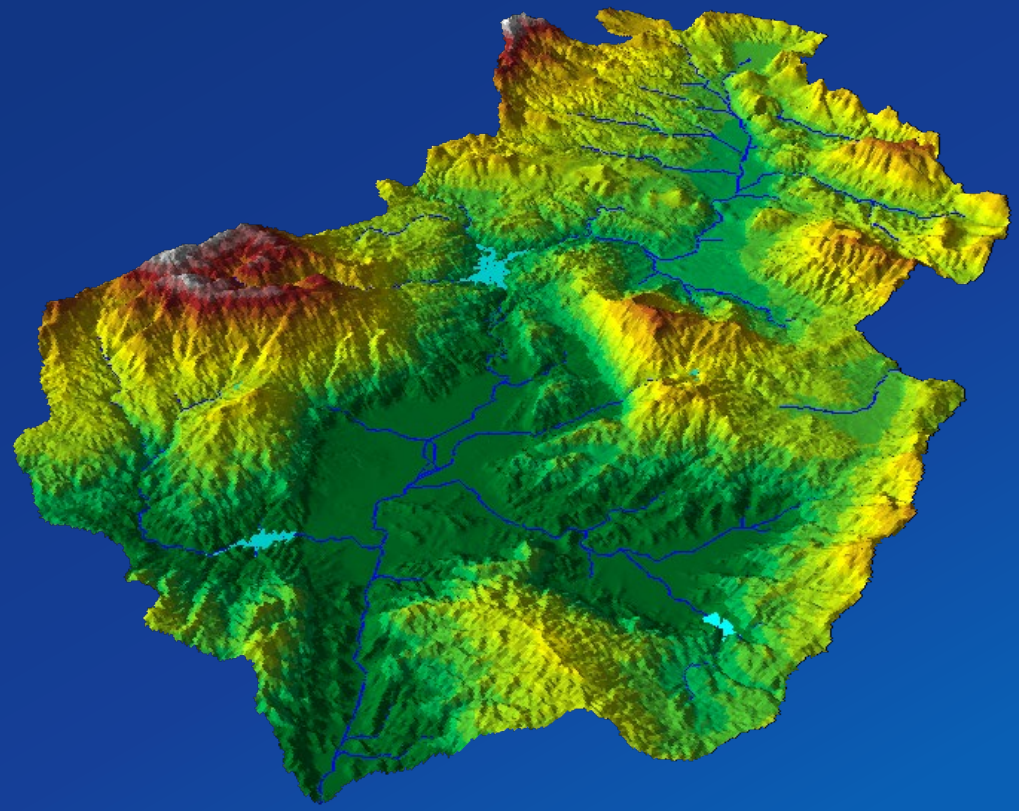
- Digital Elevation Model and land cover
  - http://seamless.usgs.gov/
  - https://www.usgs.gov/core-science-systems/ngp/national-hydrography/nhdplus-high-resolution
- Watershed boundaries
  - http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/
- Hydrography
  - http://nhd.usgs.gov/
- Soils
  - http://www.soils.usda.gov/survey/geography/statsgo/

# GIS Data for Hydrologic and Hydraulic Modeling

- Current and historic water records
  - http://waterdata.usgs.gov/nwis
  - http://www.epa.gov/STORET/index.html
  - http://his.cuahsi.org/
- Climate and precipitation
  - http://www.weather.gov/gis/
  - http://www.ncdc.noaa.gov/oa/ncdc.html
- Channel geometry (cross sections)
- H&H data are very “local”
  - “You have to be there when it rains!”

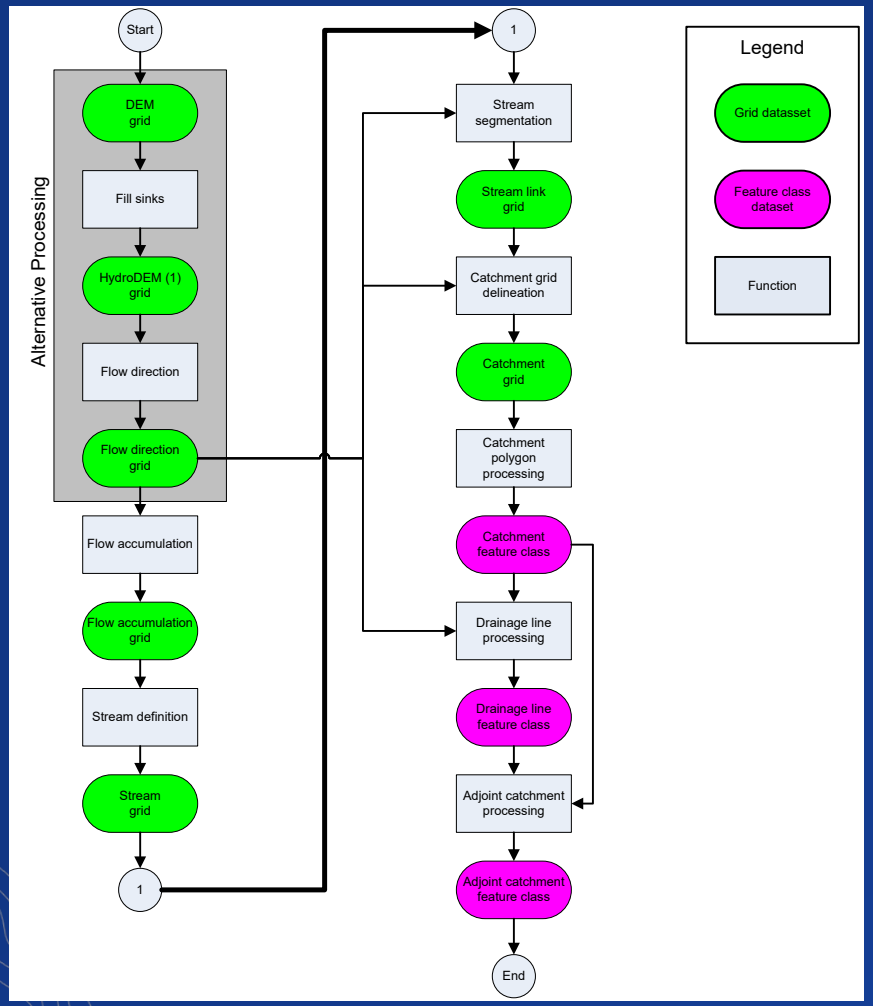
# Elevation Data – Key Dataset

- Resolution and extent
- Projection (for hydrology – use equal area)
- Source of elevation data (consistency)
- Hydro conditioning of DEM
  - Varies with the analysis purpose
    - Floods
    - Droughts
  - Different morphologies
    - Dendritic, deranged, combined

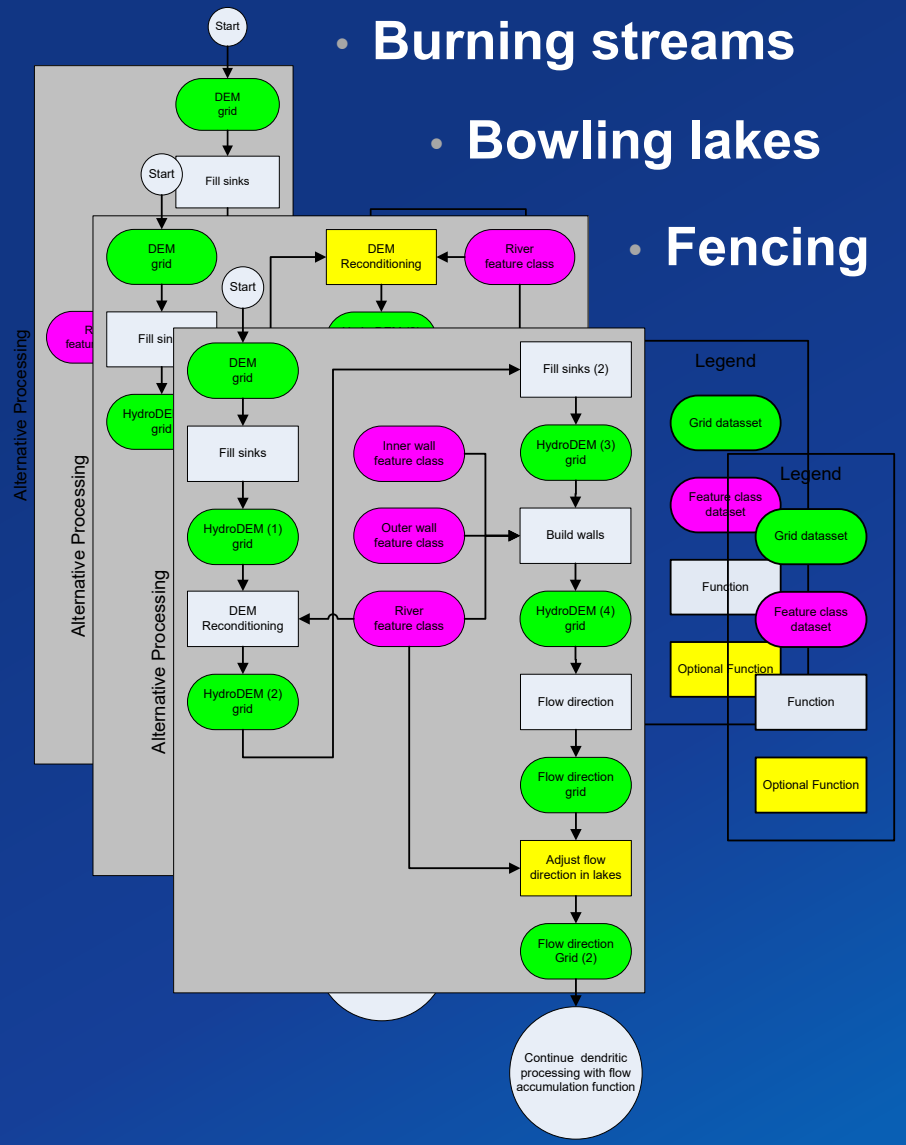


# Workflows, Workflows, Workflows

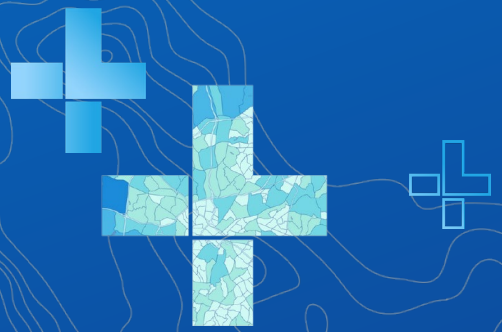
- "Basic" dendritic preprocessing




- Burning streams
- Bowling lakes
- Fencing



# Final Thoughts

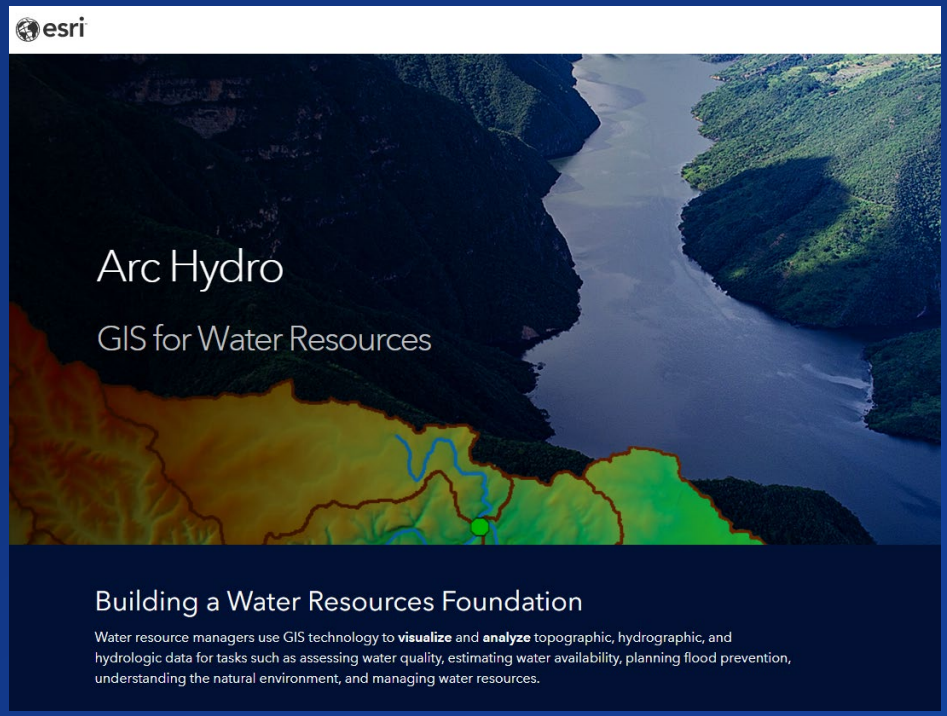


# Work in Progress

- Goal for Pro 2.8 (summer 2021)
  - Completion of code transfer for baseline capability (Trace Network based functions)
  - Model integration (HEC-RAS, HEC-HMS, ICPR4)
  - Floodplain and impact assessment tools and workflows
  - Documentation, documentation, documentation
    - Getting started with Arc Hydro
    - Domain specific workflows, docs
- Prioritization of further updates
  - Talk to us!!!

# Getting involved

- **Arc Hydro GeoNet:**
  - https://community.esri.com/community/gis/solutions/arc-hydro
- archydro@esri.com
- ddjokic@esri.com




- **Water resources industry page:** https://www.esri.com/en-us/industries/water/segments/water-resources

- **Arc Hydro landing page:** https://www.esri.com/en-us/landing-page/industry/water/2020/arc-hydro-gis-for-water-resources

# 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.

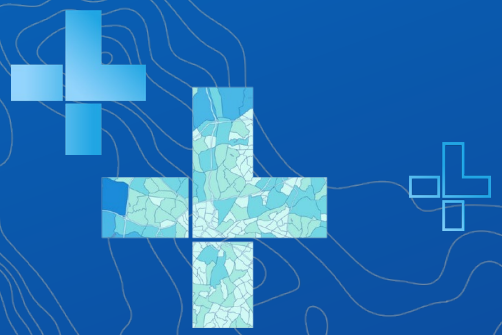
New hillslope analysis tools.

**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?



# Questions: NHD / NHDPlus

- How much of dependency exists if any between Arc Hydro and EPA/USGS standardized hydrological data sets such as the Watershed Boundary Dataset and the National Hydrography Dataset?
- Were Arc Hydro tools used to develop NHDPlus?
- Does Esri provide tools to make use of NHD data?

# Questions: Snapping

- Why is the snap distance important in the Watershed tool?
- How do you know what snapping distance you need?
- Do you have input on how to determine snapping distance (how large or small a number to choose so that you don’t snap to another flow accumulation line all together but don’t miss it either)?

# Questions: Miscellaneous I

- Can Arc Hydro be used in a micro scale?
- Can trace be used to trace pollution points and potential affected areas?
- How does Arc Hydro account for constructed infrastructure such as ditch diversions, where water may be pumped against the natural gradient of the terrain?

# Questions: Miscellaneous II

- Is there any advantage of Arc Hydro when compared to HecRAS?
- Are there any functions/tools that were not migrated from Arc Hydro in ArcMap to Pro?
- Is this (terrain preprocessing) a Model Builder tool that is included in the Arc Hydro toolset?

# Thank You!