Effectiveness of stormwater management practices in protecting stream channel stability

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Hypotheses

1. Channel instability in Minebank Run is caused by high shear stresses generated during even relatively frequent storm events.
2. Retrofitting the Minebank Run watershed with additional watershed stormwater controls will reduce channel incision and bank failure (will compare environmental site design (ESD) only, traditional downstream controls only, and combination of both).
3. Had Minebank Run been developed with ESD channel incision and degradation would have 1) been prevented, or 2) been reduced.
4. Current channel degradation in tributaries to Little Seneca Creek are the result of recent large magnitude storm events, which are typically not well controlled by ESD.
5. Had the Clarksburg watershed been developed using traditional stormwater control measures (SCMs), more extensive channel degradation would have occurred.
6. A combination of ESD controlling small storms and SCMs controlling larger events is necessary to protect stream channels against erosion.

Research Questions

- Results of this study will help in:

  - evaluating the effectiveness of environmental site design (ESD) in protecting channel stability.
  - providing insight into the causes of and potential solutions to channel degradation in:
    - a watershed with limited traditional stormwater management and;
    - a watershed where ESD was implemented during development.
  - Explore through modeling the expected difference in development impact on stream channel integrity if measures were done differently

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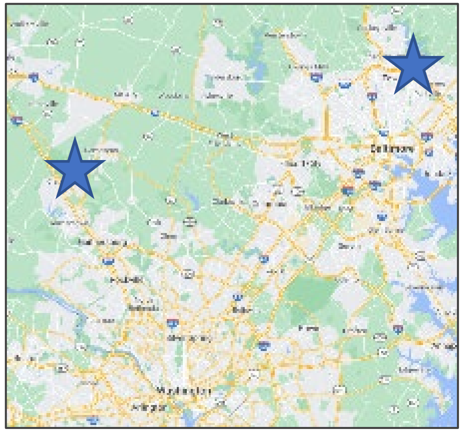
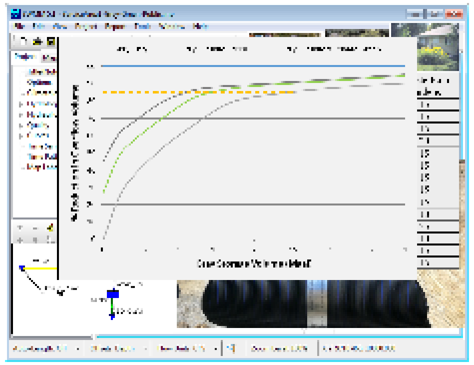
Performance of environmental site design (ESD)

- Is designing and implementing best management practices according to state stream channel protection regulations protective enough of the stream channels on a watershed level?

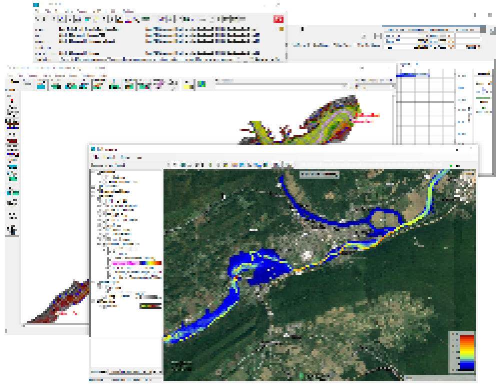
How these questions were answered…



Parameterize Two watersheds



Flows modeled in SWMM



Channels modeled in HEC-RAS 6.0

Natural and man-made features represented within the two watershed models including low impact development measures as well as traditional stormwater management measures.

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How these questions are answered - watersheds

How these questions are answered - watersheds

- Two Maryland watersheds were used

1. Minebank Run watershed (1,425 acre) in Baltimore Co.
   - Bulk of development took place in the 1950s and 1960s
   - Minimum environmental site design implementation
   - Land cover imagery were analyzed since the 1930s to explore development timeline
   - Models were built since the 1940s when watershed experienced little development

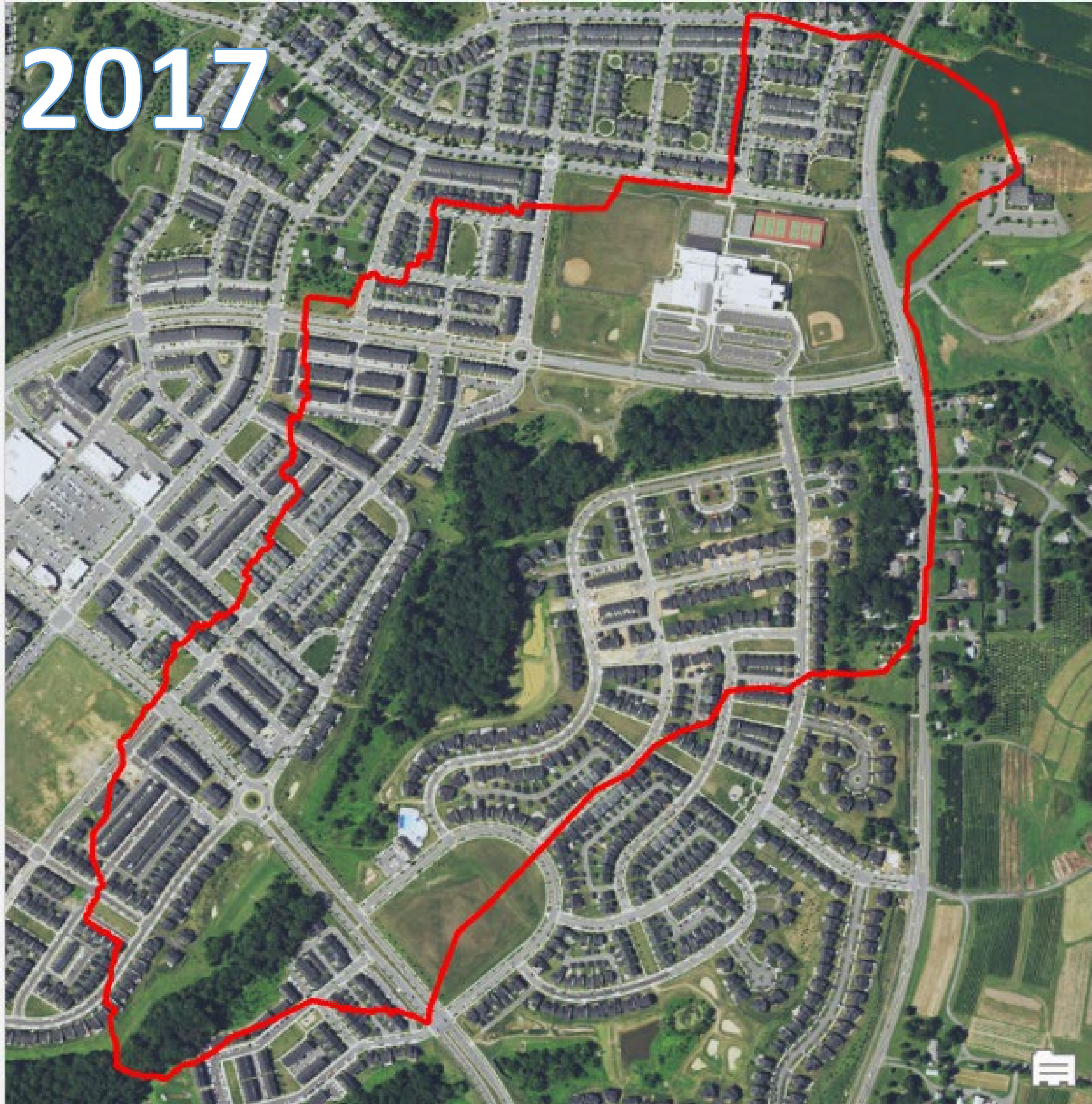
How these questions are answered - watersheds

- Two Maryland watersheds were used

2. Tributary 109 to Little Seneca Creek (212 acre) in Montgomery Co.
    - Watershed development started in 2005
    - Extensive environmental site design measures were implemented during development
    - Land cover imagery were analyzed since the 2005 to explore development timeline
    - Models were built since the 2005 when watershed development started

Watershed changes through time – Minebank Run

Watershed changes through time – Trib109



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How these questions are answered - Modeling

- Watershed characteristics as well as man-made stormwater infrastructure were entered into models
- Models were calibrated based on observed field data
- Calibrated models were used to explore multiple scenarios
- Modeling approach was performed in two tiers:
  - Watershed level (SWMM) simulating area characteristics and man-made facilities
  - Stream channel model utilizing output from SWMM into HEC-RAS 6.0

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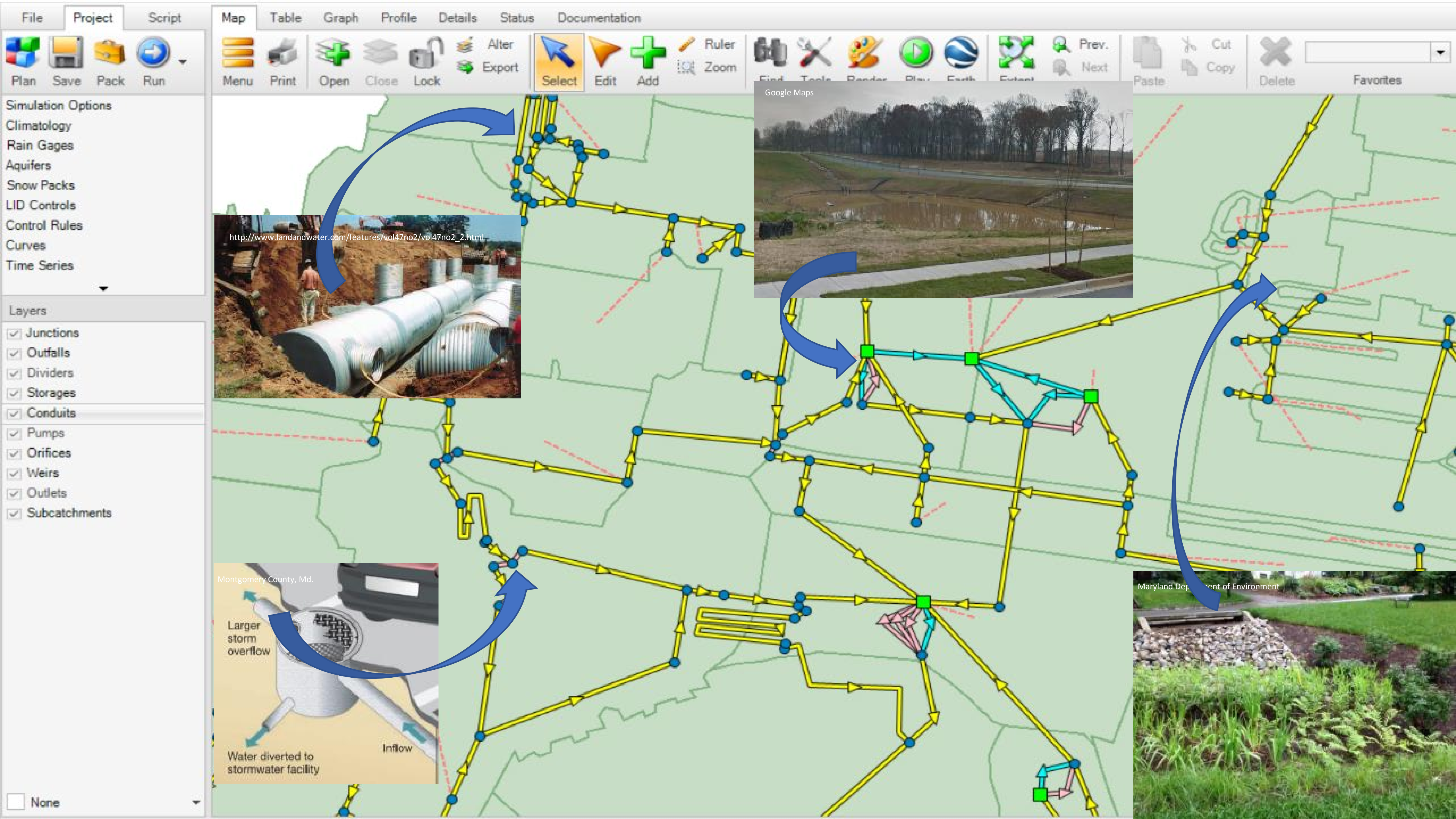

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Zoom
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Next
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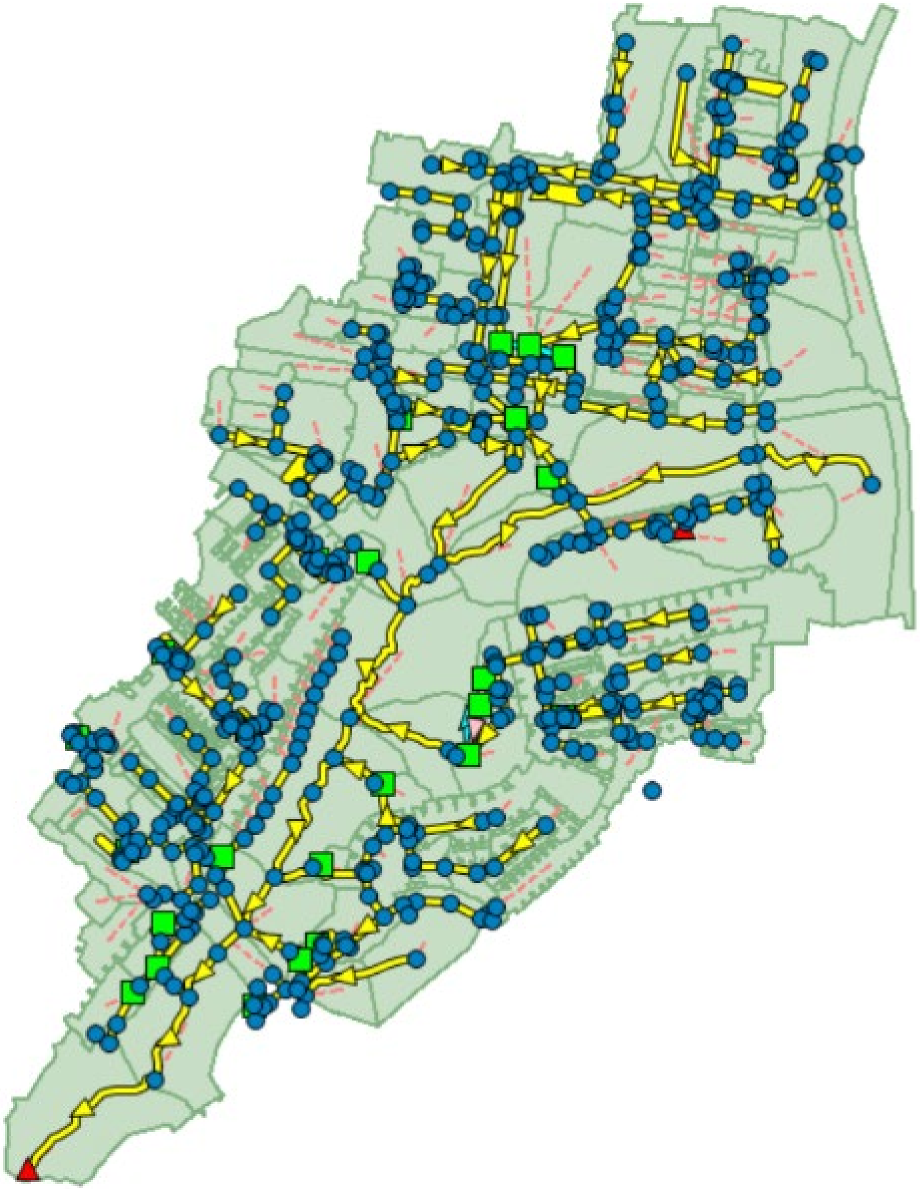
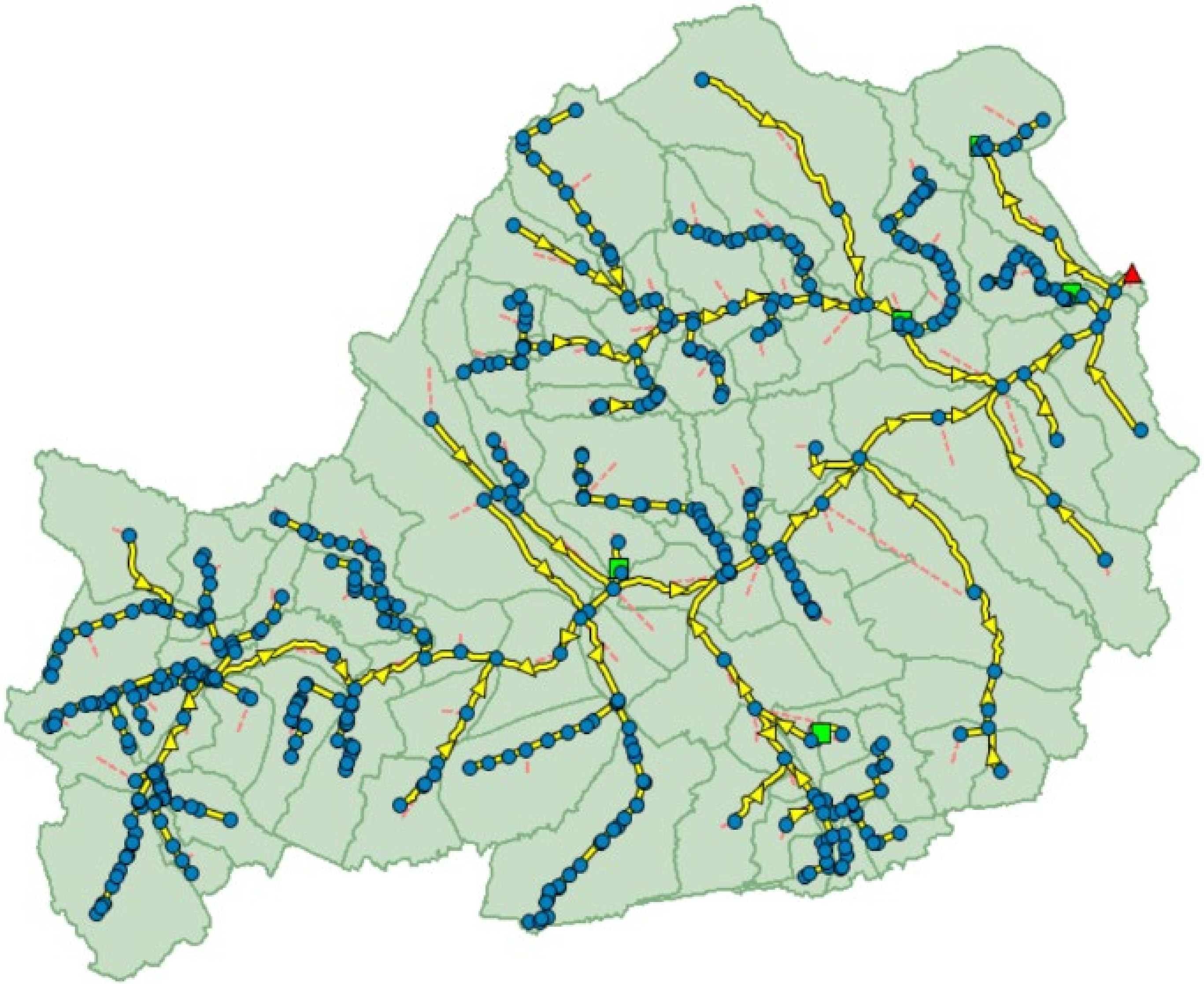
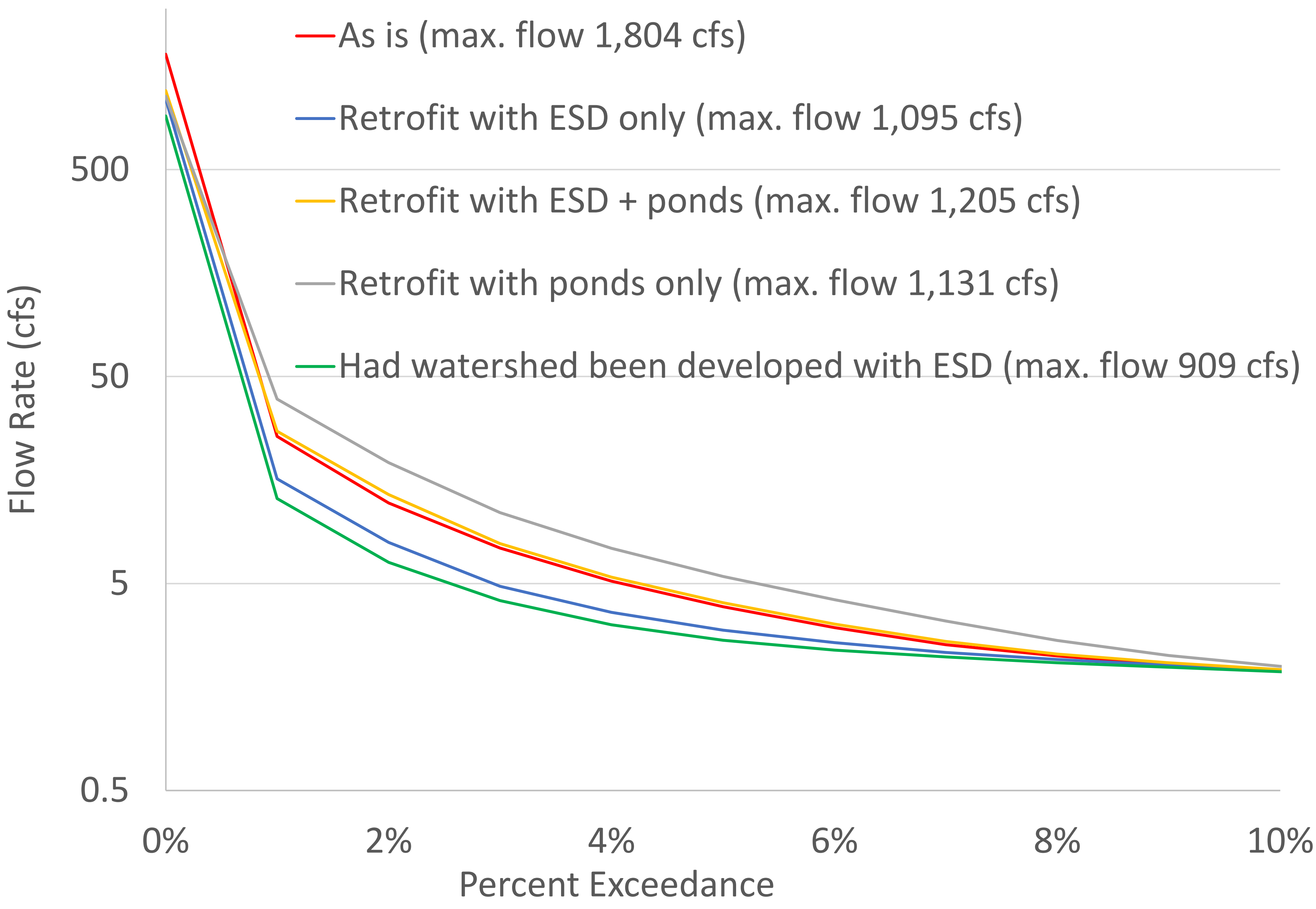
Copy
Delete
Favorites
Simulation Options
Climatology
Rain Gages
Aquifers
Snow Packs
LID Controls
Control Rules
Curves
Time Series
Layers
Junctions
Outfalls
Dividers
Storages
Conduits
Pumps
Orifices
Weirs
Outlets
Subcatchments
None
http://www.landandwater.com/features/vol47no2/vol47no2_2.html
Google Maps
Montgomery County, Md.
Larger storm overflow
Inflow
Water diverted to stormwater facility

How these questions are answered – SWMM model





Preliminary Results – Minebank Run



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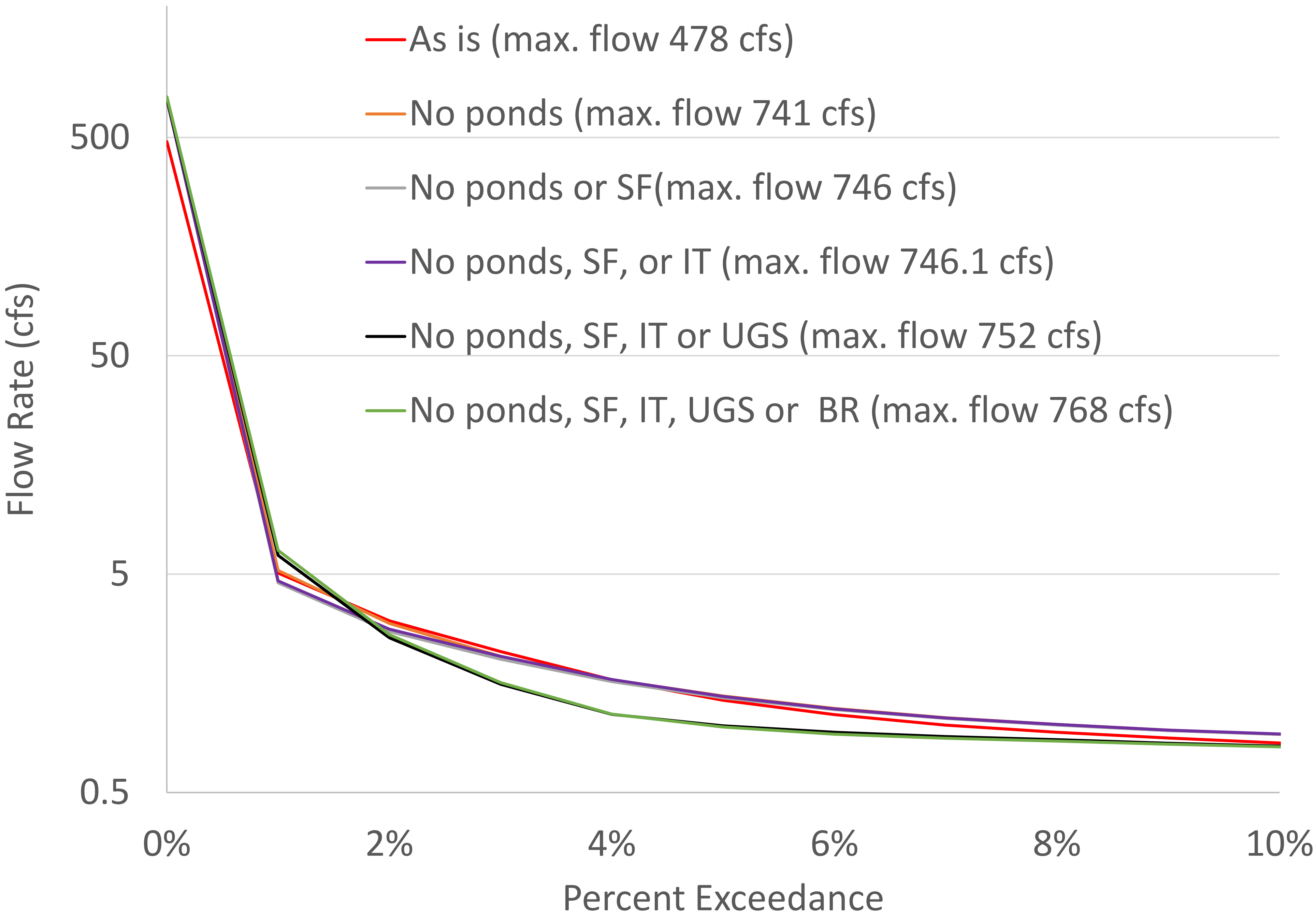
Preliminary Results – Trib109



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What’s next?

- Finalizing the representation of ESD within the Minebank Run model
- For each one of the 6 hypotheses, the 5-minute flow timeseries for the entire period of simulation will be run in HEC-RAS 6.0.
- We are currently finalizing the HEC-RAS 2D model to incorporate the above mentioned flows along with channel geometry, channel bed and bank soil characteristics and other parameters to explore the impact of each scenario on channel degradation.

Acknowledgment Slide

- Many thanks to the Chesapeake Bay Trust and other partners for funding, providing critical data, and collaborating in developing this project.

Joe Berg, Biohabitats

What does this mean for me?

- ESD works for high frequency storms to reduce channel erosion forces
- ESD role in attenuating impacts from larger storm events on watershed level is being explored
- Our SWM practices need to continue to improve, perhaps targeting “no net increase in runoff” relative to the pre-development condition

Ultimate Outcomes (coming soon!)

What do I take from this if I am a practitioner:

- Utilizing a watershed-based approach allows for the quantification of net impact of upland practices on stream channel stability
- Practitioners may utilize modeling tools to quantify the anticipated impact of upland practices vs. traditional SWM practices or a mix of both on stream channel stability

What do I take from this if I am a regulator:

- Are current regulations protective enough of channel stability
- Effective retrofits may require ESD and quantity control basins
- We need to continuously improve our SWM practices

Appendix
Minebank sensitivity (1-yr 24-hr storm)

	peak flow rate (cfs)	total volume (ft3)
as is	561.5	4,019,000
IMP reduced by 50%	300.9	2,626,000
depression storage doubled	531.5	3,431,000
depression storage X5	515.4	2,854,000
conductivity doubled	549.1	3,523,000
conductivity X5	528.2	3,273,000
route all impervious to pervious	204.2	2,667,000
route 50% of impervious to pervious	342.2	3,284,000
Ponds only scenario	337	3,969,000