Arc Hydro for Stormwater: An Overview

Dean Djokic, Christine Dartiguenave

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Arc Hydro for stormwater

- Concepts
- Database design
- Data processing workflows
  - Data driven!
- Terrain preprocessing tools (standard Arc Hydro)
- Stormwater delineation (new Arc Hydro tool)

- Foundation for stormwater analyses

Concepts

- Two “systems” in play:
  - Collection system – takes overland flow and places it into the conveyance system.
  - Conveyance system – takes the collected water and moves it through
- These systems interact through open channels and inlets.
  - Overland flow does NOT interact with pipes directly

Concepts

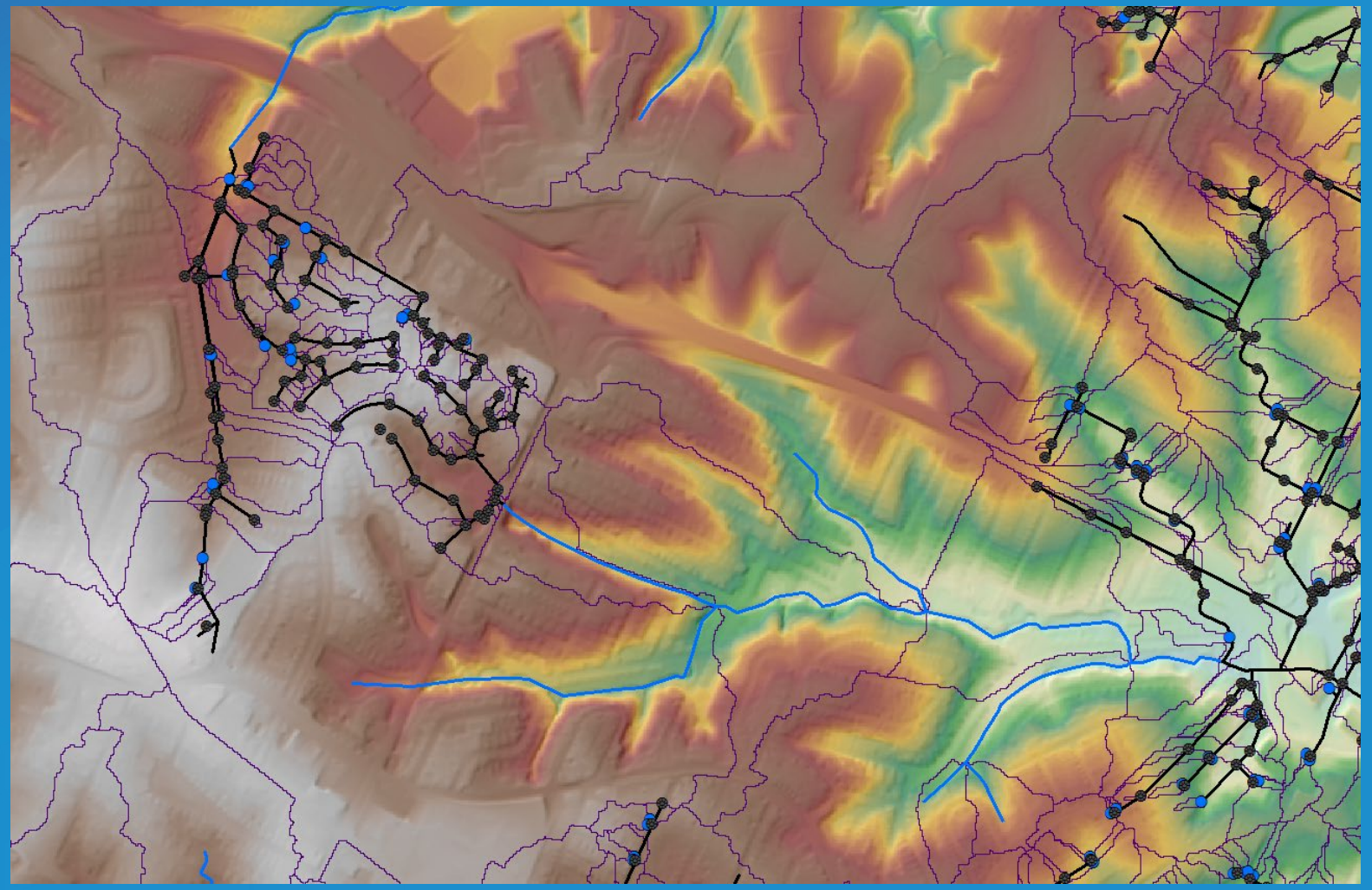
- Surface water is collected by:
  - Open channel system
  - Built “inlet” infrastructure (manhole, catch basin, …) that connects surface to subsurface (pipe) elements
  - Not all stormwater point structures are inlets
- Water is conveyed by a connected system consisting of:
  - Open channel system
  - Pipe network

Concepts

- Arc Hydro is about data element “connectivity” – it does not solve hydrologic and hydraulic equations governing collection and transport of water.
- Relationship class is used to connect drainage areas with conveyance system
- Geometric network is used to “move” water (tracing)
- This concept was in Arc Hydro data model since its release (2002)

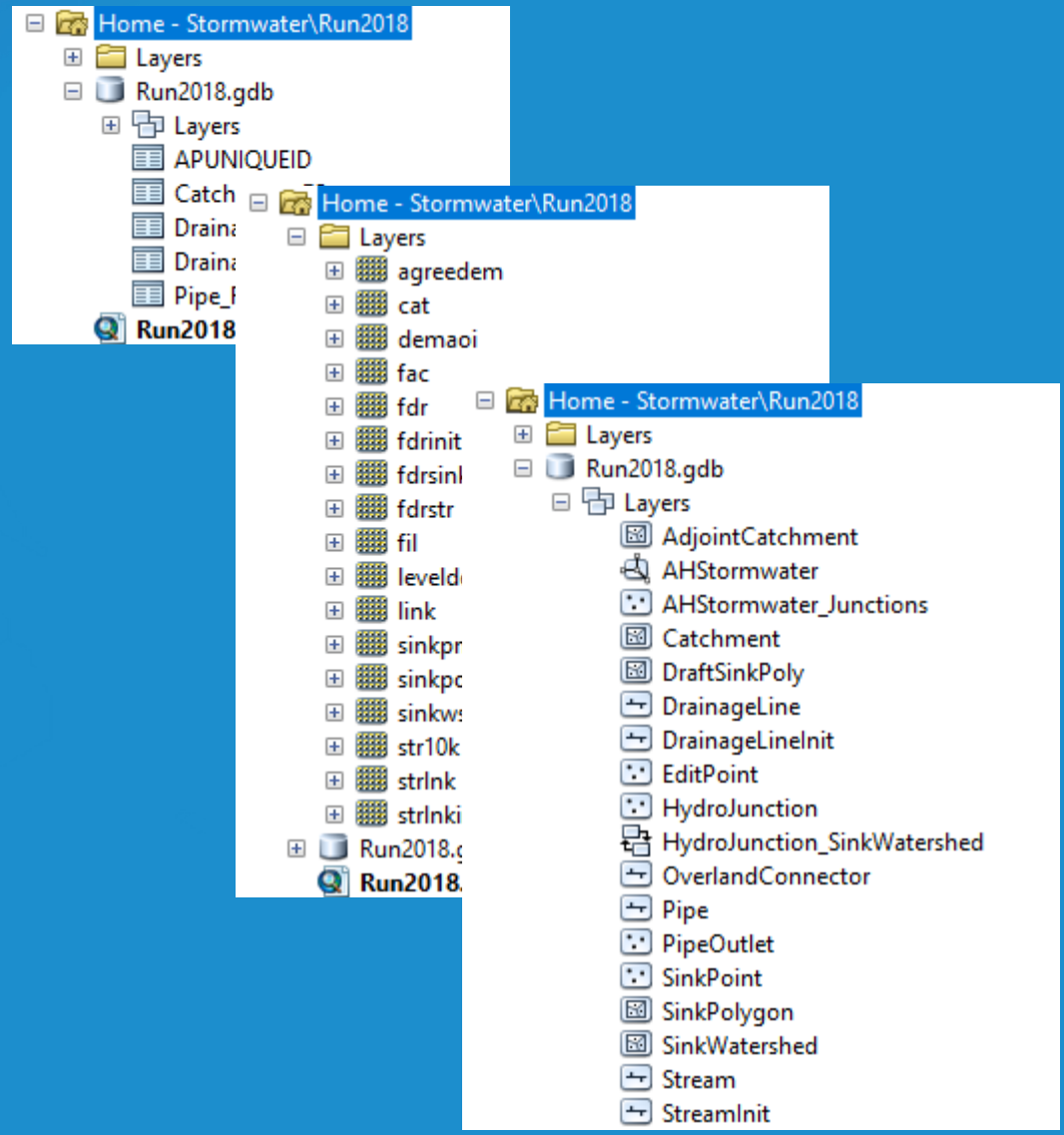
Concepts

- Start with a surface
- Identify open channels
- Identify storm pipes
- Identify operational inlets
- Define open channel contributing areas
- Define inlet contributing areas
- Tie it all together through network and relationships



Database design

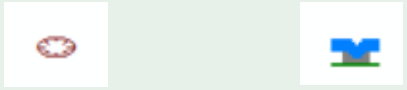
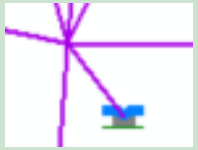
- Feature dataset containing:
  - Catchments (surface drainage areas draining into streams and inlets)
  - Open channel line features (“blue” lines)
  - Pipe line features (“black” lines)
  - Inlet points
  - Geometric network built from line and point features above
- Relationship class between hydro junctions and catchments (HydroID -> JunctionID relationship).
- Raster layers



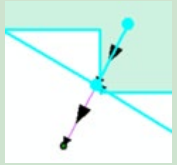
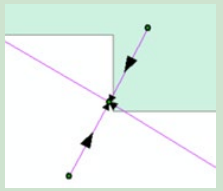
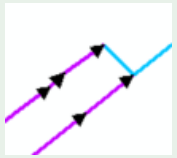
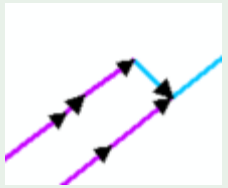
Data processing workflows

- **Data quality:**
  - Are linear features connected (snapped) and properly oriented?
  - Are features properly attributed so their role in the system can be determined programmatically (which elements are inlets and which are not)?
  - Are point features snapped onto the linear features?
  - Are data complete (connected network, all inlets present)?
  - Is DEM of enough resolution to support delineation to individual structures (horizontal and vertical resolution)?

Data processing workflows - topology

Use Case	Rule	Action
Terminal stream. 	Stream must end in a Sink or Inlet, or extend outside of the DEM processing area.	• Create Sink or Inlet at the end of terminal Stream.  • Extend Stream outside of DEM. 
Disconnected sink/inlet. 	May be disconnected. Need to check whether they should connect to a line.	Check connectivity to ensure points are really supposed to be disconnected or connect them.
Pipe.	• Water must enter the Pipe network through an Inlet. • Pipe may end in a Sink, at the surface, or may connect to a Stream.	
Pipe to stream connection.	No Inlet/Sink required at end of Pipe/start of Stream.	

Data processing workflows – network connectivity

Use Case	Rule	Action
Line direction. 	Line must be digitized in the direction of the flow.	Flip the direction of the line to match the direction of the flow. 
Line to line connectivity. 	A line cannot connect to another line in the middle of the line.	Split the line in the Geometric Network editing environment by connecting the junction. 
Terminal line connectivity.	Line may end at surface. Possible, but check whether it should connect to a line.	Add line to connect end of line to other lines in network. 
Disconnected features.	Check whether features are really disconnected or whether they need to be moved to snap on the network.	

Data processing workflows

- Data driven – one size does not fit all!
  - While conceptually simple, data organization and lack of quality require careful implementation
  - Key decisions related to
    - “Inlets” – how does the water enter the conveyance system?
    - DEM size related issues (what to do if multiple structures fall into the same DEM cell)
- Organize analytical data separately from the “inventory” data
  - Build data maintenance workflows for keeping new data “clean”
  - Build ETL workflows to keep inventory and analytical data in sync
  - Minimize manual processing

Data processing workflows - vector/raster integration issues

Data processing workflows

- DEM Reconditioning (Arc Hydro tool): Burn the stream grid into the DEM to enforce the location of the streams and force water near the streams to flow toward the closest stream
- Sinks (Arc Hydro tools):
  - Sink Evaluation: Generate and characterize sink for the input DEM
  - Create Sinks for Line/Point Structure: Identify the location where sinks/inlets should be created at the end of line or point structures
  - Create Sink Structures: Create sink points and polygons associated to structure sinks using a deranged polygon
- Create Geometric Network (Data Management tool): Build geometric network out of pipes, streams, and inlet junctions

Data processing workflows

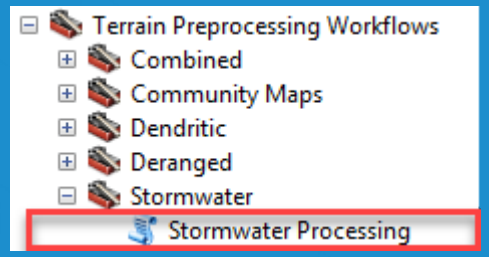
- **Once data roles are defined, the data development process is (fairly) well defined:**

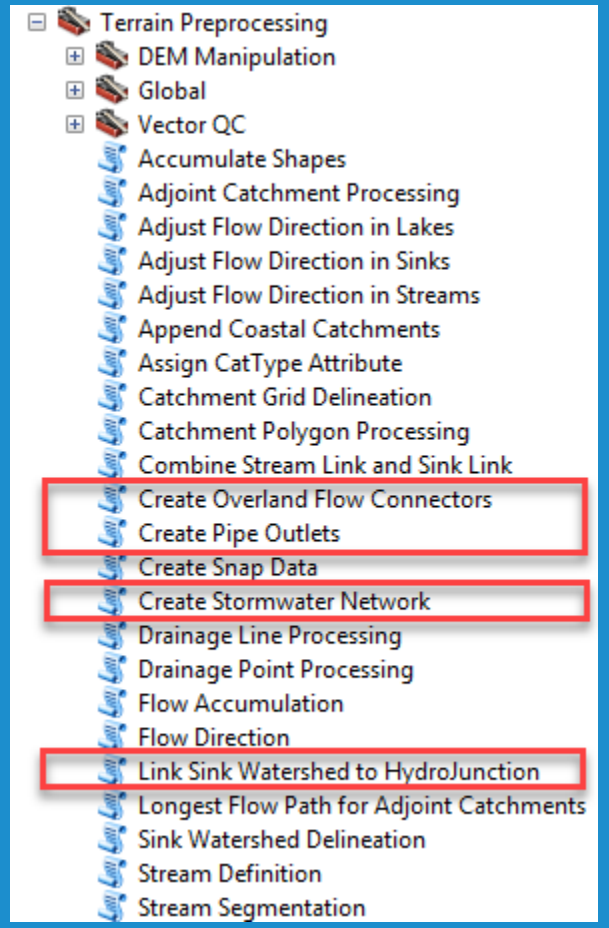
Step	Tool	Objective
1	Create Sink Structures	Create Sink Points and Polygons associated to draf sink poly (structure inlets and sinks created at end of DrainageLine.
2	Create Drainage Line Structures	Create rasterized vector representation of the input streams as Drainage Line features.
3	DEM Reconditioning	Burn the stream grid generated in step 1 in the DEM to enforce the location of the streams and force water near the streams to flow toward the closest stream.
4	Level DEM	Level DEM within terrain and structure sink polygons using the lowest elevation along the sink polygon boundary – 10000 offset.
5	Fill Sinks	Fill the DEM at all locations except within the sink polygons (both terrain and structure).
6	Flow Direction	Generate flow direction grid.
7	Adjust Flow Direction in Sinks	Modify flow direction within sink polygons so that water flows toward the sink point in the sink polygon.
8	Adjust Flow Direction in Stream	Modify flow direction in the streams so that the water flows in the digitized direction along the streams.
9	Create Overland Flow Connectors	Build vectors representing missing overland connectors from pipe outlets.

Step	Tool	Objective
10	Combine Stream Link and Sink Link	Combine link grids generated from the streams and from the sinks.
11	Catchment Grid Delineation	Delineate catchments for each link.
12	Catchment Polygon Processing	Convert catchment grid to vector.
13	Adjoint Catchment Processing	Generate Adjoint Catchment associated to each input Catchment and set the connectivity between Catchments.
14	Sink Watershed Delineation	Delineate watershed associated to terrain sinks.
15	Link Sink Watershed to HydroJunction	Create and populate JunctionID in SinkWatersheds with HydroID of associated HydroJunction. Create relationship.
16	Append Coastal Catchments	Build catchments on DEM fringes that do not drain to existing stormwater infrastructure.
17	Create Stormwater Network	Create geometric network from HydroJunction, Pipe and Stream layers and set flow direction in digitized direction.
18	Flow Accumulation	Create Flow Accumulation to support next step, Create Snap Data.
19	Stream Definition	Create snap raster to support snapping when delineating.

Terrain preprocessing tools

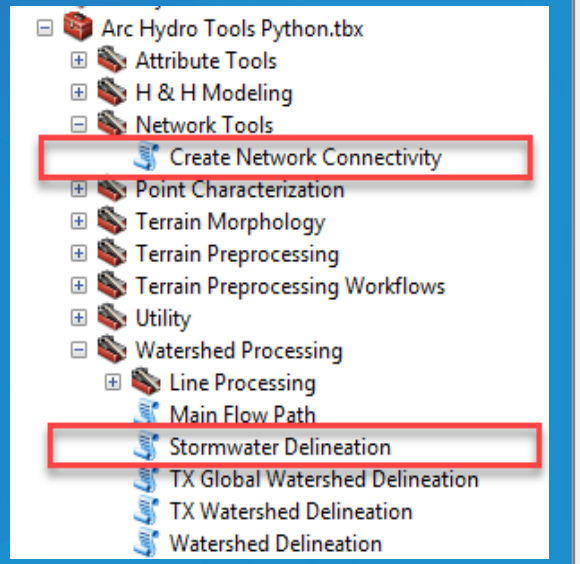
- Use standard Arc Hydro terrain preprocessing tools
  - Added new tools for preprocessing specific to stormwater
- A “combined” terrain processing approach (dendritic + deranged) is used
  - Streams are “burned”
  - Inlets are “sinks”
- Workflow automation, but …
  - Make sure data are “well behaved”
- BYO process as a function of YOUR data:
  - It is just geoprocessing
  - It is just Arc Hydro tools
  - You know the target gdb structure
  - Go for it!

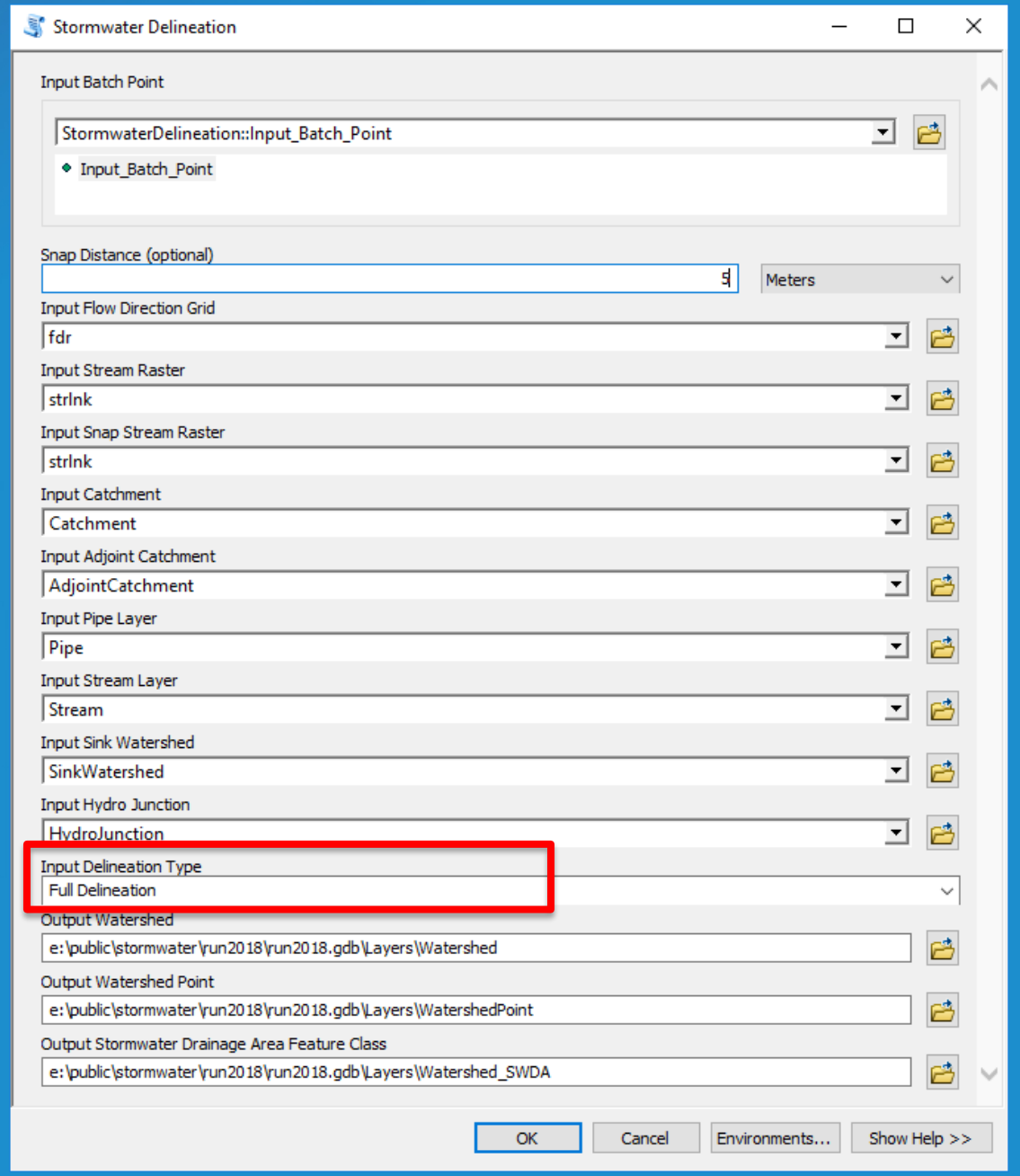




Stormwater delineation

- New Arc Hydro gp tool (Stormwater Delineation) to capture different options in contributing area determination
  - Single point
  - Multiple points
- New Arc Hydro gp tool (Create Network Connectivity) to define connectivity of elements through node-link tables





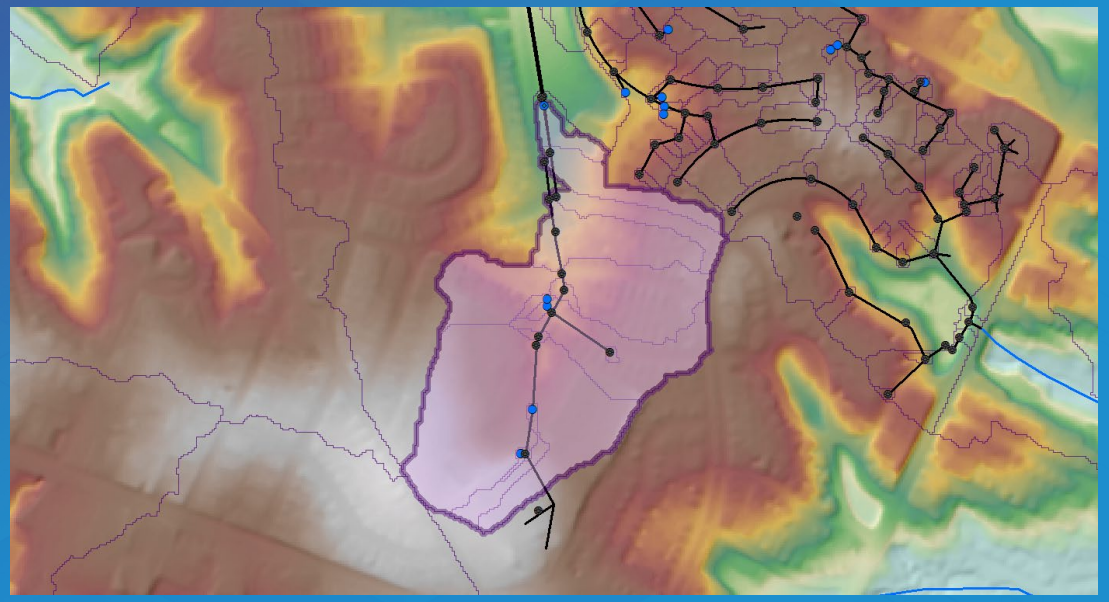
Stormwater delineation

- **Tool functionality matrix:**
  - **Where the point is?**
  - **Where the line is?**
  - **Local or global contribution (direct surface or full conveyance)?**

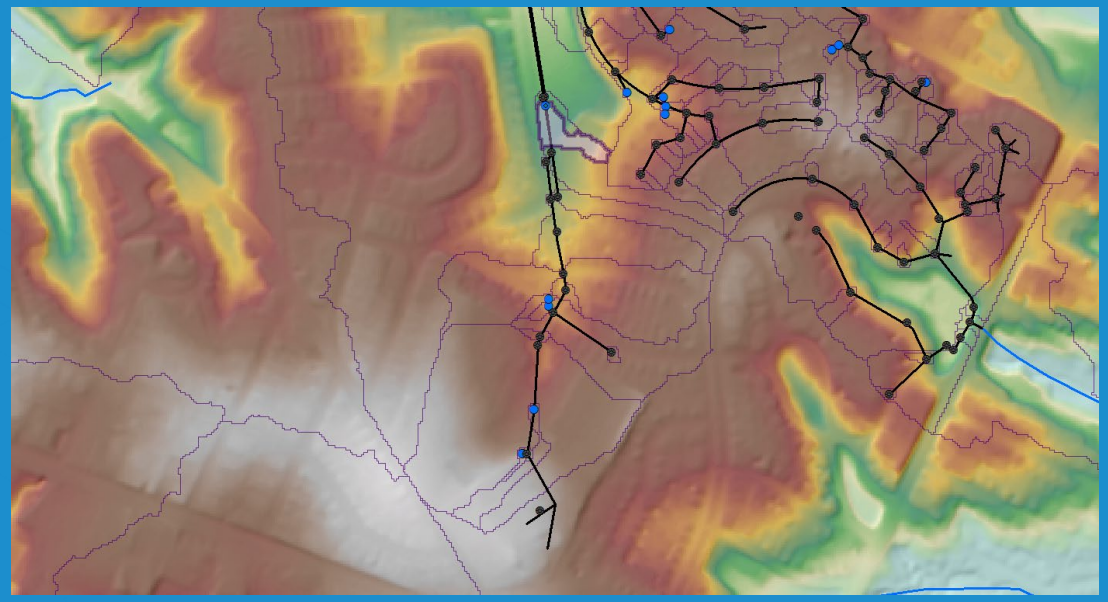
Clicking on	Delineation Type: Full (Default)	Delineation Type: Direct Surface Contribution
Inlet	SinkWatersheds linked to selected + traced upstream HydroJunctions	SinkWatershed related to selected HydroJunction only.
Pipe	SinkWatershed linked to traced upstream HydroJunctions only.	Watershed draining to the surface location.
Stream	Directly connected Surface Area Watershed + SinkWatersheds related to traced upstream HydroJunctions.	Directly connected Surface Area Watershed only.
Land	Directly connected Surface Area Watershed.	Directly connected Surface Area Watershed.

Stormwater delineation - inlet

Global

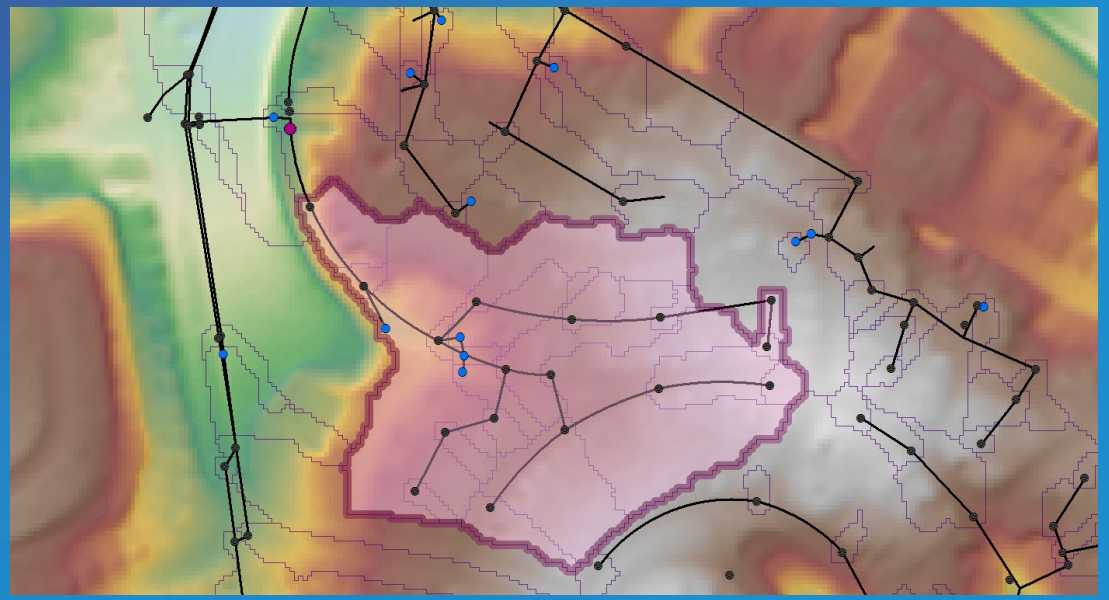


Local

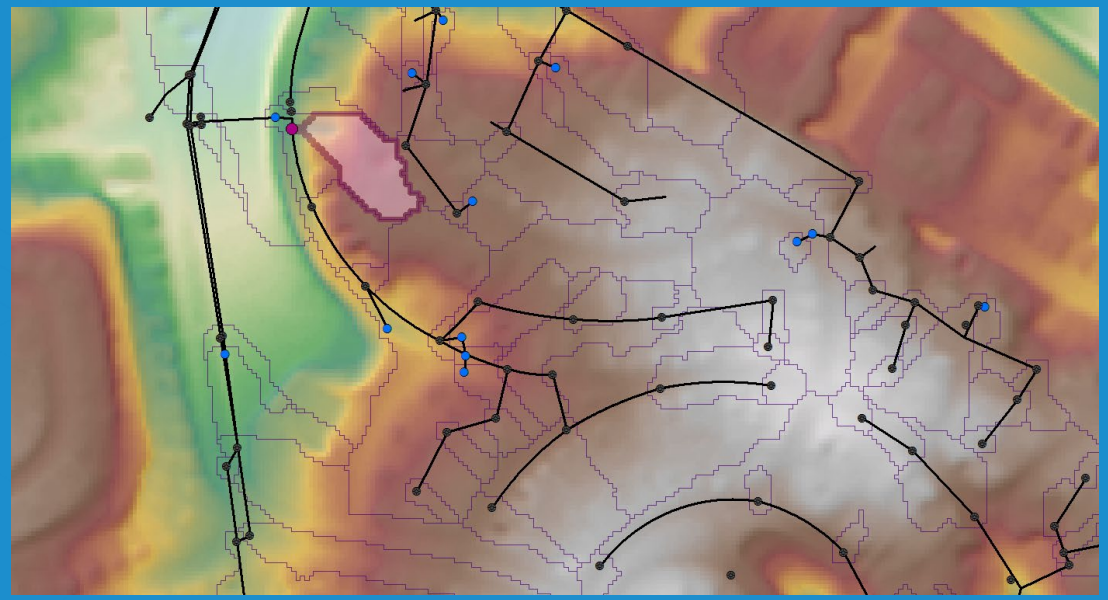


Stormwater delineation - pipe

Global (in the pipe)

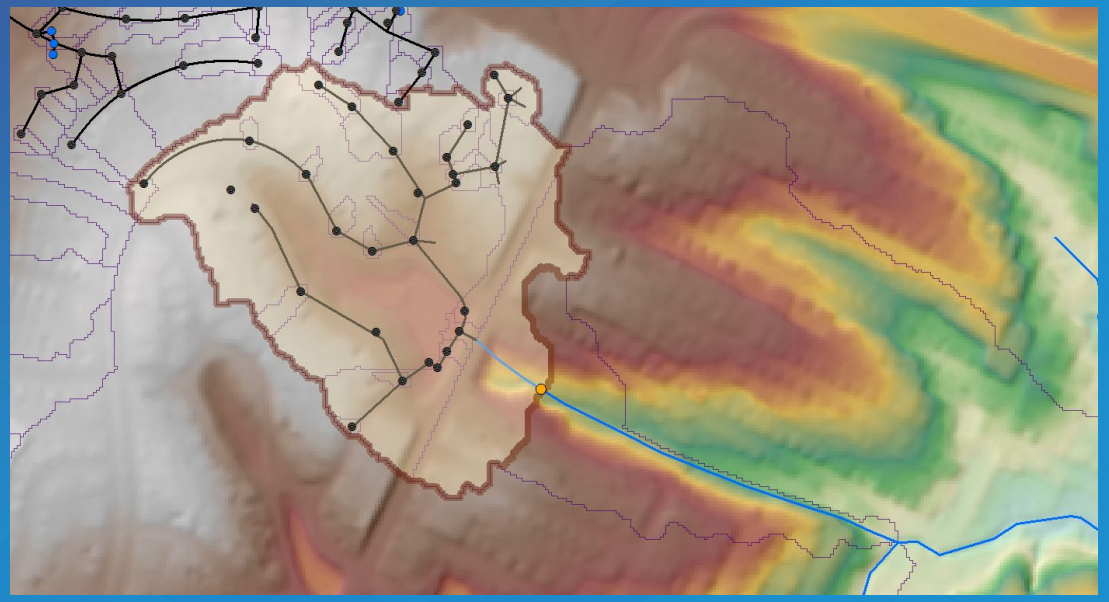


Local (same as land)

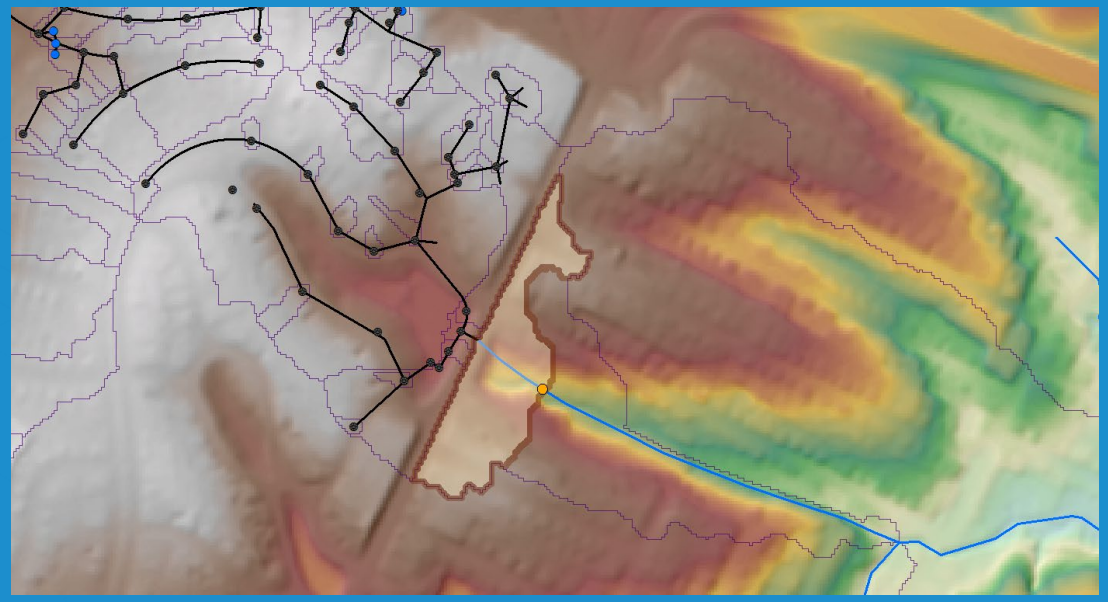


Stormwater delineation - stream

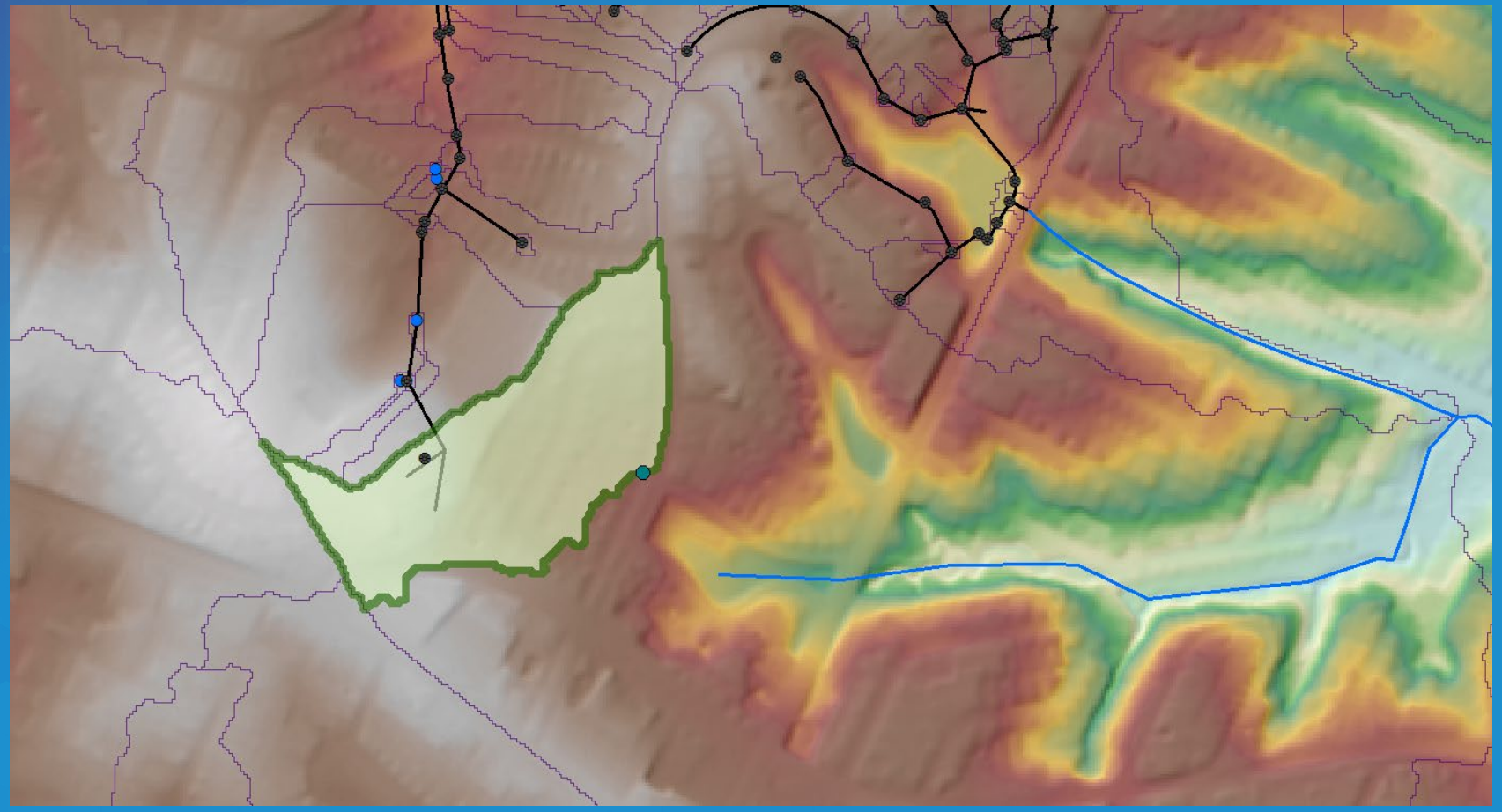
Global



Local



Stormwater delineation - land

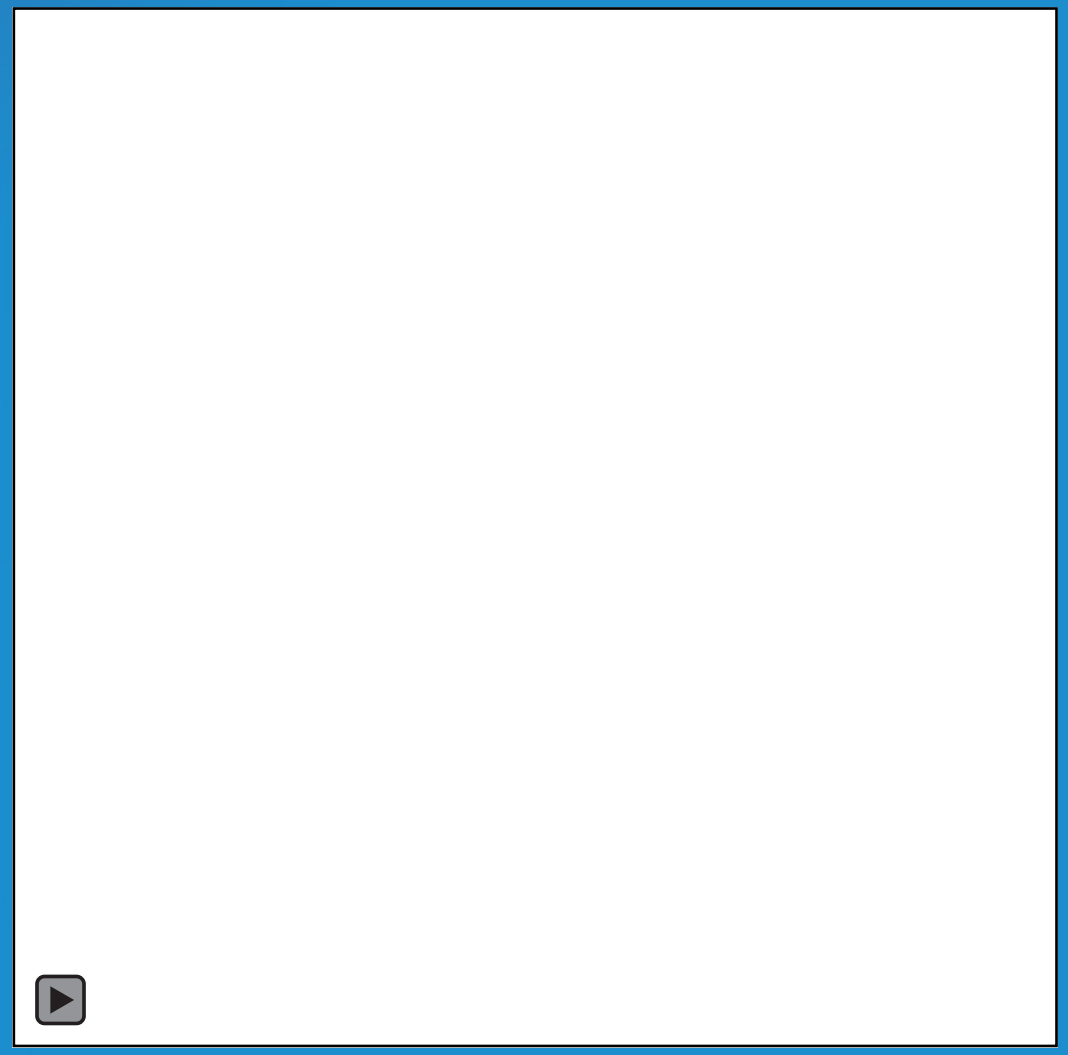


Foundation for stormwater analyses

- Data preparation applies required rigor.
- Data model allows separate (surface and pipe) but interconnected (through inlets) system.
  - Allows “lose” coupling of vector and raster data components.
- Stormwater delineation covers various possible options.
- Use standard Arc Hydro functionality for watershed/catchment characterization.

But wait, there is more!

- If full solution of flow equations is required, GIS can be used to interface with detailed stormwater H&H models (e.g. ICPR 4).
  - GIS used as pre- and post-processor for the models.
- Design and operational scenarios can be supported.



ICPR4 Model: Cross Bayou - Mariners Cove Area
Flood Depth Animation: T.S. Hermine (Aug 31 – Sept 1, 2016)

Questions?

Dean Djokic: ddjokic@esri.com

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