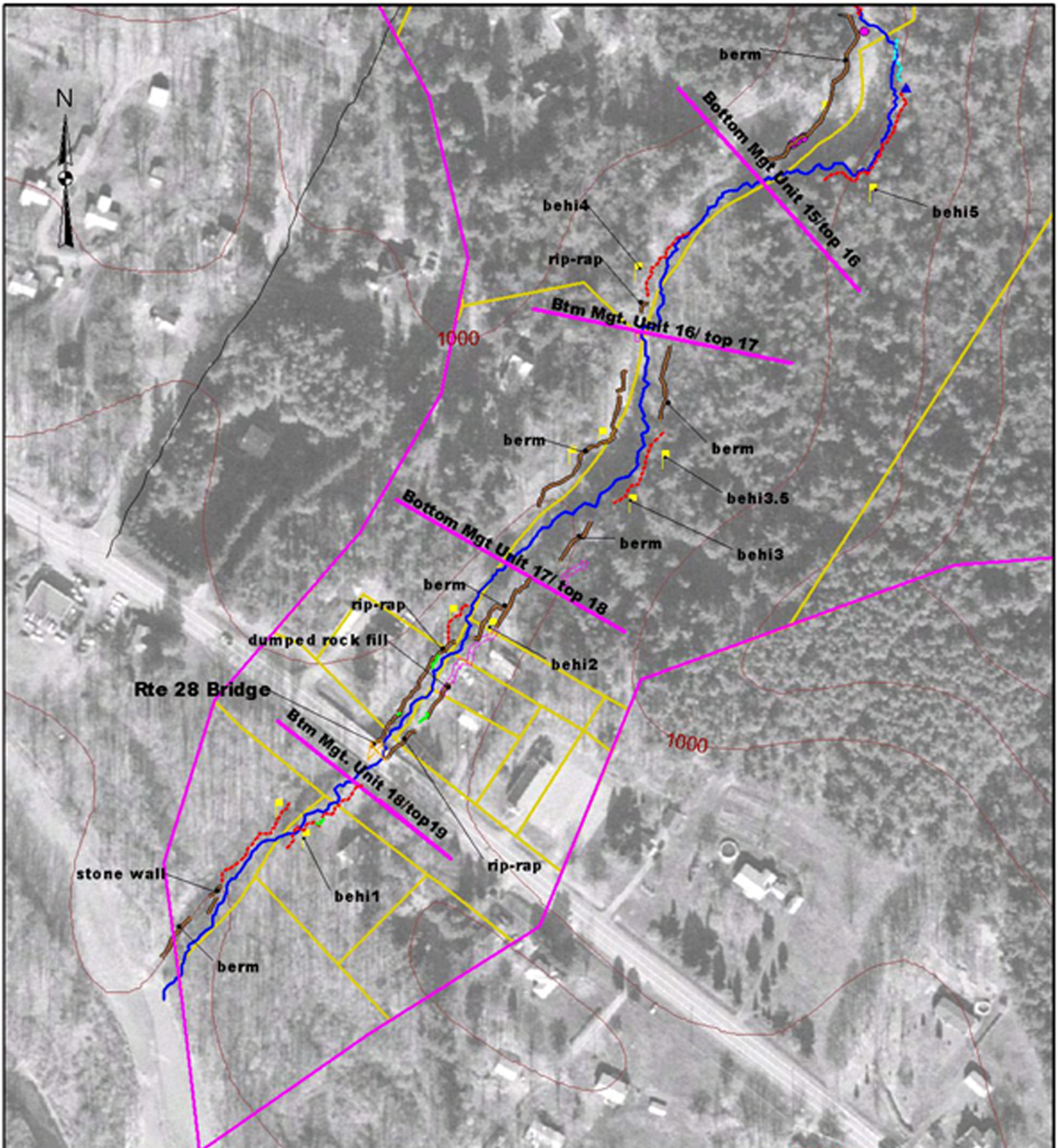

GIS Parcel, Contour and Wetland coverages are edited and provided by NYC DEP, 2000, UTM NAD 27, Zone 18 North, meters. Aerial Photography Provided by UCSWCD & NYC DEP November 2001 All other coverages were developed using GPS in the UTM, Zone 18 North projection, NADCON (Conus), datum. GPS data collected 2001, by UCSWCD & NYC DEP SMP.

Note: G.I.S. data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey. Parcel coverages are based on Ulster County Real Property tax maps 2000 and may not reflect actual surveyed property boundaries.

Broadstreet Hollow Management Unit 16 -19

50 0 50 100 150 200 Feet

Scale 1:2,400

LEGEND

247 Street Address/911 Code
Green Parcels
Ulster Parcels
Landfills
Management Units
Stream Center (Thalweg)
Culvert
Wetland
Clay Exposure
Revetment
Eroding Bank
Tributary
Behi Pin
Bridge
Broadstreet Hollow Road
Knotweed

Broadstreet Hollow Management Unit 18

General Description:

Management Unit (MU18), though very short at approximately 470 feet long, is a complex section of the Broadstreet Hollow. The unit begins just downstream of the pond outlet at the Fischzang property, after which the stream straightens into a very narrow, straight and highly managed section ending at the bridge over NY State Route 28 [1&2] (Photo 1).

Photo 1. Looking upstream from the Route 28 Bridge, near the bottom of MU18, with partially vegetated rip-rap and hardened areas on both banks.

The structural shape, or *morphology*, of the stream (i.e., slope, width and depth) is uniform in this unit, comprising a single section, or *reach*, with distinct structural character, or *stream type*[5]. The valley in MU18 is particularly narrow compared to other units, as the stream has incised, or cut into its bed, deep enough so that the wide flat area on either side, which may have historically functioned as an overflow area, or *floodplain*, is now far above the stream, forming an abandoned floodplain, or *terrace* (Photo 2). Additionally, MU18 contains multiple areas of bank hardening and stabilization, or *revetment*, fixing the channel in place and limiting stream access to any remaining floodplain or low terrace areas that could absorb flood flows. This combination limits the available valley area through which the stream can wind, or meander. Because the stream is so confined, with a predominantly *entrenched* stream shape, this section represents a stream in poor, or *unstable*, condition. This unit may therefore be more vulnerable to disturbance in the vicinity of the bridge than a section of stream that is less crowded by its valley: excess stream energy has no where to go but down into the stream bed or into the banks, creating ongoing erosion and instability problems.

Photo 2. Looking upstream into the top of MU18, note concrete slabs to the left, terrace at top of bank to the left.

Typically stable stream types associated with this type of valley are relatively narrow, with riffles and pools, and stream banks formed into low benches, or *discontinuous floodplains*, that function as overflow areas during floods and provide areas for healthy streamside, or *riparian*, vegetation. MU18 maintains essentially none of these discontinuous floodplain bench features, limiting the capacity of this section to absorb flood flows[5&7].

I. Flooding and Erosion Threats

A. Roads, Infrastructure, and Private Property

There are six properties (land parcels) associated with MU18. Five of these are privately owned, and the stream course forms a boundary for these parcels. The sixth parcel is the New York State right of way for Route 28. Landowners in this unit have expressed concerns about flooding, flood damage to homes and property, and stream bank erosion. Two of the four landowners in this reach have reported flood-related stream bank erosion and property damage.

All of these properties are within the 100-year flood boundary of the Esopus Creek, according to FEMA Floodplain Maps from 1985. There is a small shed on the stream bank just upstream from the bridge, and three homes within 150 feet of the stream.

Stream assessment data for 2001 show the centerline of Broadstreet Hollow Road ranges from 500 to 530 feet from the stream, measured from the deepest part of the stream, or *thalweg*. Broadstreet Hollow Road does not cross the stream in this unit[1].

Photo 3. Looking upstream at bridge crossing NY State Route 28. MU18 ends just downstream from the bridge.

State Route 28 crosses MU18 at the bottom of the unit (Photo 3). This bridge is maintained by the State Highway Department, and appears wide enough to accommodate the natural stream width. Under the bridge, between the abutments, a gravel bar area is developing that may evolve into a small floodplain bench over time, enhancing stream morphology and preserving stream function, including sediment transport capacity (Photo 4).

Photo 4. Right abutment of Rte. 28 bridge, showing gravel bar forming within the abutments, narrowing and deepening the active channel to improve sediment transport capacity, and reducing potential for further maintenance. Stream flow is from right to left.

Several different types and ages of revetments on both banks upstream and downstream from the bridge show evidence of ongoing bank erosion over time. However, much of this area shows colonization by streamside, or riparian, vegetation that will help keep these areas from eroding, and will provide additional water quality and habitat functions[7].

B. History of Stream Work

Approximately 510 feet, or 56%, of the stream banks in MU10 have been altered or hardened with some type of revetment (Table 1).

Table 1. Altered Banks*Broadstreet Hollow MU18 [2].

*based on linear feet of both sides of stream bank.

Revetment Type	Length (ft.)	Percent of Unit
rip-rap	190	**20**
berm	170	**18**
dumped rock fill	150	**16**
Total Revetment	**510**	**56%**

Approximately 190 feet, or 20% of the stream bank in MU18 has been rip-rapped, in three main sections, using mixed materials including dumped and laid up boulders, and concrete or blacktop slabs [1&2] (see left side of Photo 2). The newest section of dumped boulder rip-rap is the upstream-most rip-rapped section (Photo 5), on the right bank just downstream of a section of eroding bank (see discussion below). This rip-rap was placed following the January 1996 flood event, which resulted in stream bank erosion and property damage in this area. Large quarried boulders were piled and rearranged from the bank, with no work in the stream channel.

Photo 5. "New" dumped boulder rip-rap on right bank, just downstream from eroding bank section. Stream flow is from right to left.

Photo 6. Upstream end of "new" boulder rip-rap section shown in Photo 5, with bank erosion just behind the end boulders, continuing upstream. Note trees eroding just behind, on the terrace. Stream is behind the viewer, flow is from right to left.

The disadvantage to dumping rock over the stream bank is that without having either a wall or other larger structure, and without individual boulders *keyed-in* (stabilized by other boulders being placed under the stream bed and into the bank), the stability of the bank relies simply on the size and weight of each boulder to maintain stability. Unfortunately, the Broadstreet Hollow stream is powerful enough to erode soil and larger sediment in the stream bed and banks out from under and behind each boulder, eventually digging a hole into which the boulders can fall, causing the entire bank to fall in as the rocks at the base of the pile shift and drop. Additionally, without proper stabilization of the transition between the rip-rap and non-rip-rapped banks, the abrupt change in materials often results in the water swirling, or eddying, behind the boulders and eroding the "softer" bank material on either end. This phenomenon can be seen at the upstream end of this rip-rapped section, where the bank area with tree roots that may have assisted keeping the bank in place are being eroded at the edge of the boulder pile (Photo 6).

Photo 7. "Laid up" boulders along the right bank in the middle of MU18. Note trees with buried trunks. Stream flow is from right to left.

Just downstream from the dumped boulders is a fairly recently constructed section of rip-rap composed primarily of flat boulders "laid up" in a smooth wall along the bank (Photo 7). While the structure of these boulders may add some stability, note that the bottom boulders are also not keyed in, so are vulnerable to the same erosion and under-cutting as the boulders in the dumped section upstream. Also, trees in this section that contribute to bank stability, shade and cover, have their trunks buried with material, which causes stress to many tree species and may make them unhealthy or even die, reducing benefits to bank stability in addition to the aesthetic, water quality and habitat benefits they provide[7].

Photo 8. Mixture of dumped rock fill and laid up stone, with some vegetatation colonizing the bank, just upstream from Rte. 28 bridge. Stream flow is from right to left.

Further downstream, adjacent to the bridge, both banks contain an older mixture (actual age unknown) of dumped rock fill, laid up and stacked boulders (Photo 8). These sections have been re-colonized by a mixture of riparian shrubs and trees, and show greater stability and provide more water quality and habitat benefits as a result. The banks in this section are not as steep, which also increases revetment function and life[5&7].

Dumped rock fill revetment, even with vegetation and a low slope, can continue to wash or fall into the stream during and following flood events, remaining an ongoing maintenance problem for County and State Highway Departments (Photo 8). Broadstreet Hollow stream can transport very large rocks along the stream bed (rocks and gravel moving along the bed of the stream is called *bedload sediment*). The size of sediment in dumped rock fill is often smaller than the bedload, and gravel or bank run material is always smaller than the bedload. As a result, rocks on the bank continue to wash downstream over time from the toe (base of the slope), needing periodic replacement[5]. Continuing disturbance of the bank area can prevent streamside, or *riparian*, trees and other vegetation from becoming established, reducing the likelihood the bank area can stabilize on its own. Further, some riparian tree species become stressed and weakened when their trunks are buried, so existing trees that may be providing some bank protection are eventually killed by ongoing maintenance, reducing long-term bank stability, as well as compromising other important habitat and aesthetic benefits. Alternatives to dumped rock fill should be strongly considered, to reduce maintenance costs and preserve riparian areas[3]. Existing mixed revetments should be re-vegetated or augmented with a mixture of native riparian species to increase longevity as well, to reduce revetment maintenance or replacement costs[7].

The left bank, starting at the top of MU18, contains a mixture of bermed areas, rip-rap and dumped rock fill. The berms total approximately 170 feet in length, in two overlapping sections. These berms appear to be material pushed up onto the banks in response to 1996 flood damages, and may have been the site of such practice in earlier floods (Photos 9 and 10). This practice of "cleaning" the gravel out of a stream in this way is sometimes thought to increase flood capacity by creating a larger stream channel.

Photo 9. Pushed up material forming a berm along the left bank near the top of MU18.

Photo 10. Pushed up material forming a berm along the left bank, just downstream from the berm shown in Photo 8, and opposite the eroding bank area documented in MU18. Stream flow is from left to right.

Unfortunately, berms such as these generally do not offer much if any protection from flooding (inundation), especially if the berm is uneven or ends abruptly, and typically represents a place to store material in what is thought of as an "out of the stream" location. The channel is typically made too wide (not deep enough) for the stream to transport its sediment, causing additional deposits (gravel bars) and ongoing flooding and/or maintenance problems.

These berms also prevent floodwaters from spreading out onto low lying floodplain or terrace areas, increasing flood height, or *stage*, and causing greater erosive potential. The berms at the top of MU18 are opposite an eroding bank area, which may be exacerbated by this constriction.

Floodplains function to reduce flood velocity, increase absorption of floodwaters, encourage deposition of silt and fine sediments (keeping them from being washed further downstream) and decrease flood stage in downstream areas[5]. The majority of Broadstreet Hollow stream floodplains consist of small, low, discontinuous floodplain benches that perform the important floodplain functions in small mountain streams. MU18 is in a section of the Broadstreet Hollow Valley that would benefit from any additional floodplain storage area, lacking any floodplain or overflow bench areas. Removal or restructuring of these bermed areas should be considered to add floodplain function to this area, perhaps setting berms back where flood inundation protection might be desired (such as in the vicinity of homes on the right bank in the middle of MU18 [1])[3]. The other bermed area upstream could safely be removed entirely, as there are no structures and no other development in the floodplain.

C. Exposed Banks

Stream assessment conducted in 2001 revealed approximately 75 feet (8%) of eroding stream bank in MU18, in one section at a forested terrace on the right bank (Photo 11). Though the bank on the right was the primary site of interest for monitoring (Photo 12, the berm on the left bank was noted to be eroding as well (see Photo 10). This site does not appear to contain any glacial lake clay.

Photo 11. Looking upstream into location of monitoring cross-section 2, location shown by white tape stretched across the stream.

A representative location was chosen and permanently *monumented*, or marked with metal rebar, for future monitoring (designated as "monitoring cross-section 2") to determine erosion rates and priority for potential restoration (see Photo 10, white tape across the channel marks the cross-section location) [3]. This site has been assessed and ranked based on calculation of a *Bank Erodibility Hazard Index* (BEHI) using data collected at the time of the stream assessment survey in 2001[4].

Photo 12. Eroding right bank, monitoring cross-section 2, at forested terrace, just upstream from hardened banks with boulders and concrete slabs. Stream flow is from right to left.

This bank received a BEHI rank of "high" potential for further erosion, though no structures or other development are currently threatened by erosion at this site. Removal of the berm on the opposite bank would decrease stream entrenchment, reconnect the stream with a section of floodplain, and would probably lower the erosion potential on the right bank.

II. Water Quality

A. Sediment

The eroding bank at monitoring cross-section 2 contains fine sediments (silts and sands) that may continue to contribute to turbidity, especially during high flows. Other sections of this unit, especially in vulnerable areas at the base and edges of rip-rapped and hardened areas, may also contribute fine sediments to the stream during floods.

B. Landfills/Dumping Sites

One long but fairly sparse dumping area, containing mixed materials, was documented along the stream bank in MU18, covering a total of approximately 150 feet (16%). This area, while not appearing to contain hazardous materials (though no specific analysis was conducted in 2001 as part of the stream assessment survey), is very close to the stream and may pose a safety hazard. Planning efforts to organize cleanup of sites like this were initiated in 2002, and should continue, as labor and funding are available.

C. Other Water Quality Issues

Investigation of other possible sources of contamination was not part of the stream assessment conducted in 2001. However, no evidence was found for *nutrient* or *pathogen* contamination in the stream (i.e., odors or discolored water).

Any runoff of water from Route 28 that may contain salts or other pollutants was not specifically investigated, but sparse or stressed riparian vegetation in this area, combined with heavy salt usage and traffic, may result in higher loadings and a reduced capacity for riparian areas to absorb or slow the input of contaminants to the stream.

III. Stream Ecology

A. Aquatic habitat and populations

No specific aquatic habitat or population monitoring was conducted in MU18 as part of the stream assessment survey in 2001. However, as part of the stream restoration demonstration project completed in MU3 in 2000, fish and aquatic insect population data have been gathered yearly since 1998 within the stable reference reach (MU1), the project site (MU3) and the control reach (MU17). These data show the Broadstreet Hollow self-supports, without stocking, populations of all three common trout species (rainbow, brook and brown) as well as a healthy and diverse community of aquatic insects[6&9]. The impact that stream bed and bank instability in MU18 has on these aquatic organisms or their communities in unknown.

B. Riparian Vegetation

Stream assessment conducted in 2001 did not investigate specific streamside (riparian) plant species or density condition, other than to note areas of insufficient or stressed vegetation that could affect stream stability, flooding or erosion threats, water quality or aquatic habitat for trout species. Based on these general observations, riparian vegetation throughout MU18 is inadequate to provide the full benefits of a healthy riparian area.

Particularly in hardened, eroding or bermed sections, bank areas should be re-vegetated or existing vegetation augmented with a mixture of shrub, tree and annual vegetation to improve shade, cover and bank stability throughout MU18[7]. Rip-rapped areas should be "inter-planted" (spaces between the boulders planted) with shrub and small tree species with small roots, to improve water quality and habitat functions, while preventing destabilization of the bank rock structure.

Japanese Knotweed, a non-native, invasive plant, was documented on 50 feet (5%) of the banks in this unit during stream assessment in 2001 (Photo 13). This species is an invasive exotic, and damaging to riparian integrity[7]. Japanese Knotweed is fast growing, can crowd out native vegetation and the roots provide little or no soil-anchoring action.

Photo 13. Japanese Knotweed, a non-native, invasive plant that colonizes disturbed areas and out-competes native species adapted to provide riparian habitat, water quality and bank stability benefits. Though it looks lush, it is shallowly rooted and weak. Stream is behind the viewer; flow is from right to left.

Japanese Knotweed is aggressive and spreads easily; pieces break off, wash downstream and can take root where they land, especially in disturbed areas (such as eroding banks or continually disturbed maintenance areas). To avoid further spread of this plant to downstream areas that may be vulnerable to colonization, Japanese Knotweed at this reach should be removed, and the area replanted with a mix of competitive native species to prevent re-colonization. Additional maintenance of this area may be needed, as Japanese Knotweed is very difficult to remove successfully.

[1]Broadstreet Hollow Management Unit 18 Map
[2]Broadstreet Hollow Management Unit 18 Workbook.
[3] Stream Bank Stabilization Methods and Alternatives
[4]BEHI Monitoring Cross Section Workbooks and BEHI Score Summary
[5]Stream Dynamics Discussion
[6]Attachment ___: USGS
[7]Riparian Vegetation Management
[8]Stream Stability Restoration Projects, Techniques and Contact Information
[9] Habitat Requirements for Trout
[10] Broadstreet Hollow Geology