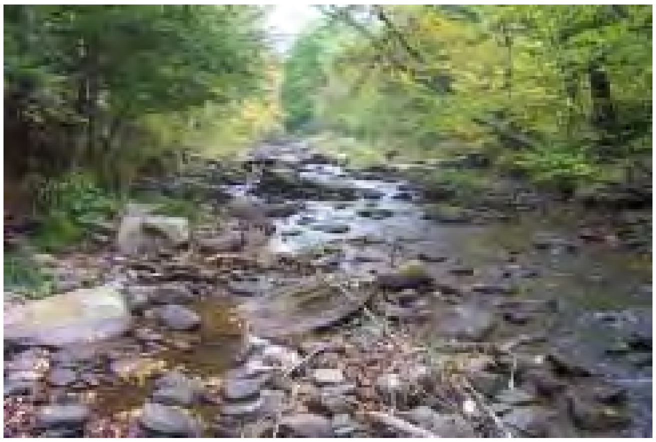
3.2 Physical Stream and Valley Characteristics

3.2.1 Introduction to Stream Processes



"You cannot step twice into the same river; for fresh waters are ever flowing in upon you."

-Heraclitus, 2500 B.P

Ask anyone who lives streamside, and they'll tell you that living around streams carries both benefits and risks; to enjoy the benefits, we accept the risks. Both the pleasures as well as the dangers of living near streams stem in part from their ever-changing nature. Icy spring flood-flows are exciting and beautiful as long as they don't creep up over their banks and run across your yard into the basement window, or suddenly tear out a streambank and begin flowing down the only access road to your house. For many reasons, the relatively flat land in the floodplain of a stream may be an inviting place to build a home or road –in fact it may be the only place– but as long-time residents of floodplains know only too well, it's not a matter of *if* they will see floodwaters, but of *when*.

As changeable as streams are, though, there is also something consistent about the way they change through the seasons, or even through an individual storm. As unpredictable as streams can be, they are also predictable in many ways. 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 their benefits to us, and to reduce the risks they pose.

This section of the management plan is provided to offer the reader a basic explanation of what stream scientists know about how streams "make themselves": why they take different forms in different settings, what makes them evolve, and how we can manage them effectively to increase the benefits and reduce the risks they offer.

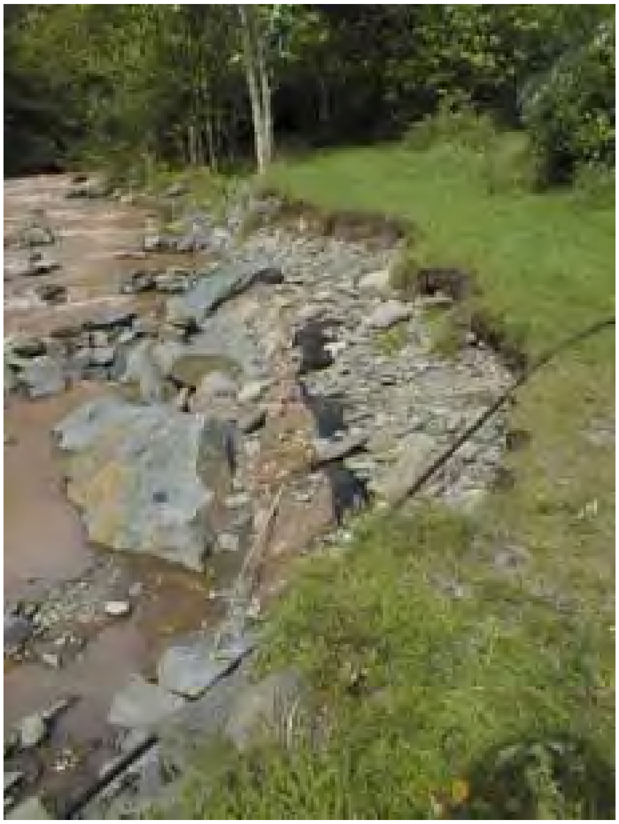
It's obvious that streams drain water off the landscape, but they also have to carry *bedload* –gravel, cobble, and even boulders– eroded from streambeds and banks upstream.

If you stand near the bank of a mountain stream like the Broadstreet Hollow during a large flood event, you can feel the ground beneath your feet vibrate as gravel, cobble and boulders tumble against each other as they are pushed along by the force of the floodwaters down the streambed. As the water begins to rise in the channel during a major storm, at some point the force of the water begins to move the material on the bottom of the channel. As the stormwaters recede, the force falls and the gravel and cobble stop moving. The amount of water moving through the channel determines the amount of *bedload* moving through it as well.

To effectively manage the stream, then, managers first need to understand how much water is delivered from the landscape to the stream, at any particular point in the system. The amount of water any stream will carry off the landscape is primarily determined by four characteristics of the region:

-the climate, specifically the amount of rainfall and the temperatures the region typically sees throughout the course of a year;
-the topography of the region;
-the soils and bedrock geology; and
-the type of vegetation (or other landcover like roads and buildings) and its distribution across the landscape.

These characteristics also play key roles in determining the type and frequency of flood hazards in the region, the quality of the water, and the health of the stream and floodplain ecosystems. This Plan includes sections describing in greater detail the specifics of these four characteristics for the Broadstreet Hollow watershed.



The shape and size of a stream channel adapts itself to the amount of water and bedload it needs to carry. Within certain limits, the form, or *morphology*, of a stream is self-adjusting, self-stabilizing, self-sustaining. If stream managers exceed those limits, however, the stream may remain unstable for a long time.

Over the period since the last glaciers retreated some 12,000 years ago, the Broadstreet Hollow has adapted its shape to these regional conditions. Because the climate, topography, geology and vegetation of a region usually change only very slowly over time, the amount of water moving through a stream from year to year, or *streamflow regime*, is fairly consistent at any given location.[1] This stream flow regime, in turn, defines when and how much bedload will be moving through the stream channel from year to year. Together, the movement of water and bedload carve the form of the stream channel into the landscape. Because the streamflow regime is fairly consistent year after year, then, the form of the stream channel also changes relatively slowly, at least in the absence of human influence. Over the 120 centuries since the Broadstreet Hollow was covered by glaciers, the stream and the landscape conditions evolved a dynamic balance.

However, as we made our mark on the landscape – clearing forest for pastures, or straightening a stream channel to avoid having to build yet another bridge – we unintentionally changed that balance between the stream and its landscape. We may notice that some parts of the stream seem to be changing very quickly, while others remain much 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 the 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 stream activity has upset that balance and altered the stream's ability to move its water and bedload effectively.

[1]One exception is when the vegetation changes quickly, such as can happen during forest fires, volcanic eruptions or even rapid commercial or residential development.

The amount of potential force water has to move rock is determined by its **slope –** the steeper the slope, the more force, and its **depth –** the deeper the stream, the more force. So, for example, if changes made to a stable reach of stream reduce its slope and/or depth, the stream may not be able to move effectively the bedload supplied to it from upstream. The likely result will be 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 *degrade* and, ultimately, to become *incised*, like a gully in its valley. 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 and downstream, causing great lengths of stream to become unstable.

The lay of the land determines the pattern and grade of the stream, but the stream also shapes the lay of the land. The stable form for a particular stream depends on the larger form of the valley it flows through.

The stream pattern we now see throughout the Catskills is the result of millions of years of landscape evolution: fractured bedrock, chiseled repeatedly by rivers, and then glaciers, and then rivers again, as glacial ages came and went, as valleys were eroded out of the mountains and washed out to sea. In the broader valleys like the Esopus', floodplains formed as they filled with cobble and gravel, sand and silt carved away from the steeper mountainsides by roaring meltwater. The material often settled out as the streams entered into local lakes, created where notches at the lower end of the valley were dammed by glacial ice. When the ice dams melted, the lakebed remained a fairly flat valley floor, poorly vegetated initially, through which the stream could meander from one side of the valley to the other.

As the streams, century by century, shaped these flatter valleys they flowed through, the resulting shape of the valleys in turn changed the streams. As valleys developed floodplains, the streams flowing through them became less steep, and their pattern and shape progressively adjusted to assume new stable forms, in balance with the new landscape.

In the Broadstreet Hollow, the story is even more complicated. The main valley was widened out by glacial scouring, while in many small pockets, soil materials melting out of glaciers created complex local deposits of clay, sand, gravel, cobble and boulders, and leaving diverse terrace forms throughout the valley. As the steeper streams coming off the mountainsides joined into a more gently sloped main channel running through the main valley, the stream became wider, and less deep.

The stable form that a stream takes in balance with the steep, mountain notches will be different from the one it takes in the lower Broadstreet Hollow valley, and this will be different still from the stable form in a broad floodplain valley like the Esopus Creek.

In the Catskills, and especially in narrow valleys like Broadstreet Hollow, a naturally stable stream will have trees and shrubs all along the stream bank to help hold the soil together. If you take the woody vegetation out and mow right down to the edge of the stream, you may be risking big-time erosion problems.

As our climate warmed, the evolving valley floor was recolonized by grasses and then trees. As vegetation returned to the floodplains, the conditions that determine the balance between stream shape and the landscape changed once again. Streambanks that have a dense network of tree and shrub roots adding strength to the soil can better resist the erosive power of flood flows, and consequently a new stable stream form emerges; a new balance is struck between resistive and erosive forces.

In the Broadstreet Hollow, that thick mat of woody roots is essential if we want to maintain a stable stream. If streamside trees and shrubs are removed, we can expect the bank to soon begin eroding.

If we want to maintain healthy, stable streams then, we need to maintain a stable stream *morphology* and vigorous streamside vegetation. Stable streams are less likely to experience bank erosion, water quality and habitat problems. In the sections that follow, this Plan describes the current condition of the stream form and streamside vegetation throughout the Broadstreet Hollow, and then makes recommendations for protecting healthy sections of stream and for restoring the stability of those sections that are at risk.