Geomorphic Evaluation of Little Topashaw Creek: June 2000

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Introduction

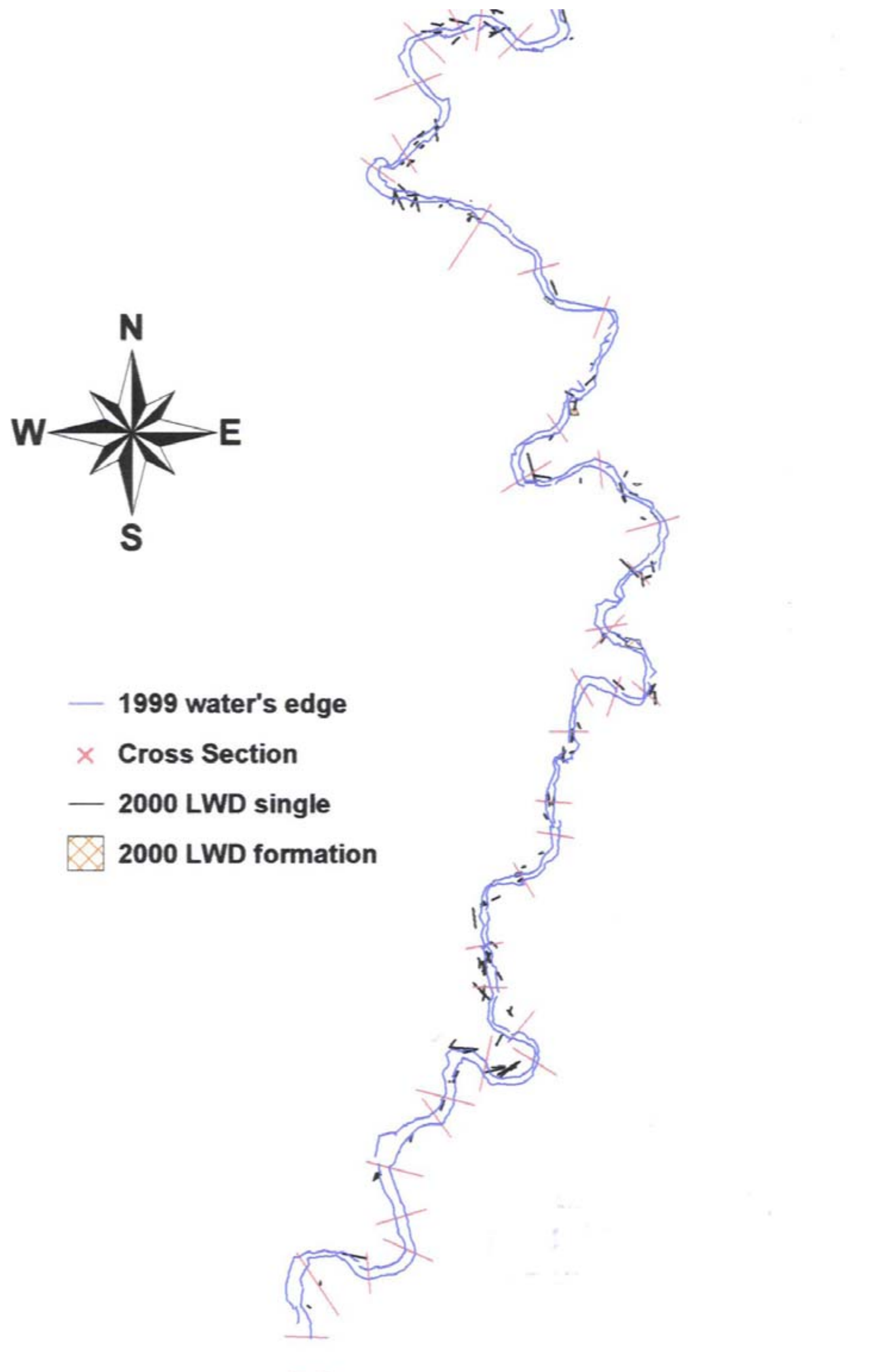
This brief report outlines observations made on the geomorphology of Little Topashaw Creek in June 2000. The reason for this analysis is to give a baseline survey of the reach prior to the installation of large woody debris structures which will be placed in the outside of the apex of several bends to protect the banks from fluvial erosion. The reach in question is located immediately north of the bridge carrying a county road along the Chickasaw-Webster county line and is approximately 2000 meters in length.

Thirty-nine cross sections were surveyed in the reach between 1999 and January 2000. Cross sections 1-27, 29, 31,33, 35,37 & 39 were surveyed by a crew from Colorado State University and cross sections 28, 30, 32, 34, 36 and 38 were surveyed by the USDA, NRCS. Figure 1 shows the path of the low flow channel, the location of each cross section and the location of major large woody debris elements surveyed in June 2000. Cross sections were also surveyed by the US Army Corps of engineers in 1997 but these sections do not tie in with the 1999-2000 locations.

A geomorphic evaluation of each cross section was undertaken in June 2000 to assess stage of evolution in the Simon six-stage evolution sequence. Data collected includes channel bed and bankfull widths, berm widths, bank angles, bank materials, processes operating on either bank and the rate of sedimentation/bank failure which was determined using dendrochronological techniques. The geomorphic evaluation sheets, cross section diagrams from the 1999-2000 survey and photographs of each cross section (looking downstream, upstream, right bank and left bank) can be found in individual hard copy files kept by Dr. Andrew Simon.

A spreadsheet of the geomorphic data, Power Point slides of the photographs, raw cross section survey data, plots of the 1997/1999-2000 cross sections and plots of the 1997/1999-2000 thalwegs are available on computer files. The files are located on the UDSA, ARS National sedimentation laboratory LAN. The file path is Sedlab\Topashaw\Data\Geomorphology\2000 Geomorphic Survey.

Figure 1: Plan view of low flow channel, cross section locations and large woody debris structures in study reach of Little Topashaw Creek, Chickasaw County, MS.



Thalweg Data

The surveyed reach is currently undergoing adjustment due to channel incision and is therefore highly active. There is a knickpoint in the reach that is currently cutting into a hard clay horizon approximately 4 meters below the floodplain surface. This knickpoint is located at cross section 7 and is 1.8 meters high (see figure 2). Instability due to the upstream movement of the knickpoint is evident in the downstream reach but the thalweg plot (figure 2) shows that the knickpoint did not move between 1997 and February 2000, probably as a result of moving into a reach with a hard clay pan layer. However, the knickpoint migrated about 70 meters upstream during an event in early April, 2000. In so doing, the knickpoint was transformed into a series of smaller scaprs, drops and over-steeped zones. It is evident from the thalweg plots that degradation of the bed has continued in the past three years downstream of the knickpoint with the current bed elevation being about 0.1-0.2 meter lower than that in 1997. Degradation of roughly 0.4 meter has occurred in a reach approximately 250 meters long immediately downstream of the knickpoint over the last three years.

Regression analysis of the thalweg data (see figure 3a and 3b) shows that the average bedslope is 0.0031 above the knickpoint and is at a lower gradient of 0.0021 below the knickpoint. Stream power is therefore lower downstream of the knickpoint so the reach is probably coming back into dynamic equilibrium.

Figure 2. Comparison of 1997 and 2000 thalweg for Little Topashaw Creek

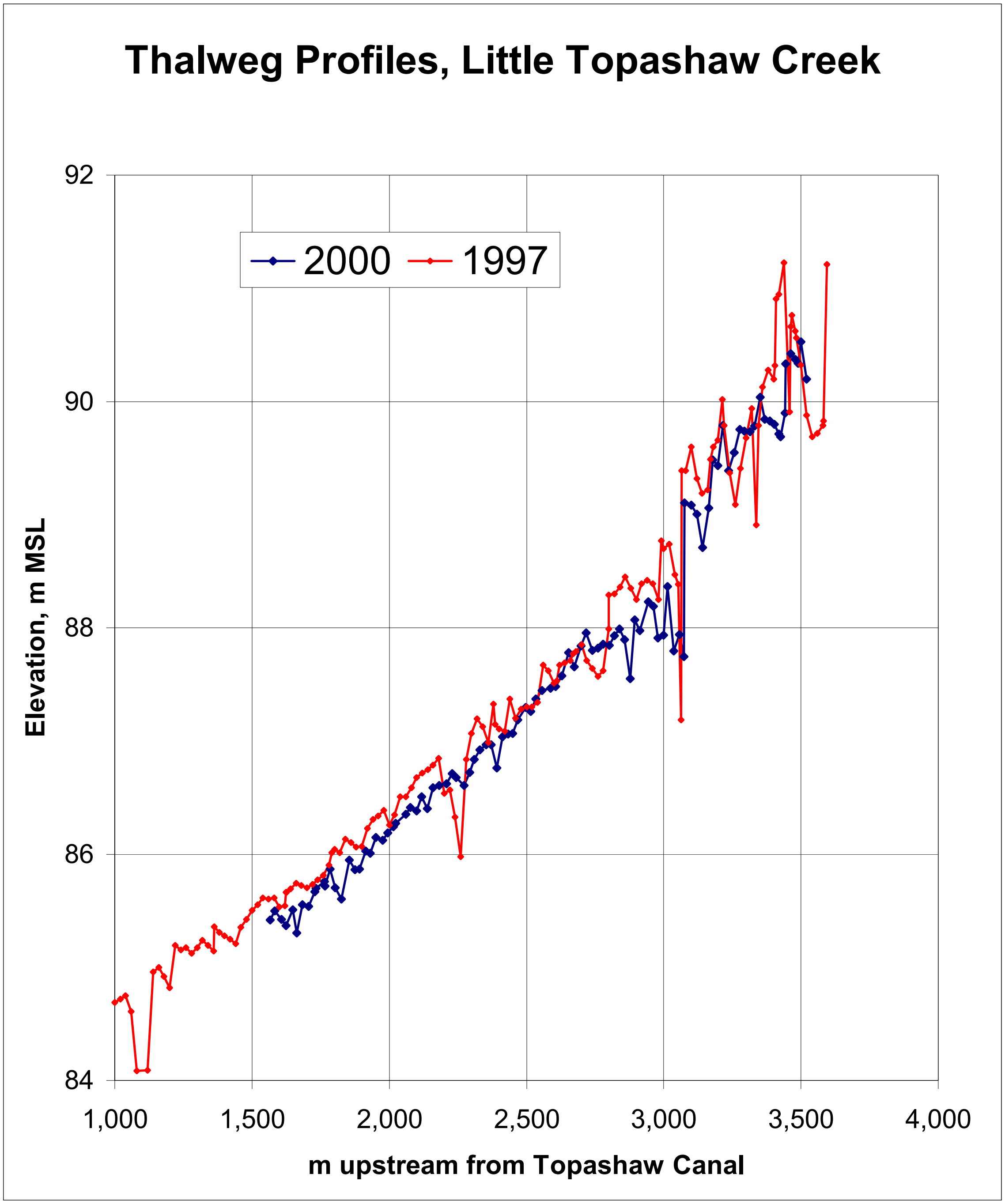


Figure 3a: Thalweg regression above the Little Topashaw knickpoint

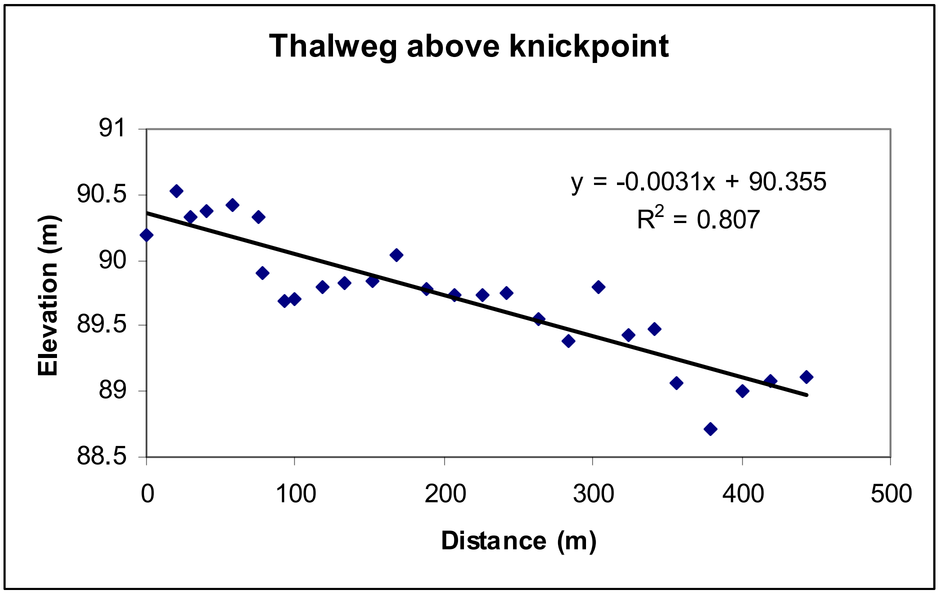
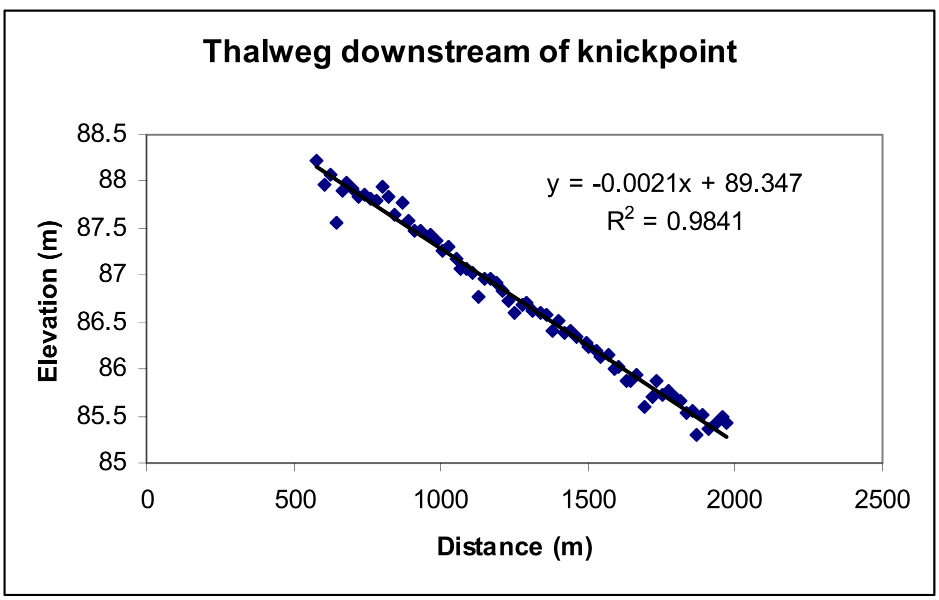


Figure 3b. Thalweg regression below the Little Topashaw knickpoint



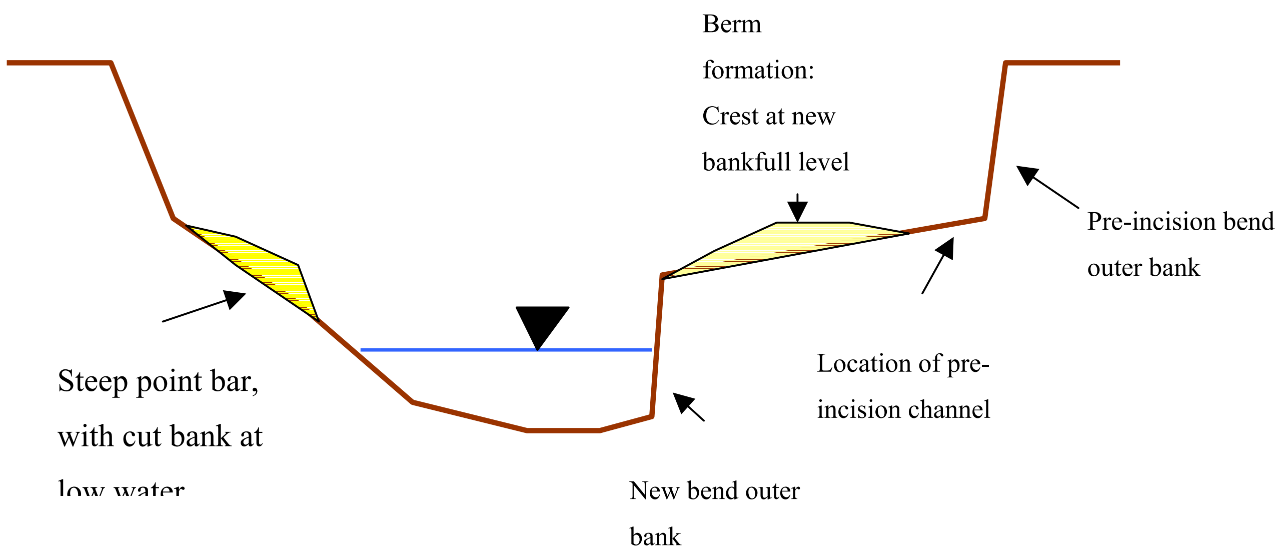
Geomorphic Evaluation

Averaging observations of both right and left banks, reaches from section 39 to 18 can be considered to be in stage 5 of evolution, reaches from section 17 to 11 are in stage 4 of evolution, and reaches from section 10 to 1 currently in stage 3 of evolution.

It is a noteworthy point that the Schumm and Simon evolution models represent an idealized situation where processes are varying only with distance from the knickpoint and not laterally across the channel. Simple classification of each of the cross sections into evolution stages is therefore complicated in this reach by the fact that the channel is highly sinuous. (The reach has a sinuosity of 2.1; calculated as reach thalweg length divided by straight line distance between the two ends of the reach). As a consequence different processes are operating on either bank downstream of the knickpoint. The outside of bends appear to be actively retreating by slab type mass failure, induced by toe scour, while on the inside of bends point bars are being laid down through the deposition of sand. The outside of bends therefore on initial inspection appear to be at stage four of evolution, while the inside of bends appear to be in stage 5 or even 6. It is hard therefore to disaggregate width adjustment due to excessive downcutting and that due to active meander migration, which would occur even in a non-incised channel. Analysis of channel migration rates in a river which is not incised with a similar drainage basin area/discharge in the same geologic region as Little Topashaw Creek could give the data necessary to determine whether the reach downstream of the knickpoint has already re-adjusted it's width and is merely actively migrating or whether a component of bend apex erosion is actually due to stage 4 type width expansion.

It might intuitively be thought that a certain degree of slope reduction due to excesses stream power might be taken up by adjustment of channel planform as well as width, that is to say meander amplitude would increase and wavelength decrease downstream of a knickpoint. It is surprising therefore to find that exactly the opposite is occurring on Little Topashaw Creek. Several bends downstream of the knickoint have been or are close to being cut off through the point bar, a process which must take place during high flow events when the entire channel cross section is inundated. It is evident in several bend sections that at the onset of degradation the knickpoint cut back, not round the thalweg of the bends but actually through the inside of the point bar. This has left several relict bend apices at a pre-incision level, with the channel now flowing through what was once below the point bar (see figure 4).

Figure 4. Diagram of channel morphology in bend apices downstream of the knickpoint



The channel has therefore increased meander wavelength and reduced meander amplitude during the processes of degrading. With such changes must come an increase in slope, but this is evidently not the case as slope is lower downstream of the knickpoint as compared with upstream. The slope can only have been reduced therefore by deposition of material on the channel bed. Indeed observations in the downstream reaches suggest that a considerable layer of sand has been laid down on the bed, on the point bars and in some cases at the base of the outside bank. Sedimentation rates appear to be quite rapid as few young trees are evident on the point bars. The rate of deposition has therefore outstripped the germination and growth rate of pioneer species. As a consequence dendrochronological dating of sedimentation rates has been difficult with few trees to give statistically significant results.

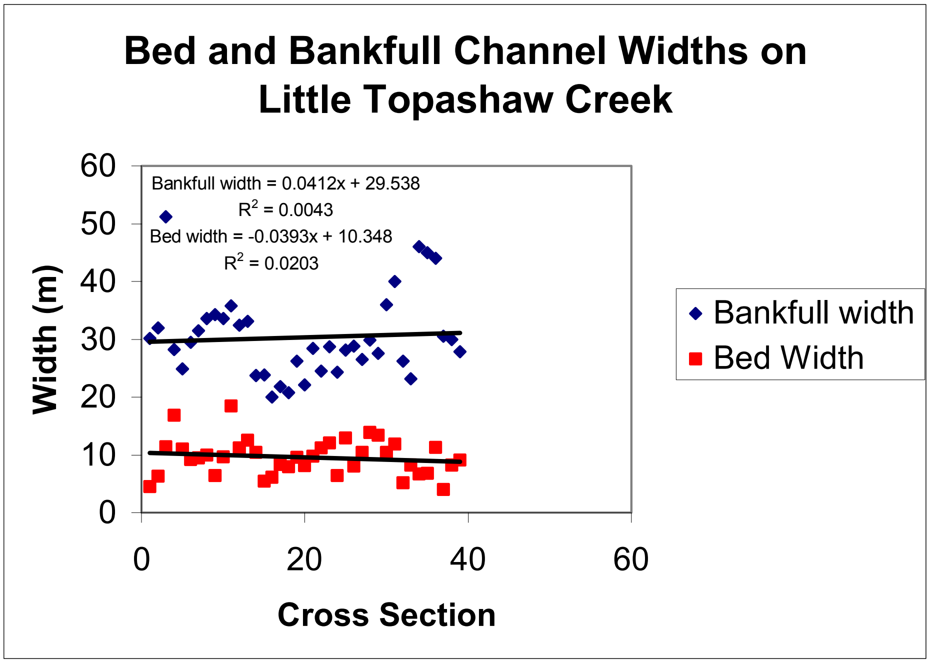
It must be recognized that this rapid rate of deposition is not entirely due to sediment production by the knickpoint in the survey reach as there is at least one other knickpoint located upstream of the bridge which is generating a percentage of the deposited sediment. Sediment generation by the upstream knickpoint is also confusing the geomorphology idealized by evolution models in the reach upstream of the knickpoint in the survey reach. In theory, upstream of a knickpoint the channel should be undisturbed (unless there has been human intervention). This is not the case in the survey reach as upstream of section 7 the channel appears to have undergone at certain degree of incision and lateral erosion (there are oversteepend cut banks). The reach is therefore still in stage 3 after the passage of the upstream knickpoint and in about to have stage 3 superimposed on top again as the downstream knickpoint migrates upstream.

Cross Section Data

Figure 5 shows a plot of bed and bankfull widths against cross section. The regression trend lines show that width does not increase systematically when moving downstream, but this is to be expected, as the reach is quite short. Peaks in the bankfull width are observable at cross sections 4, 11, 32 and 35. These are all bend apex locations.

Figure 6 shows cross section plots for each of the 39 cross sections from the January-February 2000 survey. Looking at sections in the vicinity on the knickpoint (section 10) it is hard to detect a stage 3-type incision slot into the bed of the channel. Rather it appears that the full channel width has been eroded immediately downstream of the knickpoint. This was also observed in the field. Stage 5 type berm formations are clearly evident in the downstream reaches (see for example section 31 and 34). In the field these berms appear to be quite steep on the channel-ward side, and many of the new point-bar/berm formations have vertical cut banks over 1 m high, suggesting that the process of channel cutting into the *inside* of bends is either ongoing from the time of incision or has stopped and begun again more recently. Such a re-start of erosion processes could be caused by complex response due to oversteepening at the downstream end of the stage 5/6 reach.

Figure 5. Bed and Bankfull Widths along the Survey Reach



The bed slope may yet therefore be too steep to balance between stream power and sediment supplied from upstream. Further reduction of bed slope downstream of the knickpoint is likely. This observation is a cautious one, however, as it may also be the case that the cutting into point bars and berms is merely a cyclic process, the features being renewed channel-ward as high flows recede then cut into during low flow conditions.

The meandering nature of the reach planform is manifest in the cross sections through their asymmetrical shape. The point bars and bend apex cut banks are also clearly discernible. Incision away from the bend apex thalweg, through the pre-degradation point bar is also observable in some cross sections, sections 34 and 35 for example, where the outside of the bend is on the left bank.

Figure 6. Cross Sections 1 to 39, Little Topashaw Creek.

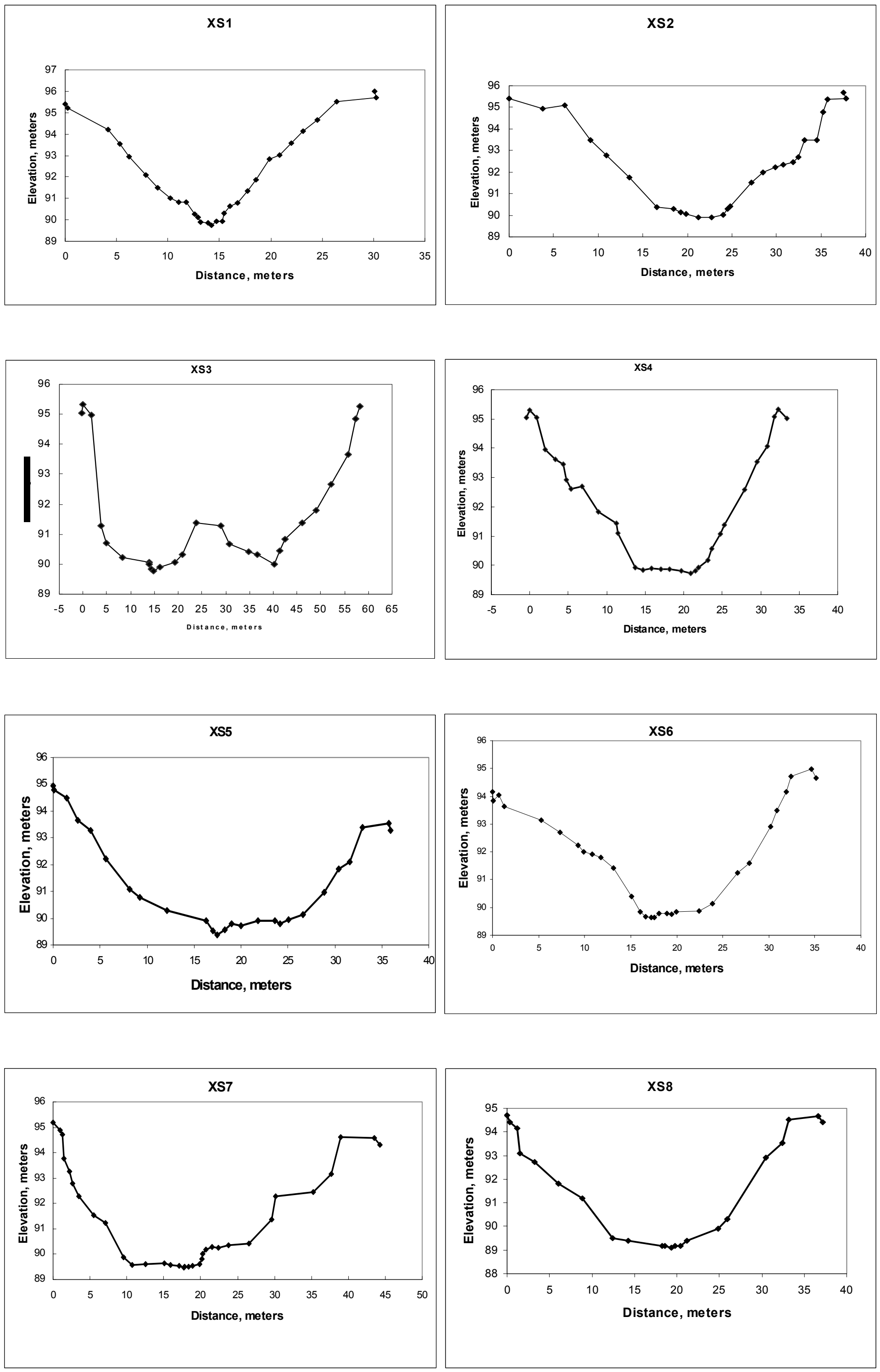


Figure 6. Cross Sections 1 to 39, Little Topashaw Creek (cont).

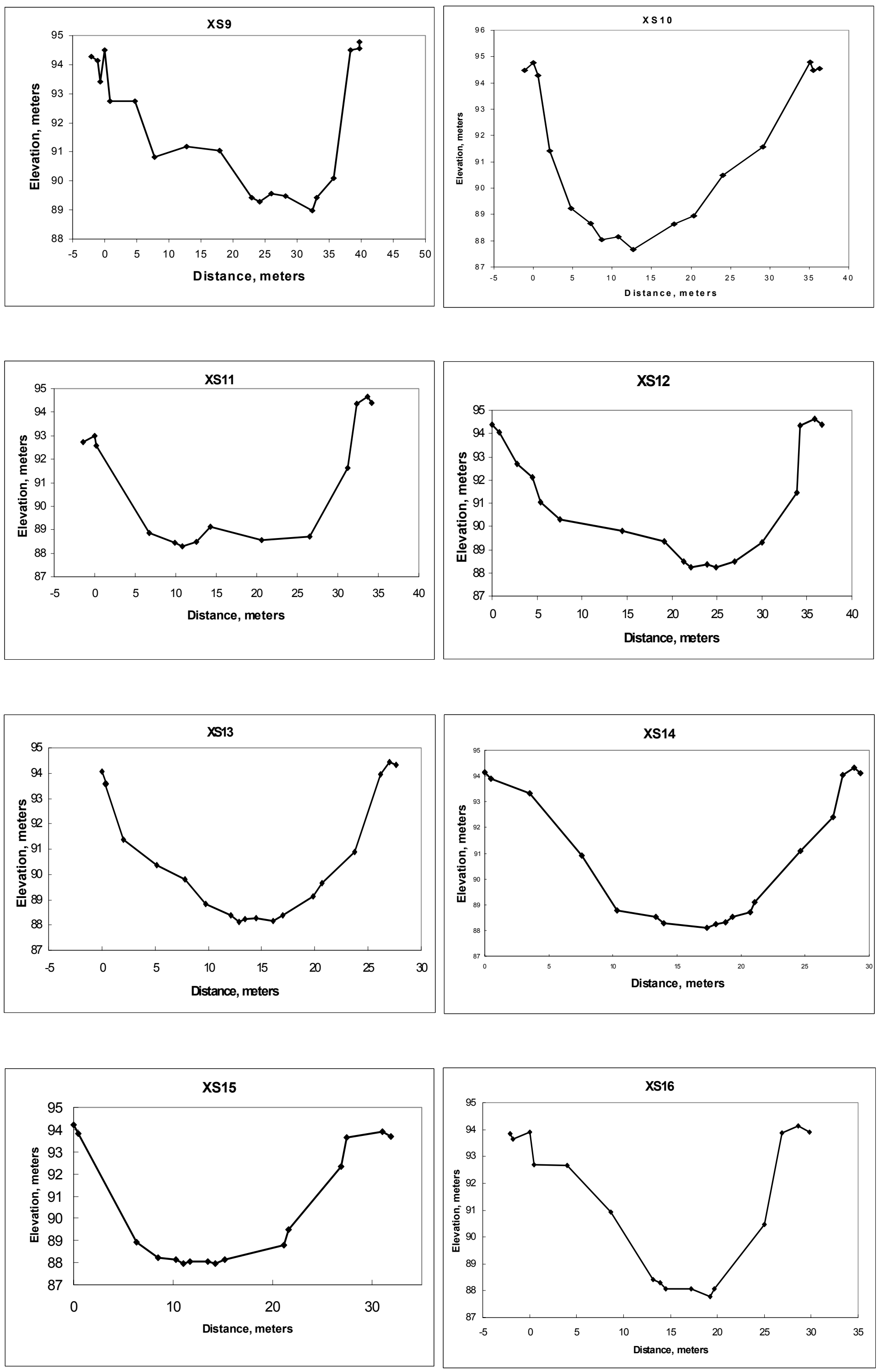


Figure 6. Cross Sections 1 to 39, Little Topashaw Creek (cont).

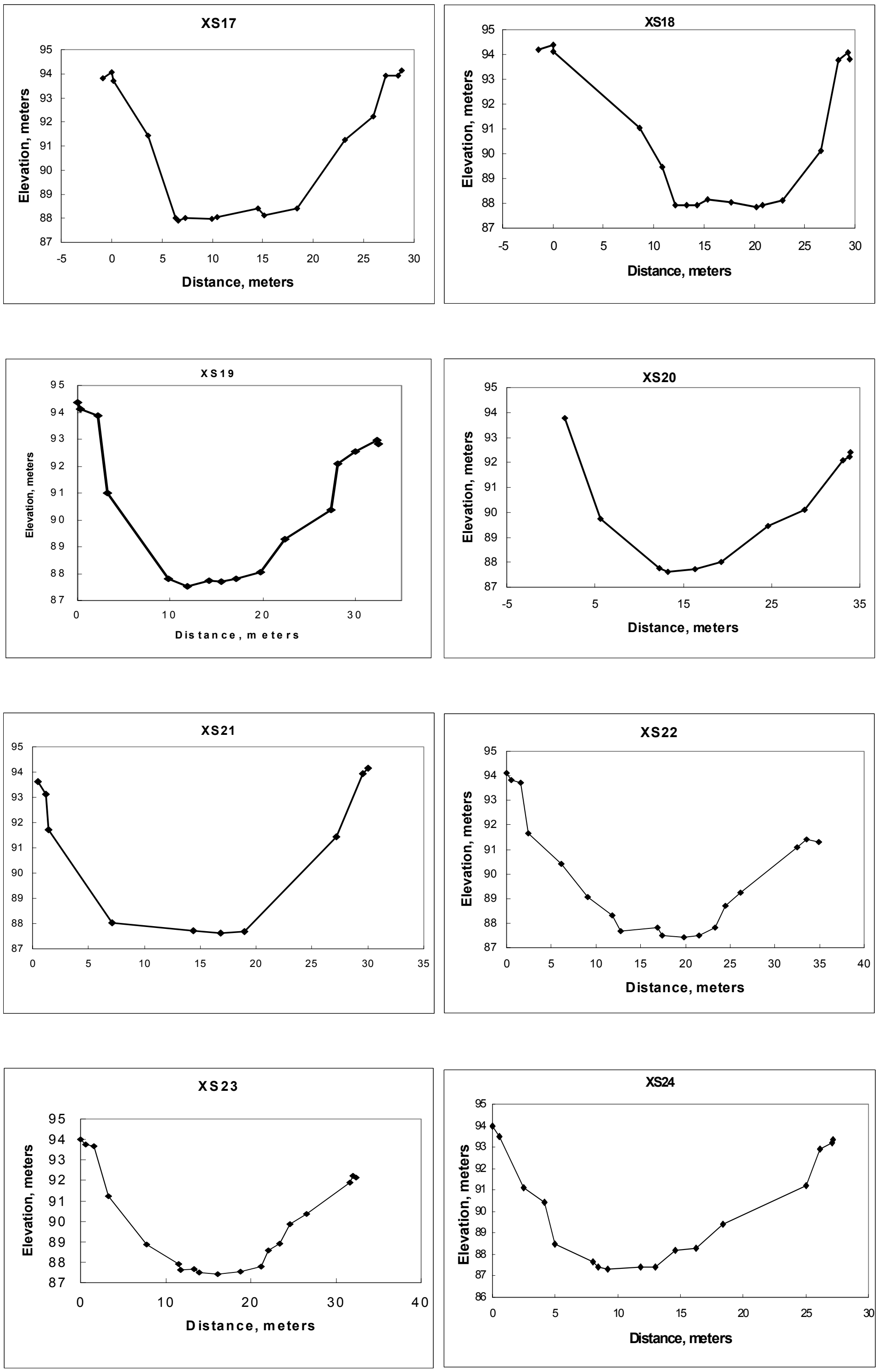


Figure 6. Cross Sections 1 to 39, Little Topashaw Creek (cont).

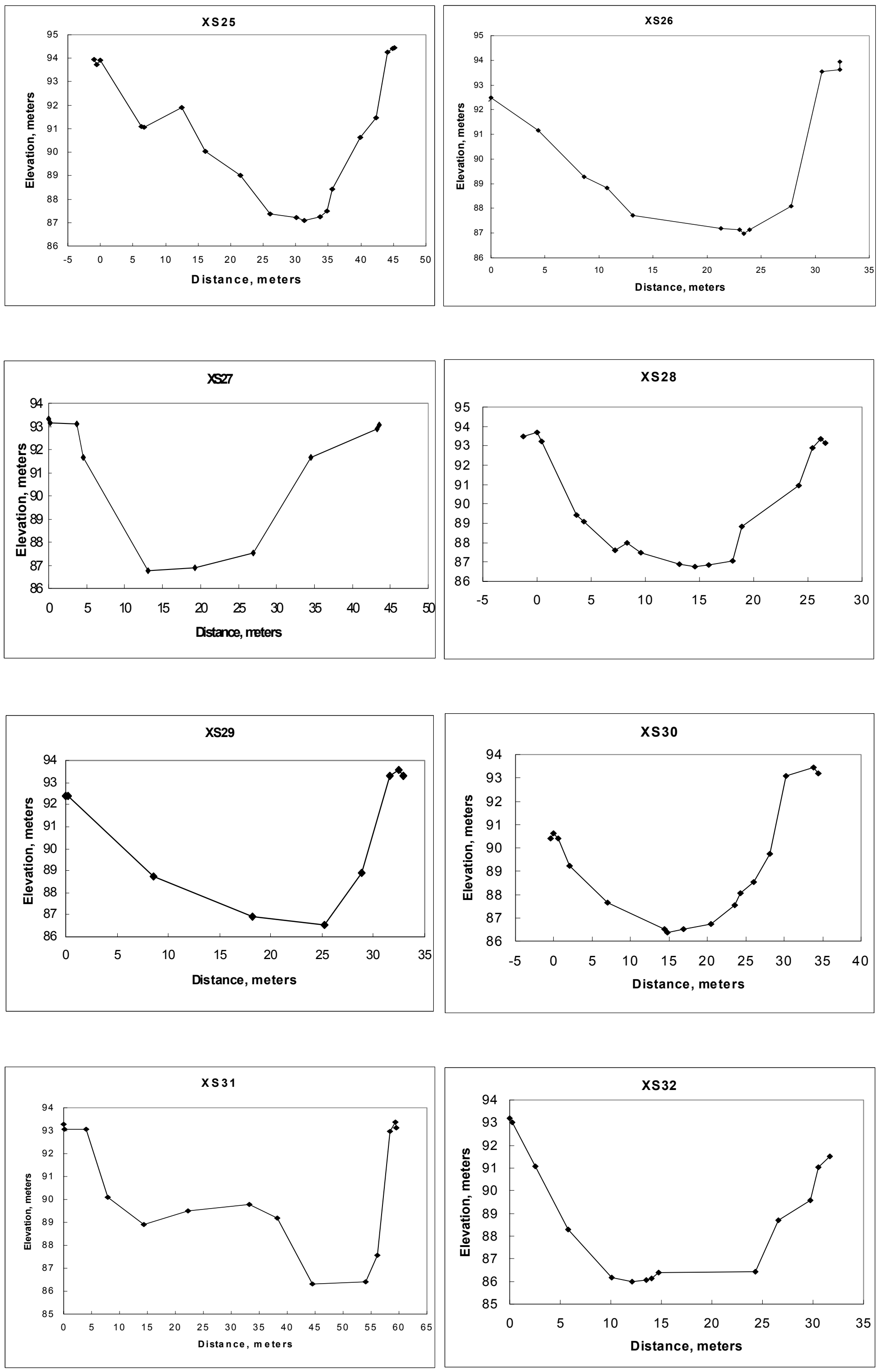
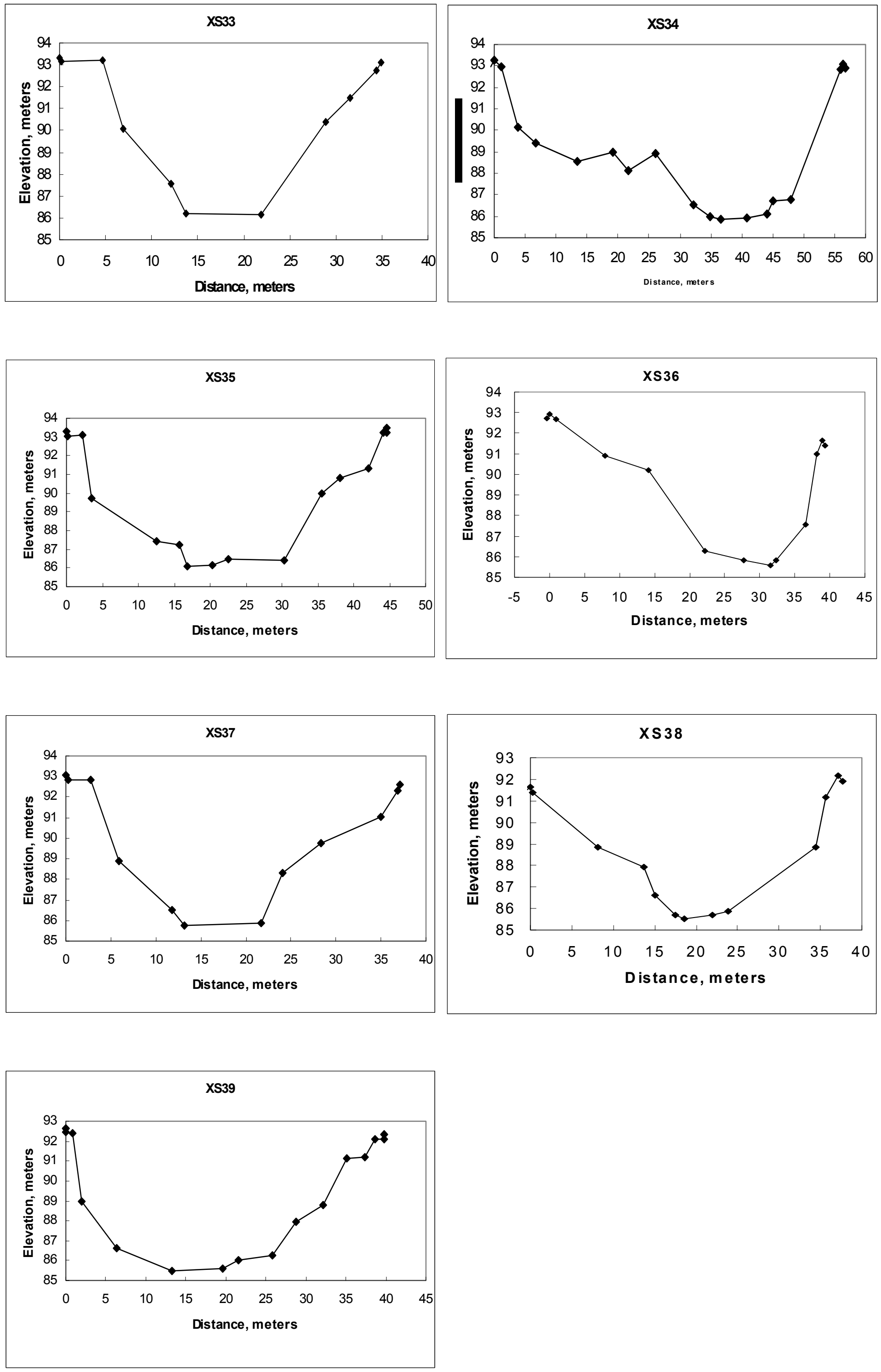


Figure 6. Cross Sections 1 to 39, Little Topashaw Creek (concluded).



Deposition and Failure Rates

Refer to figure 7. Deposition rates at each cross section were determined by digging at the base of woody vegetation on the berms/point bars, finding the depth from the root wad to the ground surface, and dividing by the age of the tree. However, as noted before, few trees were found in the reach below the original floodplain level, so there were many berms and bars that could not be dated. The data presented in figure 7 therefore presents an incomplete picture of the true nature of sedimentation in the reach. It might be expected that sedimentation rates would have some trend away from the knickpoint but no relationship is discernible in the plot. What is evident, however, is the lack of sedimentation upstream of section 10, which is just downstream of the knickpoint. This is as might be expected as the channel in this reach is in stage 3 of evolution. Sedimentation rates appear to be quite low, but the opposite was probably true in the recent past, as the lack of trees suggest deposition rates too quick for tree growth to keep up. Depth of deposits the stage 5 reaches were observed to be well over 1 meter, but there are few trees growing from the berm bases, suggesting an initial rapid rate of sedimentation which has now slowed.

Figure 7. Deposition Rates For Each Cross Section.

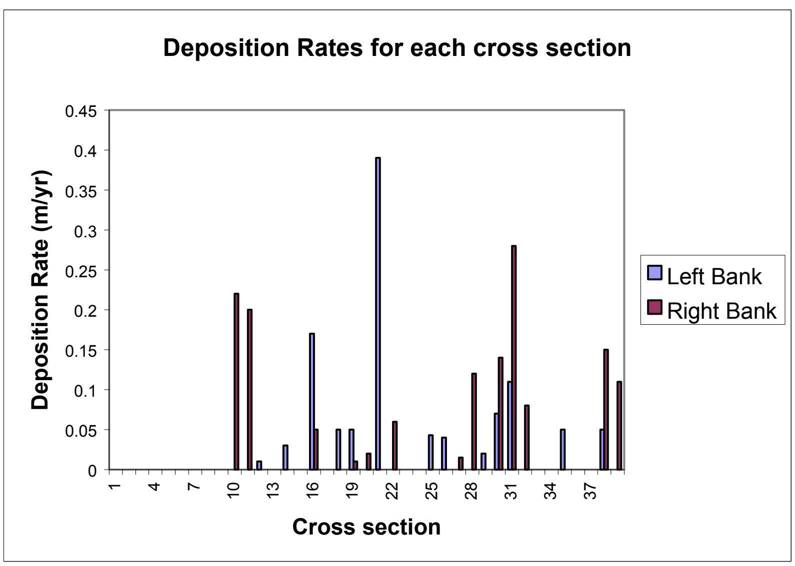
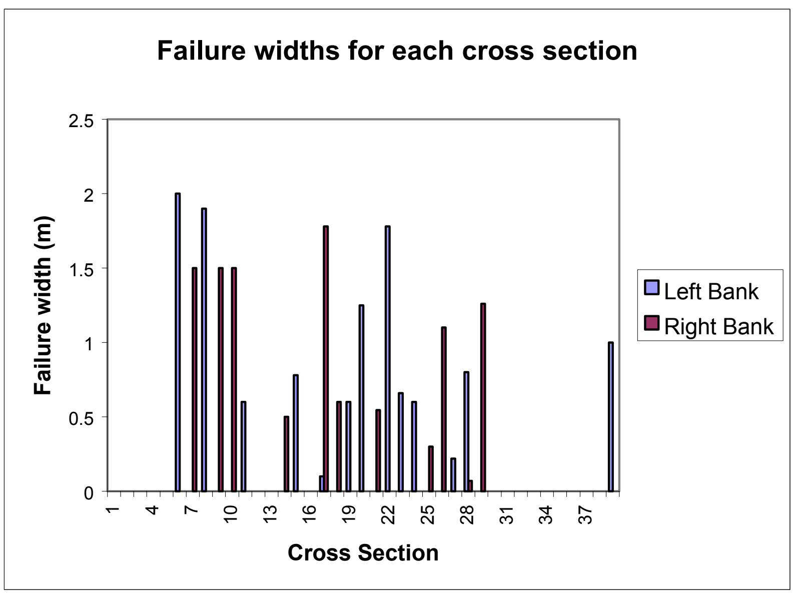


Figure 8 presents bank failure widths measured in the field. Failure widths were determined by measuring the width of failed blocks lying at the bank base, and by measuring the distance by which exposed roots protruded from the banks. The rate of bank retreat is more difficult to quantify from vegetation than the rate of deposition as one can only determine that failure was less than one year ago if the exposed roots have hairs on them, or greater than one year if there are no hairs. Only two bank failure locations had roots with hairs on them, so this data does not represent the *rate* of failure, just gross recession over an unknown period of time. Again the data is somewhat inconclusive but there is some evidence that active bank retreat has ceased downstream of section 29 (39 is an exception, but this is in a bend apex). It should be noted that the majority of failures observed in the field were located either in the apex of bends against the outside bank (on those bends where the thalweg has not cut through the point bar). The lack of exposed root hairs suggests that there has not been sufficient flow in the past 12 months for active fluvial erosion of the bank bases, and consequently mass failure, to take place.

Figure 8. Failure widths for each Cross Section



Summary

The reach surveyed on Little Topashaw Creek is currently in a dis-equilibrium state due to knickpoint migration through the reach. However, the idealized progression of evolution stages are not to be found through the reach as there are other knickpoints upstream which have already imposed geomorphic adjustment prior to the passage of the in-reach knickpoint. Slope has reduced with the passage of the knickpoint, and planform is also changing.

The lower end of the reach (sections 39-18) has now reformed a new equilibrium channel within the older degraded cross section. The reach from section 17-11 is still adjusting to an excess of stream power by width expansion, while further upstream through the knickpoint region the channel is, or has recently, degraded its bed due to the passage of at least 2 knickpoints.

The reach has a high sinuosity, so normal meander processes of lateral migration and point bar deposition are superimposed on the degradation sequence.