Stability of Gravel Bars in Paint Branch Creek

Andrew Kosiba

Abstract: Streams in urbanized watersheds respond to changes in water and sediment supply, often resulting in bank erosion and channel enlargement. I examined an unconstrained reach of Paint Branch Creek with a gravel-bar complex. In the areas where the gravel bars are being formed, the channel widths are 2-3 times wider than adjacent reaches. The channel initially widens at the bar head, and becomes less wide downstream. The upstream portion of the divided reach has lower average shear stresses than the upstream reach, but the bar tail is a zone of active bed and bank scour and sediment transport. Shear stresses over the bar top are significantly lower than in the channels.

Figure 1 : River showing channel widening and central gravel bar

Figure 2: Upstream of Figure 1

Hypothesis: Gravel bar formation results in channel stabilization by increasing channel width, decreasing channel depth, which decreases bed shear stress in the divided reach in comparison with non-divided reaches.

Methods: cross section and water surface surveys to obtain

Fluid Shear Stress, **T= ρgRS**

g= acceleration due to gravity (9.81 m/s^2)

ρ = water density (1000 kg/m^3)

R = Hydraulic radius (A/P) often similar to depth (m)

S = energy gradient

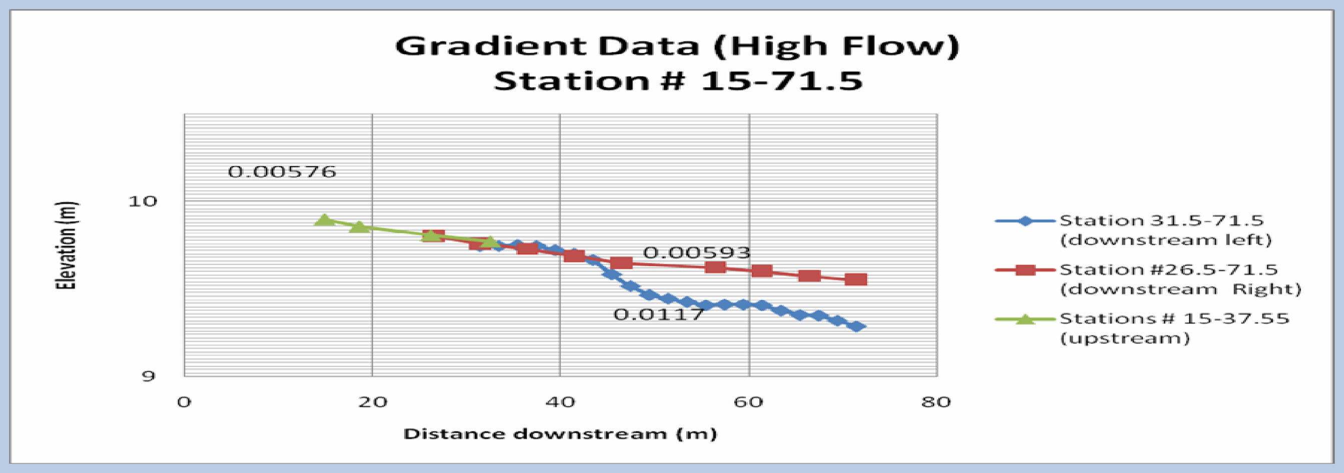

Fig. 3: Bankfull water surface profile for Feb. storm

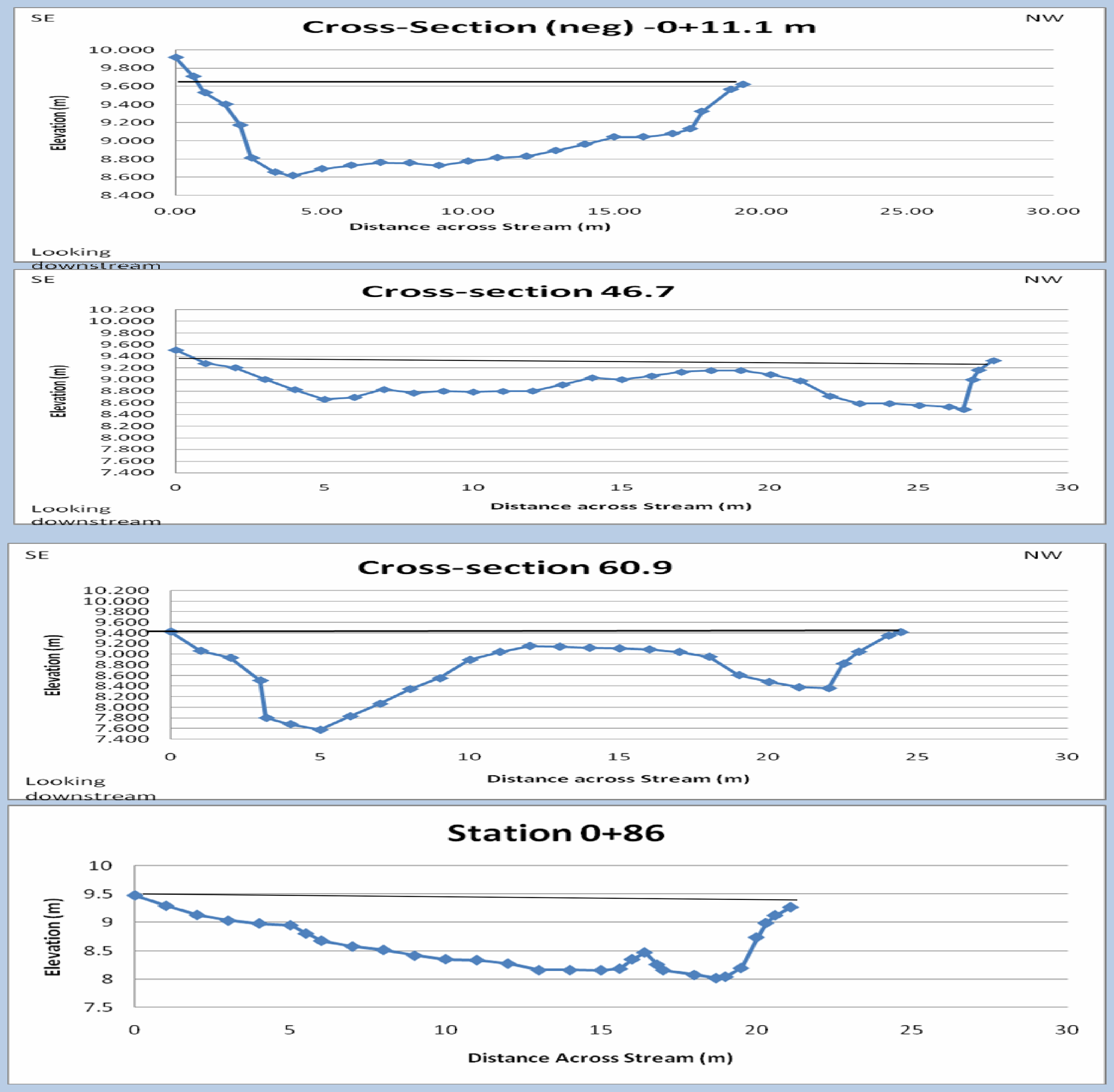

Fig. 4: Channel cross sections through braided reach, showing width expansion and contraction.

Data Analysis to determine bed particle mobility

T* Crit = Critical Dimensionless shear stress, the ratio of critical fluid shear stress to grain resisting forces

T* crit = T crit/((ρs- ρ)gD$_{84}$)

ρs = Density of sediment (Quartz = 2,600 kg/m^3)

ρ = Density of Water (1000 kg/m^3)

g = acceleration due to gravity (9.8 m/s^2)

D = grain size of surface material (from field sampling)

T*crit = 0.045 for heterogeneous gravel

Grain Size Distributions: Average Grain size remained constant (fig. 5), But material on the gravel bars is finer-Grained than in channels. (fig. 6)

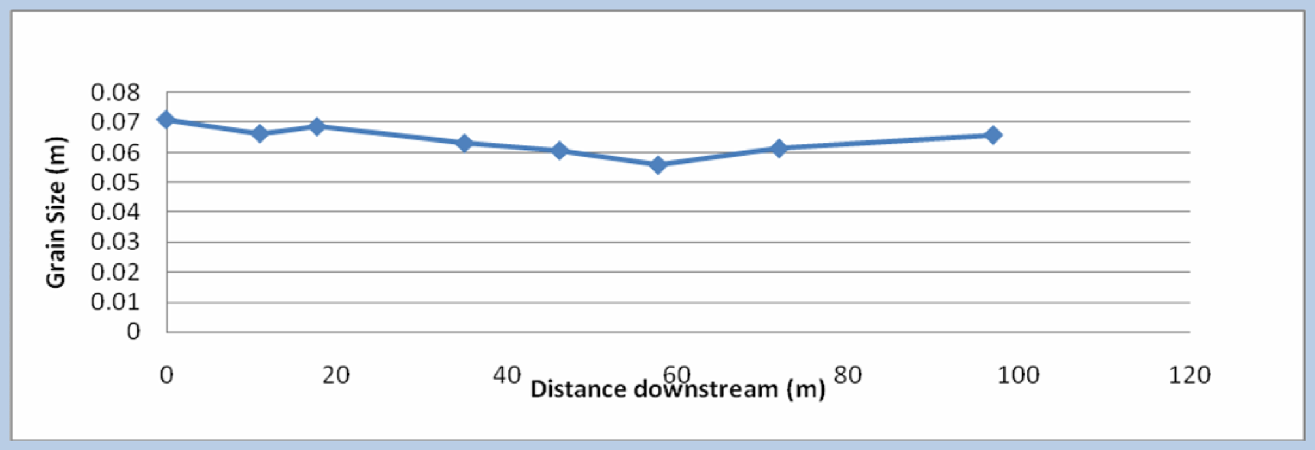

Fig. 5: Cross section averaged grain size did not change significantly over the reach

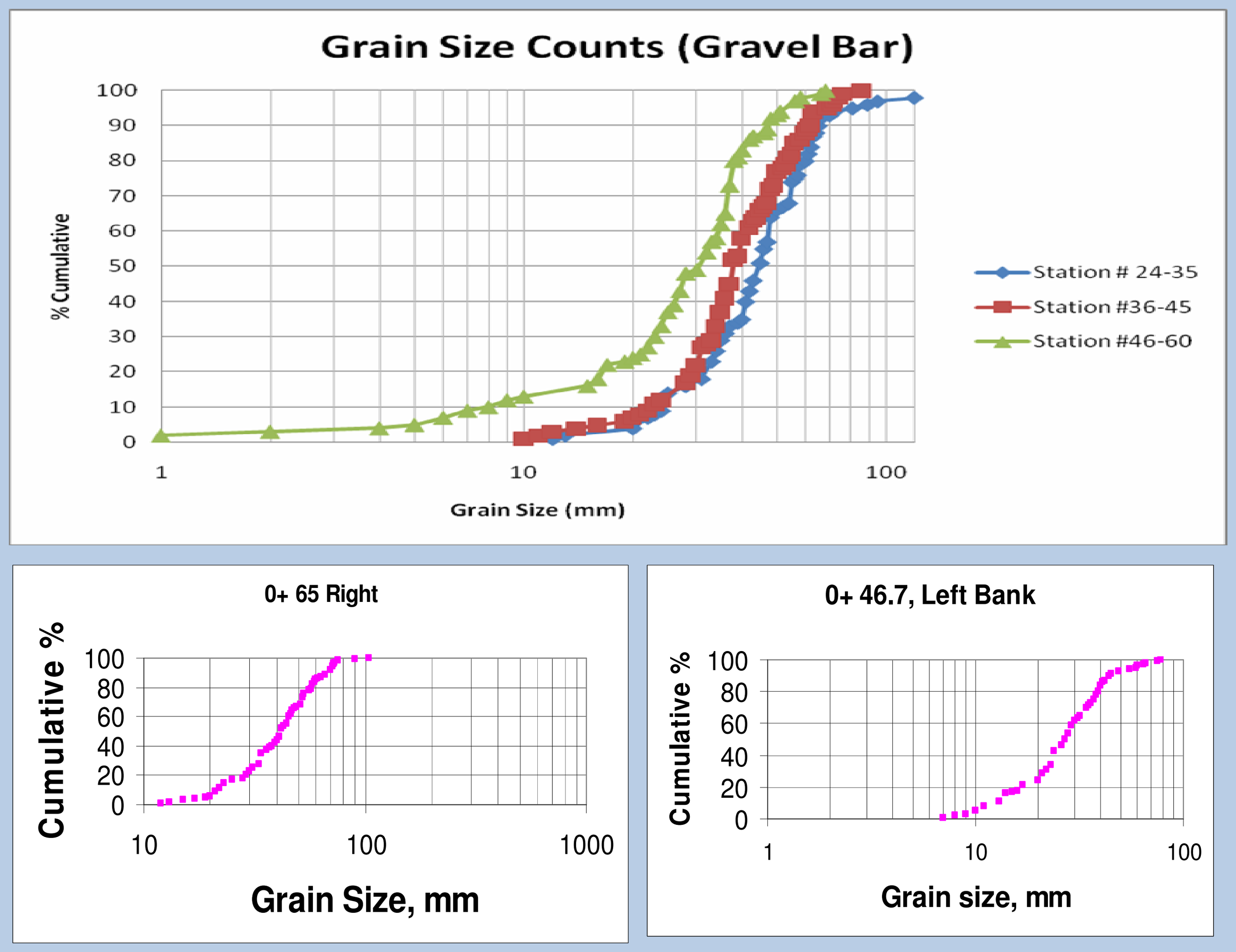

Fig. 6: Grain Size Distribution of bar (upper) and channel sediments (lower diagrams).

Summary of Morphology and Grain Size Data

Table I (below) shows the channel morphology and grain size parameters for the cross section- averaged data for each of the sites. Survey error is 2% for the measurement of channel depths and channel areas.

Site	Distance	Station #	Depth	Width	W/d	D84	depth/d84	Gradient
1	0	(neg)-0+11	0.650	19.41	29.862	0.0710	9.15	0.0145
2	11	0+00	0.559	16.38	29.302	0.0663	8.43	0.0145
3	17.7	0+6.7	0.472	14.71	31.165	0.0686	6.88	0.0145
4	35	0+24	0.862	12.75	14.791	0.0630	13.68	0.0145
5	46.15	0+35.15	0.302	19.14	63.377	0.0606	4.98	0.0223
6	57.7	0+46.7	0.445	27.50	61.798	0.0557	7.98	0.0225
7	71.9	0+60.9	0.765	24.40	31.895	0.0613	12.47	0.0228
8	97	0+86	0.783	21.10	26.948	0.0658	11.89	0.0222

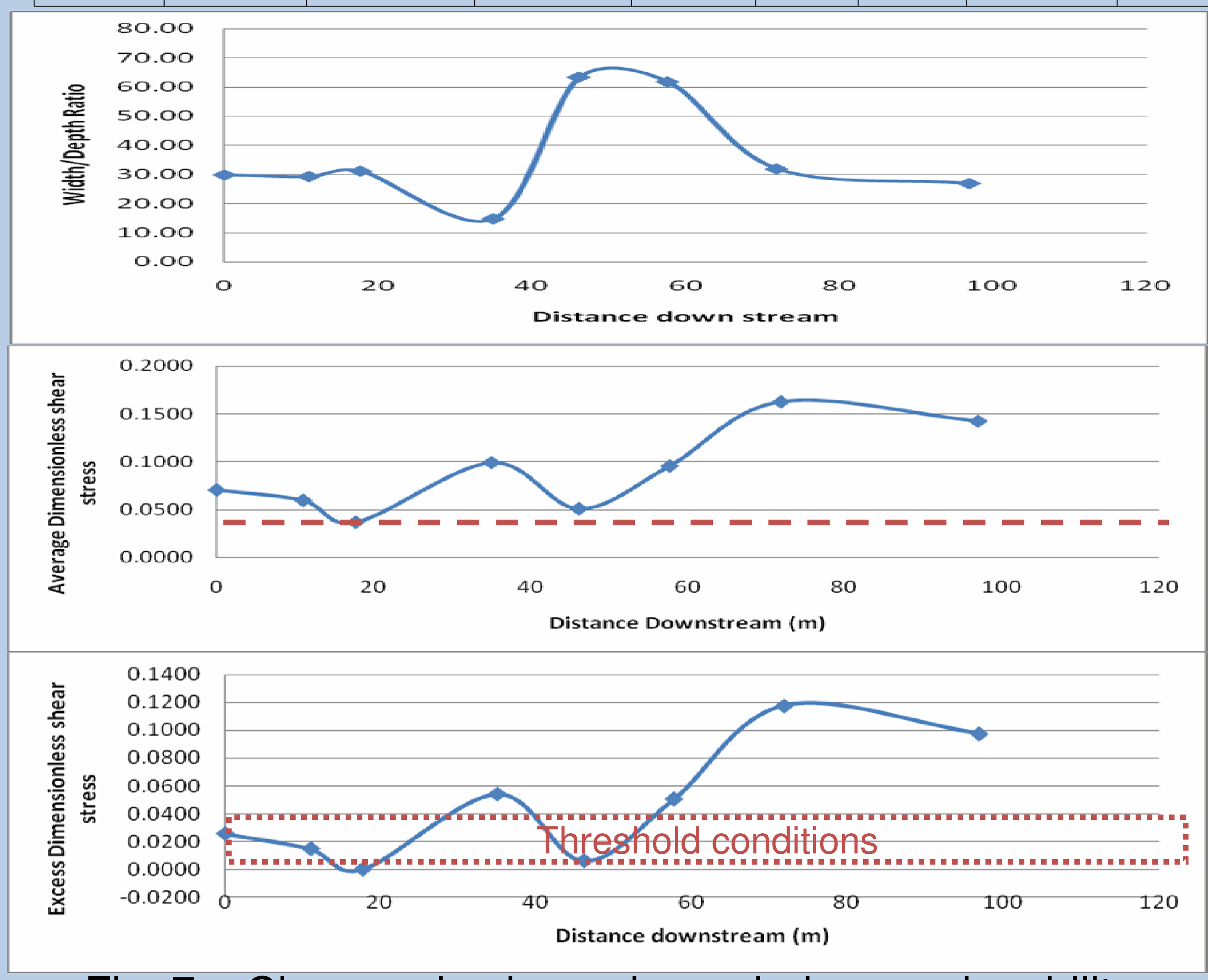

Fig. 7: Changes in channel morphology and mobility

Conclusions:

1. The channel widens at the entrance to the gravel bar reach, but contracts at the bar tail.
2. The finer-grained fraction of the bed material is stored on the gravel bar.
3. The energy gradient is higher through the gravel-bar reach.
4. Cross-section averaged dimensionless shear stress values are highest at the downstream end of the bar, but bar tops and channel banks are near or below the threshold of motion at most sites.