THE PHYSICAL LANDSCAPE

The Kettle Creek watershed lies in the heart of the north central Pennsylvania mountain region. The stream carves its way, north to south, through the unglaciated Appalachian Plateau. The geology of the watershed and the region is characterized by layers of sedimentary rock, subdivided by narrow stream tributaries. The resultant terrain is moderately to extremely rugged, limiting intensive development.

PHYSICAL
LANDSCAPE

Physical Setting

The watershed can be broadly divided into three geologic sections. The southern portion of the watershed is influenced by the highly resistant Pennsylvanian Sandstones of the Pottsville and Allegheny group (Geyer and Wilshusen 1982). In this section of the watershed, generally flat, broad ridges are broken by extremely steep valley sideslopes and narrow floodplains. The important coal seams of the Allegheny group have played a key role in the development, land-use, and water chemistry of this section. The central and northern sections of the watershed are underlain by Mississippian and Upper Devonian shale, siltstone and sandstone formations. This portion of the watershed has narrow to broad ridges and moderate to steep valley sideslopes interspersed by floodplains of various width. The rolling plateau and broad floodplains of these sections have allowed for some moderate development of agriculture and residential areas. The sedimentary layers of this portion of the watershed are being explored and developed for natural gas production and storage.

Soils of the watershed are variable and are greatly dependent on the surface bedrock geology. Hazleton and Laidig soils are common in the coves of the tributary streams. Ungers and Meckesville soils occupy the sideslopes and Hustontown soils are often on the ridges. Many of the floodplains are composed of the Barbour and Craigsville soil series. A small section of glacially derived Lordstown soils occur on the extreme headwaters of the watershed. Soils can be classified based on their ability to infiltrate water. Kettle Creek has primarily B and C hydrologic soil groups. These soils are well drained to moderately drained, respectively. Most of the land-use limitations of soils on the watershed are due to slope and stoniness and subsequently much of the watershed is publicly owned as state forest.

The watershed contains 429 miles (690 km) of stream. Large streams have been broken into subwatersheds to assist in the description of key ecological and cultural processes (see map 1.2). Figure 1.3 is a summary of some of the physical characteristics of the subwatersheds of Kettle Creek.

Hydrology

Water is a large part of what makes the Kettle Creek watershed a special place. In order to appreciate the various processes and issues related to watershed health, we first attempt to discover the patterns and relationships of stream flow and climate. United States Geological Survey (USGS) stream gages at Cross Fork and Westport and precipitation measurements at the Alvin Bush Reservoir provide some of the data needed to assess the nature of the hydrologic cycle on Kettle Creek.

Stream flow on the Kettle Creek watershed is primarily dominated by rainfall inputs, although snowpack on the higher elevations of the watershed can influence water storage and runoff during the winter. In any region, rainfall amount and timing is uniquely distributed throughout the year. (See Figure 1.1: Alvin

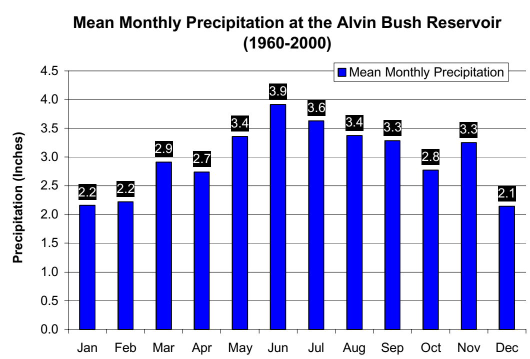


Figure 1.1 - This chart shows average monthly precipitation at Alvin Bush Reservoir. Average monthly rates of precipitation provide us with a "measuring stick" to judge unusual events.

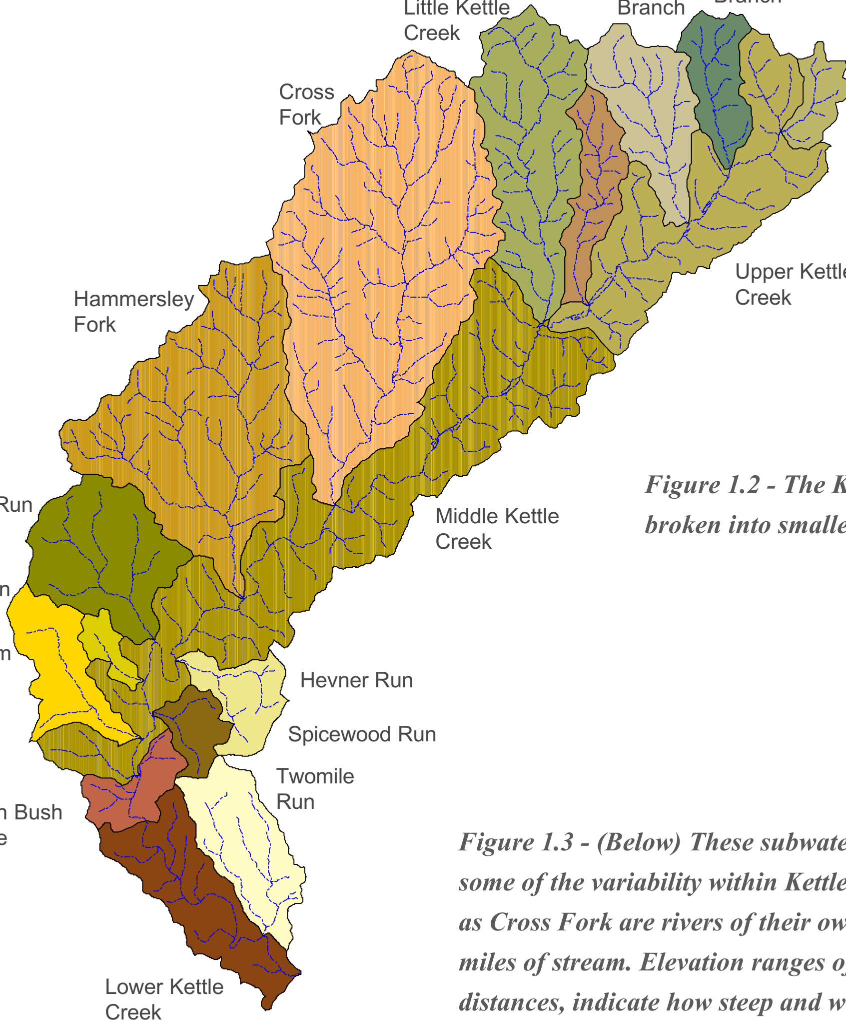


Figure 1.2 - The Kettle Creek watershed can be broken into smaller, unique sub-watersheds.

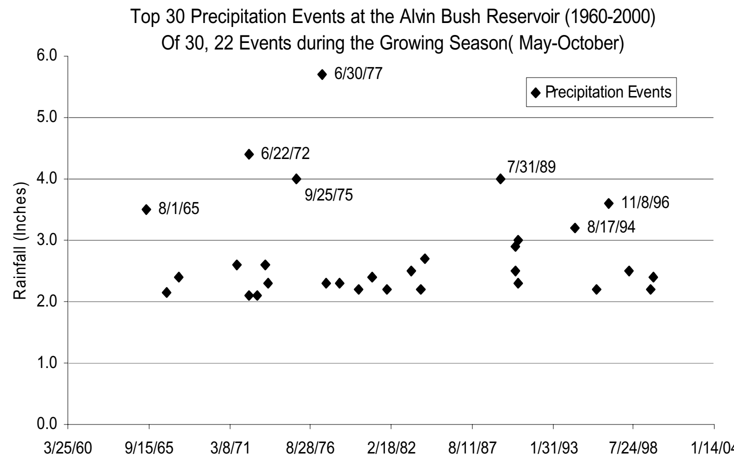
Figure 1.3 - (Below) These subwatershed descriptions indicate some of the variability within Kettle Creek. Subwatersheds such as Cross Fork are rivers of their own, with almost one-hundred miles of stream. Elevation ranges of over 1000', often over short distances, indicate how steep and wild the subwatersheds of Kettle Creek really are.

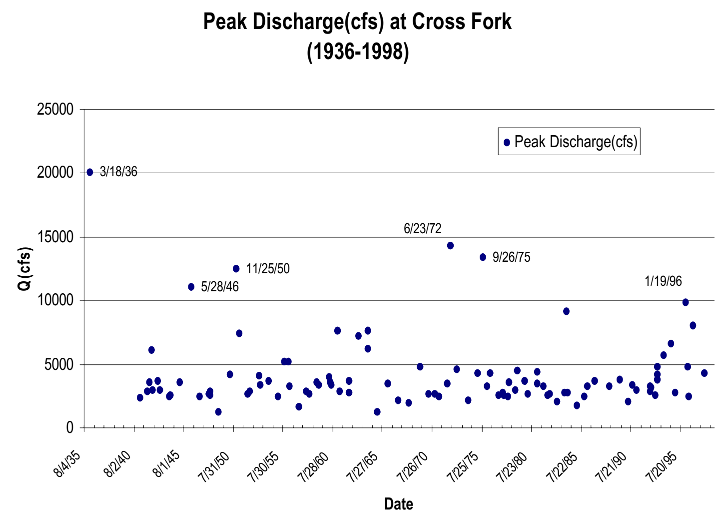
Subwatershed	Area(mi2)	Stream Length(mi)	Drainage Density (km/km^2)	Mean Basin Slope°	Elevation Range(ft)	Max. Elevation(ft)
Lower Kettle Creek	11.25	18.44	1.02	15.00	1499	2162
Twomile Run	9.15	13.74	0.93	8.32	1469	2204
Alvin Bush Lake	3.93	6.74	1.07	19.12	1348	2165
Middle Kettle Creek	45.29	79.73	1.09	16.78	1397	2237
Beaverdam Run	7.18	6.88	0.60	16.13	1437	2293
Spicewood Run	3.11	3.97	0.79	18.54	1348	2204
Walters Run	1.77	2.00	0.70	17.32	1269	2145
Trout Run	13.07	13.95	0.66	13.98	1401	2296
Hevner Run	4.81	7.57	0.98	14.87	1322	2240
Hammersley Fork	32.55	57.42	1.10	16.24	1374	2365
Cross Fork	49.92	94.70	1.18	14.65	1466	2512
Little Kettle Creek	18.25	36.23	1.23	13.84	1194	2437
Upper Kettle Creek	21.77	41.97	1.20	13.78	1210	2467
Long Run	6.01	13.19	1.36	12.31	1082	2388
Germania Branch	9.70	18.29	1.17	10.51	889	2388
Sliders Branch	5.54	9.74	1.09	11.51	813	2417
Billings Branch	3.01	5.35	1.10	9.18	686	2450
Total/Average	246.31	429.91	1.02	14.24	1247	2316

Bush Precipitation) The timing and intensity of precipitation will affect watershed functions, including fishing quality, flooding or the generation of pollution. An understanding of the timing and nature of precipitation can help us develop the best strategies for assessing water quality, fisheries productivity and habitat limitations. For example the majority of high flows occur on Kettle Creek in the spring, but the heaviest rain events are often in the summer (See Figure 1.4). These heavy summer rains are effective at creating erosive runoff events (Brooks and others 1997). If we are interested in monitoring stream sediment concentrations, it is advisable to sample in the summer during these large events. Alternatively, it may be best to sample for nutrient enrichment in the spring during high flows (See Figure 1.6).

During most years, the stream flows provide positive benefits to the Kettle Creek community, but at other times, Kettle Creek can react violently to unusual weather events. Stream gages on the watershed record these peak events and this information can be valuable for the prediction of the likelihood of future flood flows (See Figure 1.5). These peaks can have a dramatic effect on floodplain residents and will also influence the stream channel and fish habitat. While many of these "extreme" events have had negative consequences, it is the recurrence

RIGHT TOP AND MIDDLE: These charts illustrate a variety of hydrologic information. The top chart shows the peak storm events on record at Alvin Bush Reservoir. Most large storms occur in the summer, potentially contributing to erosive runoff. The middle chart shows peak stream flows at Cross Fork. Most high flows occur in the spring, but many of the largest events can occur in the growing season. It is likely that these flows are created by hurricanes.





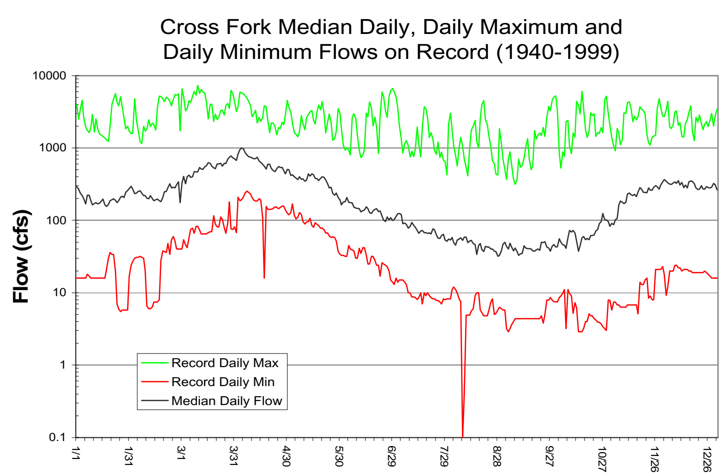


Figure 1.4,1.5,1.6 - The average maximum and minimum streamflows by date are indicated above.

of less-destructive, moderate flows called bankfull events, which shape and maintain the quality and character of Kettle Creek streams.

The size and frequency of these bankfull events are critically important in the design of fish habitat improvements and bank-erosion reduction projects (Rosgen 1994b). Based on field data around the U.S., bankfull events generally occur about every 1-1.5 years (See Figure 1.7). Bankfull flows at Cross Fork are probably about 2300 cfs. These are simply the probability of stormflows based on the historic flows. Future high water events may occur more or less frequently. The probability distribution was developed based on the Log-Pearson Type III distribution.

The Alvin Bush Reservoir, constructed in the late 1950's, has an influence on the hydrology of the Kettle Creek watershed. Built primarily as flood control for the town of Renovo, the dam limits peak flow events on lower Kettle Creek and distributes the flow over a longer period of time. Flow hydrographs provided by the

BANKFULL FLOWS

The term "bankfull flow" can be misleading. To a resident a bankfull event may involve the stream leaving its banks, but to a hydrologist or engineer the term "bankfull discharge" implies something slightly different. Any given stream has a particular flow that does the most "work". This "work" is the manipulation of streambed material. The movement of streambed material can create changes in stream slope, meander and habitat. These changes are all a natural part of a stream and can be extremely beneficial to stream organisms. The bankfull event is the flow that does the most work because of its frequency. Occurring on average every 1-1.5 years, these are generally our typical spring "high flows". Understanding bankfull events is critical in the design of stream restoration projects.

Average Return Interval (yr)	Flood Flow (cfs)
1.01	1359
1.05	1690
1.11	1940
1.25	2344
2	3617
5	6195
10	8588
20	11532
50	16528
100	21375
200	27385
500	37589

Figure 1.7 - (Above) This table shows how frequently high flows return at Cross Fork. Floods of the magnitude of Hurricane Agnes, are likely to occur every 50 years.

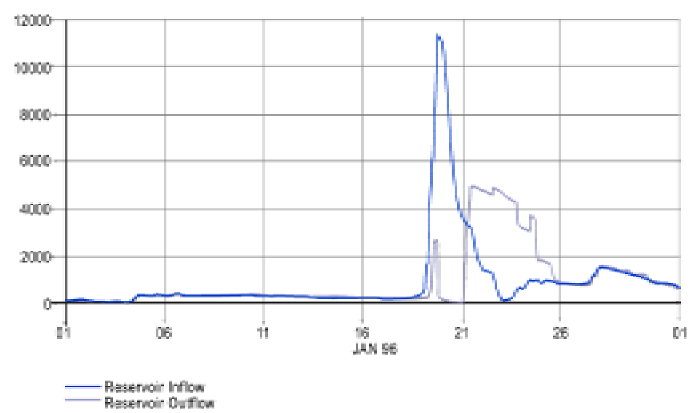


Figure 1.8 - This flow hydrograph shows the reduction of flood peaks by the Alvin Bush Reservoir. This is the flood of January 1996.

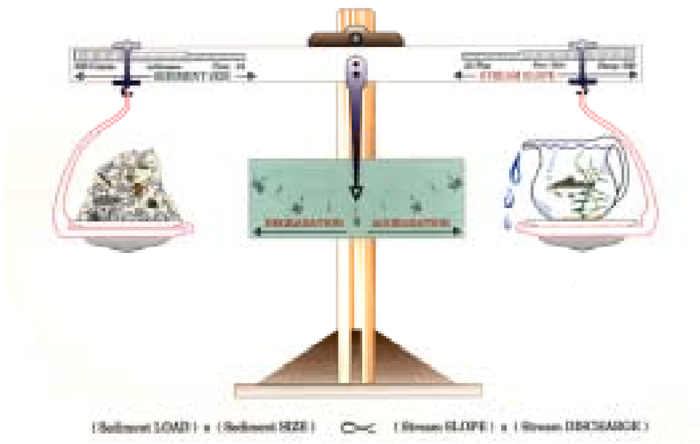


Figure 1.9 - Lane Scales (from Rosgen, 1994a). This image was developed in 1955 to illustrate the balance of watershed inputs and outputs. Any changes in the amount of streamflow or amount of sediment can affect the balance.

Class B stream channels have narrow floodplains that can be developed. Unfortunately, flooding in these areas is common.

Army Corps of Engineers illustrate these effects (See Figure 1.8). Peak flows at the USGS Westport stream gage are greatly restricted by the reservoir, making this gage station less valuable for hydrologic analysis. Unfortunately, the dam also provides a reservoir for sediment and will require periodic maintenance in order to maintain aesthetic quality.

The hydrologic properties of a watershed are often in a delicate balance. The Lane diagram helps to describe the relationship between inputs of water, sediment supply and stream slope. If we significantly change one of these values the others must compensate (Lane 1955). This balance of watershed inputs and outputs can help explain the changing character of Kettle Creek.

Stream Channel Classification

Stream channel classification helps to group stream sections according to their physical characteristics. Physical characteristics could include stream slope, streambed material sizes, cross-sectional area, or stream meandering. The classification system allows us to look at sections of the watershed as similarly functioning units. These units can provide a necessary framework for detailed habitat assessment, flood hazard areas, restoration design or bank erosion reduction.

The Rosgen stream classification system is the most common of these methods (Rosgen 1994a). This increasingly popular system of stream classification provides engineers, watershed managers and landowners a common "language" when discussing stream projects. Furthermore, the Rosgen classification system is based on the measurable physical characteristics of a stream segment. This approach allows a variety of observers to survey a stream reach, or section of stream, and come up with the same results. The Rosgen system was established to help river managers predict the re-

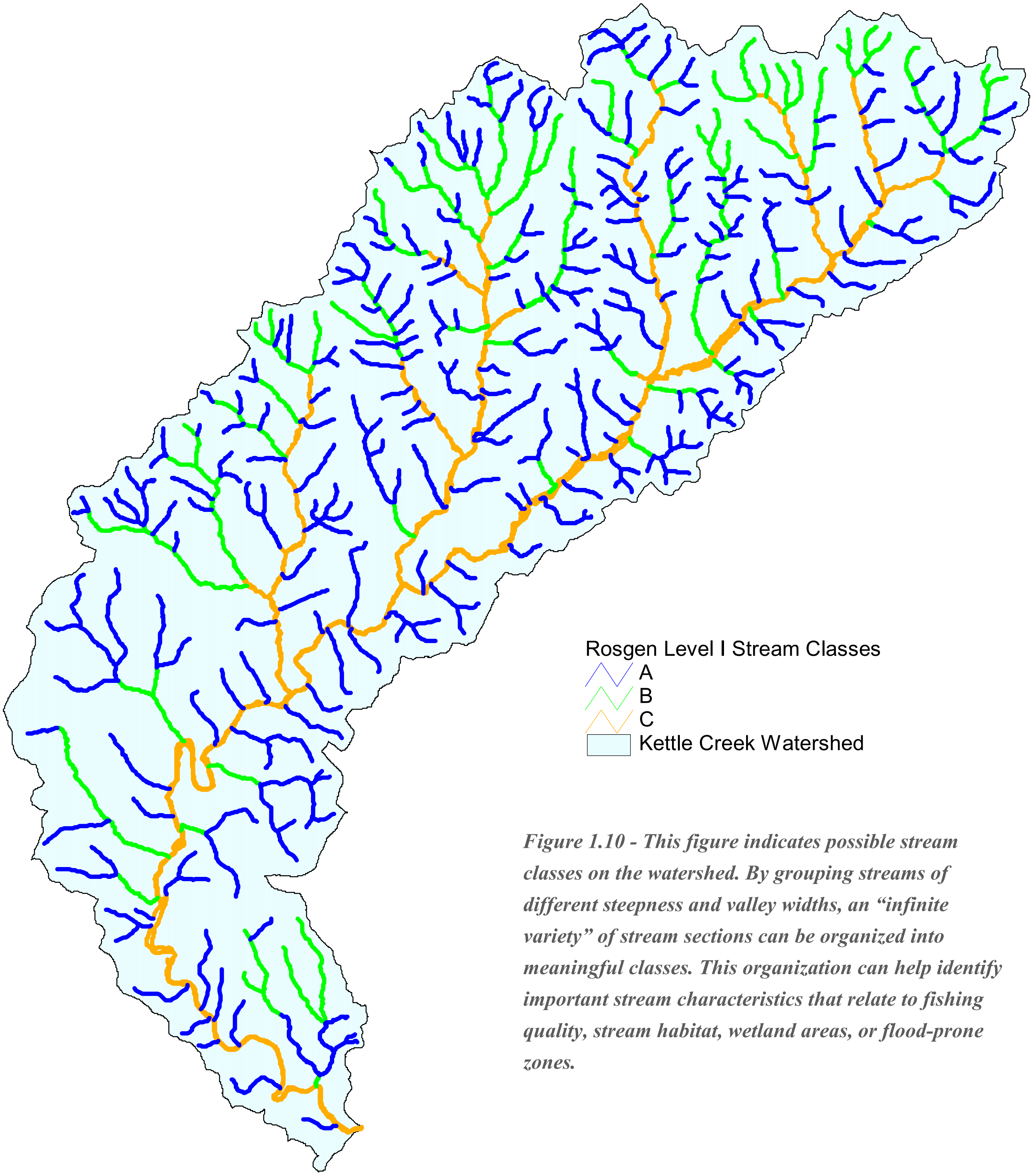
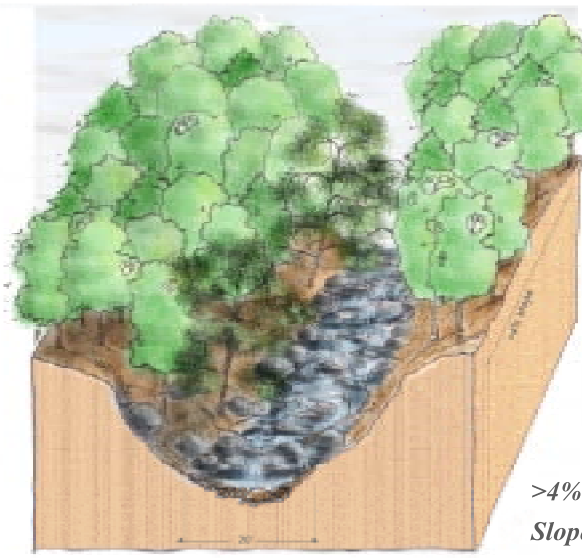


Figure 1.10 - This figure indicates possible stream classes on the watershed. By grouping streams of different steepness and valley widths, an "infinite variety" of stream sections can be organized into meaningful classes. This organization can help identify important stream characteristics that relate to fishing quality, stream habitat, wetland areas, or flood-prone zones.



>4% Slopes

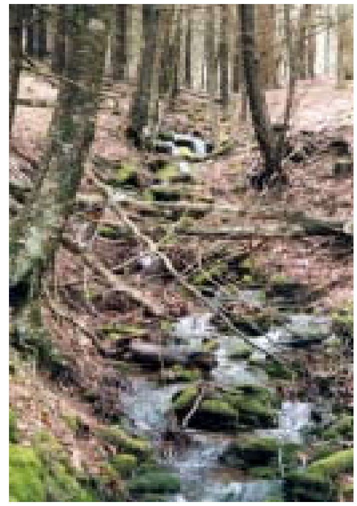
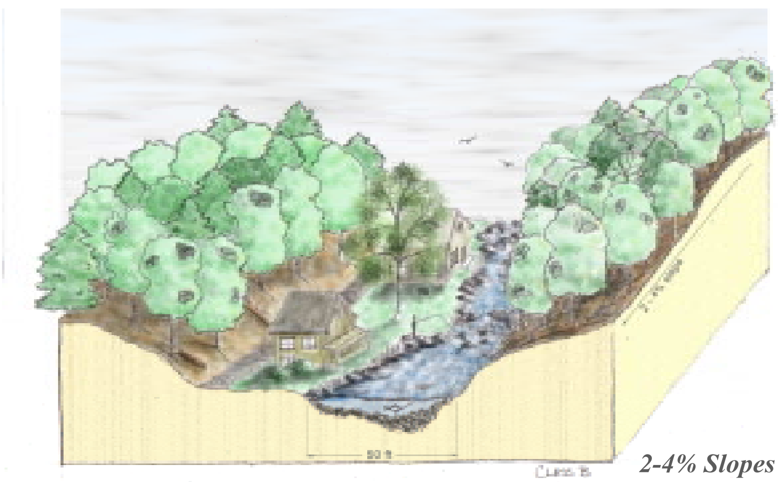


Figure 1.11 - Class A streams have steep slopes and narrow floodplains. These are often small headwater streams that act as sources of critical nutrients, sediment and food for downstream organisms.



2-4% Slopes

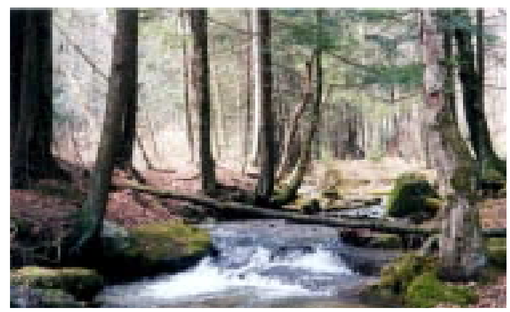
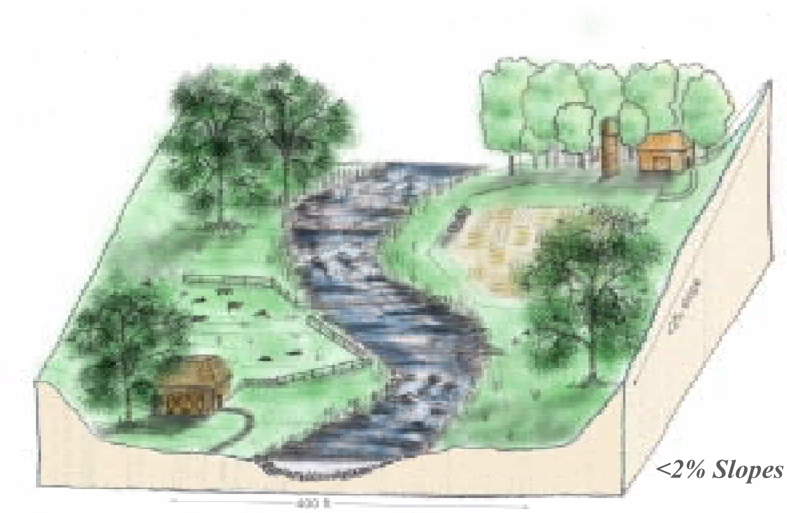


Figure 1.12 - Class B streams have moderate slopes and gravel and boulder streambeds. These streams are often the favored spawning grounds for wild trout.



<2% Slopes

Figure 1.13 - Class C streams have low slopes and wide valleys. These streams are valuable cool and warm water fisheries and are often developed for agriculture.

sponse of a river to human or natural changes. According to Rosgen (1994), a "natural stream channel stability is achieved by allowing the river to develop a stable dimension, pattern and profile over time." The ability to identify what such a "natural stable channel" should look like has greatly improved our ability to create effective stream restoration projects and improves our prediction of their influence to upstream and downstream reaches. Rosgen has established useful tables to predict the potential success of stream restoration projects based on stream class. Unfortunately, the accurate classification of stream reaches requires fairly extensive data collection within a watershed.

In order to begin to classify the streams of Kettle Creek, the Kettle Creek Keystone Projecct engaged in a Level I Classification of the watershed. This characterization was done largely from topographic maps and aerial photos. Stream reaches were grouped by similar slope class and valley confinement (the relationship of stream width to valley width). Stream slope provides a measure of stream energy, which is a dominant control on sediment transport and channel shape. Three stream classes are designated at this level of classification, Type A, B and C channels. (See Figures 1.11 - 1.13 Stream Class Illustrations) Type A channels have steep slopes and are often found in very narrow valleys. Type B channels have moderate slopes (2-4%) and Type C channels have low slopes (<2%) and are often found meandering through broad valleys. Most of the other channel types in the Rosgen Classification system relevant to this watershed would be variations of these three classes. It is probable that a variation of B channels occurs at the mouths of tributary streams and that variation of C channels occur in the larger floodplains. This initial classification provides a framework for the future prioritization of stream habitat assessments and restoration strategies. For example, habitat surveys performed on the Kettle Creek watershed are only partly representative of the stream types on the watersheds. Type A and B channels occupy over 66% of the watershed but are only represented in 25% of the habitat evaluations. Future habitat assessments should focus on these "less studied" stream reaches.

References

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