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Wolf Spider at Grahamsville Town Hall. Photo taken by Lori Kerrigan, SCSWCD.

III. Introduction to Stream Processes and Stream Ecology

For many people streams are beautiful features of our natural landscape. Residents of the Chestnut Creek watershed have told us that the sight and sounds of the creek enhances the quality of their lives here. But as all streamside landowners know, living streamside can bring as many dangers and challenges as it does pleasures. If we are to live in balance with our streams and water resources we need to understand more about how they function and why they are important to a healthy environment.

Part of the conflict between people and streams arises from the stream's ever-changing nature. As unpredictable as streams seem to be, there is something consistent about the way they change through the seasons, or even through an individual storm. If we take the time to observe them carefully, we can begin to understand the patterns in the way streams behave and, more importantly, what we might do in our individual roles as stream stewards and managers to increase the benefits and to reduce the risks they pose.

This section of the management plan is provided to offer the reader a basic explanation of how streams "create themselves": how they take different forms in different settings, what makes them evolve, and how we can manage them (and manage with them) more effectively.

A. Streams "101"

Chestnut Creek watershed is that area of land that contributes water to Chestnut Creek, in other words, the watershed land area "sheds water" to streams, which channel the water out of the landscape toward larger rivers and eventually the sea (Figure 1). The hydrologic cycle represents the collection of processes that determine routing of water through the atmosphere to the landscape and back. The amount and timing of water that flows through Chestnut Creek into Rondout Reservoir reflects the integrated net effect of all watershed characteristics that influence the hydrologic cycle.

The amount and timing of water a stream carries off the landscape is primarily determined by four landscape-scale characteristics:

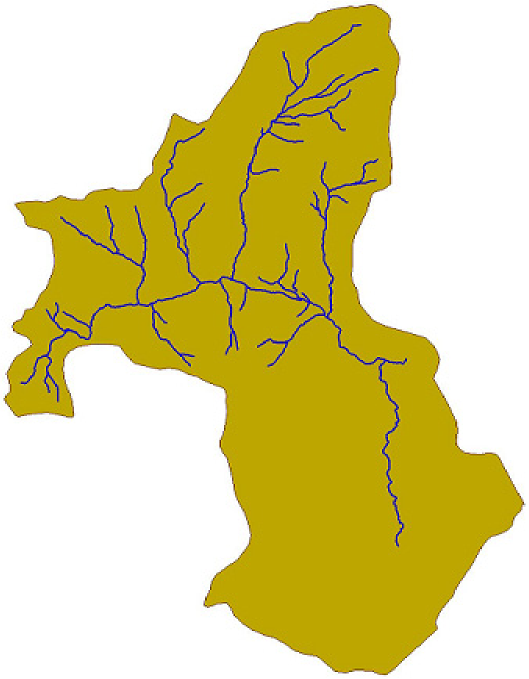


Figure 1. Diagram of Chestnut Creek Watershed.

- climate of the region, specifically the amount of precipitation (rainfall or snowfall) and the temperatures the region typically sees throughout the course of a year;
- topography (landform relief, or the shape of the land and range of elevation change) of the region and especially the watershed;
- soils and bedrock geology; and
- type and distribution of vegetation and land use (like roads and buildings), across the landscape.

These characteristics also play key roles in determining water quality and health of stream and floodplain ecosystems.

1. Stream Hydrology and Stream Flow

To begin to effectively manage a stream, managers first need to understand how much water is delivered from the landscape to the stream at any particular point in the system. *Stream flow* (or discharge, the volume of water carried per unit time, usually measured in cubic feet per second) can vary widely, dependent on weather patterns and time of year. One can watch a stream swell and shrink over the course of a year or a single storm. Hydrologists use a stream hydrograph, or a graphical representation of stream flow over some period of time, to characterize the relationship between flow and time – for example, how long it might take rainfall to reach the stream after a storm starts, how long it takes for flood stage (water level) to drop once the storm is over, or at what rate does the stage fall in a drought period. In order to develop a hydrograph, hydrologists need active stream gages, or devices that measure the height of the water surface to calculate discharge. For more detailed information about stream gages and a picture of a hydrograph see Volume I, Section IV.B.2. Hydrology and Flood History.

While the primary focus of stream assessment, classification and restoration is typically on bankfull discharge and channel morphology, base flow and flood flow channels are also critical to health and function of stream systems. Base flow is that flow that sustains streams between storms and in times of drought. This flow is the most important factor in determining survival of species that require flowing water year round – fish, aquatic insects and certain water plants. A healthy stable stream has a distinct and defined thalweg, the deepest part of the stream, which will contain water even in lowest flow conditions, and generally in a continuous line. A disturbed or unstable stream may not have a discrete or continuous thalweg, and may even allow water to flow under the stream bed during drought periods, especially if the stream is very wide and shallow or has large sediment deposits.

The bankfull channel does not contain flood flows; this often defines what is considered a flood. Some stream types contain floodplain – that flat or gently sloping area adjacent to streams where water can spread out during a flood. Floodplains are actually a part of the stream channel, even though they may only have water flowing over them once a year or even less frequently. Floodplains can correspond to any size flood – the lowest active floodplain is often just referred to as the floodplain or floodplain bench (if very small or only in short sections along a streambank), whereas higher, inactive or abandoned floodplains can be referred to as terraces. Floodplain features are regulated according to the risk of flooding. The Federal Emergency Management Agency (FEMA) created Flood Insurance Rate Maps (FIRMs) showing 100-year and sometimes 500-year floodplains, simply the approximate boundary of the area that would be inundated during a 100-year or 500-year flood.

Base flow and flood flow channels, while not what we typically think of when considering shape and configuration of a stream, are nonetheless critical to stream function and must be considered in any stream restoration or management project. Too often one or both of these channels may be neglected – the result can be a lack of stream flow in summer if base flow is too slow and shallow to stay on top of the stream bed, or too much stream flow during floods if flood flow can't spread out on the floodplain to slow down and sink in.

2. Stream Formation

Streams not only drain water from the landscape, but also carry sediment (soil and rocks) in the form of *bedload* – sand, gravel, cobble, and even boulders – or *suspended load* – fine sand, silt or clay – eroded from streambeds, banks and hillsides upstream. As water begins to rise in the stream channel during a storm, at some point the force of water begins to move material on the channel bottom. As stormwaters recede, the force falls and sand, gravel and cobbles stop moving (Photo 1). You may observe these changes by noting elimination or addition of sediment deposits (small piles behind boulders or other obstructions, or larger piles called bars) in some places. On the other hand, though individual sediment particles may be removed and replaced through seasons and storm events, these deposits and bars often remain, maintaining similar shape and size over time. The amount of water moving through the channel, and particularly the way water energy is channeled and focused, determines size and amount of bedload moving through the system.

Photo 1. View looking upstream on Pepacton Hollow. Cobble in the stream bed.

In addition, the amount and distribution of bank erosion, scour and channel shape change through storms and seasons is highly correlated with type and amount of vegetation in floodplains and riparian areas. Two streams with similar sediment and rainfall patterns will show dramatically different shape and function if riparian vegetation is changed. In the Catskills, and especially in narrow valleys like Chestnut Creek, a naturally stable stream will have trees and shrubs all along the stream bank to help hold the soil together. If you take woody vegetation out and mow right down to the edge of the stream, you may be risking severe erosion problems.

The combination of vegetation, streamflow and bedload determines stream channel shape and size. Within natural limits, form, or morphology, of a stream is self-adjusting, self-stabilizing, and self-sustaining.

This consistency is due to the fact that the climate, geology, topography and vegetation of a region usually change very slowly over time. However, as we make our mark on the landscape – clearing forest for pastures, or straightening a stream channel to avoid having to build yet another bridge – we unintentionally change that balance between the stream and its landscape. We may notice however that some parts of the stream seem to change very quickly, while others remain the same year after year, even after great floods.

Why is this?

Streams that are in dynamic balance with their landscape adapt a form that can pass water and bedload associated with both small and large floods, regaining their previous form after the flood passes. This is the definition of stability. In many situations, however, stream reaches or sections become unstable when some activity on or near the stream has upset that balance and altered the stream's ability to move its water and bedload effectively.

3. Stream Dynamics

The amount of force water exerts to move rock is determined by stream *slope* and *depth***.** The steeper the slope the more force and the deeper the depth the more force a stream has to move its water and bedload. For example, if changes made to a stable reach of stream reduce its slope and/or depth the stream may not be able to effectively move the bedload supplied to it from upstream. The likely result is that the material will deposit out in that section, and the streambed will start building up, or *aggrading*.

On the other hand, when we straighten a stream, we shorten it; this means that its slope is increased, and likewise its potential force to move its bedload. Road encroachment has narrowed and deepened many streams, with the same result: too much force, causing the bed of the stream to cut down or, *degrade,* and ultimately to become *incised,* like a gully. Both situations – aggrading and degrading – mean that the stream reach has become unstable, and both can lead to rapid bank erosion as well as impairment of water quality and stream health. Worse yet, these local changes can spread upstream or downstream, causing great lengths of stream to become unstable.

B. Stream and Riparian Ecology

A stream can provide many community and ecological benefits such as visual beauty, clean drinking water, recreational opportunities, and increased land values. These benefits are dependent upon stream health. Stream health can be evaluated not only in terms of physical stability but also its ecological integrity.

1. Habitat: Inside and Out

Habitat, particularly *riparian* (streamside) and *aquatic* (in-stream) *habitat*, encompasses the many characteristics needed to sustain a diverse assembly of life forms; including fish, plants, and various aquatic and terrestrial animals that require the stream or riparian areas (Photo 2). Habitat, both aquatic and terrestrial, has physical properties (structure or shelter, temperature, and amount of light), biological properties (types of organisms and assemblages), and chemical properties (amounts and distribution of various chemical compounds such as oxygen or pollutants). Chemical and biological habitat properties of water are often referred to as water quality. Most often we discuss the habitat of an area in relation to its health, i.e., whether habitat is of good or poor quality will impact the health of plants and animals that are a part of it. In the most basic terms, a healthy habitat provides plenty of good food and shelter.

Photo 2. Riparian vegetation in a stable reach on the Chestnut Creek.

In-stream habitat in the mountainous northeast can be described as "coldwater habitat". This is due to the major contribution of cold groundwater to stream *base flow* (stream flow between storms). Small, steep tributaries with extensive forest cover characterize pristine coldwater habitat in this region. These tributaries feed into slightly larger streams down towards the *mainstem* (the primary stream in the valley bottom). As water moves downstream it passes through a multitude of structural habitats, often referred to as microhabitats, including riffles, side channels or channel margin pools and flats. Food energy is added in the form of leaves and streamside plant material (Photo 3). Specialized organisms, such as macro-invertebrates (aquatic insects, primarily shredders in headwater streams) and micro-organisms (bacteria and other

Photo 3. Leaf pack available for food for benthic macro inverts.

microbes), eat and break up those leaves making the nutrients in them available for other organisms, like algae and other macro-invertebrates (filter-feeders or collectors in lower tributaries), downstream. Coldwater fish like trout, sculpin, and dace feed on these insects and other small fish. The ecologically healthy coldwater stream boasts a diversity of structure and species within and around the stream to sustain these cycles.

Riparian vegetation, or the assemblage of plants and trees along a stream, plays a significant role in sustaining in-stream health and habitat. As rainfall or snowmelt runs off the landscape, riparian vegetation slows the rate of runoff, captures excess nutrients and sediment carried from the landscape, protects stream banks and floodplains from the erosive force of water, and moderates water temperature changes. Thus, riparian vegetation can serve as a buffer for the stream against our activities in upland areas. Most of our activities, whether agriculture, development, or even recreation, can result in disturbance or negative effect on the unprotected (or "unbuffered") stream. Given the significant role riparian vegetation can play to improve the quality of streamside living it is important to understand how to protect those functions. For further discussion and actions see Volume I, Section IV.B.3. Riparian Vegetation Issues in Stream Management.

2. Water Quality

Water quality describes a suite of important habitat components for many organisms living in and around a stream. Water naturally contains a wide variety of ions (charged molecules) including minerals from rocks, soil and the atmosphere. These ions include sodium, calcium, chloride, sulfates, and nitrates, to name a few. Water can contain many other dissolved or suspended substances, such as sediment (clay or silt particles), algae, or other compounds both natural and human-made. Pollution occurs when human activities alter the quantities of these substances in water to a degree that creates a harmful imbalance – to some target species, for human use, or other natural ecological process. The term "water quality" refers to the types and amounts of substances in water and is meant to describe the extent to which a body of water is polluted.

Water quality typically becomes poorer as human activities and development increase in proximity to a stream, especially in the absence of efforts or practices to mitigate impacts. Salts, oils and sediment from roads and parking lots, bacteria and nitrates from failing septic systems, and pesticides from lawns or agricultural fields are just a few of the types and sources of stream pollution. Remote headwater streams with fewer potential pollution sources upstream will often have better water quality than more developed mainstem creeks.

Resource managers can evaluate water quality in a number of ways. We can measure concentrations of pollutants in a stream and compare these to a set of standards established by the New York State Department of Environmental Conservation (DEC) or other regulatory or scientific guidance agencies. These standards can be based on designated use of a stream, such as for drinking water or for recreation, or a set of target values for aquatic species of interest. We can also assess water quality by evaluating certain aspects of the biological community of the stream, such as species type and composition of fish or macro-invertebrate communities.

Significantly degraded water quality can dramatically impact species in a stream, from aquatic invertebrates, to fish, to birds and other animals that live in the riparian zone. The relationships between water quality and aquatic macro-invertebrates are very well established and reliable enough to use as water quality criteria. In fact, the DEC has developed a set of guidelines for sampling aquatic macro-invertebrates to assess water quality. NYCDEP maintains a stream macro-invertebrate sampling program in the Catskills water supply watershed, including Chestnut Creek, to compare with state-wide standards and other measures of water quality (Volume I, Section IV.B.4.c. Chestnut Creek Biomonitoring Results). Volunteer stream organizations can use these guidelines and sample streams themselves to submit for DEC review.

3. Conclusions

If stream managers and residents want to maintain healthy, stable streams, we need to maintain a stable stream *morphology* (channel shape) and vigorous streamside vegetation. Stable streams are less likely to experience bank erosion and habitat deficiencies, and streams with healthy, functioning riparian vegetation can maintain resilience from upland water quality threats. In the sections that follow, this Plan describes the current condition of stream form and streamside vegetation throughout Chestnut Creek. Volume II makes recommendations for protecting healthy sections of stream and for restoring stability of those sections that are at risk.

C. Stream Morphology and Classification

This section provides more technical information about the relationship between stream *form* (or *morphology*) and physical stream *function* (i.e., flood behavior and sediment transport). *Stream Formation,* Section III.A.2., describes how a stream's form, particularly slope and depth, determines its *hydraulics* and sediment transport function. We focused on slope and depth because they are easy to visualize and measure, and are often changed --intentionally or unintentionally-- by stream managers. There are, however, many other characteristics that share an influence on how a stream creates and maintains itself and determine whether a stream is stable or unstable in a given valley setting. Stream managers use a number of terms to define and describe stream form and function. These include:

1. Stream flow (Q)

Stream flow, also called *discharge*, is represented by a volume of water passing by a certain point in a stream in a set amount of time, or volume per unit time, usually cubic feet or cubic meters per second (cfs or cms). Stream flow changes constantly, naturally increasing or decreasing as inputs (from rainfall, snowmelt, springs or groundwater) and outputs (evaporation, downstream flow, infiltration into the ground from the stream bottom, or uptake from riparian vegetation) shift in balance through storm events or seasons. The typical pattern of stream flow over the course of a year is called the *stream flow regime.*

We can divide stream flow into two basic types for management discussions; *storm flow* and *base flow*. Storm flow appears in the stream channel in direct response to a precipitation or snow-melt event. Base flow is that source of water that sustains a stream throughout the year during drier conditions.

Sources of storm flow can be divided into three sub types:

Channel interception is simply precipitation that falls directly into the stream. Intercepted precipitation shows up on a storm water hydrograph immediately (i.e., becomes part of in-channel flow instantly), though comprises a very small amount of total stream flow. When the precipitation event stops, this input to stream discharge ceases.

Overland flow, or surface runoff, is the portion of precipitation or snow-melt that runs off over the land surface. Overland flow is not generated consistently over a watershed; it can vary with topography, vegetation type, land use or cover, and time of year. The amount of water that reaches the stream by overland flow is determined by characteristics of landscape materials (soils, etc.) and how long water sits on the surface. Relatively impermeable areas (exposed bedrock, frozen ground, clayey-soils, paved or compacted surfaces) will generate more runoff than more permeable areas (deep, coarse soils) due to how well water can infiltrate (penetrate) the material. Any landscape characteristic that affects the amount of time water is kept on the surface will also impact amount and timing of overland flow. Flat or densely vegetated landscapes slow runoff rate, allowing greater time for infiltration and producing less total runoff; steep or bare watersheds will produce very fast runoff in higher amounts, often called “flashy” watersheds. The speed at which overland flow appears on the stream flow hydrograph depends on the speed at which water runs over the landscape and how far it has to travel. The time it takes precipitation falling on the farthest point in the watershed to a point in the stream by overland flow is called “time of concentration”.

Subsurface flow, or through flow, comes from rain or snow-melt that infiltrates and runs downslope through the soil. Subsurface flow speed depends on soil permeability, slope and the presence of fractures or other pathways in the soil. Subsurface flow typically shows up on a stream flow hydrograph after directly intercepted or overland flow, and sustains stream flow long after storm events have passed.

Certain specific stream discharge plays a more significant role in determining stream shape when compared to others. Very large floods may induce catastrophic changes in a stream — severely eroding banks and washing trees into the channel — but these major floods are relatively rare. Summer and winter base flow moves very little sediment, but occurs very frequently. Flows that have the greatest effect on channel shape are those that come fairly frequently, but which are still powerful enough to mobilize the gravel and cobble on the streambed. Flows that move sediment and occur fairly frequently will move the greatest amount of sediment over time, and therefore theoretically exert the greatest impact on stream morphology. *Bankfull flow*, recurring every 1 to 3 years on average, is often used in place of *channel-forming flow*, considered most responsible for defining stream form. This discharge is important for stream channel morphology and can be measured or calculated for most streams making it a useful management tool.

Height of water, or stream water surface level, is called *stage*. At flood stage, a stream overtops its banks or reaches some predetermined level associated with flood risks. *Bankfull stage* is associated with bankfull flow or discharge, and often corresponds with flood stage, or the point at which a stream breaks out onto the floodplain.

2. Slope (S)

Water surface slope, also discussed above, is one of two variables important in determining the force of moving water on stream beds and banks, and the potential for erosion, scour and bed sediment mobility. Slope typically refers to the average water surface slope at "current" discharge (the day a stream survey is conducted) for the purpose of classification. Other water surface slopes can be measured and used for flood calculations or sediment mobility estimates, such as bankfull slope.

3. Channel average depth (d)

Depth, also discussed above with regard to sediment transport, is measured from the streambed to the current water surface and used to calculate sediment transport capacity at a particular discharge. When used to compare one stream reach to another in *stream classification systems* (see below), the average depth at bankfull stage is used.

4. Channel width (w)

With average depth, stream channel *width* at the water surface determines *cross-sectional area* (Area = width x depth), usually measured perpendicular to flow direction. Stream width at bankfull stage is used in stream classification.

5. Channel roughness (n)

So far we've only talked about what gives the water force to erode the streambed and banks. There are also characteristics of the stream that slow water down, or resist the flow. One of these is bed or boundary *roughness*: it's harder for water to flow through a section of stream filled with boulders than through a reach with a clay bed with no obstructions. Roughness can also occur on floodplains in the form of trees or other coarse vegetation, which slow flowing water.

6. Sinuosity (k)

A different kind of roughness that slows water down has to do with whether the channel runs straight or has curves or bends (called *meanders*). When stream flow is slowed as it moves around a bend, we say the flow is encountering *form roughness*. The "curviness" of a stream is called *sinuosity*, measured as stream length divided by valley length. That is, if a stream runs completely straight down a mile long valley, both valley and stream are the same length, or k =1 mile /1 mile =

1. If a stream running down the same length of valley contains multiple *meanders* such that the stream channel is 1.5 miles in length, k = 1.5 miles /1 mile = 1.5.

7. Radius of curvature (Rc)

Radius of curvature is a measure of the "curviness" of the stream, but at a single curve. To find the radius of curvature, you measure the size of individual meanders, as if the bend were a perfect circle.

8. Sediment size (D50)

To classify or assess a stream reach using the Rosgen classification system, at least 100 bed surface sediment particles are randomly selected and measured, and the median sized particle (*D50*, meaning that 50% of the particles in the stream are smaller) is calculated. Specific size fractions (D50, D84, etc.) are used for classification, assessment or sediment mobility calculations.

9. Bank Cohesiveness

Due to the glacial history of the region, soils in the Catskills are extremely variable from place to place, and some soil types hold together better than others, or are more *cohesive*. Soil cohesiveness is a function of clay content in the soil. Roots of trees and shrubs can reach deep into the soil of a streambank, and the web of fine root fibers can add a tremendous amount of structural strength to banks and floodplains.

The "balance" that streams develop over time when they are not disturbed is the balance between the erosive forces of floodwaters and the strength of the bed and banks to resist that erosive power. This balance develops because streams will erode away their banks until, eventually, lengthening meanders reduces the slope, or the stream is widened and depth is decreased sufficiently, such that the cohesiveness of the soil and vegetation together just equal the erosive potential of floodwaters.

10. Sediment discharge (Qs)

Just as water flow in a stream is called *stream discharge*, stream transported silt and sand, gravel, cobble and even boulders, is called *sediment discharge*. Sediment discharge is measured as a weight, volume or size of sediment moving past a particular point over some interval of time, typically tons or kg per year. *Bedload* is sediment that moves (by rolling, bouncing or sliding) along the bottom of the channel (typically coarse sediment, gravel and larger), while *washload* or *suspended load* is sediment that is suspended in the water column (typically fine sediment, sand or smaller).

Measuring (or estimating) sediment discharge is one way to determine whether a stream is stable. If the amount of sediment coming into a reach of stream does not roughly equal the amount leaving the reach in the same time period, the form of the reach will have to change. Short or even medium term sediment transport imbalances do not necessarily constitute instability, however. A sudden increase in load or a very large discharge can temporarily change sediment dynamics in a reach, sometimes taking years to equalize. A stable stream is better equipped to mitigate and recover from these types of disturbances in shorter time frames.

11. Entrenchment

Entrenchment, as used in assessment and classification (Rosgen, 1996), is a quantitative expression of the degree to which a valley contains or confines a stream. Rosgen's *entrenchment ratio* compares stream width at bankfull flow with its width at twice the maximum depth at bankfull flow (also called the floodprone width). A large ratio of floodprone width to bankfull width indicates a stream that is not entrenched (i.e., the stream has access to a wide floodplain).

When a reach of stream is straightened or narrowed, it may cut down into its bed (degrade), so flood flows can not spill out onto the floodplain. When even large floods are confined to a narrow deep channel they can become very erosive and entrenched, potentially resulting in severe bank erosion or bed scour.

D. Applying the Science of Stream Form and Function to Stream Management

By carefully measuring and interpreting selected stream morphology characteristics, stream managers can get a fairly good idea about the relative stability of a stream, reach by reach, over its whole length.

Throughout this Plan you will find references to these different characteristics. By understanding the relationship between stream form and function, managers can prioritize severely unstable stream reaches for treatment, and can apply different management strategies more appropriately and cost effectively. Analysis of stream morphology can also make for more successful design of stream restoration projects; designers can identify and survey stable stream reaches and then use their form characteristics as *Reference Reaches* as part of a restoration design template.

Classifying Streams by Their Form

One useful tool for stream managers, developed by Dave Rosgen, is a system for stream reach classification based on channel form. Rosgen's system gives letter and number designations to different stream types, depending on the combination of five characteristics (discussed individually in sections above):

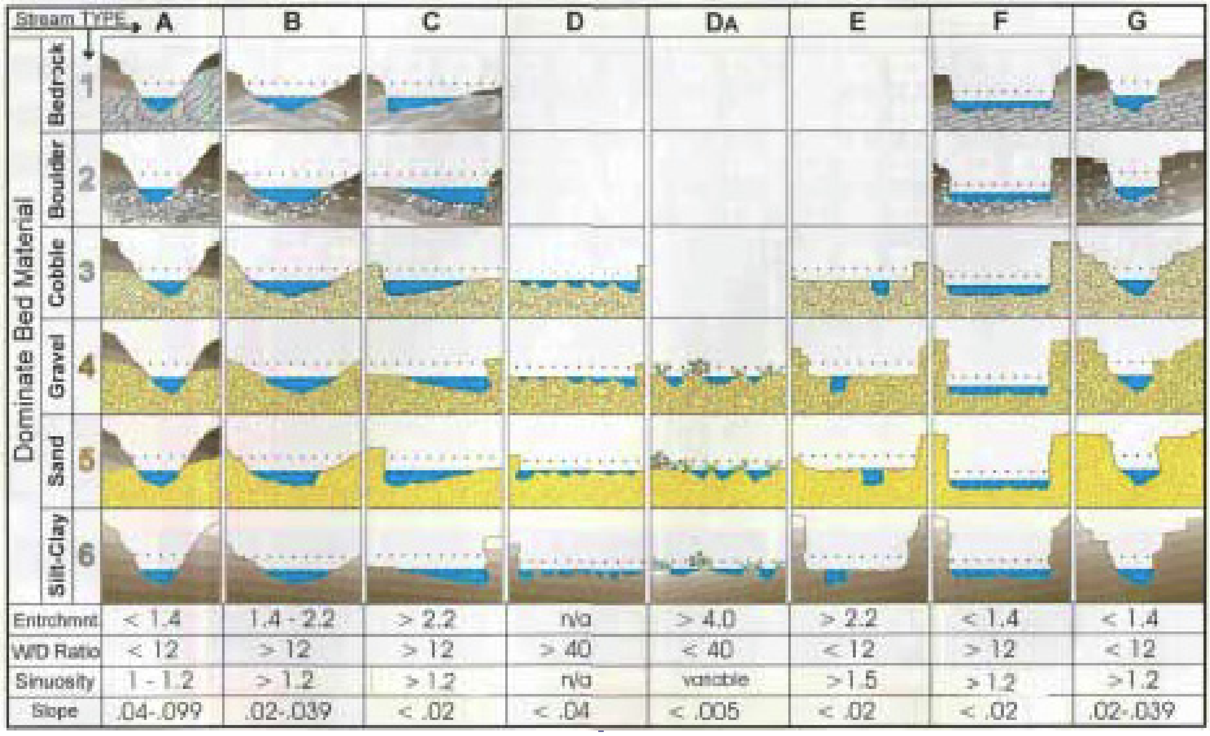
1) Entrenchment ratio, ER
2) Ratio of width to depth, w/d
3) Slope (water surface), s
4) Sinuosity, k
5) Sediment size (D50)

Different combinations of these characteristics result in a great number of different stream types, from A1 through G6 (Figure 2. Stream types from Rosgen). These letter/number designations provide a sort of shorthand for describing the form of a stream reach.

For example, a B3 stream type has a cobble dominated bed, a moderate amount of accessible floodplain, is greater than 12 times as wide as it is deep, is moderately sinuous, and drops between 2 and 4 feet for every 100 feet of stream length. How does a B3 differ from an F3? An F3 is more entrenched, meaning that it can't spill out onto its floodplain during storm flows, and it is also less steep, dropping less than 2 feet for every 100 feet of stream length. How is a B3 different from a G3? Though the G3 has similar slope, it is more entrenched, like the F3, but has a lower width-to-depth ratio.

Because locations of bedrock exposure represent an important control on stream morphology, these sections can be documented as a double stream type, such as B1/B3. A B1/B3 reach would be predominantly a B3 (cobble), but would have section(s) of B1 (bedrock) too small to be broken out into a separate reach or reaches. A B1 reach would be a bedrock dominated reach only. Additional reach types may include additional slope classification, such as B3a, where the "a" signifies an A channel slope with a B3 cross-section morphology, or B3/B3a where slope is borderline between B and A slope.

As discussed above, each of these different forms functions a little differently from the next, especially with regard to the stream's ability to transport its sediment effectively. By classifying different stream types in a watershed, different management strategies can be applied appropriately to different sections of stream. Rosgen (1994) created a stream management table, which suggests how different stream forms can be interpreted with regard to a number of management issues. In the following sections, Chestnut Creek will be described in terms of these Rosgen stream types.



Stream TYPE	A	B	C	D	DA	E	F	G
Entrchmnt	< 1.4	1.4 - 2.2	> 2.2	n/a	> 4.0	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 40	< 12	> 12	< 12
Sinuosity	1 - 1.2	> 1.2	> 1.2	n/a	variable	>1.5	> 1.2	>1.2
Slope	.04-.099	.02-.039	< .02	< .04	< .005	< .02	< .02	.02-.039

Figure 2. Stream types from Rosgen, 1996.