The pages in this document were taken from the "Millers Creek Watershed Improvement Plan" published in April 2004. The entire document can be found at http://www.aamillerscreek.org/Findings.htm.

Millers Creek Watershed Improvement Plan

Excerpt Showing an Example of How to Develop Indicators to Measure Progress

April 2004

2.4 Stream Stability and Rehabilitation

In this plan the term ‘stream rehabilitation’ is used to distinguish between full restoration to some pre-development state and an intermediate end point that lies between a completely degraded resource and a completely restored one. The intent of the plan is to partially compensate for human damage to biodiversity and ecosystem dynamics by working with natural regenerative processes in ways that lead to the re-establishment of more sustainable relationships between nature and culture.

Natural stream stability is achieved when the dimensions, pattern and profile of a channel are maintained and the stream neither aggrades nor degrades. A generalized stable channel balance for flow and sediment discharge was first proposed by Lane (1955) as:

$(Q_s)(D_{50})$ is proportional to $(Q)(S)$

where,
Q_s = sediment discharge
D_{50} = mean particle size
Q = flow
S = bed slope

A change in any one variable will be offset by a change in the companion variables and characteristics of the river. For instance, wholesale increases in the magnitude and frequency of peak flows will result in sediment load increases and likely lead to channel degradation. This channel degradation means the channel "cuts down" and becomes incised.

Several decades of research on stream shape have found that there are distinct relational patterns between channel shape and bankfull flows. In natural rivers, bankfull flow is, as the name implies, the discharge that just fills the stream to the top of its banks. Bankfull flow has also been defined as the flow that does the most work to determine channel shape. Although extreme floods can radically alter a channel, the basis for the average channel characteristics, size, bars, bends, and meander shape is bankfull flow. This discharge moves the most sediment over time due to its size and relative frequency of occurrence.

Bankfull flow has been shown to occur on average once every 1.5 years; however, a wide range, between 1 and 25-year occurrence rates, has been reported in the literature (Rosgen, 1996). For incised streams, such as Millers Creek, bankfull flow is not necessarily descriptive of existing conditions because incised, deeper channels flood much less frequently, if ever. However, the idea that a certain size event of a given frequency does most of the work to shape the stream is still meaningful. In this regard, we will refer to the theoretical idea of a channel-forming event as the "effective discharge" and will assume that it is somewhere in the vicinity of the 2-year recurrence interval design storm for this region. Where the stream cuts through the Ruthven Nature Area, flooding occurs between the 1-year and 2-year design storms. This is probably indicative of the flooding frequency along most or all of the stream before the watershed was built out.

The relationships between effective discharge and channel shape are related to the regional climate, lithology, depositional and erosional history and vegetative cover. In this area, a broad database relating shape and discharge is not available. In order to have a fluvial geomorphological basis for management decisions on Millers Creek, the Project Team applied Rosgen's hierarchical stream classification system (Rosgen, 1994). This system was developed with several decades of quantitative research on rivers across the country as a systematic way to understand river behavior. Rosgen's analysis found that parameters used to describe stream morphology tend to cluster into definable groups and have predictable patterns of variation [*See* ***Appendix I*** *for a PDF version of Rosgen's original paper on his stream classification system*]. Most importantly, Rosgen has demonstrated that the stream response to management actions can generally be predicted in relation to the stream type (Rosgen, 1996).

2.4.1 Incised Channel Evolution Model

Schumm, et al. (1984) used a location-for-time substitution to develop a model of incised channel development. The assumption of this substitution technique is that reaches in different states of development reflect differences in the local channel reaction along the same trajectory in time. In other words, channels undergoing incision have to pass through the same stages of channel morphology, and at any given time, reaches in the channel can be found at different stages along that continuum.

Rosgen has characterized a similar series of stages that channels pass through in reaction to changing conditions in the watershed. Rosgen has defined sequences of channel adjustments by use of his stream classification system. **Figure 2.8** demonstrates one possible evolutionary sequence for a type E4 stream undergoing incision that correlates well with the five-stage channel evolution model of Schumm. The Rosgen classification system offers the utility of expressing a series of field parameters as an identifiable stream type or stage in the evolutionary cycle of stream development.

Most importantly, Rosgen and others have been able to associate a stream’s overall capacity for rehabilitation and the effectiveness of specific rehabilitation measures with specific stream types (Rosgen, 1996). This project will rely upon the Rosgen stream classification method to corroborate hypotheses of underlying problems and to help judge potential success of restoration measures in relation to the classification results.

Below are the descriptions (a-f) of the channel types shown in order from top to bottom in **Figure 2.8**. On the left of **Figure 2.8** are representative channel cross-sections along Millers Creek, with the bankfull water surface elevation shown. On the right of **Figure 2.8** are the theoretical set of adjustments one particular channel section would go through over time as it adjusts to a new and more intense hydrologic regime. This comparison highlights the location-for-time substitution idea proposed by Schumm; i.e., different reaches in a stream will make adjustments to hydrologic changes at different times (e.g., the representative cross-sections in Millers Creek on the left side of **Figure 2.8**), while each impacted cross-section eventually passes through the same trajectory of channel morphological changes over time (e.g., the right side of **Figure 2.8**).

Figure 2.8 Description

a. An existing E-stream type experiences higher and more frequently occurring peak flows that widen the channel to a C-stream type. The E-stream type is a very stable stream type unless the banks are disturbed and there are significant changes in hydrology and sediment supply (Note: dashed lines on the Rosgen figure represent the future trajectory of the same cross-section at each stage).

b. The C-stream type continues to experience disturbance. Increased shear stress at the toe deepens the low point of the channel. The C-type stream is more susceptible to shifts in both lateral and vertical stability caused by channel disturbance and hydrologic changes than the E-type stream. Rates of lateral adjustment are influenced by the presence and condition of riparian vegetation.

c. The C-stream type is still out of equilibrium with existing conditions and converts to a G-stream type. The G-stream type is moderately to extremely incised and has lost its connection to the floodplain. This process of incision increases velocities and shear stresses because all flows are now confined within the banks. The channel rarely if ever experiences overbank flow. G-type channels tend to have high bank erosion and bedload transport rates. These stream types are very sensitive to disturbance (inherently unstable) and tend to make significant adverse channel adjustments to changes in hydrology and sediment supply.

d. The G-stream type eventually widens to an F-stream type. Velocities begin to slow down and the stream begins to meander. Sediment supply in an F-stream type can be moderately high. Depositional features are common and tend to promote the creation of a new floodplain within the channel.

e. Meandering creates a C-type stream within the confines of the original channel.

f. Additional settling out of solids builds up a new, active floodplain, and a new E-stream type within the original channel. The old floodplain is perched above the active stream and is now referred to as a terrace.

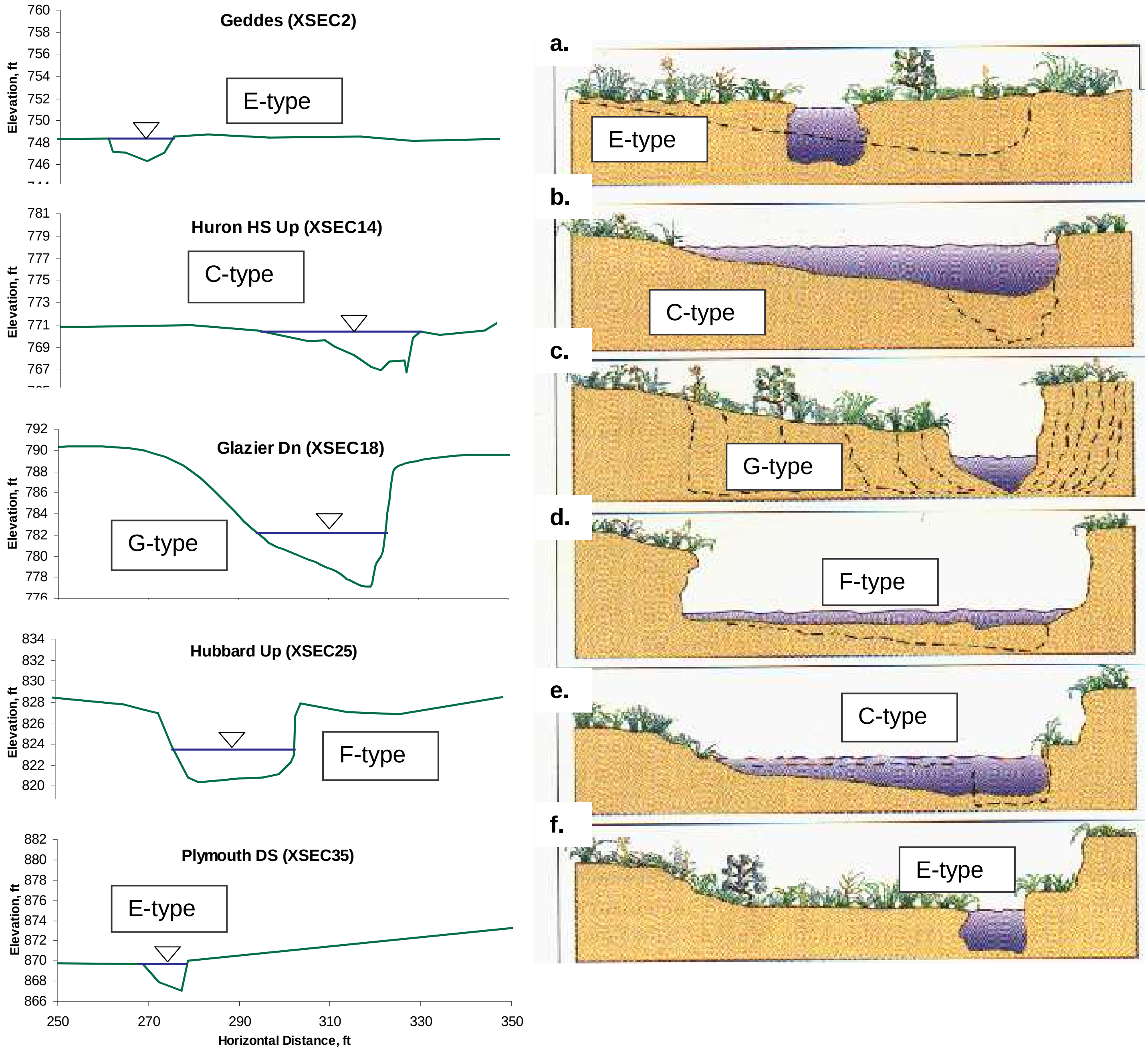

Figure 2.8 Millers Creek Cross-sections (left) and an Example of Channel Evolution (right), modified from Rosgen (1996)