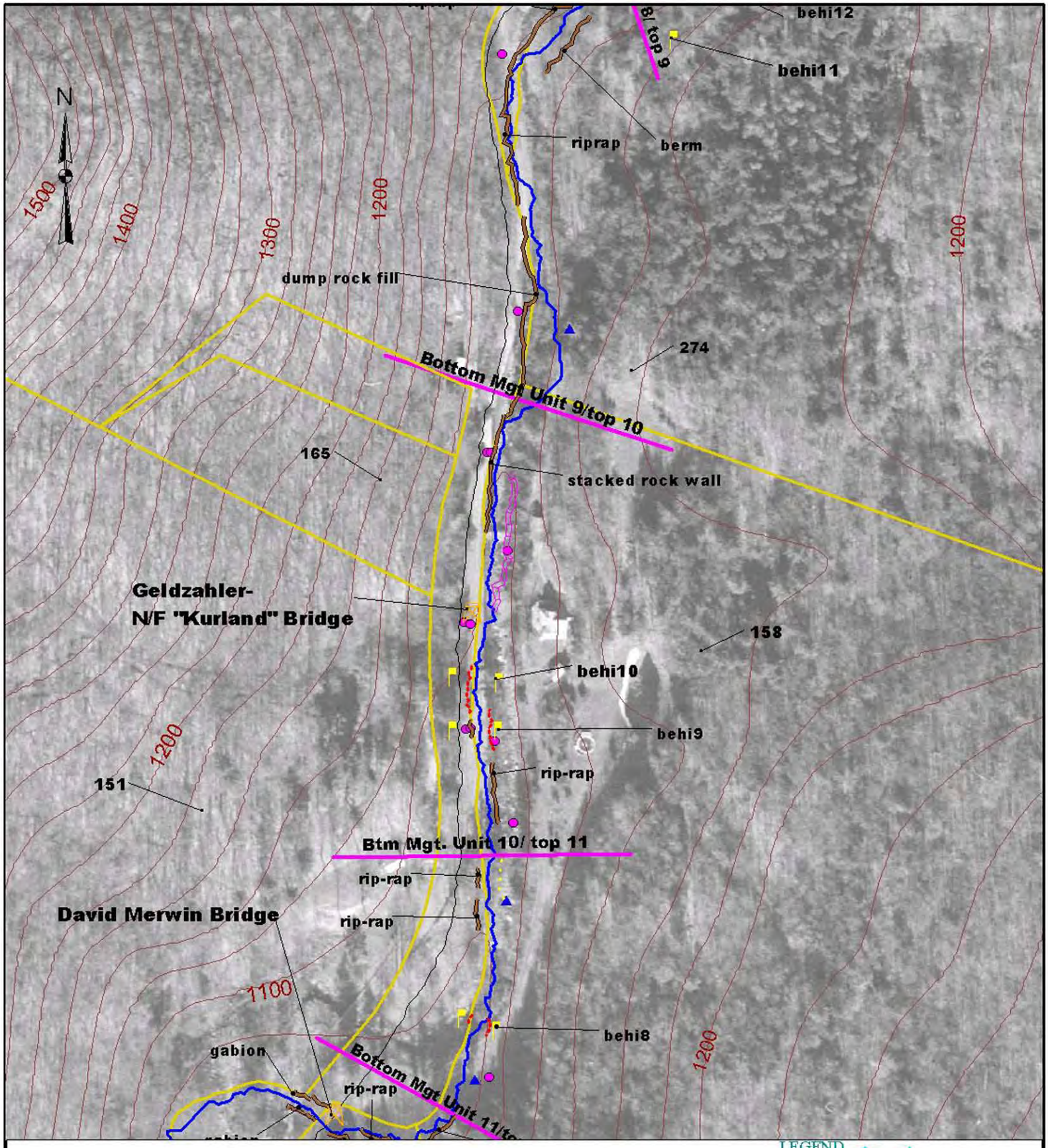

GIS Parcel, Contour and Wetland coverages are edited and provided by NYC DEP, 2000, UTM NAD 27, Zone 18 North, meters. Aerial Photography provided by UCSWCD & NYC DEP November 2001. All other coverages were developed using GPS in the UTM, Zone 18 North projection, NAD CON (Conus), datum. GPS data collected 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 10

Contour Interval 20 feet

50 0 50 100 150 200 Feet

Scale 1:2,400

LEGEND

- 247 Street Address/911 code
- Greene parcels
- Ulster parcels
- Land fills
- Managment units
- Stream Center (Thalweg)
- Culvert
- Wetland
- Clay exposure
- Revetment
- Eroding bank
- Tributary
- Behi pin
- Bridge
- Broadstreet Hollow Road
- Knotweed

Broadstreet Hollow Management Unit 10

General Description:
Management Unit 10 (MU10) is a long straight stretch of the Broadstreet Hollow, in Ulster County, NY, beginning where the guiderail starts along the road just upstream of the stacked rock wall installed in 2002 (Photo 1). MU10 extends approximately 650 feet, through a private bridge, and ends approximately 100 feet downstream of the end of the guiderail[1&2].

Photo 1. Looking upstream near the top of MU10, Broadstreet Hollow Road at left, valley wall at right.

This unit is characterized primarily by its extreme closeness to the Broadstreet Hollow Road, the steepness of the right bank (looking downstream) along the road, and the narrowness of the valley. Despite these factors, the structural shape, or *morphology* (i.e., slope, width and depth), of the stream in this unit is in fairly good condition, or *stable*. The valley in MU10 is particularly narrow throughout, with steep, close valley walls on the left side (looking downstream) and the road on the other, producing a predominantly *entrenched* stream shape. The valley widens out somewhat toward the bottom of the unit, allowing a more natural, sustainable stream morphology consistent with the valley type. 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. MU10 lacks these discontinuous floodplains entirely on the banks near the road except near the bottom (Photo 2), and for much of its length on the opposite bank as well where the valley walls are particularly close.

Photo 2. Right bank near the bottom of MU10, showing partial discontinuous floodplain bench, with grasses and trees between the stream and Broadstreet Hollow Road. Stream flow is from right to left.

Unfortunately, because the stream is confined by the valley and the road, this unit is more vulnerable to disturbance than a section of stream that is less crowded by its valley. Less steep areas with more floodplains have more space in which to bend, or *meander*, and better riparian vegetation to stabilize the banks and provide other habitat benefits[5&7].

I. Flooding and Erosion Threats

A. Infrastructure, and Private Property

There are four properties (land parcels) associated with MU10. One parcel comprises the entire length of the left bank, and the others lie across the road from the stream. Stream

assessment data for 2001 show the centerline of Broadstreet Hollow Road ranges from 40 to 125 feet from the deepest part of the stream, or *thalweg*, though runs less than 50 feet from the stream for most of the unit[1]. Landowners in this unit have expressed concerns about flooding and access, as well as flood-related property damages and stream bank erosion. Some of these issues are discussed below.

The one private stream crossing (bridge), serving one house on the stream is at 158 Broadstreet Hollow Road, serving the (Photo 3). This bridge, with a span of about 43 feet, appears to be constructed with an appropriate width for the stream, which averages 37 feet in width upstream and downstream of the bridge structure. No further management of the bridge is recommended at this time, though with the narrow valley and proximity to the main road, this bridge could be at increased risk from flood damages, so should be visually inspected yearly to detect any structural problems or stream bank erosion that could indicate increased potential for structural problems[8].

Photo 3. Looking upstream at private bridge crossing, serving property at 158 Broadstreet Hollow Road (road is at left).

B. History of Stream Work

Approximately 275 feet, or 23%, of the stream banks in MU10 have been altered or hardened with some type of bank stabilization measure, or *revetment* (Table 1).

Table 1. Altered Banks*
Broadstreet Hollow MU10[2].
*based on linear feet of both sides of stream bank.

Revetment Type	Length	Percent of Unit
stacked rock wall	135 feet	10
rip-rap	95 feet	7
dumped rock fill	45 feet	4
log crib wall	30 feet	2
Total revetment	**275 feet**	**23%**

Revetment in MU10 is dominated by a new length of stacked rock wall stabilizing the right stream bank along the road near the top of the unit, installed by the Town of Shandaken Highway Department in 2001 [3] (Photo 4). By using a stacked rock wall, they were able to preserve existing stream morphology and maintain the road width, with a minimum of disturbance to the stream bed in this area.

Augmenting stacked rock walls with *bioengineering*, or re-vegetation, should be considered to enhance riparian functions in these areas. Bare banks and un-vegetated rip-rapped areas store heat from the sun, and can increase stream temperature by contact with stream flow and rain runoff. Though stacked rock walls produce less of a heating effect because they contain less surface area for the same degree of slope stabilization, they still do not afford any shading to the stream or stream banks that keeps water temperatures low. Elevated aquatic temperatures may adversely affect water quality and stream ecology. Un-vegetated stacked rock wall in this reach should be "inter-planted" (planting small shrub species with small root systems between the rocks to provide some vegetative cover without compromising the structural integrity of the wall) with a mixture of native riparian species to improve shade and cover conditions for aquatic habitat, as well as to improve bank stability and reduce the need for ongoing bank stabilization work that causes stream ecosystem disturbances[7].

Photo 4. Looking upstream at stacked rock wall along road embankment, installed 2002 by Town of Shandaken Highway Department.

Approximately 95 feet, or 7% of the stream bank near the bottom of MU10 have been rip-rapped primarily with large boulder material (Photo 5). As discussed above, un-vegetated rip-rapped areas such as this do not provide the benefits of a healthy riparian zone, the boulders acting as a heat sink and lack of vegetation preventing longer term bank stability. This rip-rapped bank is flanked on each end with a short eroding bank area, a common feature at the edges of hardened stream banks (the upstream eroding bank is described below). Rip-rap tends to act to accelerate water over its relatively smooth surface (compared to a bank covered with trees and small shrubs) [3& 8]. A transition between a hardened area of stream bank and a "softer" area tends to produce erosion, especially if the banks are disturbed or unprotected by vegetation, which is often the case following stream bank work. Both the rip-rapped bank area and the two eroding bank areas on either end would benefit from additional vegetation, or *bioengineering*, to increase and preserve bank stability and other benefits of a healthy streamside, or *riparian* area[7].

Photo 5. Looking upstream near the bottom of MU10, upstream end of rip-rap section at right, downstream of eroding bank at residential lawn area, Broadstreet Hollow Road at left.

Dumped rock fill along the road, upstream of the stacked rock wall in this unit, is a continuation of an extensive length of this type of bank revetment from MU9 above.

Much of this revetment continues to wash or fall into the stream during and following flood events and remains an ongoing maintenance problem for Town and County Highway Departments (Photo 6). Though not mapped as such, there is also a small section (about 50 feet) of bank run gravel material on the stream bank at the top of MU10 (photo 7).

Photo 6. Right bank dumped rock fill, along Broadstreet Hollow Road embankment near the top of MU10. Stream flow is from right to left.

Both of these types of bank fill methods are problematic[3]. Broadstreet Hollow stream can transport very large rocks, or *sediment*, along the stream bed (sediment in transport is called *bedload*). 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, needing periodic replacement[5]. Continuing disturbance of the bank area prevents 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[7]. Alternatives to dumped rock fill or use of bank run gravel material should be strongly considered, to reduce maintenance costs and preserve riparian areas[3].

Photo 7. Looking upstream into the top of MU10, dumped rock fill at left in foreground, bank run gravel material at left in background, Broadstreet Hollow Road at top of bank.

<u>MU10 Culverts</u>

Five culverts were located in MU10 during the stream assessment survey conducted in 2001, three providing roadside ditch drainage for Broadstreet Hollow Road, one providing spring drainage opposite the main road, and one providing ditch drainage under a private road parallel to the main road. An additional drainage pipe was noted from the residential lawn area on the left bank just upstream from the boulder rip-rap area[1&2].

Only one culvert did not have flowing water in it at the time of the survey, during the lowest yearly flow, or *summer base-flow*, condition, and despite drought conditions during 2001. This indicates good groundwater supply, and shows the stream is spring fed year round. Culvert flow under flooding conditions was not documented, though there

The upstream-most culvert was installed as part of the new stacked rock wall constructed by Town of Shandaken in 2002, and provides drainage from the *inboard* roadside ditch (along the valley wall), crossing the road to enter on the right stream bank (Photo 8). This culvert outlet is high above the stream, potentially increasing erosive power as water falls to the stream bed below, though currently the number and arrangement of boulder material at the toe (base) of the wall in the stream bed appears to be sufficient to absorb this energy. This should be visually inspected yearly to detect any changes in stream bed stability that could impact either stream function or threaten the rock wall structure.

Photo 8. Looking upstream, black plastic corrugated culvert in stacked rock wall at left, draining inboard roadside ditch on Broadstreet Hollow Road.

Additionally, this wall is un-vegetated, as discussed above, so may add heat to the water as it falls and flows over the rocks before it enters the stream. A mix of vegetation should be added to this wall, particularly in the vicinity of the culvert, to shade the culvert (which is black, so may absorb a greater amount of solar heat before water even reaches the rocks) and the rocks below to preserve cool temperatures both for water quality and aquatic habitat functions.

The second culvert from the top of MU10 drains through an old dumping site along the stream bank across from the road (the left bank looking downstream) approximately 50 feet upstream of the private bridge crossing (Photo 9). Despite refuse materials in this area, the relatively steep angle of the bank and height of the drop, the culvert outfall appears stable, with large rocks and boulders in the bank well covered with moss, showing little if any erosive power at work in this area. No monitoring or amendments are recommended at this time for this culvert.

Photo 9. Corrugated culvert in left bank landfill/dumping site. Stream is behind the viewer, flow from left to right.

The third culvert provides inboard ditch drainage for Broadstreet Hollow Road, entering the stream on the right bank (looking downstream), just downstream of the private bridge (Photo 10). The outlet is

Photo 10. Smooth metal culvert on right bank, draining inboard ditch on Broadstreet Hollow Road, just downstream of private bridge crossing. Stream is behind the viewer, flow from right to left.

several feet above the stream bed on a steep bank, with some erosion evident below. Because of the steepness of the bank, and the lack of strong woody riparian vegetation, this culvert outlet should be inspected frequently to detect any problems, and should be augmented with additional vegetation to reduce streambed erosion at the toe (base) of the bank that could eventually lead to compromising structural integrity of the bridge.

Photo 11. Looking upstream toward smooth metal culvert in log crib wall on right bank, along Broadstreet Hollow Road embankment. Culvert was dry at the time of the 2001 stream survey.

The fourth culvert, the only one that was dry at the time of the stream survey in 2001, is part of a section of log crib wall, of unknown age, along the road embankment, entering the stream on the right bank (Photo 11). Though this culvert and the crib wall could benefit from additional riparian vegetation to improve stability and preserve cool water temperatures, boulders at the base of the wall appear to be functioning to dissipate the energy of water falling from the culvert outlet. Other than potentially augmenting this area with additional riparian vegetation and annual visual inspection, no further action on this culvert or the crib wall is recommended at this time.

The downstream-most culvert provides drainage under the private road on the opposite side of the stream (along the left bank, looking downstream) and parallel to Broadstreet Hollow Road (Photo 12). The outlet is well protected with boulder walls, and enters the stream at a low angle, set back far enough from the active stream channel, making this the most stable culvert in MU10. No additional management is recommended for this culvert at this time.

Photo 12. Culvert providing drainage for private road, on the left bank opposite and parallel to Broadstreet Hollow Road. Stream is behind the viewer, flow from left to right.

C. Exposed Banks

Approximately 140 feet, or 11%, of the stream bank in MU10 was mapped as eroding or exposed bank area in 2001, in two sections near the bottom of the unit. Both eroding banks were monumented at a representative location for future monitoring (designated as "monitoring cross-sections 9 and 10") to determine erosion rates and priority for potential restoration[3]. These sites have 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].

Monitoring cross-section 9 was set up to document erosion of the left bank lawn area opposite the log crib wall location, approximately 50 feet upstream from the boulder rip-rap section (see right side of Photo 5). Bank instability in this section is primarily due to lack of deeply rooted vegetation, and may be exacerbated by the narrowness of the valley

in this section. The hardened right bank does not allow excess stream energy to be dissipated by moving the channel in that direction, so stream forces will preferentially erode the "softer" surface. This area received a "moderate" BEHI rating, indicating an ongoing but not serious or acute potential for continued erosion. No structures are threatened, though the drainage pipe in this bank may be of concern. Continued monitoring of this section is recommended to detect any changes that could lead to additional instability. Minimally, riparian vegetation should be augmented on the left bank lawn area, with additional grasses and shrub or tree species as appropriate for additional stability and to reduce further erosion and property and soil loss[7].

Monitoring cross-section 10 was set up to document ongoing erosion along the road embankment in this particularly narrow reach of stream (Photo 13). While vegetation along this bank generally includes a mix of herbaceous (small, annuals and grasses) and woody (shrub and tree species) vegetation, the proximity of the stream to the road, and the steepness of the bank, prevent a fully functioning riparian zone from holding this bank in place. This area also received a "moderate" BEHI rating, but due to the shape of the stream channel here, the potential for ongoing erosion is likely higher, as the main flow of the stream is right up against the bank with high energy, compared to cross-section 9, in which there is a gravel bar deposited against the toe of the bank, indicating a depositional zone and lower stream energy. Continued monitoring of this section will be critical to ensuring integrity of the road embankment. Augmenting with additional vegetation should also be implemented, including woody, deep-rooted species that can provide structural bank stability in addition to reducing soil and embankment material losses to the stream[7].

Photo 13. Looking upstream into reach with monitoring cross-section 10, eroding bank along road embankment associated with inadequate riparian vegetation and very steep slope, close to the stream.

Photo 14. Right bank along Broadstreet Hollow Road embankment, showing steep slope, leaning trees and active stream processes at the toe (base) of the bank. Stream flow from right to left.

In addition to mapped areas of active bank erosion, stream assessment in 2001 documented generally lower level bank instability along the road embankment (Photo 14). The active bank erosion was evidenced by some exposed soil areas, very steep banks and stressed vegetation (including the classic "pistol-butt" shape of tree trunks that indicate a continual, slow downward movement of the slope (see Photo 13), as well as trees leaning

streamward from the slope). Additionally, landowners in this area have noted that fill material and past stream bank work has been eroding through this reach, though not necessarily catastrophically or all at once [3].

II. Water Quality

A. Sediment

Eroding banks in MU10 may cause minor increased turbidity in this reach from fine sediment (*silt* or *clay*) coming from stream bank and bed material. Of the approximately 140 feet of actively eroding bank documented in 2001, no exposures of *glacial lake clay* were documented[10].

B. Landfills/Dumping Sites

Approximately 227 feet (18%) of MU10 was mapped as a single dumping site, the longest, though not the densest, documented in 2001[1&2] (see photo 15). This site appears not to contain any materials that could contribute to water quality impairment from leaching of toxic materials.

Photo 15. Close-up of left bank landfill/dumping site in MU10. At 227 feet, this is the longest landfill documented in the watershed, though isn't very densely littered.

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 the road and/or culverts that may contain salts or other pollutants was not specifically investigated. Compromised riparian buffer areas, particularly between the stream and the road for the length of MU10 along the right bank, could reduce the capacity of the stream banks to assimilate, or slow the input of, contaminants to the stream[7].

III. Stream Ecology

A. Aquatic habitat and populations

No specific aquatic habitat or population monitoring was conducted in MU10 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].

B. Riparian Vegetation

Stream assessment conducted in 2001 did not investigate specific streamside (riparian) plant species or density, other than to note areas of insufficient or stressed vegetation that

could generally affect stream stability, flooding or erosion threats, water quality or aquatic habitat for trout species. Based on these general observations, riparian vegetation throughout MU10 is insufficient to provide the full benefits of a healthy riparian zone to this section of stream through the length of MU10, though has some healthy sections especially opposite the road in the upstream section of the unit (Photo 16).

Photo 16. Looking upstream in MU10, just above private bridge crossing, stacked rock wall at left in the background. Riparian vegetation at the right is healthy, away from the steep road embankment at left. The road embankment area should be augmented with additional vegetation.

As mentioned above, the road runs less than 50 feet from the stream thalweg through most of MU10. This narrow area is generally quite steep, making vegetation both more difficult to support as well as more important for maintaining stream bank and road fill stability and preserving other riparian vegetative benefits. Existing riparian vegetation between the road and the stream can be stressed by ongoing road runoff, plow side-cast, and maintenance of revetments. Under-vegetated areas in the vicinity of the stacked rock wall, dumped rock fill, rip-rap and non-hardened road fill sections in this reach should be vegetated with a mixture of native riparian species to improve shade, cover and water temperature conditions for aquatic habitat[9], as well as to improve bank stability and reduce the need for bank stabilization work that could cause or increase stream ecosystem disturbances[3].

No *Japanese Knotweed* [7], a non-native, *invasive* plant was noted in this reach at the time of the assessment survey.

[1] Broadstreet Hollow Management Unit 10 Map
[2] Volume II Appendix 3.1.5 Management Unit 10 Workbook.
[3] Volume II Section 2.2 Watershed Management Recommendations
[4] Volume II Section 2.2.1-Monitoring Cross Section and Summary Tables
[5] Volume I Sections 3.2.1&2 Stream Processes, Morphology and Classification
[6] Volume I Section 3.5 Fisheries and Wildlife
[7] Volume I Sections 3.4 & Volume II 2.2.2 Riparian Vegetation Issues and Recommendations
[8] Volume II 2.0 Stream Stability Restoration Projects, Techniques and Contact Information & Appendices
[9] Volume I Sections 3.4 & Volume II 2.2.2 Riparian Vegetation Issues and Recommendations
[10] Section 3.2.4.2 Broadstreet Hollow Geology