Sediment Transport into an Urban Tributary Junction

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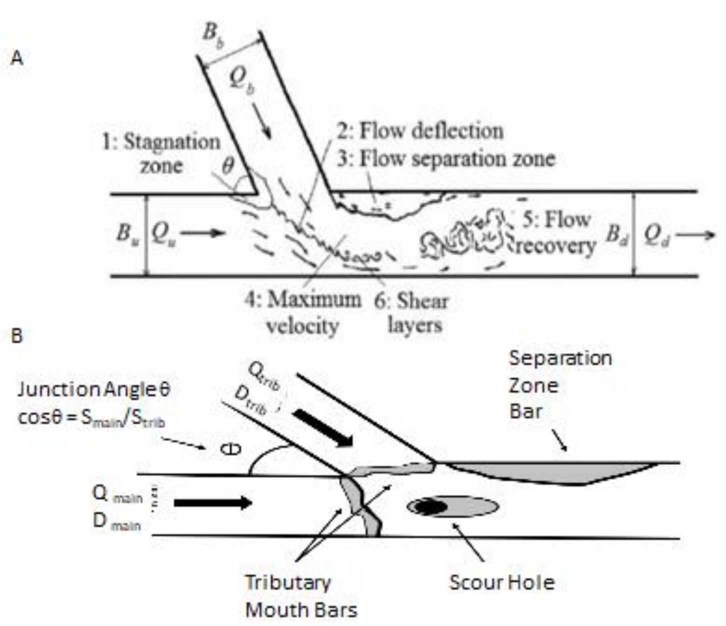
I. Problem

- Previous work on stream confluences indicates that junction of the two streams creates flow separation and turbulence in the confluence zone (Ribeiro et all, 2012)
- Tributary mouth bars form at near the junction and bars also form downstream in the separation zone.
- BUT, Most studies have been done in flumes or during constant discharge in river systems (not dynamic changes during floods).



a) Tributary junction and location of separation zones and turbulent scour, after Best, 1987. B) Morphology of tributary confluence showing location of bars and scour holes

II. Hypotheses

1. During a storm event, the smaller tributary will respond faster than the larger one (shorter lag time).
2. When peak flow occurs in the smaller tributary, the gradient of the larger stream decreases, decreasing shear stress.
3. Due to the low stream gradient at the tributary junction,: coarse sediment will be deposited upstream of the tributary junction in the larger stream. fine sediment will be deposited in the tributary junction during storms.

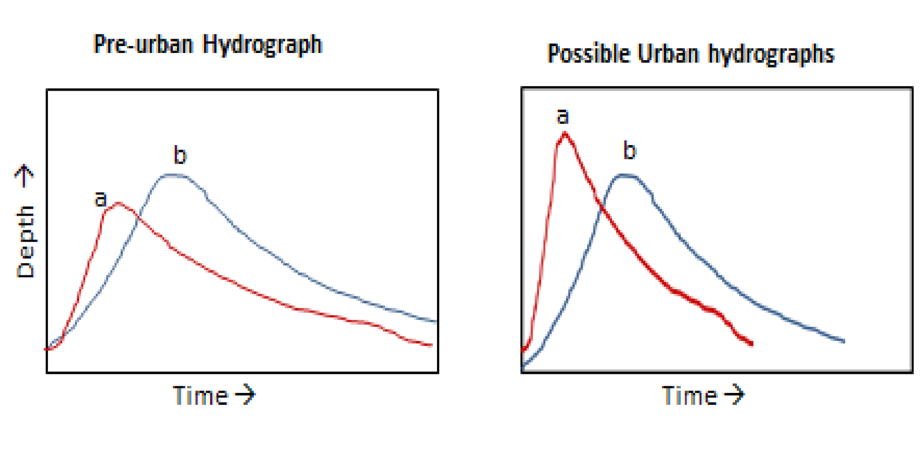


Fig. 3a: Smaller stream (a) has a shorter lag time And a smaller peak water depth than the Stream in the larger watershed (b)

Fig. 3b: Smaller stream (a) is in a more Impermeable watershed, which decreases Lag time and increases peak discharge. Channelization of the larger stream (b) Could also reduce its peak depth.

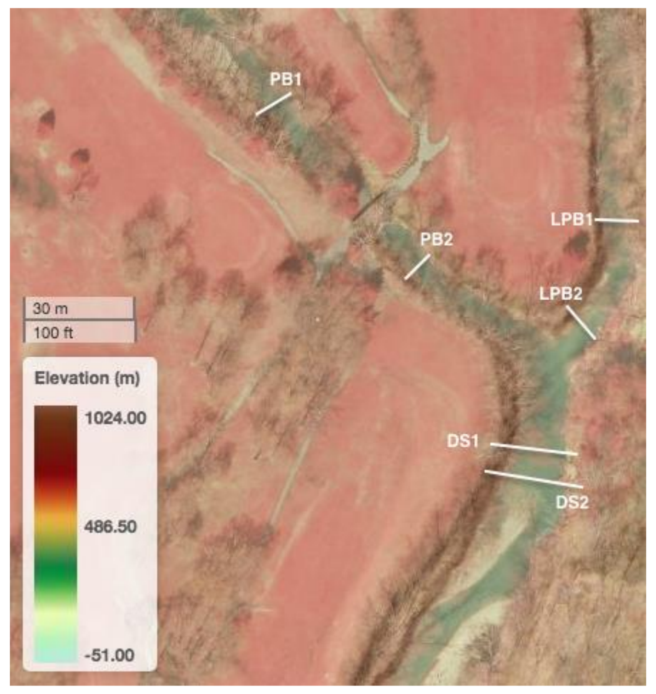
III. Study Site

Photograph of Little Paint Branch at the confluence zone. Taken Nov 12, 2017

- Public Land (MNCPPC)
- Close to campus
- Located at the confluence of Paint Branch and Little Paint Branch Creek tributaries

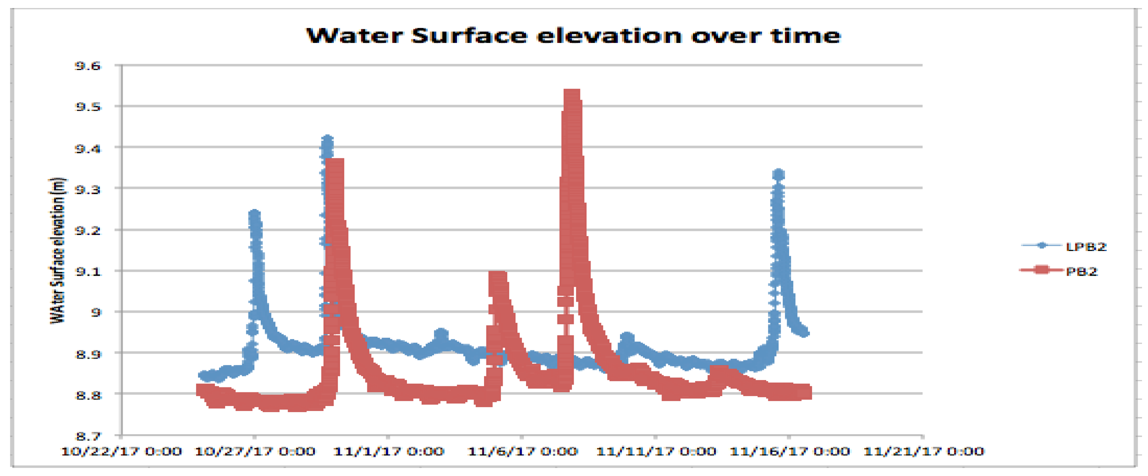
IV. Methods: Field Data Collection

- Cross section surveying
- Grain size
- Monitoring flow depth
- Calculating water surface gradient
- Calculate boundary shear stress at cross sections
- Critical shear stress based on grain size and critical dimensionless shear stress
- 6 pressure gauges were installed that record temperature and water pressure



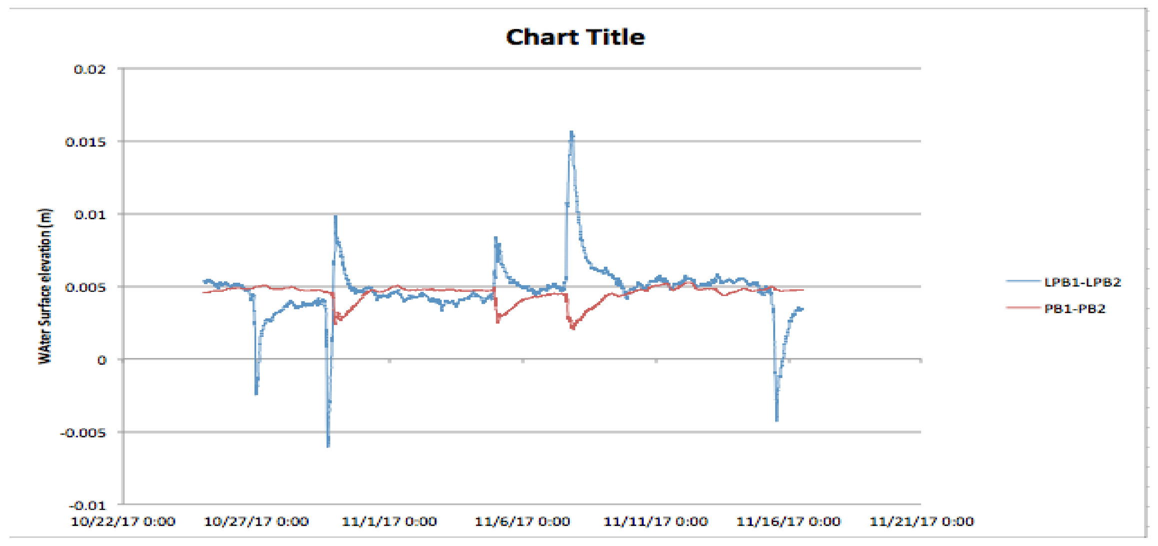
Colored-Infrared image of site. The lines represent where each gauge was installed and the cross section across them

V. Results: Water Surface elevation



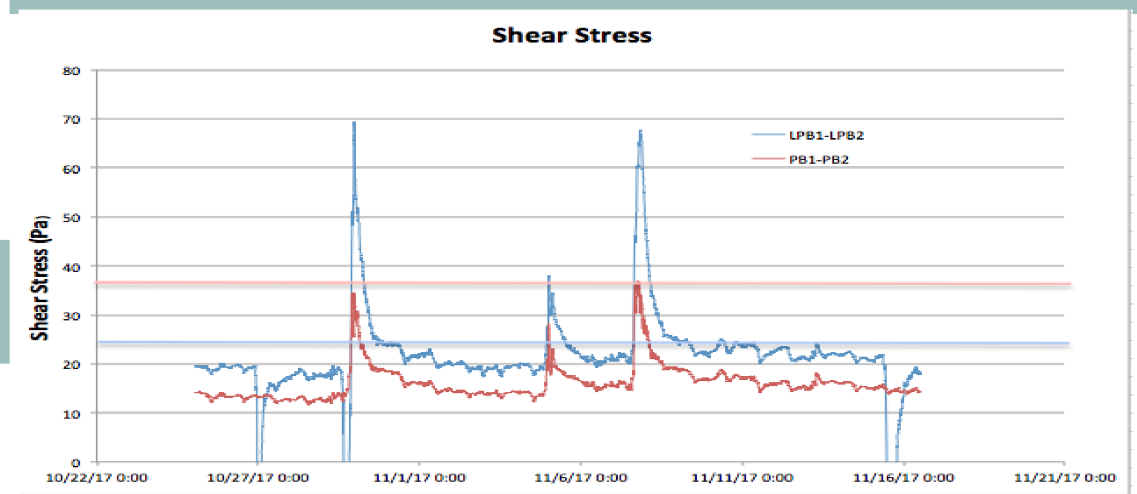
Graph of sensor depth over time between October 25 and November 16, 2017 for LPB2 and PB2

Results: Water Surface Gradient



Graph of water surface slope over time for the upstream sites between October 25 and November 16, 2017

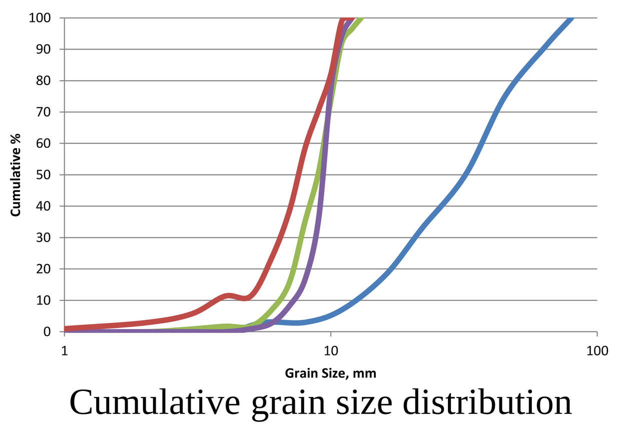
Results: Shear Stress



Graph of water shear stress over time for the upstream sites, the lines (LPB: 23.28 Pa, PB: 36.6 Pa) represent the critical shear stress that's required for sediment transport in this system between October 25 and November 16, 2017

- The critical shear stress is obtained by rearranging the Shields equation
- $\tau_c = \tau^*_{crit}(\rho s-\rho w)gD_{84}$
- τ^*_{crit} is the critical dimensionless shear stress with the value of 0.045, D_{84} is the reference grain size of the bed material, ρ_s is the density of the sediment (2,650 g/m^3), ρ_w is the density of water (1,000 g/m^3), and g is gravitational acceleration.
- Paint Branch Creek Bar 1: D_{84} is 50mm, critical shear stress is 36.6 Pa
- Little Paint Branch Bar 1: $D_{84}$is 32mm , critical shear stress is 23.28 Pa

Results: Grain Distribution

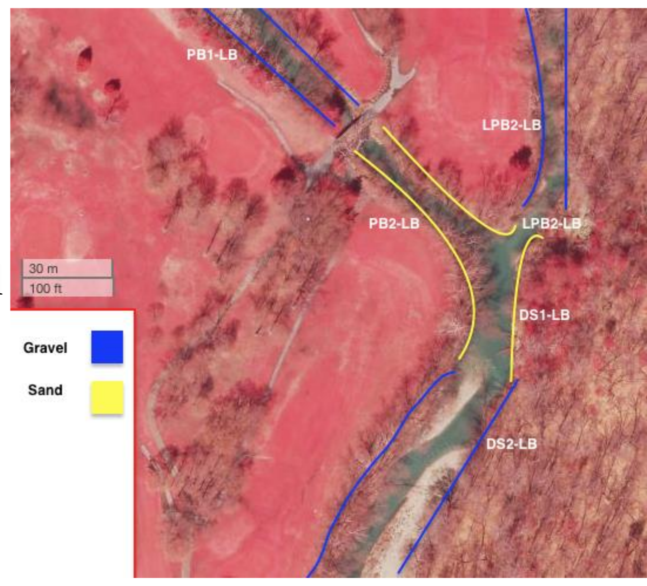


Cumulative grain size distribution curves for Little Paint Branch, taken on November 17, 2017: Bar 1: blue, Bar 2: red, Bar 3: green

Cumulative grain size distribution curves for Paint Branch, taken on November 2, 2017: Bar 1: blue, Bar 2: green, Channel 1: red, Channel 2: purple

Results: Grain Distribution

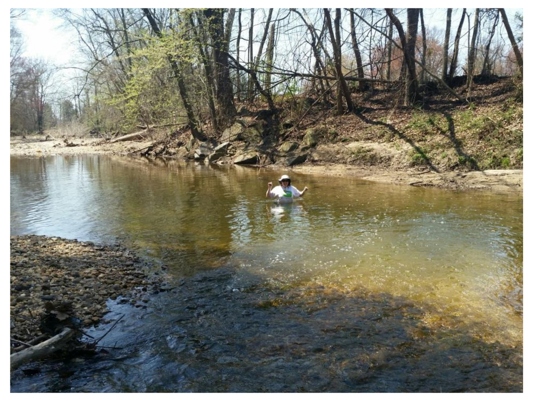
- Coarse sediment gets deposited upstream in both tributaries and downstream past the confluence.
- Fine sediment gets deposited in the confluence and in the lower section of Paint Branch, which are places with low gradient.
- These areas do not have enough shear stress to move coarser sediment. While areas with higher gradients such as the upper portion of Paint Branch, Little Paint Branch, and downstream the confluence have coarse sediment deposits.



Colored-Infrared image of site, showing the grain size of sediment deposits, where sand is outlined with yellow and gravel is outlined with blue

VI. Conclusions

1. The smaller tributary, Little Paint Branch, responds faster than Paint Branch with higher peak flows. Little Paint Branch has a higher stream gradient than Paint Branch. The lower stream gradient of Paint Branch is a result of Little Paint Branch's shorter lag time and peak flow, creating a backwater effect that lowers the stream gradient of Paint Branch
2. When peak flow occurs in Little Paint Branch, the gradient of Paint Branch decreases. This decrease in gradient results in lower shear stresses for Paint Branch
3. Due to the low stream gradient at the tributary junction, coarse sediment gets deposited upstream of the tributary junction in Paint Branch while fine sediment gets deposited in the tributary junction during storms. Paint Branch has coarse sediment bars further upstream because the shear stresses during most storm events do not exceed the critical shear stress required for sediment transport of bars.



VIII. References

- Best, J.L. 1986. The morphology of river channel confluences. Progress in Physical Geography 10: 157-174
- Ribeiro, M. L., Blanckaert, K., Roy, A. G. and Schleiss, A. J. (2012) "Flow and Sediment Dynamics in Channel Confluences," *Journal of geophysical research*, 117(F1), p. 01035.
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