

INTRODUCTION

- This research is a contribution to UWIN Project B2-D, “Hydrology and hydraulics of urban floodplains”
- Broad Goal: Assess how alternative mitigation scenarios involving modification of the channel and floodplain affect flood flow patterns, inundation extent and associated hazards
- Project Focus: Location is in one of the study watersheds from the Baltimore metropolitan area, identified as the 9th-flashiest in the contiguous U.S.³
- Specific Goals:
 - Simulate flood behavior for existing conditions at the U.S. Geological Survey gage site
 - Assess how “naturalization” of the existing concrete channel would affect flood behavior
- A 2-D depth-averaged hydraulic model is used to simulate flood behavior through the model domain for flood hydrographs extracted from the gage record and extrapolated using flood-frequency relationships²
- Hypotheses
 - Naturalization of the channel will increase frictional resistance and reduce flow velocity
 - Increased frictional resistance may lead to higher flood levels unless it is possible to increase channel cross-section area to compensate for reduced velocity

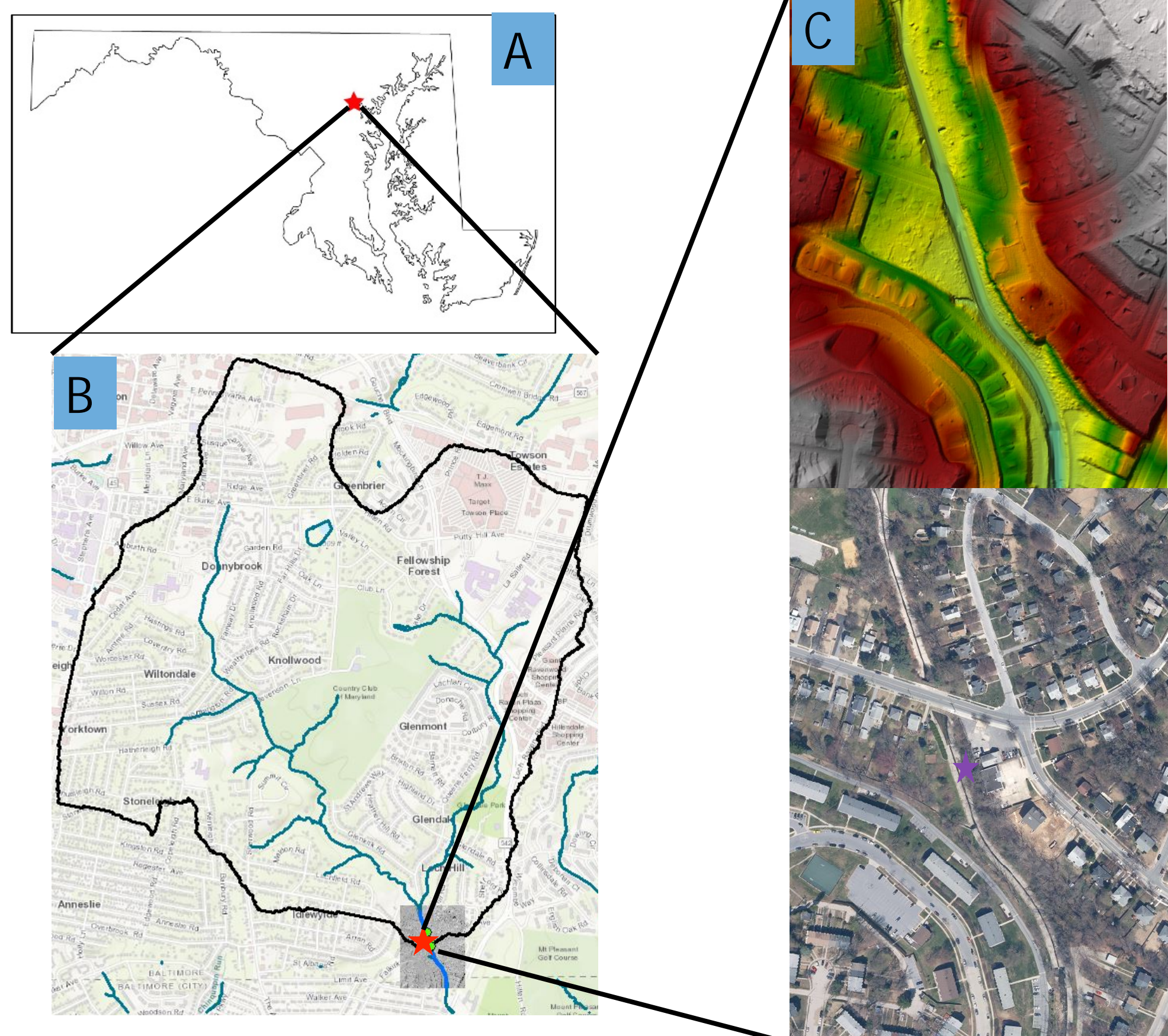
Parameter Analyzed	Expected Direction of Change
Roughness	+
Inundated Area	+
Width of Inundated area	+
Flood Height	+
Velocity	-

Table 1: Expected results for the various parameters analyzed. Positive (+) sign indicates an increase and negative (-) sign indicates a decrease in that parameter analyzed going from concrete to a ‘naturalized’ urban stream.

STUDY SITE

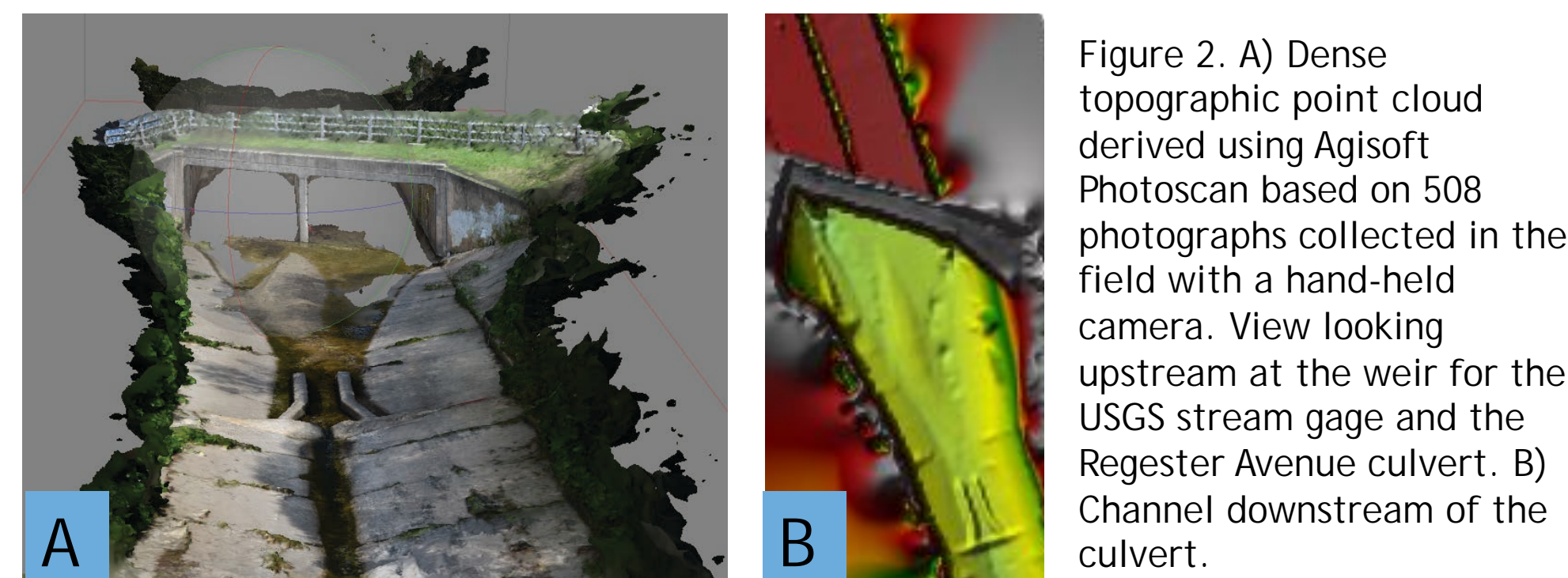
West Branch Herring Run, located in Towson, MD, has a drainage area of 2.13 mi² at the USGS stream gage which has been in operation since 1958. The watershed has 24% impervious cover and no stormwater management, and the stream responds rapidly to intense short-duration convective precipitation.³ The modeling domain with a concrete channel at the location of the USGS gage is shown in figure 1c.

Figure 1. A) Map of Maryland. B) West Branch Herring Run Watershed. C) Terrain (top) and air photo of the concrete channel (bottom). Purple star indicates where the USGS gage is located.



MATERIALS AND METHODS

- Topographic data imported from a DEM developed in ArcGIS using airborne LiDAR data from 2015
- Agisoft Photoscan Professional¹ used to develop supplementary topographic information to correct gaps in the county’s LiDAR data for the Regester Avenue bridge crossing by using hand-held photographic images of the culvert under Regester Avenue and concrete channel immediately downstream of the culvert (Structure for Motion Analysis)



- Terrain model developed to use in both the 1D and 2D versions of the HEC-RAS model

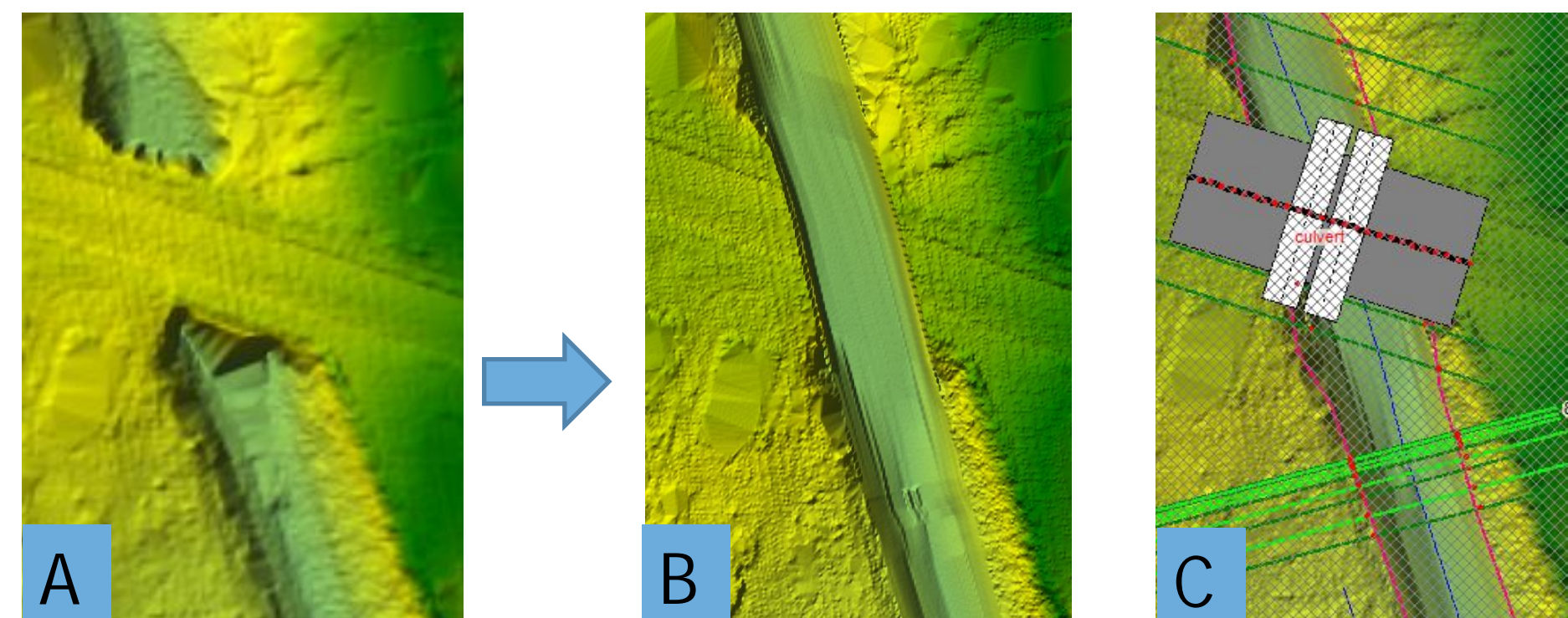


Figure 3. A) 2015 airborne LiDAR data. B) Interpolation of the concrete channel. C) HEC-RAS representation of the 1D culvert along a single cross-section at the center of the structure that routes flow through the culvert.

- Spatially varying roughness parameters (Manning’s n) mapped based on land-cover types from county high-resolution orthophotos, LiDAR topography, and field observations
- Streamflow records derived from the USGS stream gage on West Branch Herring Run at Idlewylde (01585200)
- Inundation extent compared with high-water marks observed next to the channel after the August 24, 2015 flow event (max peak ~2000 cfs)
- Estimated 100-yr flood peak derived from PeakFQ analysis of the USGS annual maximum flood series and from regional regression equations embedded in the USGS StreamStats application for Maryland⁴
 - Range of estimates ~3000 – 3500 cfs

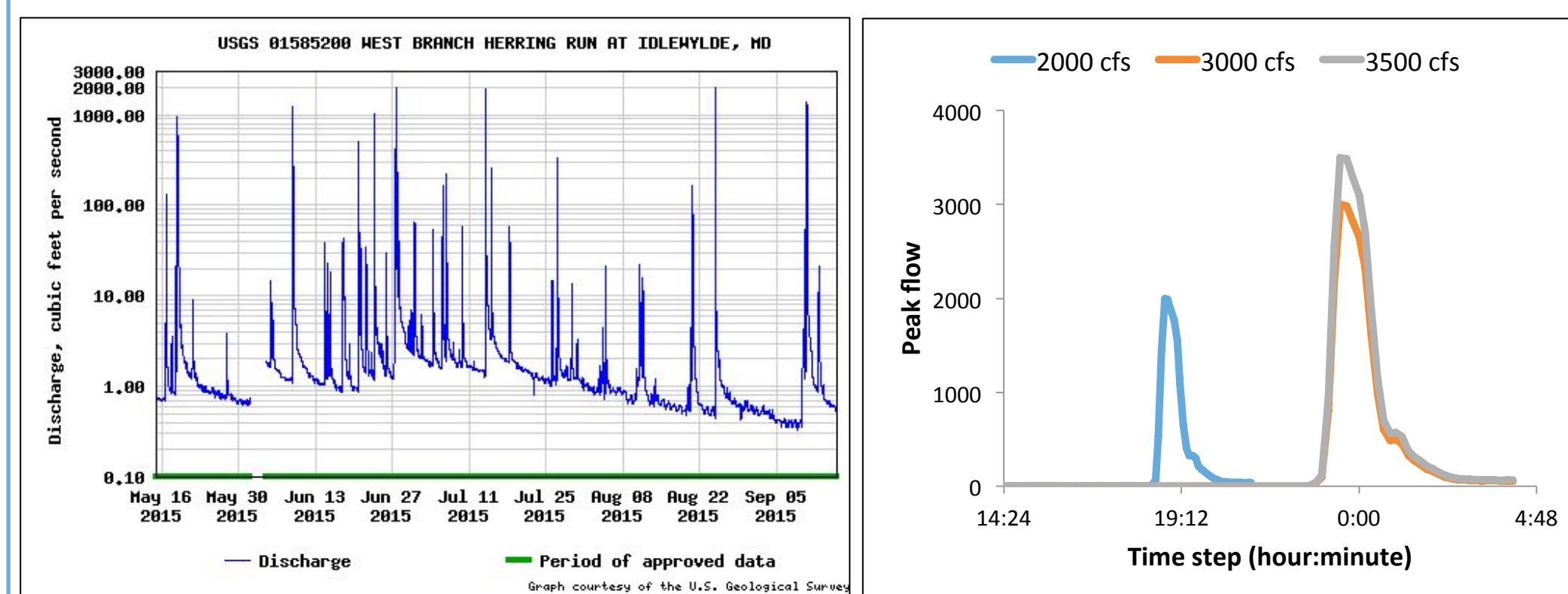


Figure 4. Flood peaks in summer 2015 at the USGS gage site at West Branch Herring Run.

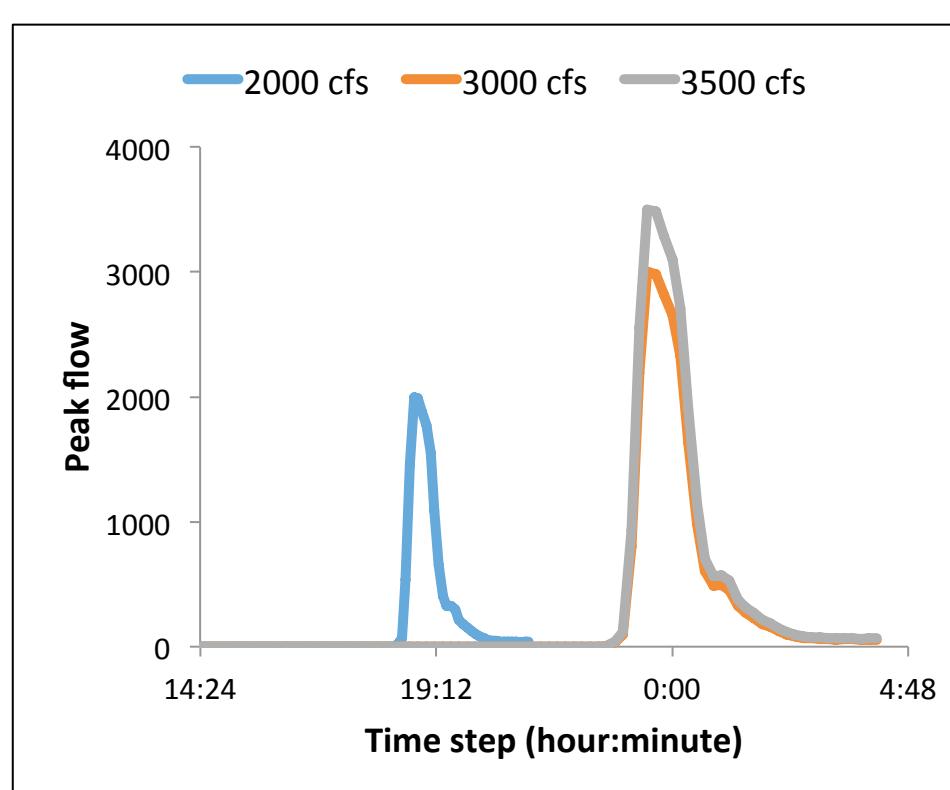


Figure 5. Simulations at the study site include hydrographs with peaks of 2000, 3000 and 3500 cfs.

- Design scenarios for naturalization of concrete channel provided by Baltimore County Dept. of Environmental Protection and Sustainability
- HEC-RAS used to simulate 1D/2D unsteady flow through the model domain, including 1D culvert/weir simulation connected to 2D flow area upstream and downstream of bridge
 - Used to predict water-surface elevation and depth as well as depth-averaged velocity for any location in the modeling domain
 - Used to simulate the dynamic behavior of a flood wave routed through the domain

RESULTS

2000 cfs and 3500 cfs with Varying Roughness Values

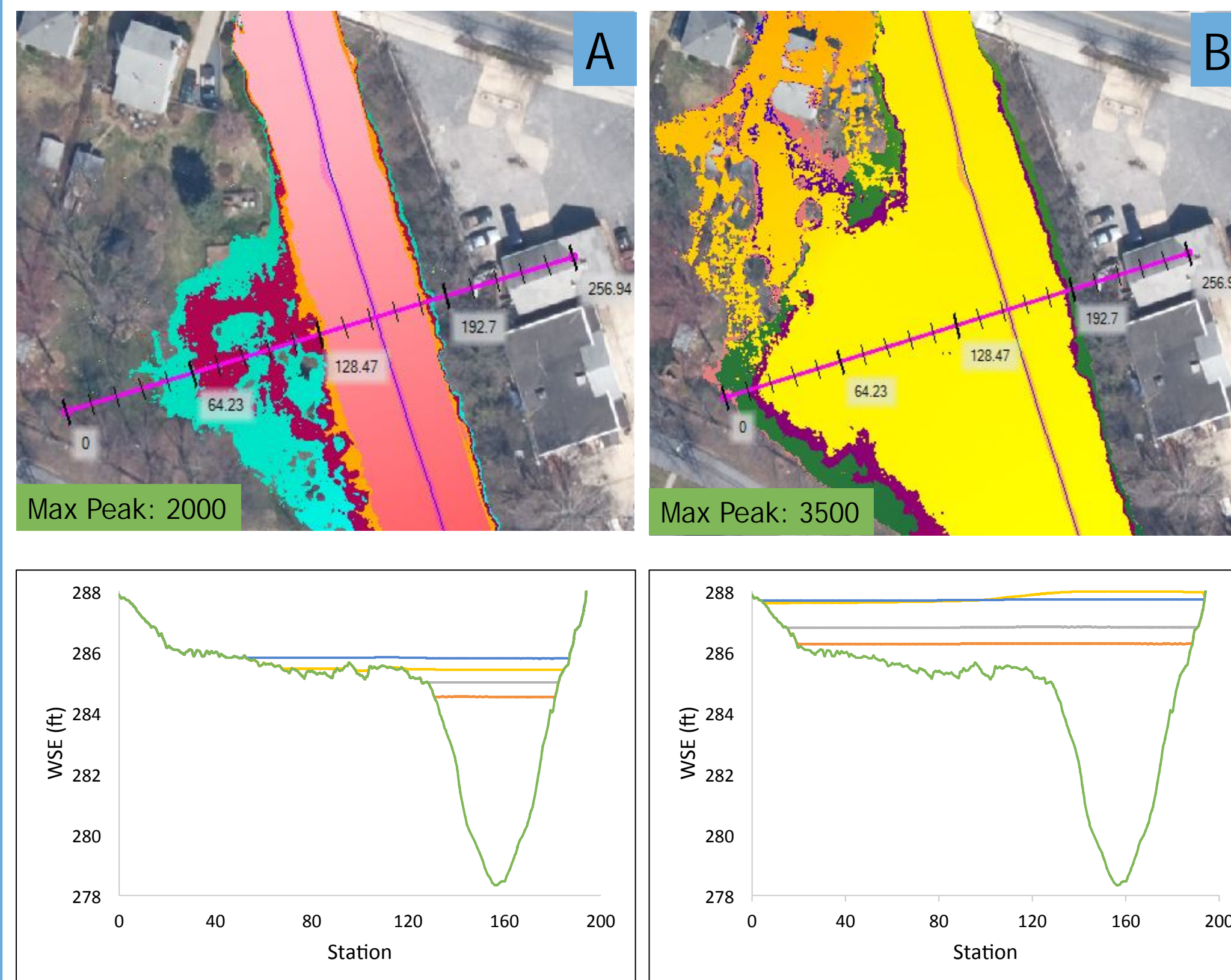


Figure 6. Different colors represent varying n values superimposed on one another (top) and Water-surface elevation profiles with varying n values (bottom). A) Max peak 2000 cfs B) Max peak 3500 cfs.

Particle Trace Visuals

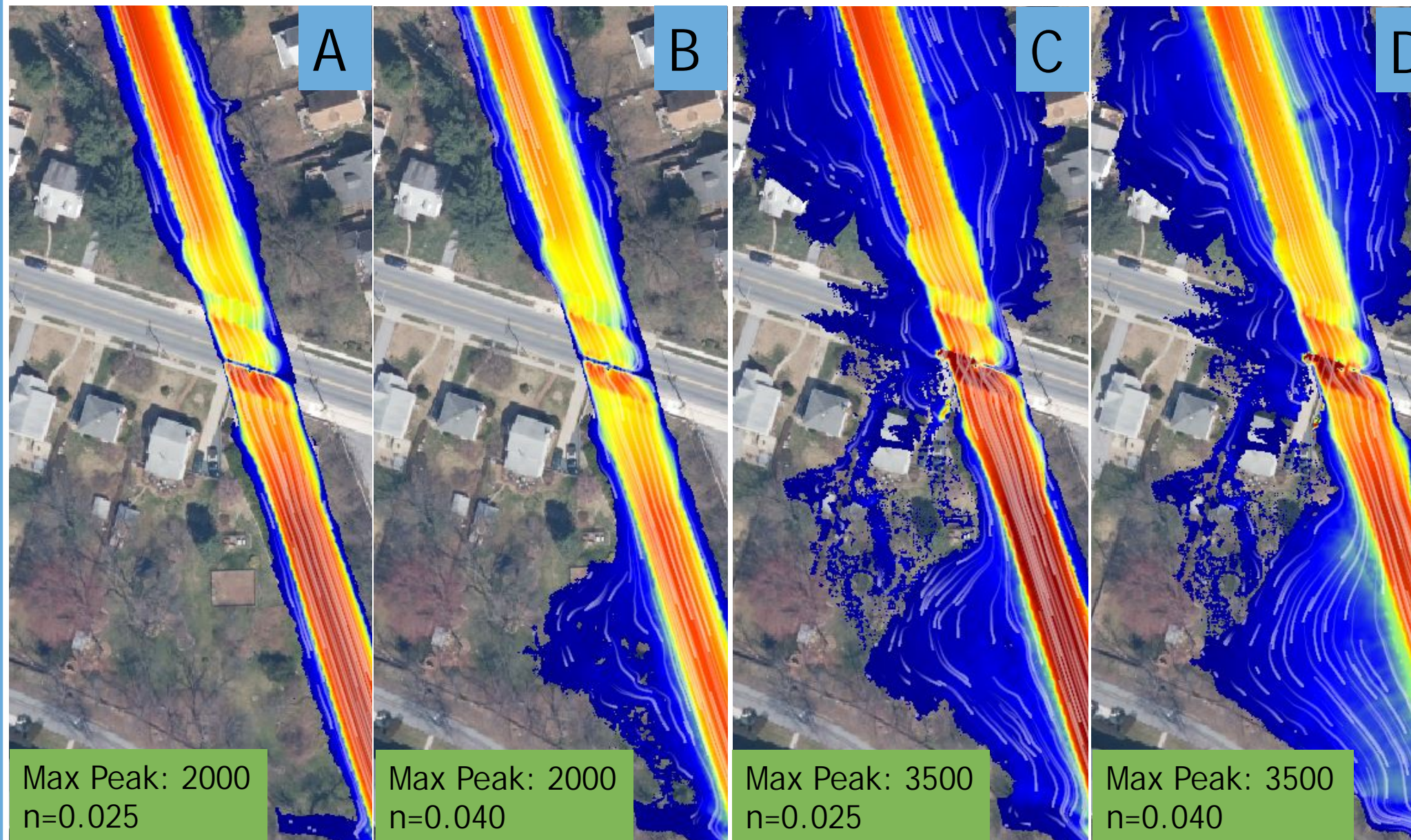


Figure 7. A) and B) show velocity and particle trace at a max peak of 2000 cfs. C) and D) show velocity and particle trace at a max peak of 3500 cfs. A) and C) have an n value of 0.025 and B) and D) have an n value of 0.040.

Maximum Flood Peak Profiles (n=0.025 and 0.04)

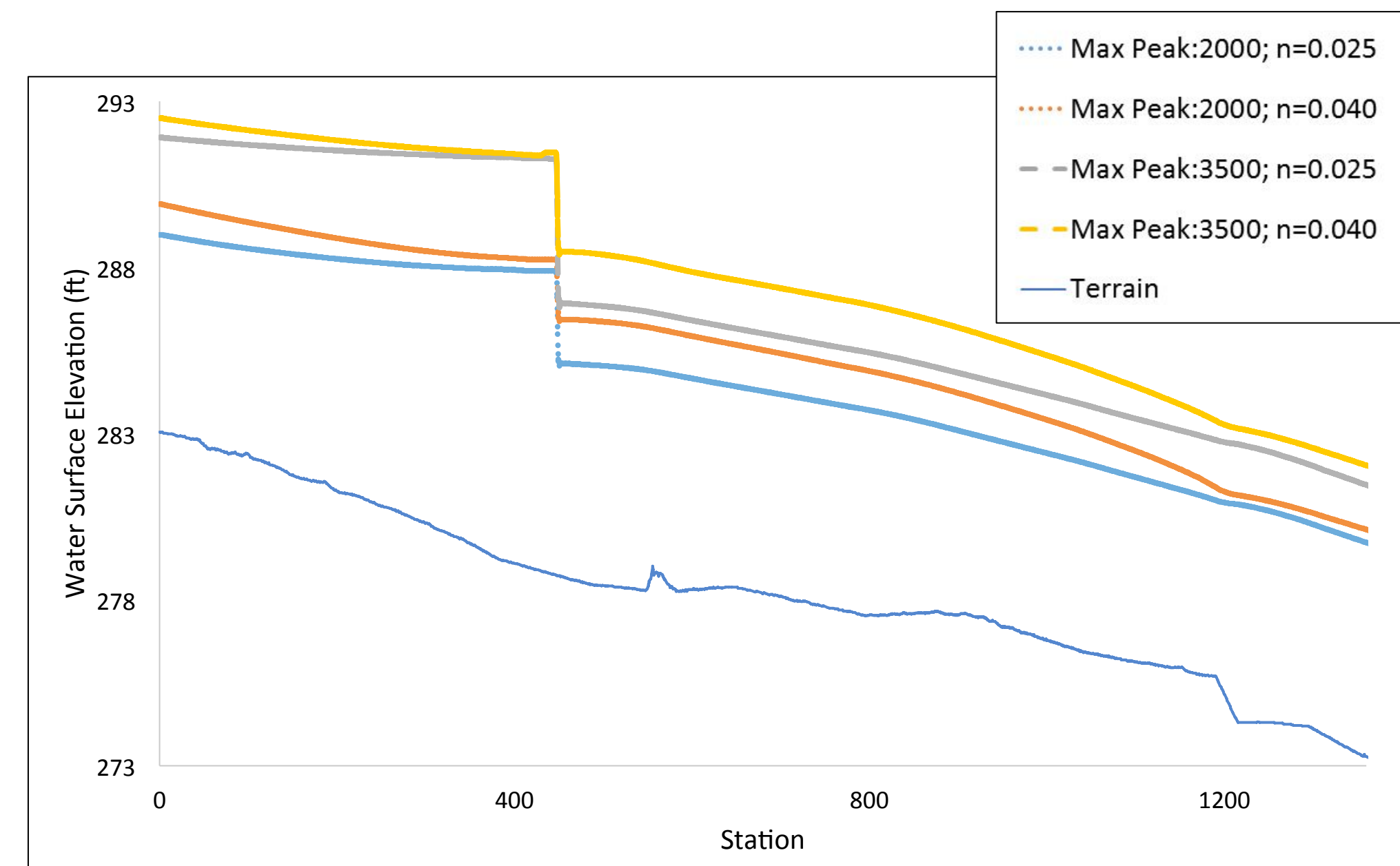


Figure 8. Maximum peak 2000 cfs (dotted line) and 3500 cfs (dashed-line) shown with an n value of 0.025 and 0.040.

CONCLUSIONS

Our simulations show that a change in channel roughness from the smooth condition associated with a concrete channel to a resistance coefficient more characteristic of a natural (or naturalized) channel will raise water levels and increase inundation extent. The relative magnitude of the increase varies both with the magnitude of peak flow and with local topography. Note that the inundation extent varied slightly when the flow was confined within the channel and varied more under the circumstance shown here. Moreover, our results show that increasing roughness causes a reduction in velocity as well as alteration in the flow pattern, which may have important implications for local impacts on properties located within the flood area. We also observed that increasing flow from a 10-year to a 100-year flood peak increases the extent of inundated area and begins to affect local properties to a greater extent. Furthermore, our results show that the bridge and culvert act as a barrier to flow and that at flows high enough to fill the culvert, backwater effects lead to greater flooding on the upstream side of the bridge. It is important to note that with potential future changes in rainfall intensity and frequency of high flows, what is now characterized as the 100-year flood could occur more frequently.

FUTURE WORK

Our goal was to generate an alternative channel terrain replacing the morphology and roughness of the straight concrete channel with a naturalization design based on plans provided to us by Baltimore County Dept. of Environmental Protection and Sustainability for a restoration site in a tributary to the Gwynns Falls in Baltimore County. However, we did not have time to complete this alternative terrain, which would have a different channel geometry and a more natural combination of roughness elements. The naturalization design below should be used to generate an alternative channel terrain for the concrete section of West Branch Herring Run to simulate potential changes in morphology, some of which might reduce the relative magnitude of increase in flood inundation.

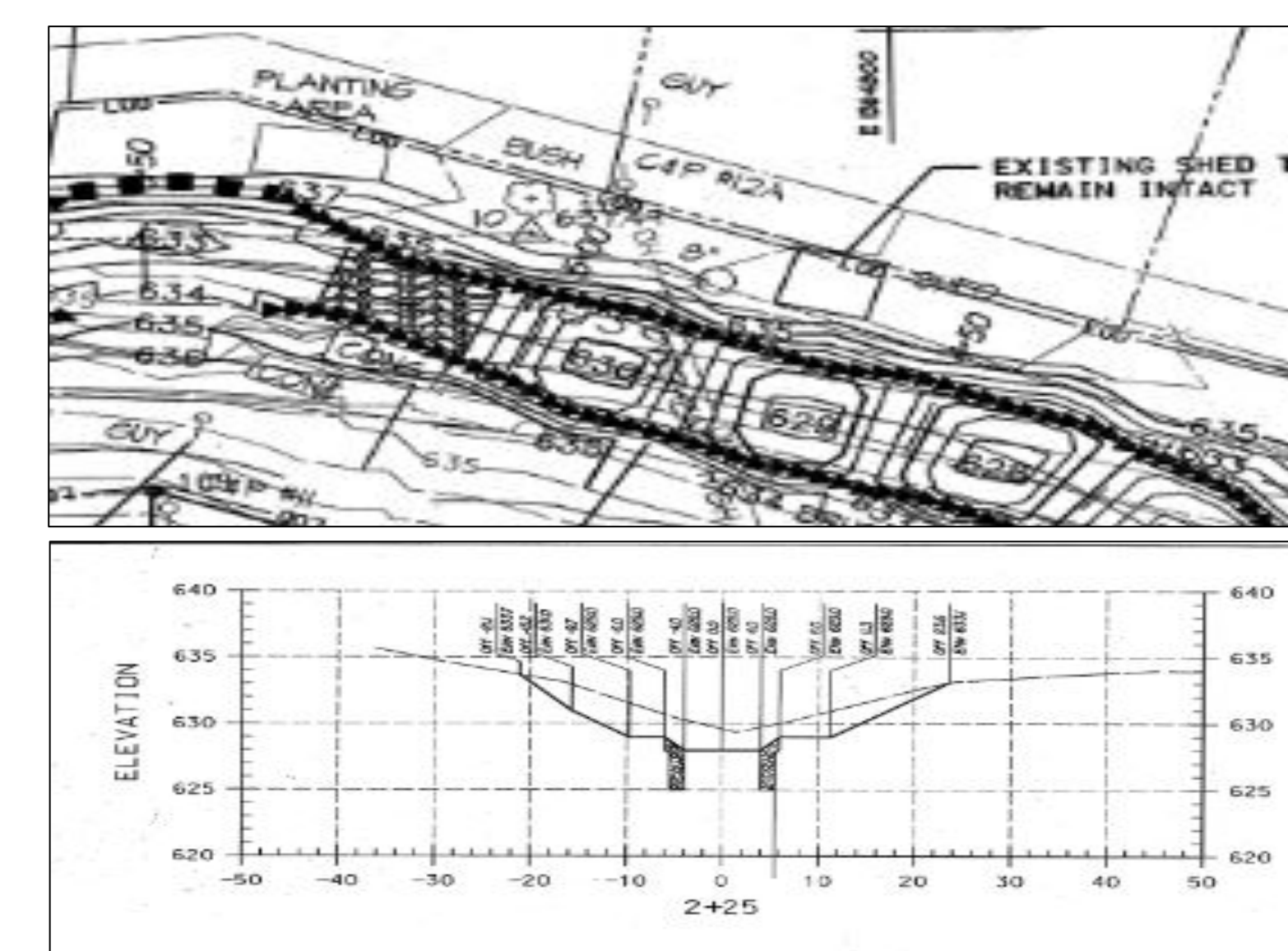


Figure 9. Shows a sample cross-section together with a plan view of the naturalized channel superimposed on the original concrete channel

REFERENCES

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- Smith, B.K. and Smith, J.A., 2015. The flashiest watersheds in the contiguous United States. Journal of Hydrometeorology 16: 2365-2381.
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ACKNOWLEDGEMENTS

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