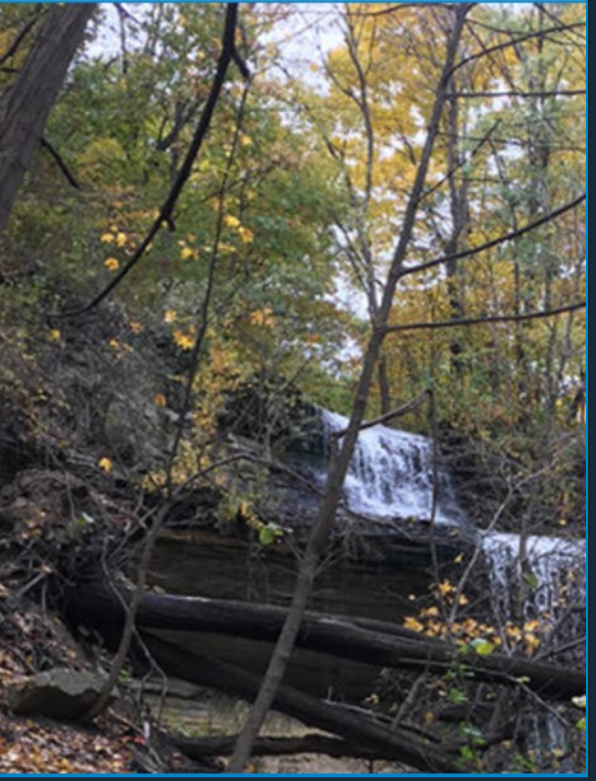
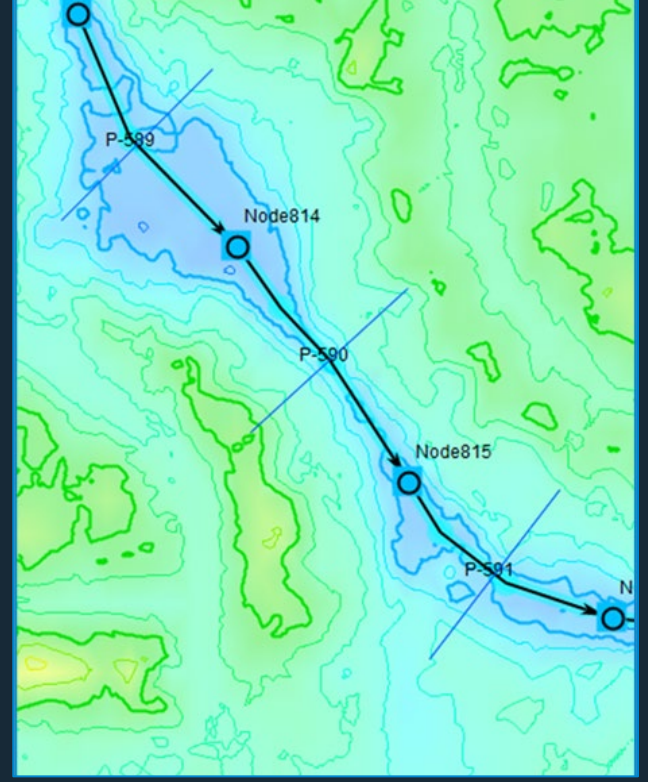
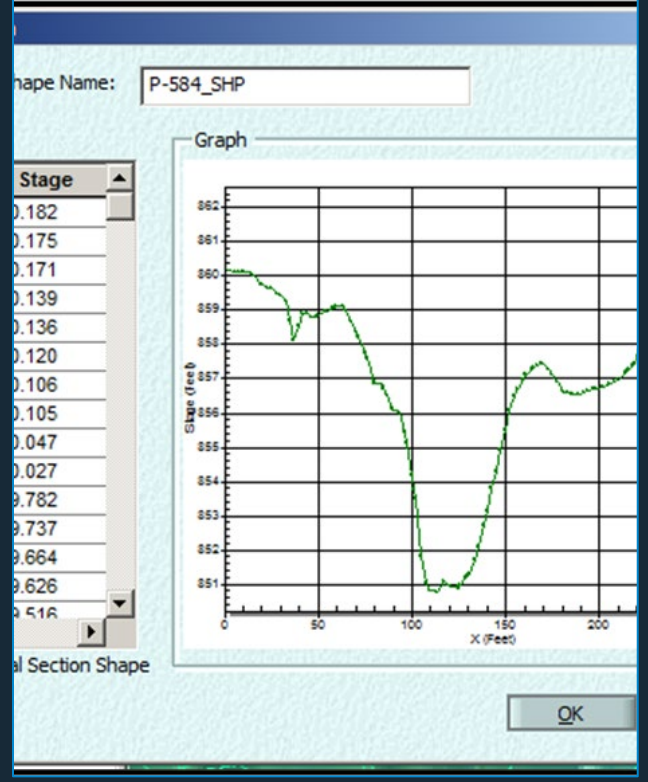






LMRWMO: Watershed Modeling 101

Overview of H&H and Water Quality Modeling

Michael McKinney and Greg Williams
Barr Engineering Co.
July 10, 2024

BARR

Agenda

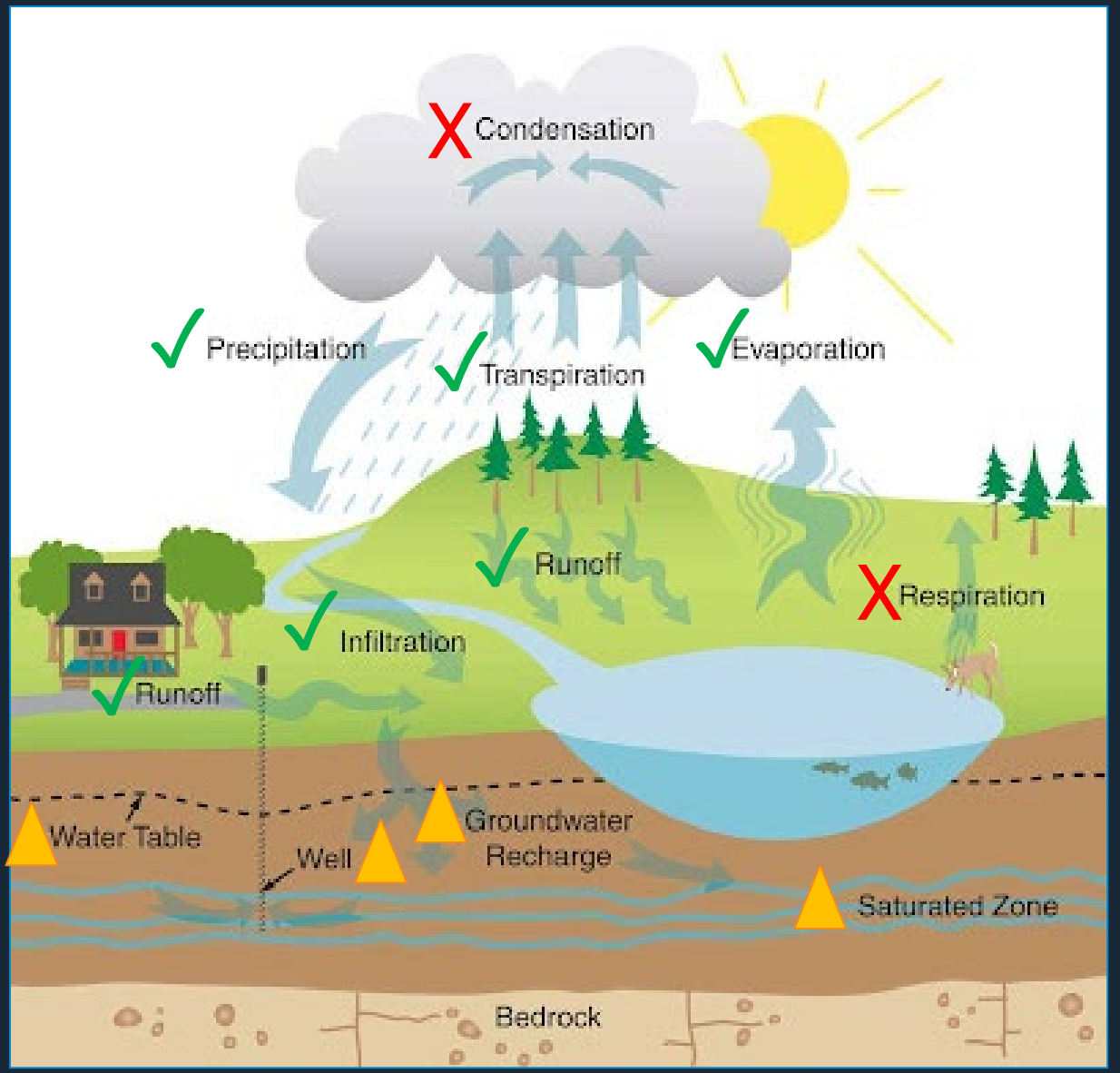
1. H&H and Water Quality Modeling Overview
   - Major functions of models
   - Model applications
   - Software Overview
   - 1D vs 2D
2. Model Development
   - General required inputs
   - Model resolution
   - Monitoring and calibration
   - Maintenance
3. General Discussion / Q&A

H&H and Water Quality Modeling Overview: Water Cycle

Water Cycle

- √ = typically modeled
- X = typically not modeled
- ▲ = typically modeled, but may require specialized modeling software

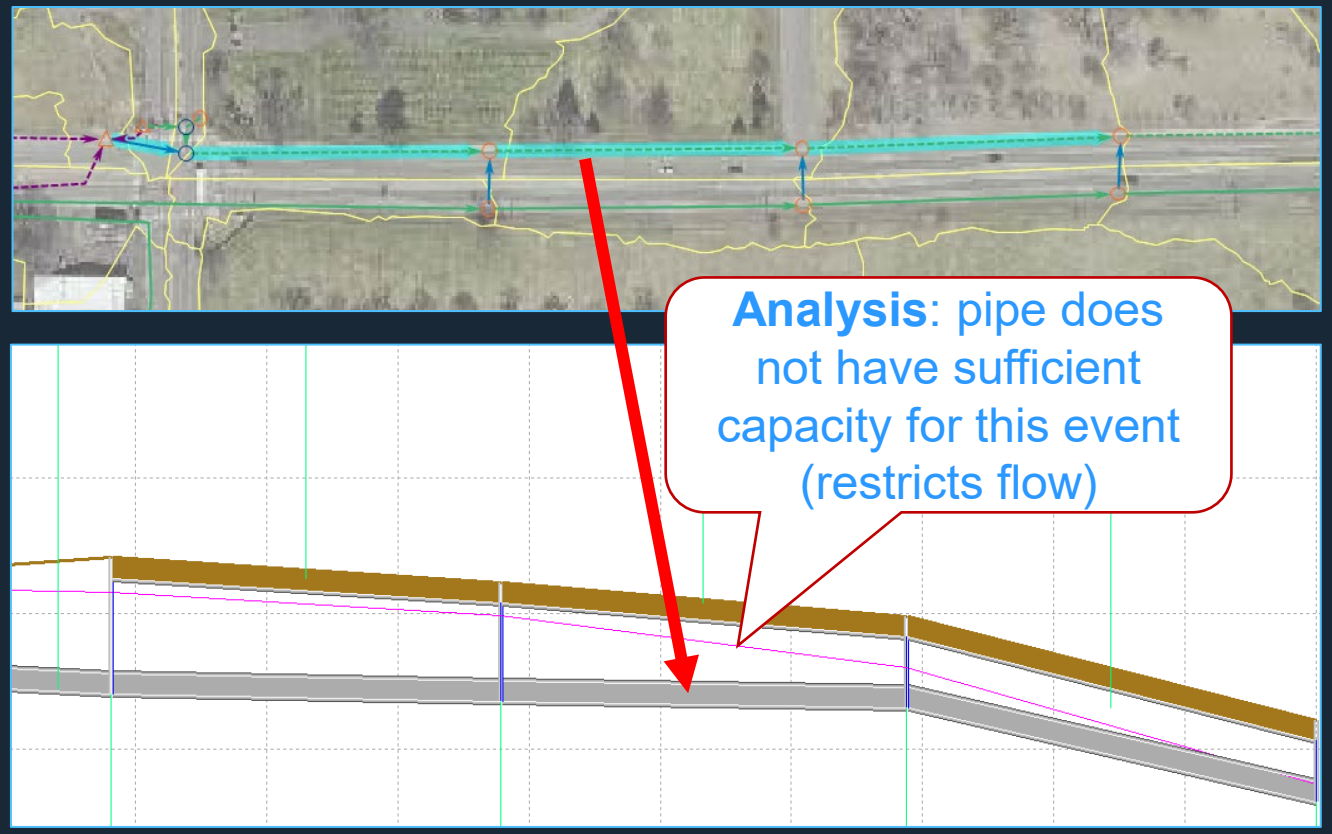
*In addition to water cycle, water quality models also model mobilization, fate, and transport of pollutants**



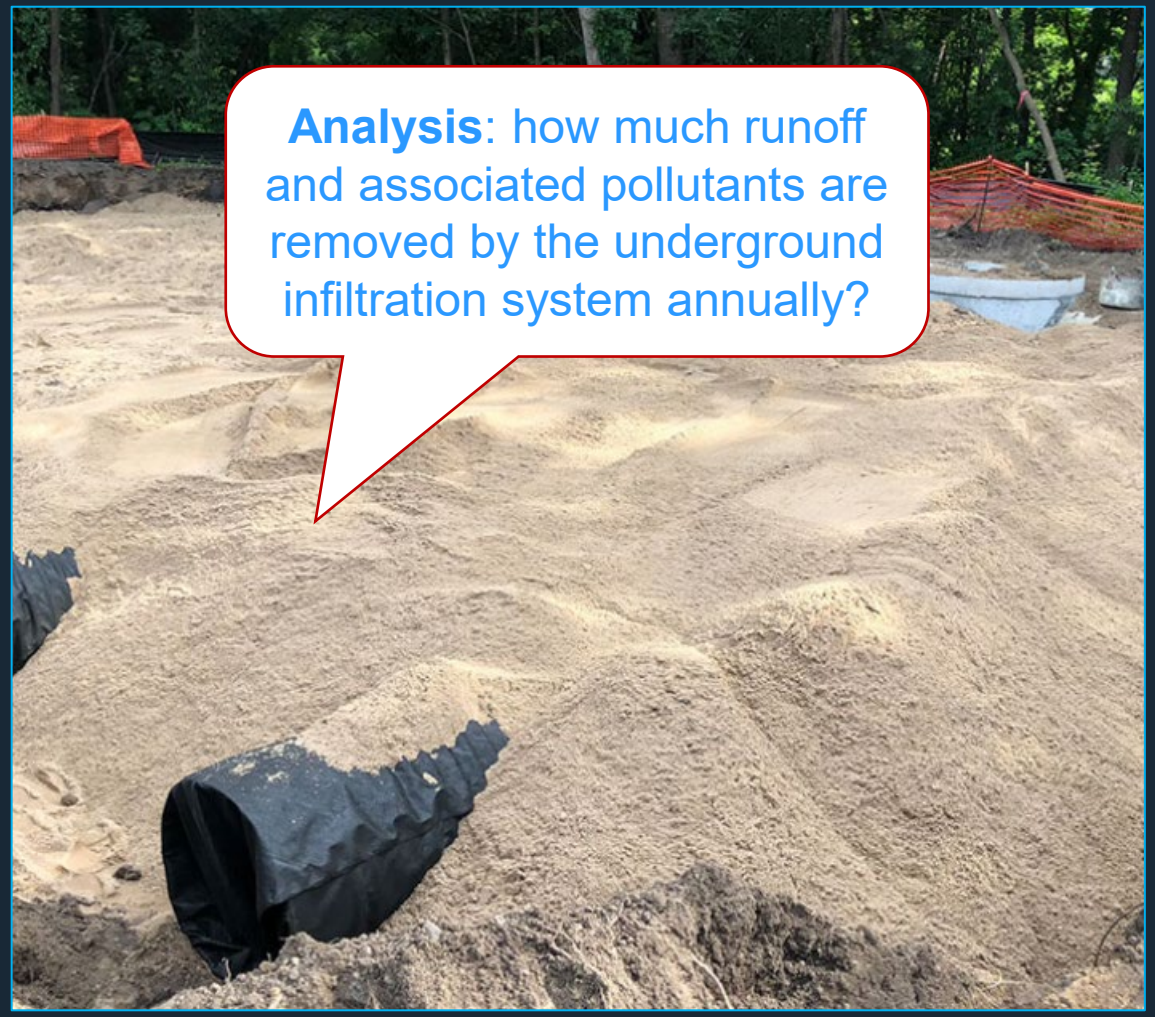
H&H and Water Quality Modeling Overview: Definitions

H&H Modeling

- H&H = hydrology and hydraulics
- Hydrology* = modeling of rainfall and generation of runoff
- Hydraulics* = storage, routing, and convenance of runoff
- Typically, more complex hydraulics than water quality models (“dynamic” vs “kinematic” wave)
- Typically, shorter time frames than WQ models (e.g., modeling single rainfall event, weeks of rainfall, etc.)



H&H and Water Quality Modeling Overview: Definitions



Water Quality Modeling

- WQ = water quality
- WQ models also model H&H! Often, more simplified than dedicated H&H models.
- Models mobilization, fate, and transport of particulate and dissolved pollutants (e.g., TSS, TP, TKN, Cu, Pb, Zn, Hydrocarbons, etc.).
- Typically longer time frame than dedicated H&H models (e.g., models a 50-year period)

H&H and Water Quality Modeling Overview: Example Applications

H&H Modeling

- How do I design this complex outlet structure to retain the 10-year event?
- Why does this manhole cover blow off anytime we have an intense rainfall event?
- Why did this landlocked wetland flood in 2019, and was bone dry in 2022?
- How should I design storm sewer to serve a new development?
- Will structures around this lake be flooded if we get a 10-year rainfall event?
- What does 500-year flooding look like across the WMO? How might a 500-year event impact infrastructure and streams?

WQ Modeling

- What would be the performance of a traditional sand filtration BMP in this location? Is iron-enhanced infiltration worth pursuing?
- What is the average annual watershed loading of total phosphorus to Sunfish Lake?
- How large should I size the forebay of a constructed wetland serving a new development to minimize forebay and wetland maintenance?
- How much area do I need to dedicate to an infiltration BMP to meet municipal water quality permitting requirements?

H&H and Water Quality Modeling Overview: Example Applications (cont.)

H&H Modeling

- Developers & Cities, small scale:
  - Design of stormwater conveyance systems
  - Evaluation of permitting compliance

- Cities / WMOs / WDs, large scale:
  - Large scale planning efforts
  - Development of stormwater management plans
  - Prioritization of flood mitigation projects
  - Flood response planning
  - Spill response planning

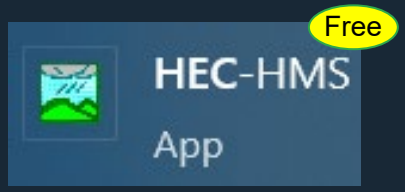
WQ Modeling

- Developers & Cities, small scale:
  - Design of water quality treatment best management practices (BMPs)
  - Evaluation of permitting compliance

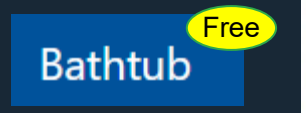
- Cities / WMOs / WDs, large scale:
  - Evaluation and tracking of TMDL / WLA compliance
  - Prioritization and cost-benefit evaluation of water quality improvement projects
  - Evaluation and targeting of pollutant loading “hot spots”

H&H and Water Quality Modeling Overview: Modeling Software Overview

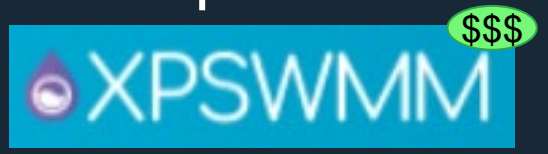
- "Simple*" H&H question?

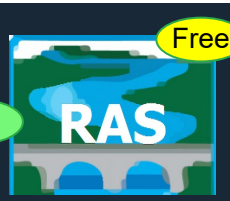


- "Simple" water quality question?

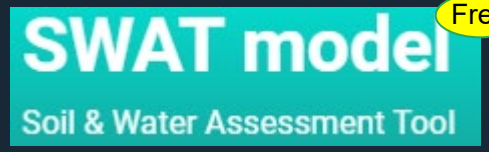


- "Complex" H&H question?



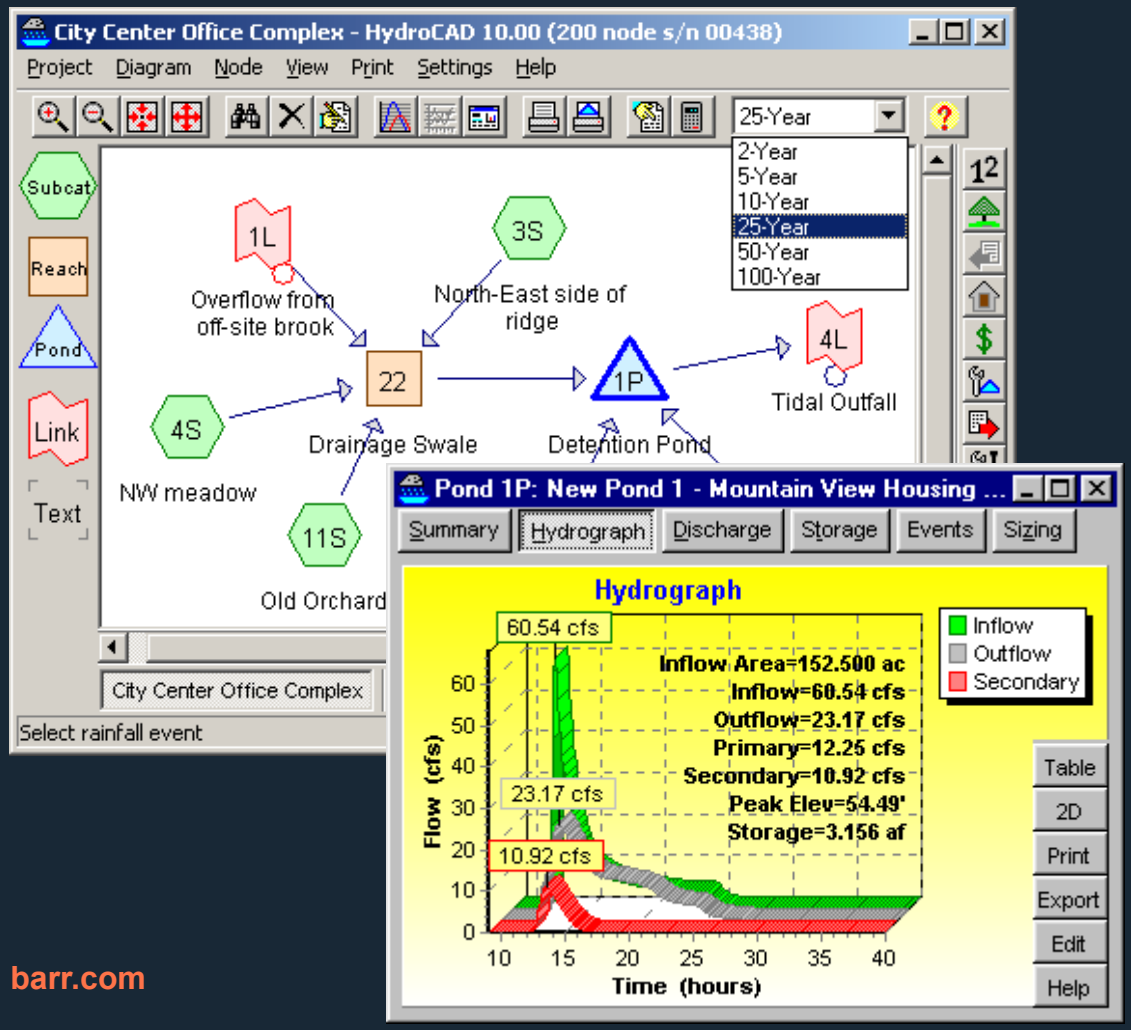


- "Complex" water quality question?

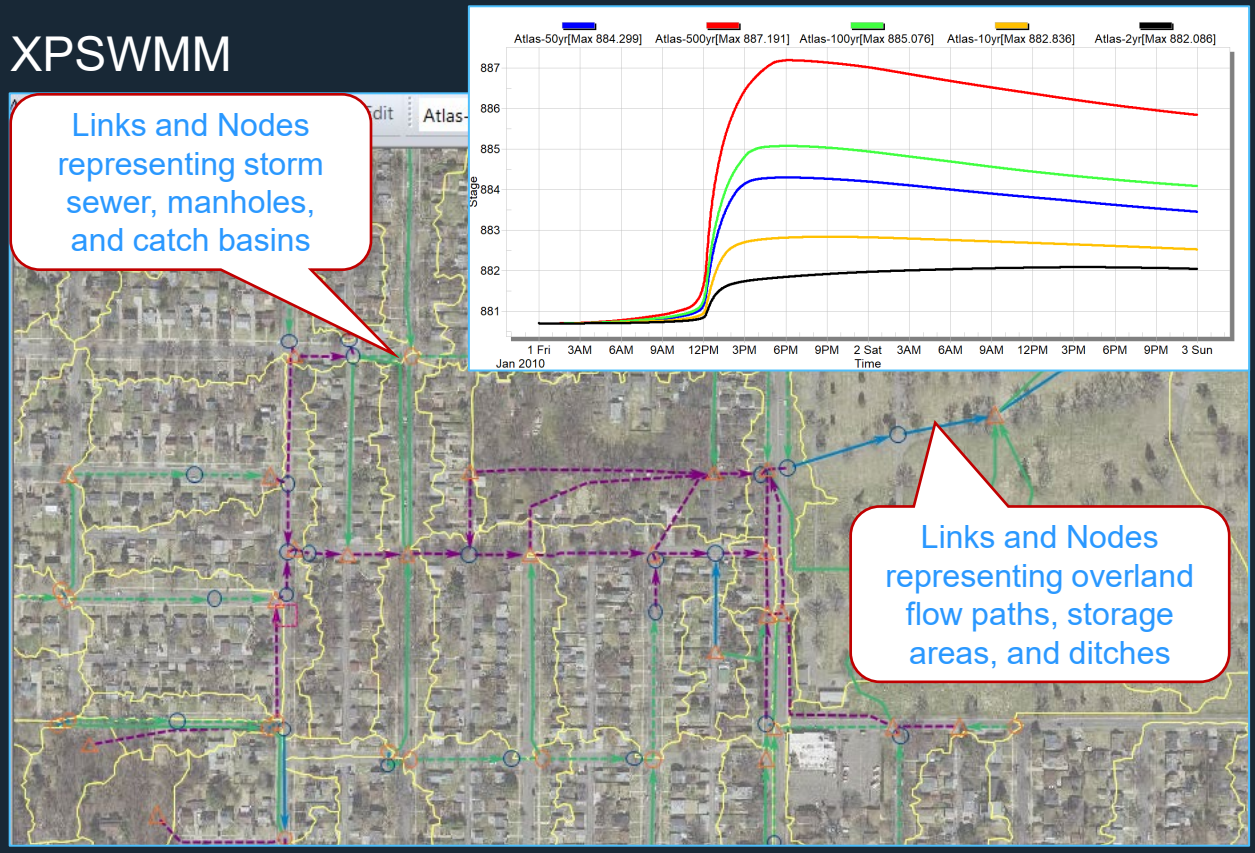


H&H and Water Quality Modeling Overview: What do Models Look Like?

HydroCAD

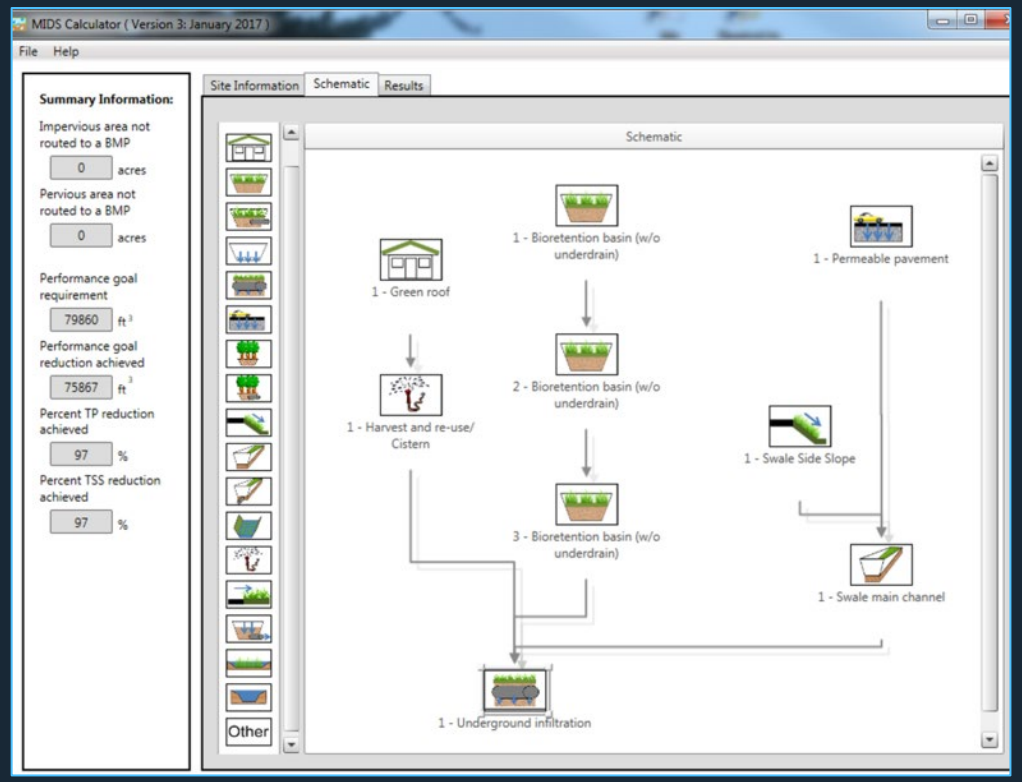


XPSWMM



H&H and Water Quality Modeling Overview: What do Models Look Like?

MIDS



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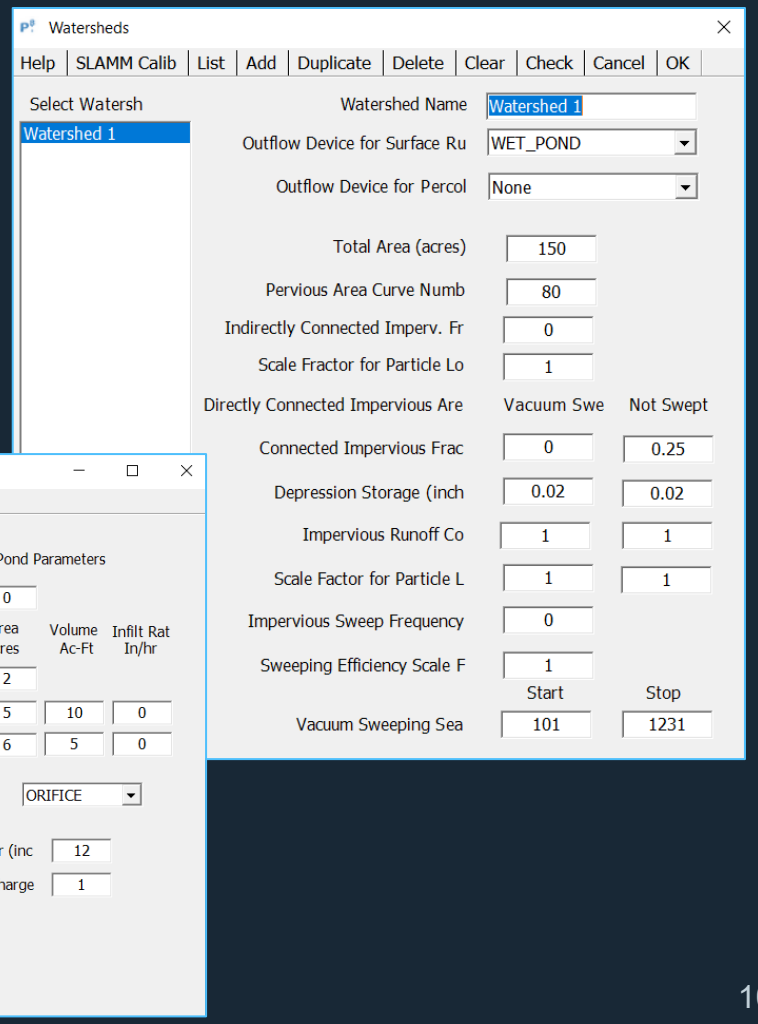
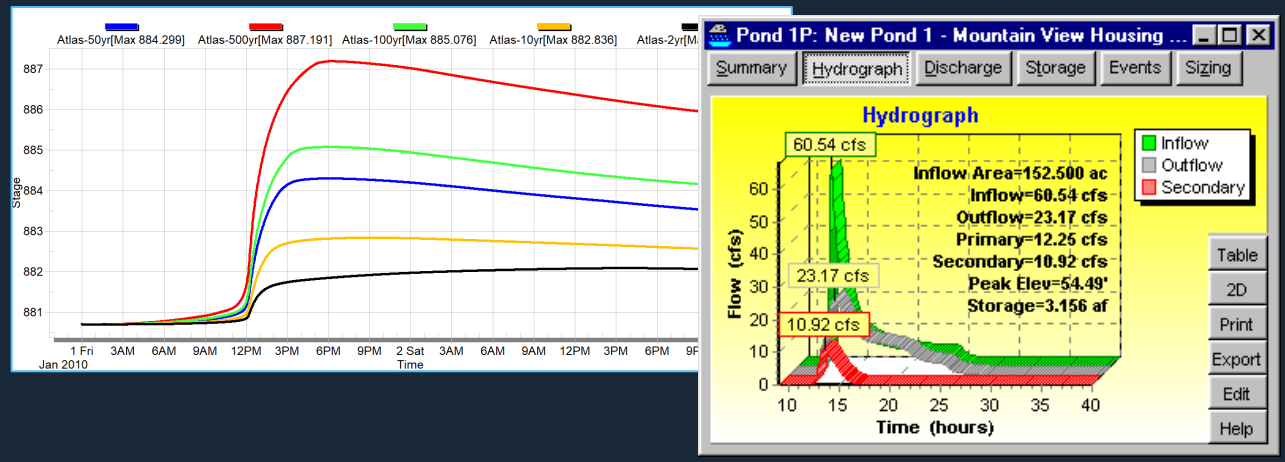
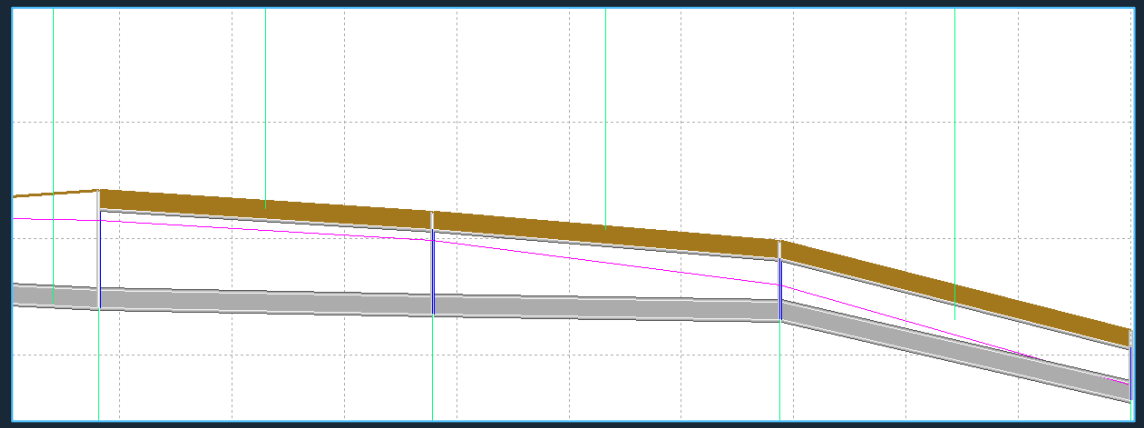


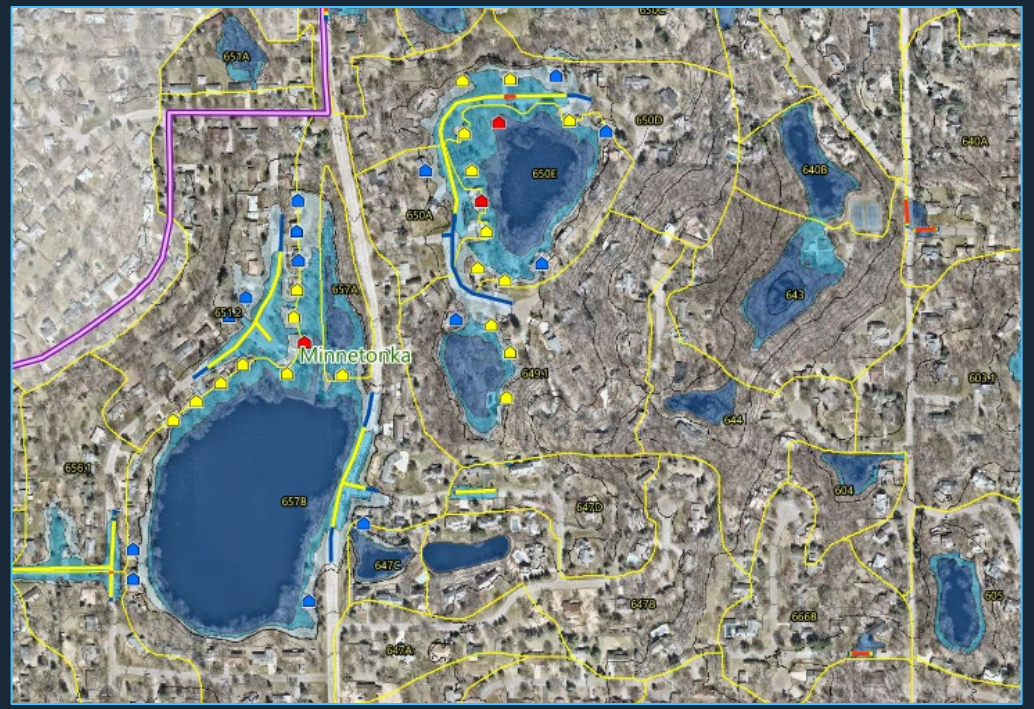
H&H and Water Quality Modeling Overview: Results Examples

H&H Modeling

- Stage hydrographs showing storage area stage over time
- Flow / velocity hydrographs
- Maximum storage volume and flooding extents
- Pipe design capacity utilized
- Rainfall and runoff depth from surfaces within the watershed
- Really… Almost anything H&H related!



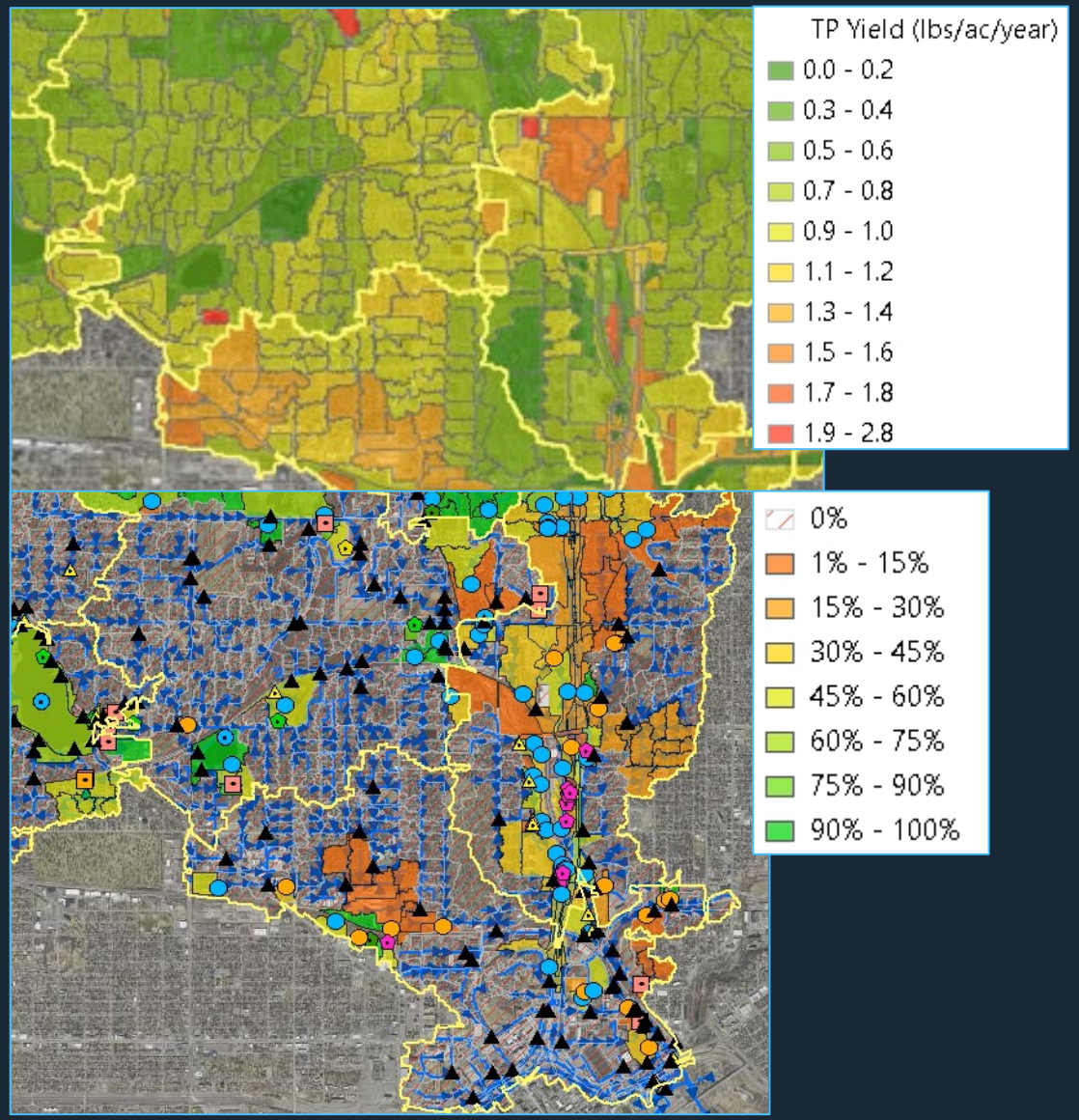




H&H and Water Quality Modeling Overview: Results Examples

Water Quality Modeling

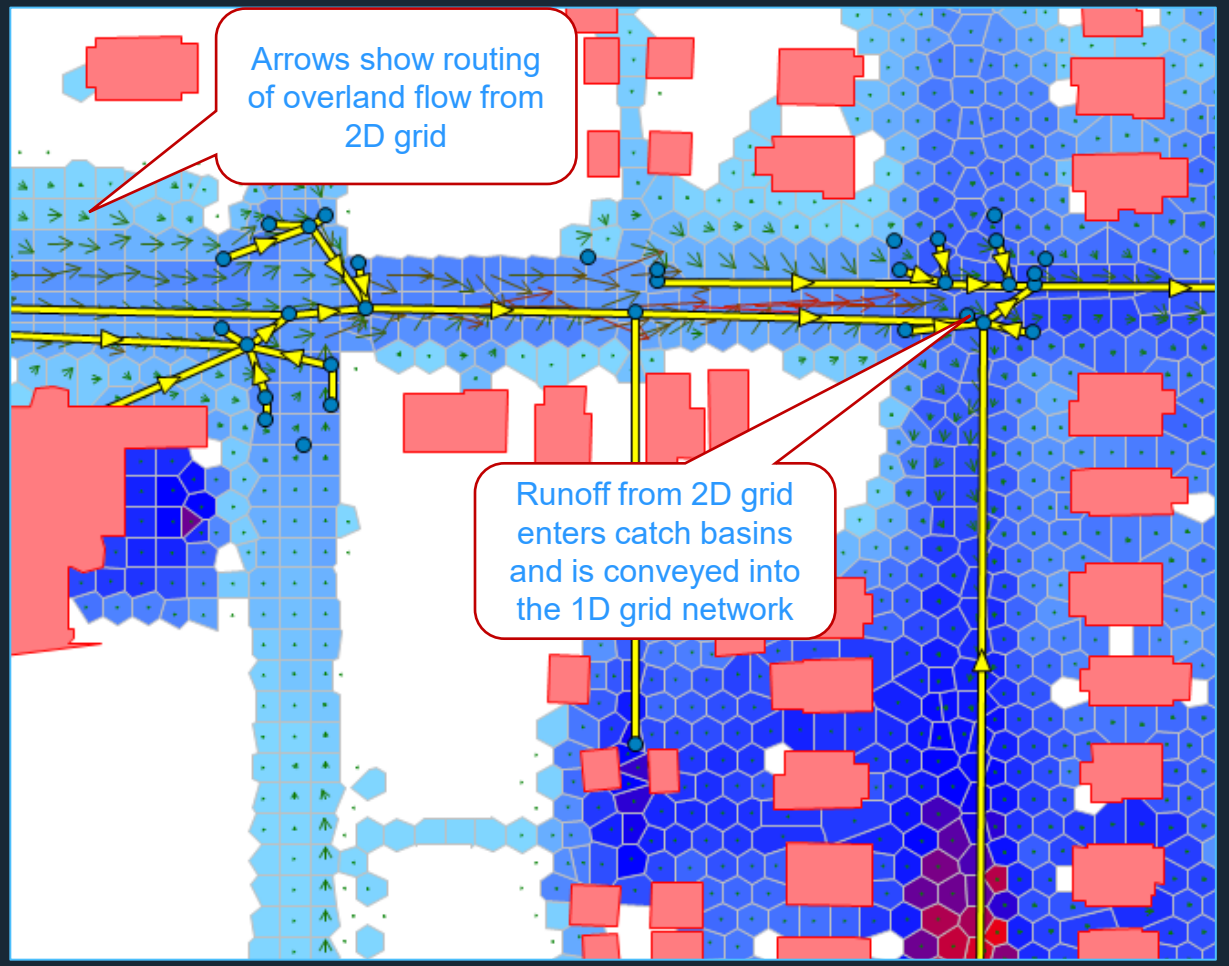
- Annual performance of individual BMPs (e.g., 60% TP and 90% TSS reduction for wet pond A)
- Areal pollutant loading and loading “hot spot” mapping
- Total pollutant loading to waterbodies and/or leaving municipal boundary (useful for TMDL/WLA tracking)
- Event-based runoff and pollutant loading results
- Particulate vs dissolved pollutant constituent removal performance at BMPs



H&H and Water Quality Modeling Overview: 1D vs 2D modeling

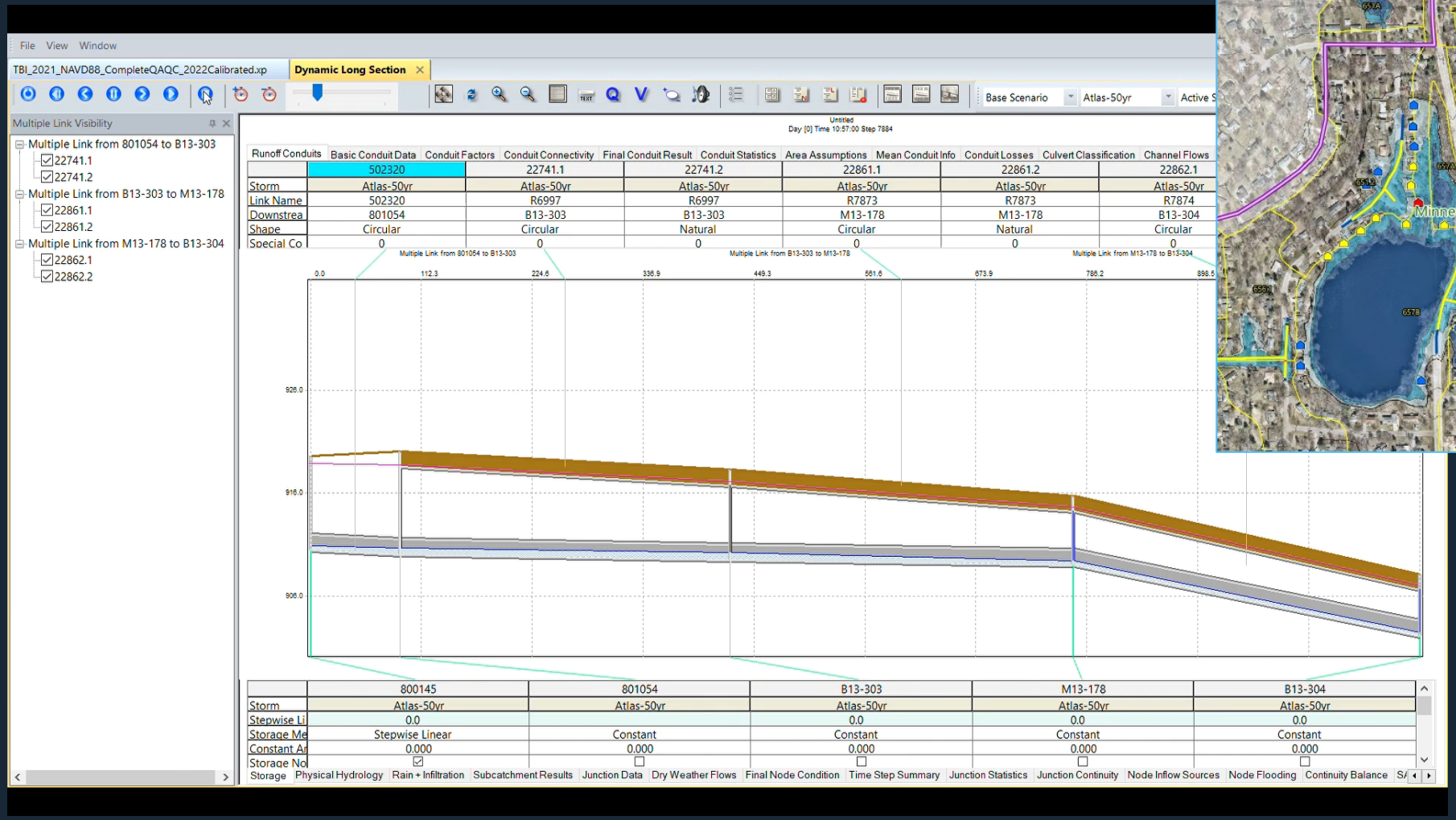
H&H Modeling: 1D vs 2D

- 1D: all runoff and hydraulic elements connected using 1D elements (e.g., nodes and links)
- 2D: surface runoff routing and overland flow routing conducted using 2D grid
- Note: a majority of “2D” models contain both 2D and 1D elements. E.g.,
  - 2D network used to route runoff, route overland flow, and fill storage areas.
  - 1D network used to represent storm sewer and simple channels



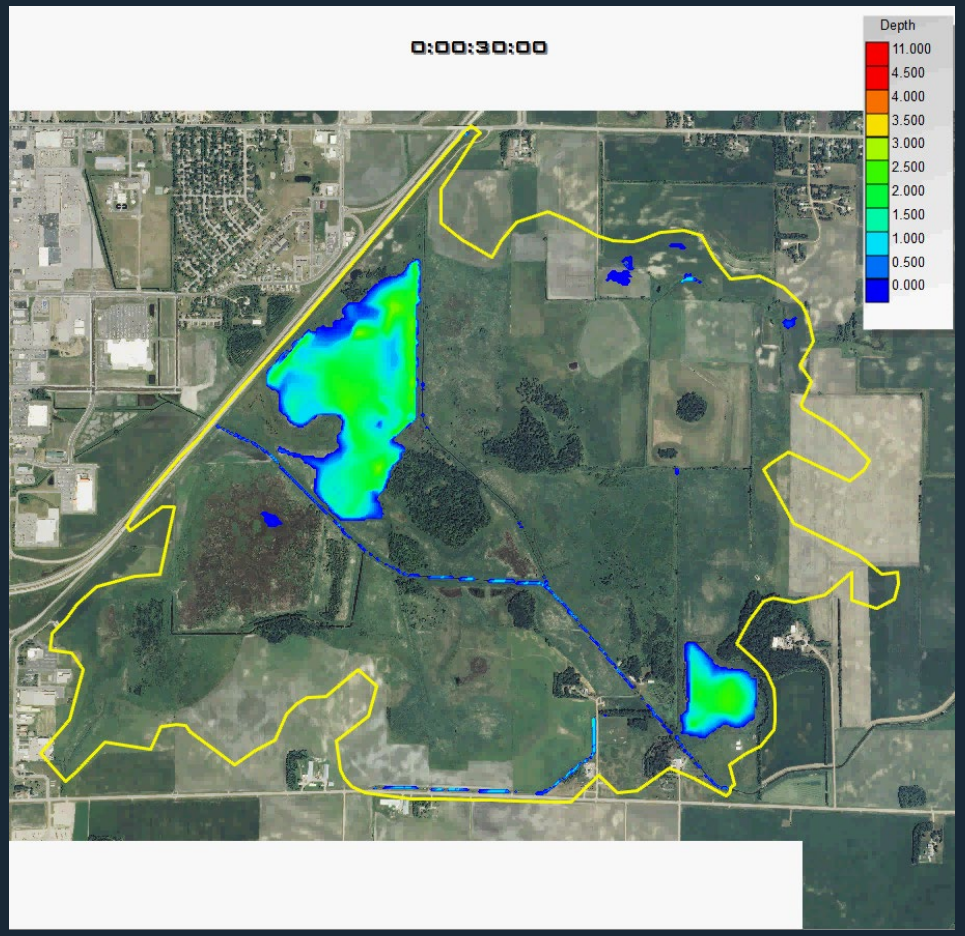
H&H and Water Quality Modeling Overview: 1D vs 2D modeling

H&H Modeling: 1D result examples



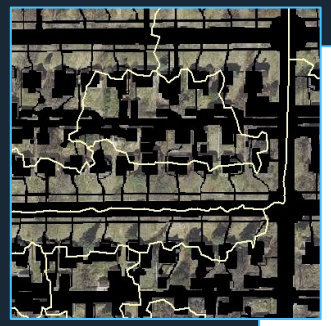
H&H and Water Quality Modeling Overview: 1D vs 2D modeling

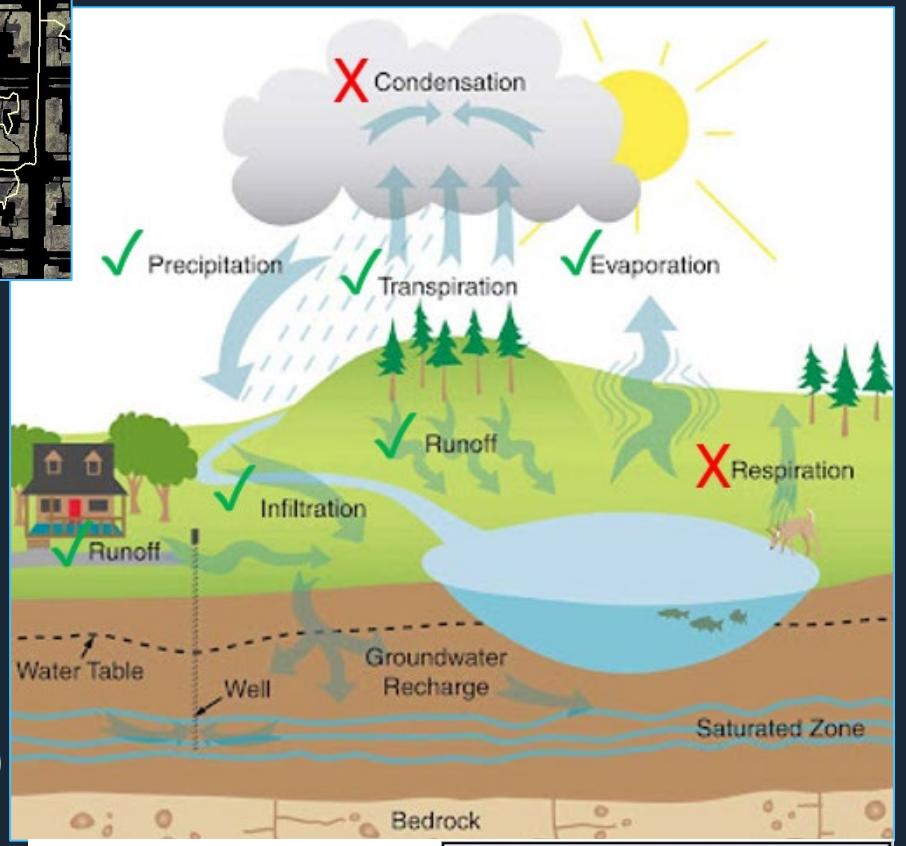
H&H Modeling: 2D result examples

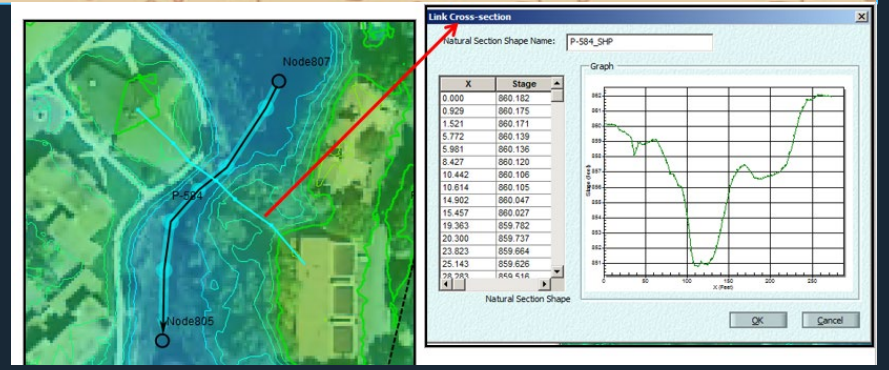


Model Development: General Inputs

- Both:
  - Rainfall data (H&H: individual events, WQ: years of events)
  - Subwatershed data: area, imperviousness, slope, time of concentration, etc.)
  - Infiltration data: min/max infiltration parameters, soil type, etc.
- H&H:
  - Detailed hydraulic information (e.g., complex outlet structures, entire storm sewer network, detailed surface storage areas, etc.)
  - Digital elevation model (e.g., 2022 LiDAR)
- Water Quality:
  - Detailed BMP information (bathymetric storage, infiltration rate, residence time, etc.)
  - Detailed water quality and pollutant information (erosivity, sediment accumulation rate, pollutant constituent concentration, particulate sedimentation rate, etc.)

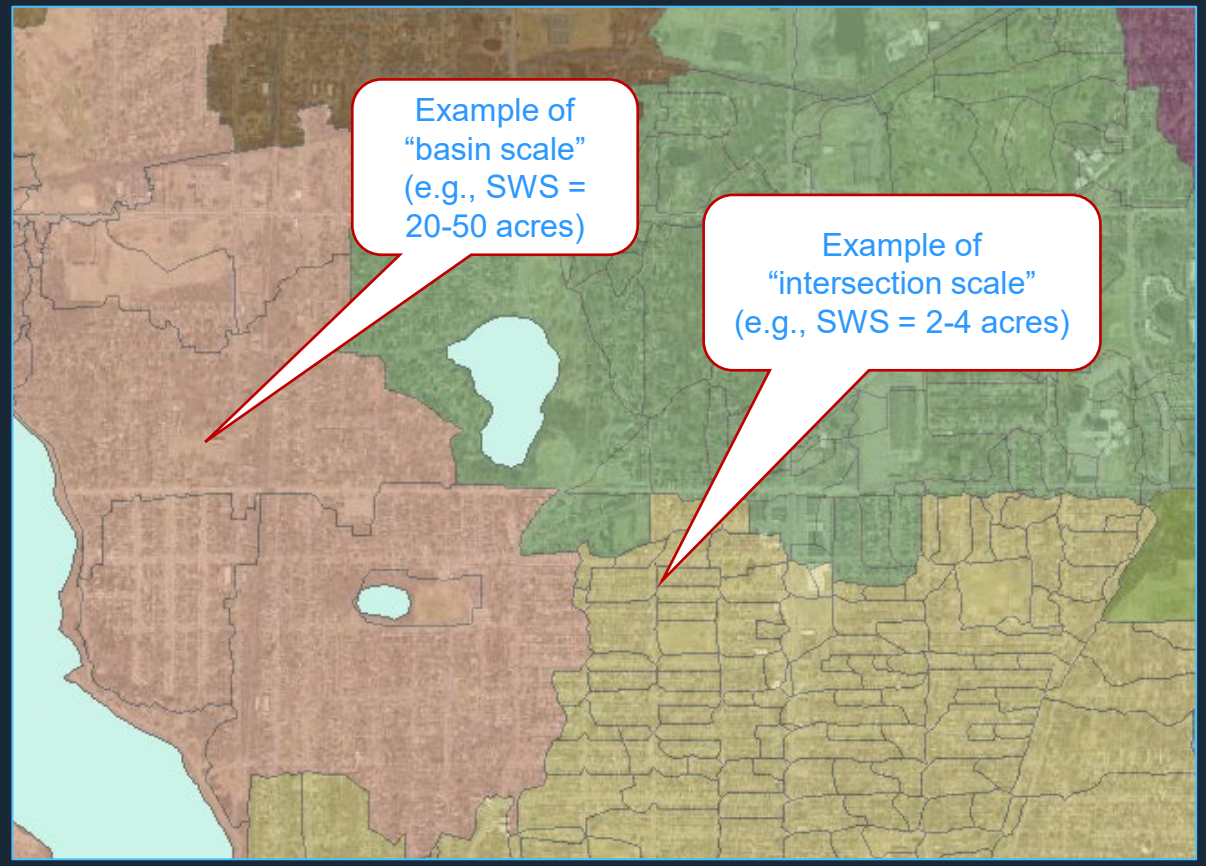






Model Development: Model Resolution

- Water Quality Models: typically “basin scale”
  - Basin scale = resolution required to capture drainage to large basins and BMPs
- Urban H&H models: typically “intersection scale”
  - Intersection scale = subwatershed divides to individual inlets and/or groups of inlets (e.g., clusters of catch basins at intersection).

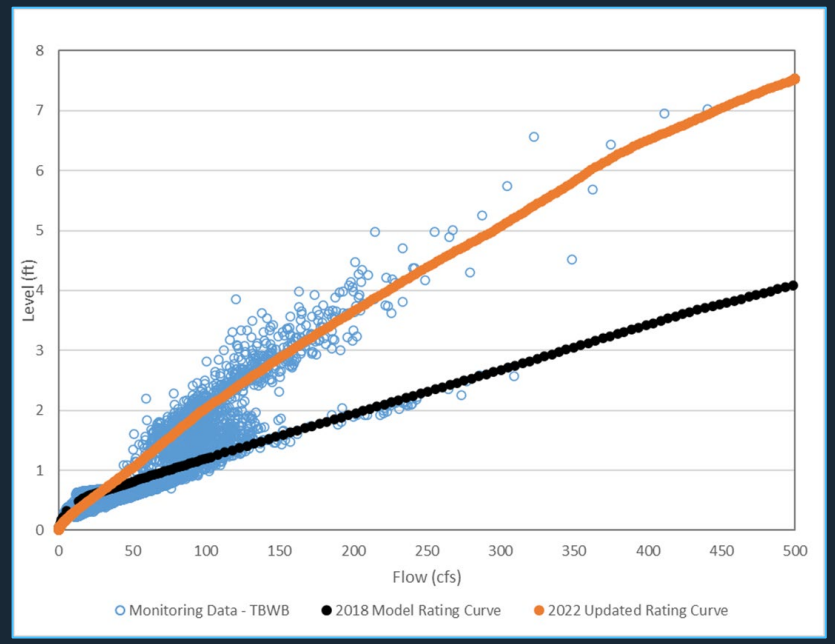


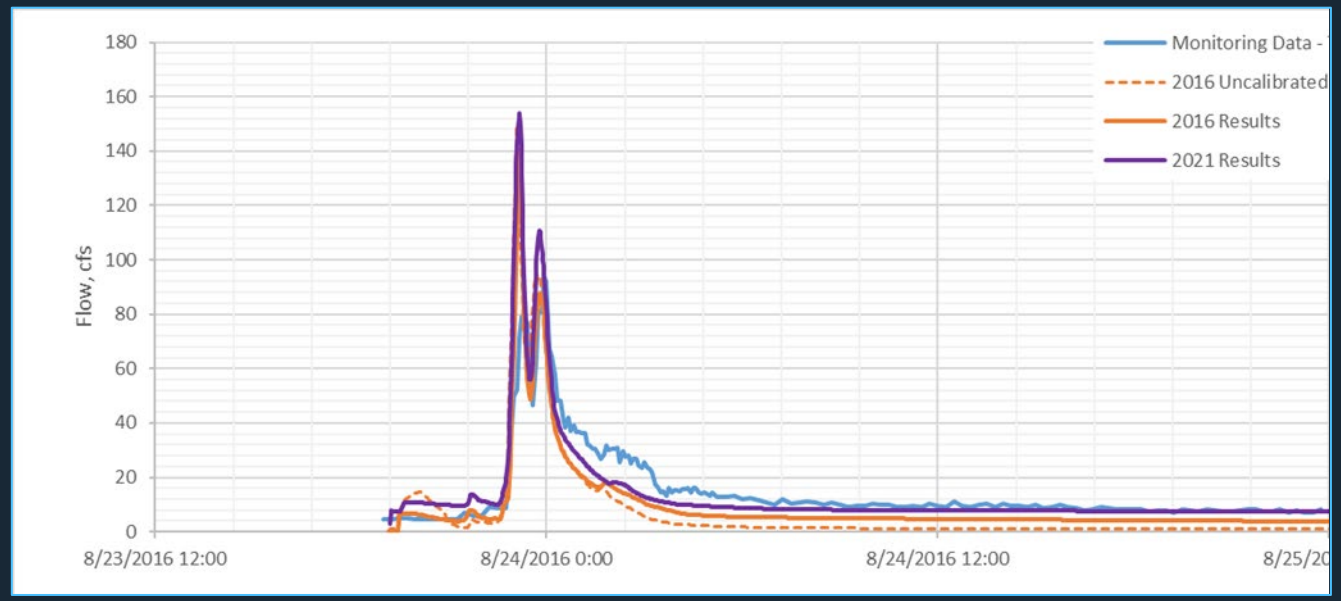
Model Development: Calibration

- Calibration is “the process of adjusting model parameters to match experimental data”
- H&H calibration overview:
  - Representative monitoring locations selected.
  - Flow and/or stage is monitored (LVQ monitoring, lake stage monitoring, etc.).
  - Model is adjusted to match monitoring data, typically for representative events.
- Calibration “light”:
  - Model event that occurred, attempt to match benchmark, observed flooding (e.g., observed flow rate, observed max flooding depth).
- Water quality calibration overview:
  - Representative monitoring locations selected.
  - Event based sampling is conducted: flow monitoring is collected for event (volume), samples are collected to obtain representative pollutant concentrations (mg/L) to get mass loading for event
  - Model is adjusted to match monitoring data, typically for groups of events (e.g., model calibrated to cumulative pollutant loading for 2-3 year period)

Model Development: Calibration

- What is the value of calibration?
  - Provides more confidence that model is performing accurately.
  - Helps to identify critical model assumption updates.
  - Has helped to identify maintenance issues / other issues not captured in base modeling assumptions





Model Development: Maintenance

- Model maintenance is often overlooked / not considered during model development.
- Model maintenance strategy examples:
  - Example 01: City has annual model maintenance plan. Updates model and mapping every year based on all developments tracked in maintained GIS storm sewer network data.
  - Example 02: WD has plan to update model every 5-years. Requires coordination with partner cities to get list of “critical” updates in past 5-years.
  - Example 03: City does not plan on updating models. Models will eventually be redeveloped from scratch.
- How often should models be maintained?
  - Highly variable based on intensity of development and/or redevelopment.
  - Highly variable based on use applications of model.
  - No hard and firm recommendation – this is a topic many Cities / WDs / WMOs are trying to figure out as modern datasets are being published (e.g., 2022 LiDAR).

Model Development: Ownership

Ownership Examples:

- For all City, WD, or WMO modeling projects I have been involved with, the City/WD/WMO owns the model.
- Does the organization use the model?
  - In some cases, yes: the model is handed over and organization staff utilize and update the model (less common)
  - In other cases, no: the owner does not have modelers on staff and relies on ongoing relationship with the consultant to house / update / use the model (more common).
    - In these cases, “Viewer” versions of many models can be provided that allow owner to view model information and results (e.g., create tables, create graphs, view data, etc.), but not update / edit / rerun the model.
    - “Viewer” model versions are often free.

General Discussion: Q&A

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