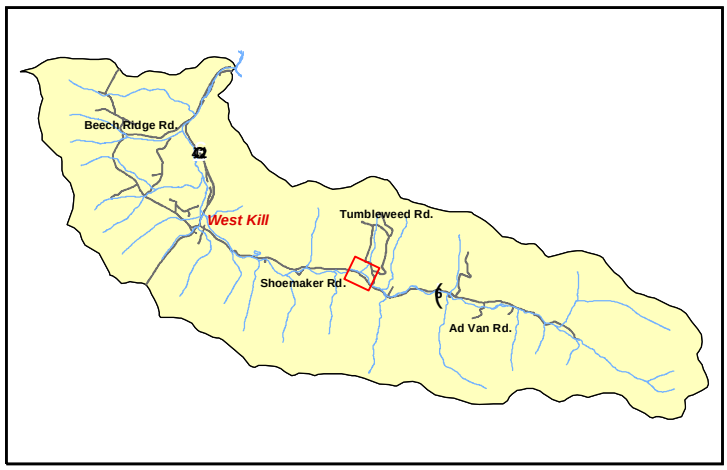


West Kill Management Unit 9

Stream Feature Statistics

10% of stream length is experiencing erosion
30% of stream length has been stabilized
12.8 acres of inadequate vegetation within the 300 ft. buffer
364 ft. of stream is within 50 ft. of the road
0 houses located within the 100-year floodplain boundary

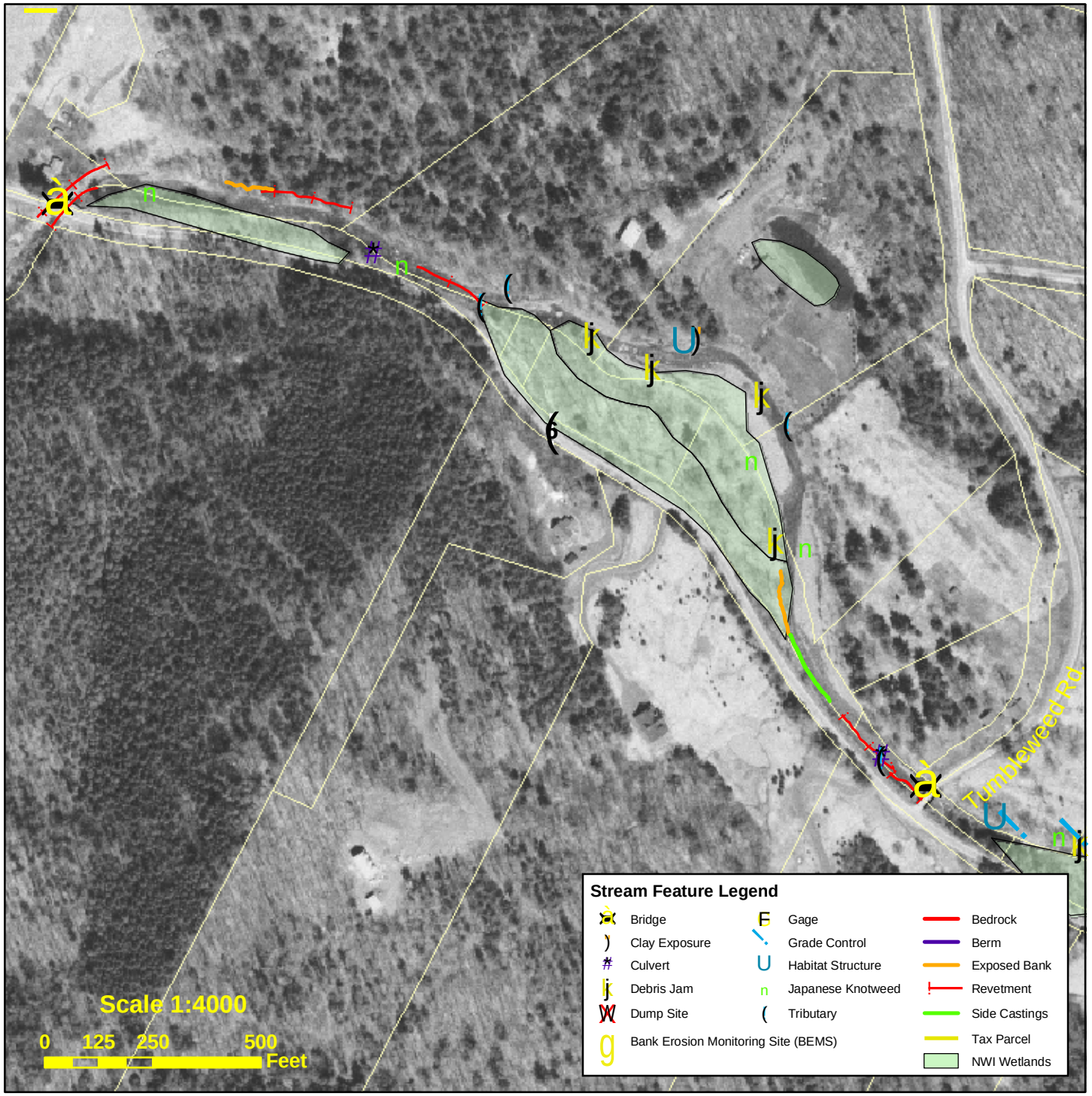


Figure 4.9.1 2004 aerial photography with stream feature inventory and tax parcels

Management Unit 9

Between Station 34845 and Station 32092

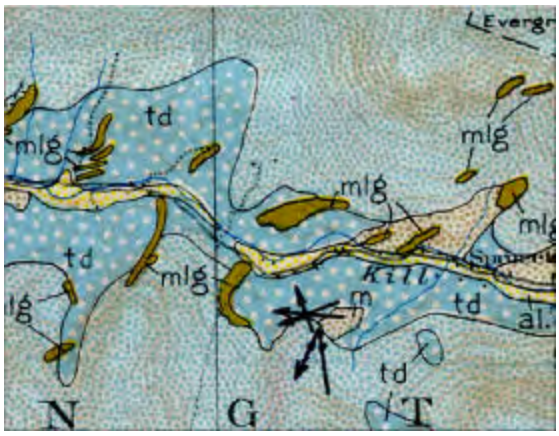
Management Unit Description

This management unit begins just downstream of the Tumbleweed Road bridge at Station 34845, continuing approximately 2,753 ft. to the Greene County Route 6 bridge, at Station 32092. The drainage area ranges from 13.4 mi^2 at the top of the management unit to 14.5 mi^2 at the bottom of the unit. The valley slope is 1.65%.

Summary of Recommendations Management Unit 9	
Intervention Level	Assisted Self-recovery, Passive Restoration
Stream Morphology	None
Riparian Vegetation	Buffer improvements at three sites; Eradication of Japanese knotweed.
Infrastructure	Interplanting rip-rap installations with vegetation.
Aquatic Habitat	Watershed-wide study.
Flood Related Threats	None.
Water Quality	Explore opportunities for stormwater treatment.
Further Assessment	Investigate potential stormwater impacts in subdivision.

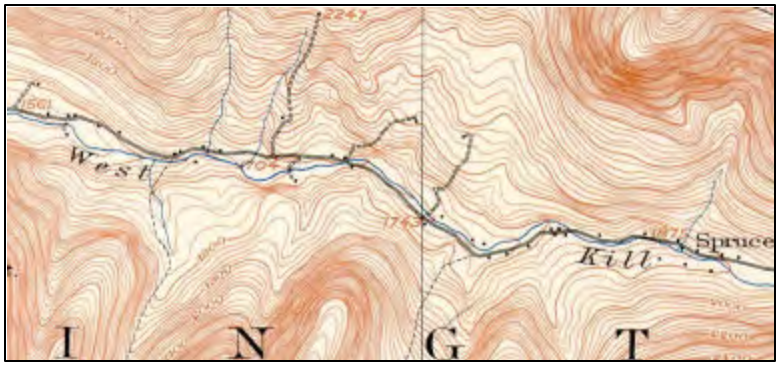
Historic Conditions

As the glaciers retreated about 12,000 years ago, they left their "tracks" in the Catskills. See Section 2.4, Geology of the West Kill Creek, for a description of these deposits.



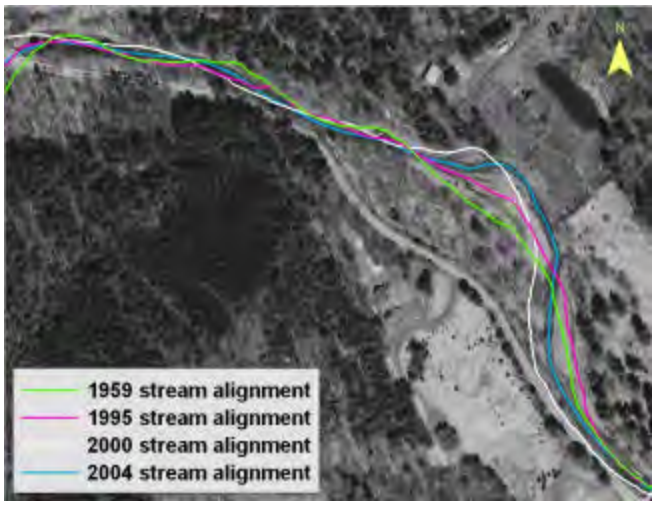
Excerpt from Rich, 1935

F.W. Beers 1863 Atlas of Greene County, New York, excerpt from the Town of Lexington



USGS 1903 topographic map, excerpt

The 1903 USGS topographic map indicates a much straighter channel through MU9, one that hugs Greene County Route 6 more closely. Aerial photography reveals relic channels that would support this interpretation.



Historic Stream Channel Alignments in MU4

As seen from the historical stream alignments, the channel alignment has changed significantly over the years (Fig. 4).

According to available NYS DEC records there were three stream disturbance permits issued in this management unit following the flood of 1996. These permits included clearing debris jams, removal of a total of 570 yards of gravel deposits over 1150 ft. of stream, and to repair rip-rap installations.

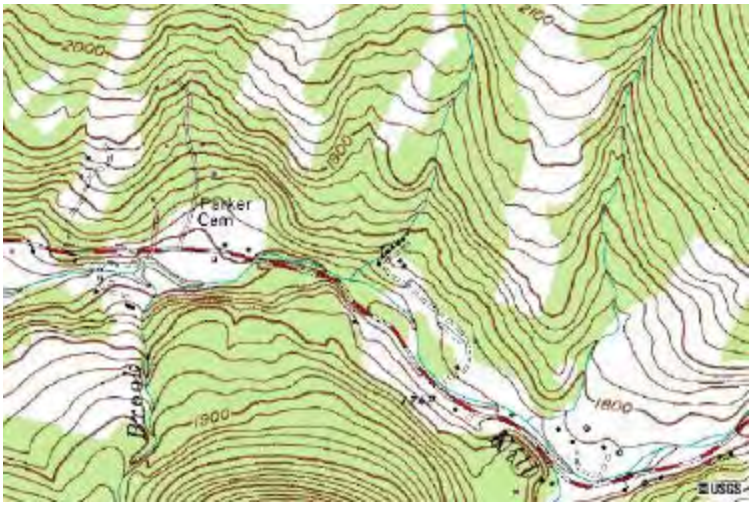
Stream Channel and Floodplain Current Conditions

Revetment, Berms and Erosion

The 2004 stream feature inventory revealed that 10% (268 ft.) of the stream length exhibited signs of active erosion along 2,753 ft. of total channel length. Revetment has been installed on 30% (839 ft.) of the stream length, including both rip-rap and log cribbing. No berms were identified in this management unit at the time of the stream feature inventory.

Stream Morphology

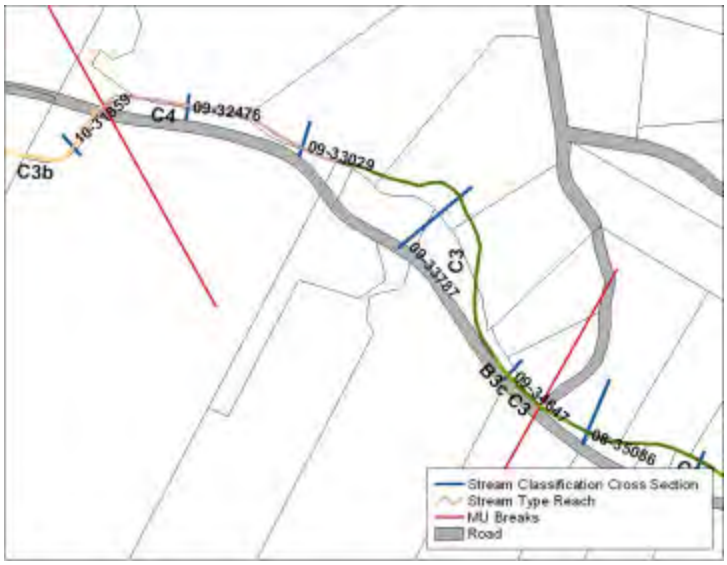
The following description of stream morphology references insets in the foldout Figure 4.9.2. "Left" and "right" references are oriented looking downstream. Stationing references proceed upstream, in feet, from an origin (Station 0) at the confluence with the Schoharie Creek at Lexington. Italicized terms are defined in the glossary. This characterization is the result of surveys conducted in 2004 and 2005.



Excerpt of 1980 USGS topographic map

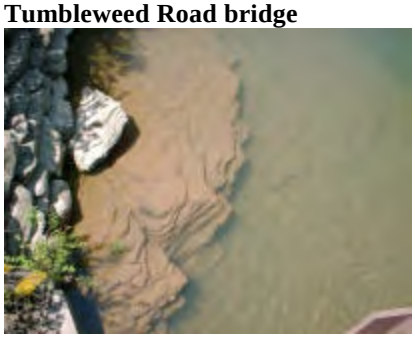
In Management Unit 9, the West Kill begins by bending northward through the middle of the valley flat, away from the influence of Spruceton Road, before it enters a pinch point just below the confluence of a major, unnamed tributary. The valley slope here flattens locally, resulting in increased channel sinuosity, a wider beltwidth and consequently, a greater tendency and capacity for sediment storage, in contrast to the reaches upstream. The development of aggradation in the upper reaches of the unit does create significant bedload storage conditions, but in the lower half of the unit, the channel has a more stable relationship with its floodplain and a reduced sinuosity until it is confined again at the Greene County Route 6 bridge crossing.

Stream morphology, or shape (i.e., slope, width and depth) changes several times in this unit, creating small reaches with differing morphologic characteristics, which are classified as different *stream types* (See Section 3.2 for description of stream types).



Cross-sections and Rosgen stream types in Management Unit 9

Tumbleweed Road bridge



Bedrock pool

Downstream of the Tumbleweed Road bridge, Management Unit 9 (MU9) begins with a 145 ft. section of C1 stream type, but quickly transitions to a 150 ft. reach of B3c stream type as entrenchment increases somewhat, documented by a monumented cross-section at Station 36414. The channel invert under the bridge is a deep bedrock pool, providing grade control but shifting the erosive forces laterally onto the streambanks. While stream flows can access the floodplain at a mown lawn on the right, just downstream of the bridge, entrenchment increases somewhat downstream, and the floodplain is interrupted longitudinally. The channel bends gently to the right, with a point bar on the right, which has been scoured at the bridge outlet by backeddy scour.

Backeddy scour, right

Bedrock sill under bridge

Stacked rock wall, left

A 500 ft. length of revetment protects the embankment of Greene County Route 6 on the left with a mix of stacked rock, log cribbing and dumped rock rip-rap, which appears progressively more compromised as you move downstream.

Log cribbing, left bank

Tributary confluence, perched, left

A small unnamed tributary enters, left, through a perched 24" culvert under the road, with a stacked rock headwall in good repair and good outfall protection (see Insert H, Fig. 4.9.2). Downstream of the tributary the cribbing transitions to dumped rip-rap over failing cribwall, with no apparent toe protection, and then to material apparently sidecast during channel grading (Inset D, Figure 4.9.2). There is no significant riparian buffer between the channel and the road. Recommendations for this site include interplanting the revetment with ecologically appropriate trees and shrubs to improve buffer function and bank stability. A monumented cross-section (Station 34647) documents this B3c reach, with entrenchment increasing, but channel slope dropping to 0.8%.

Dumped rip-rap over failing crib wall

Bank cutting, left

As the channel bends right, it becomes overwidened as a result of downstream aggradation and a significant drop in channel slope (see Insert D, G, Fig. 4.9.2). The result is 153 ft. of bank cutting on a low, well-rooted terrace at the outside of the meander bend, left (Inset G, Figure 4.9.2). Channel grading has likely exacerbated the overwide conditions here, but the point bar on the right appears to be vegetating with willows which may serve to narrow the channel, and an improvement of the riparian buffer on the right mitigates the erosion. As a result, the problem does not appear severe, and *passive restoration*, or letting the channel reestablish its own equilibrium, is recommended for this site, and for the reach in general. The site was not monumented as a Bank Erosion Monitoring Site.

A small stand of Japanese knotweed (*Fallopia japonica*) also occurs on the point bar, however, and it is recommended that a watershed-wide program of eradication of this invasive exotic be undertaken. Japanese knotweed has become a widespread problem in recent years in the Catskills. Knotweed shades out other species with it's dense canopy structure (many large, overlapping leaves), but stands are sparse at ground level, with much bare space between narrow stems, and without adequate root structure to hold the soil of streambanks.

Japanese knotweed on bar, right

Debris jam, left

A small pile of woody debris on the left bank marks the head of a channel divergence at the back of a point bar on the left, as the channel crosses over and begins to meander back to the left.

Point bar development

As access to the floodplain increases dramatically on the left, the channel transitions to a 1350 ft. reach of C3 stream type. Large woody debris is snagged at numerous locations on the floodplain. The low entrenchment, aggradational conditions might have been typical of more of the West Kill prior to European settlement, before the stream was confined by roadways and cleared agricultural fields, and when beavers and their dams played a predominant role in floodplain development. The aggradational conditions here are due to a pinch in valley morphology downstream, around Station 33000, which constricts very large floods, and may have resulted in local ponding of glacial meltwater. A small stand of Japanese knotweed was documented on the left point bar, and a small, unnamed tributary confluences on the right, slightly perched on a well-vegetated low bench.

Aggradation

Debris jam on bar

Tributary confluence, right

A monumented cross-section (Station 33787) documents this C3 reach, as slope continues to reduce to 0.67%, and floodplain connectivity increases. Cobble continues to dominate the bed material.

Continuing downstream, a large exposure of lacustrine clay was observed in the stream bed on the right. Clay inputs into a stream are a serious water quality concern because they increase *turbidity*, degrade fish habitat, and can act as a carrier for other pollutants and pathogens. *Passive restoration*, or letting the stream reestablish its own equilibrium, is recommended for the reach in general.

Clay exposure

Clay exposure

Remnants of a habitat structure (Station 33570) were observed downstream of the clay exposure, on the right bank only. Habitat structures were historically installed throughout the West Kill mainstem by the New York State Department of Environmental Conservation (NYSDEC), often to create scour pools. These scour pools offer deeper holding habitat, sometimes with associated cover, and the spillways raise the level of dissolved oxygen in the water. The structures, often in the form of a log weir perpendicular to the channel, also provided grade control. Because they provide only minimal lateral control, however, higher flows frequently flank these structures. In some settings, this can promote lateral channel migration, increase width-to-depth ratios and result in bank erosion up- or downstream, as is seen here. In wild streams, these functions – both positive and negative – are performed to a large extent by large woody debris.

Woody debris, in channel

Debris in trees on floodplain

Woody debris was observed throughout the reach, both in the channel and on the floodplain, left. Unnamed tributaries enter from the right and left over well-vegetated, well-connected low benches. The right tributary has a significant drainage (0.6 mi.^{2}), which includes recently developed residential subdivision; stormwater impacts upstream in this tributary should be investigated, both in terms of hydrology and water quality. The left tributary is primarily flow from the overflow channel on the back of the bar, but also carries some roadway drainage. The channel is confined by both the valley walls and Greene County Route 6, which bends back to the stream here, and runs immediately adjacent to the channel, protected by a 181 ft. installation of dumped rip-rap, in good condition. There is no buffer along the roadway (see Insert C, Fig. 4.9.2). The channel still maintains sufficient floodplain connectivity and width to pass moderately sized storm flows, as the stream steepens through this valley pinch point. A monumented cross-section (Station 33029) documents an increase in channel slope to 1.54%, and the bed material becomes dominated by gravel here, indicating a transition to this 1108 ft. reach of C4 stream type. The stability of the C4 stream type is very dependent on the stabilizing influence of riparian vegetation, and interplanting of the revetment here is recommended to improve buffer functions, increase the longevity of the rip-rap and improve fish habitat in this reach.

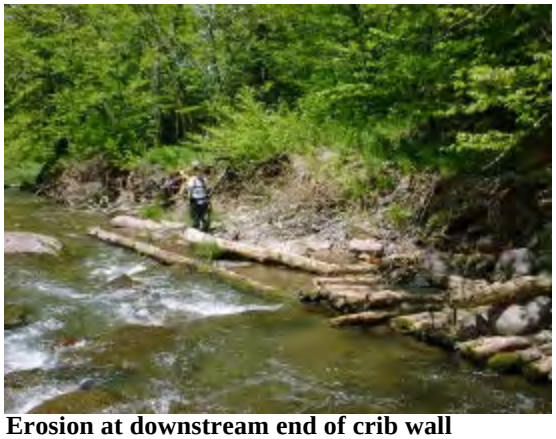
Tributary confluence, right

Rip-rap along Route 6, left

Culvert, left

Crib wall of log and rock, right

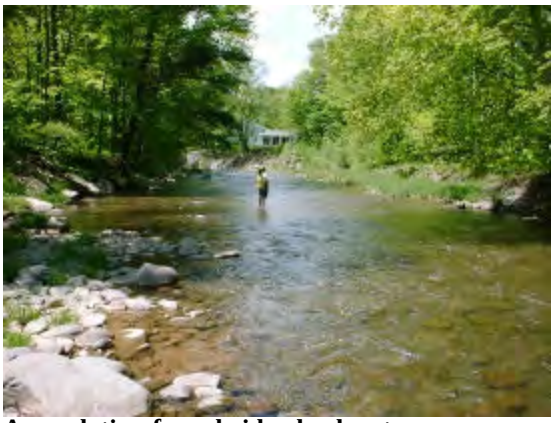
A 24" culvert carrying road drainage enters from the left, with a stacked headwall in stable condition and good outfall protection. Just downstream, remnants of log and rock crib wall, still partly functional, protect the terrace bank on the right (see Insert F, Fig. 4.9.2).



Erosion at downstream end of crib wall

Proceeding downstream, a 115 ft. section of the terrace bank is experiencing minor erosion at the downstream end of the log cribbing on the right. This erosion is exacerbated, if not directly caused, by streambed aggradation resulting from backwater at the bridge downstream (Inset B, Figure 4.9.2). The site was not significant enough to be monumented as a Bank Erosion Monitoring Site. A small stand of Japanese knotweed was observed on the left bank.

A monumented cross-section here (Station 32476) documents a decrease in channel slope to 0.67%, but the bed material remains dominated by gravel, indicating a continuation of the C4 stream type. Aggradation continues through this reach; backwatering of flood flows at the Greene County Route 6 bridge crossing is caused as much here by *form roughness*, created by the hard bend of the channel to the left just upstream of the bridge, as by an undersized opening at the bridge. The aggradation ends at a steep riffle heading into the bridge opening.



Aggradation from bridge backwater

County Rte 6 bridge, looking downstream

Looking upstream

While the relatively new Greene County Route 6 bridge (Insets A and E, Figure 4.9.2) passes bankfull flows readily, larger flows are constricted by the structure. Gravel deposits upstream of bridges are commonly caused by inadequate sizing of the bridge opening. An undersized bridge opening causes water to back up upstream of the bridge, reducing stream velocity, which results in sediment deposition. In high stage, the floodwater may seek conveyance through alternative paths, forming new channels around the bridge constriction, as appears to happen occasionally at this site. Additional *floodplain drainage*, using culverts set at the floodplain elevation under the east bridge approach, may help mitigate this problem. The upstream abutments are protected by formed concrete wingwalls and rip-rap on both the right and left.

Sediment Transport

Streams move sediment as well as water. Channel and floodplain conditions determine whether the reach aggrades, degrades, or remains in balance over time. If more sediment enters than leaves, the reach aggrades. If more leaves than enters, the stream degrades (See Section 3.1 for more details on Stream Processes).

Sediment transport in MU9 is strongly influenced by valley morphology. The valley pinch point at Station 33000 has resulted in a very flat valley floor in the upstream half of the unit. Lacustrine clay exposures in the bed in these reaches point to the likelihood that an ice jam at the pinch point may have impounded water upstream, leading to lakebed deposits and morphology. Bedrock grade control at the beginning of the unit provides a check on incision, or the lowering of the elevation of the channel. The result is a low channel slope, and the reach becomes a location where sediment from upstream is stored, and may benefit the general health of the stream system by limiting bedload delivered to downstream reaches. Sediment sinks such as this throughout the watershed should be identified and preserved where adjacent land uses permit. Mature riparian vegetation will be important in such settings to limit the extent of lateral channel migration and bank erosion.

The channel gradient steepens going through this pinch point, but then flattens again in the final reach of the management unit under the influence of backwatering upstream of

the Greene County Route 6 bridge crossing at Station 32092, producing another incidence of aggradation and some minor, associated lateral bank erosion.

Riparian Vegetation

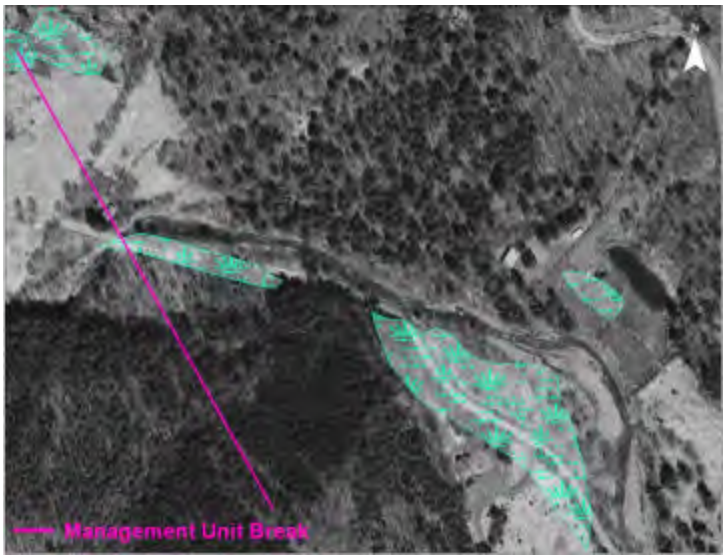
One of the most cost-effective methods for landowners to protect streamside property is to maintain or replant a healthy buffer of trees and shrubs along the bank, especially within the first 30 to 50 ft. of the stream. A dense mat of roots under trees and shrubs bind the soil together, and makes it much less susceptible to erosion under flood flows. Mowed lawn does not provide adequate erosion protection on stream banks because it typically has a very shallow rooting system. Interplanting with native trees and shrubs can significantly increase the working life of existing rock rip-rap placed on streambanks for erosion protection. *Riparian*, or streamside, forest can buffer and filter contaminants coming from upland sources or overbank flows. Riparian plantings can include a great variety of flowering trees and shrubs, native to the Catskills, which are adapted to our regional climate and soil conditions and typically require less maintenance following planting and establishment.

Some plant species that are not native can create difficulties for stream management, particularly if they are invasive. Japanese knotweed (*Fallopia japonica*), for example, has become a widespread problem in recent years. Knotweed shades out other species with it's dense canopy structure (many large, overlapping leaves), but stands are sparse at ground level, with much bare space between narrow stems, and without adequate root structure to hold the soil of streambanks. The result can include rapid streambank erosion and increased surface runoff impacts.

An analysis of vegetation was conducted using aerial photography from 2005 and field inventories (Fig 4.9.3). Japanese knotweed occurrences were documented as part of the stream feature inventory conducted during the summer of 2004, with additional occurrences identified in 2005.

In this management unit, the predominant vegetation type within the 300 ft. riparian buffer is Forest (54%) followed by Herbaceous (26 %). *Impervious* area (4%) within this buffer is primarily the Greene County Route 6, along with private residences and associated roads. Four occurrences of Japanese knotweed were documented in this management unit during the 2004 inventory, increasing to eight in 2005.

There are five wetlands within this management unit mapped in the National Wetland Inventory (see Section 2.5, Wetlands and Floodplains for more information on the National Wetland Inventory and wetlands in the West Kill watershed). Wetlands are important features in the landscape that provide numerous beneficial functions including protecting and improving water quality, providing fish and wildlife habitats, storing floodwaters, and maintaining surface water flow during dry periods (See Section 2.6 for wetland type descriptions and regulations). There are two large wetlands, one which measures 2.5 acres in size, designated *palustrine, forested, broad-leaved deciduous temporarily flooded* (PFO1A), and the other which measures 2 acres in size and is



National Wetland Inventory wetlands in MU9

designated *riverine, upper perennial, unconsolidated shore, seasonally flooded*(R3USC). There is also a small wetland, measuring 0.4 acres in size, designated *palustrine, unconsolidated bottom, permanently flooded, diked/impounded* (PUBHh). Further downstream, there are two wetlands 0.8 acres in size, one that is designated *palustrine, scrub/shrub, broad-leaved deciduous, temporarily flooded* (PSS1A), and one that is designated *palustrine, emergent, broad-leaved deciduous, seasonally flooded/saturated, diked/impounded*(PEM1Eh).

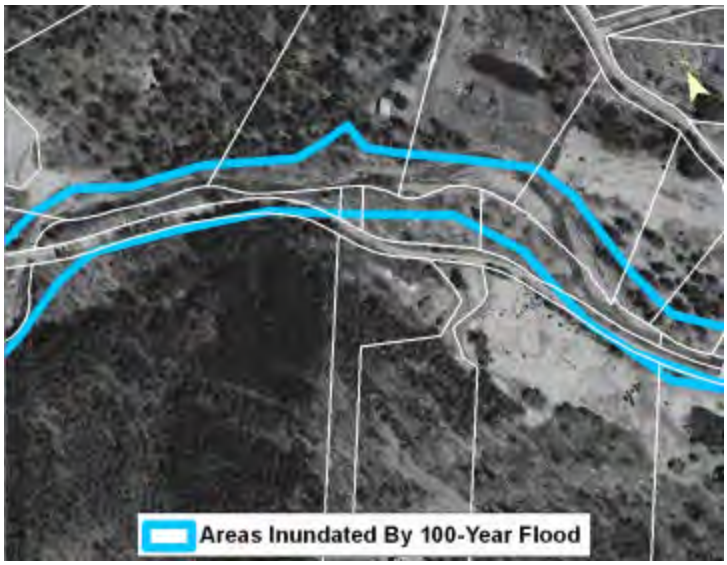
Areas identified as having herbaceous (non-woody) cover may present opportunities to improve the riparian buffer with tree plantings, to promote a more mature vegetation community along the streambank and in the floodplain. In November 2005, potential riparian improvement planting sites were identified through a watershed-wide remote evaluation of current riparian vegetation conditions in a critical buffer zone extending approximately 75 ft. from the centerline of the stream (Fig 4.9.4). These are sites where plantings of trees and shrubs on and near stream banks would likely reduce the threat of serious bank erosion, and can improve aquatic habitat as well. In some cases, these sites include stream banks where rock rip-rap has already been placed, but where additional plantings could significantly improve long-term stream channel stability, as well as biological integrity of the stream and floodplain. There are 20 potential planting sites in MU9.

In many cases, these sites can not be effectively treated with riparian enhancement alone, and full restoration efforts would include bank and/or channel restoration components in addition to vegetative buffer plantings. However, the risk to bank stability can be minimized by maintaining mature trees along the stream margin. The risks and benefits associated with management of streamside vegetation will depend partly on the current channel conditions, and local channel surveys are recommended at each site.

Flood Threats

Inundation

As part of its National Flood Insurance Program (NFIP), the Federal Emergency Management Agency (FEMA) performs hydrologic and hydraulic studies to produce Flood Insurance Rate Maps (FIRM), which identify areas prone to flooding. There are no houses in the 100-year floodplain in this management unit. The NYS DEC Bureau of Flood Protection is currently developing new floodplain maps for the West Kill on the basis of recent surveys. These maps should be completed for the West Kill Watershed in 2006.



100 year floodplain boundaries, MU9

The 100-year floodplain is that area predicted to be inundated by floods of a magnitude that is expected to occur once in any 100 year period, on the basis of a statistical analysis of the local flood record. Most communities regulate the type of development that can occur in areas subject to these flood risks. The current NFIP maps are available for review at the Greene County Soil & Water Conservation District office.

Bank Erosion

Ten percent (268 ft.) of the stream length in this unit are experiencing minor erosion, and 30% (839 ft.) has been stabilized. This and the variability of the historic alignments would indicate that the reach should be considered unstable. There are, however, no Bank Erosion Monitoring sites in MU9.

Infrastructure

Thirty percent of the stream length in this management unit have been treated with some form of revetment. While there are no immediate threats to roadways or bridges in this management unit, the revetment along Greene County Route 6 at the start of the management unit is somewhat compromised at its downstream end. It is recommended that plantings of ecologically appropriate trees and shrubs should be interplanted with the

existing dumped rip rap to increase bank stability, improve buffer function and improve fish habitat by increasing canopy shading.

Aquatic Habitat

It is recommended that a habitat study be conducted on the West Kill Creek, with particular attention paid to possible physical and temperature barriers in aggrading sections, to the frequency of disturbance of the bed due to incision at numerous points in the system, and to embeddedness resulting from excessive entrainment of fine sediment.

Habitat appeared generally good throughout this management unit, with abundant woody debris. Canopy cover, however, could be improved in a number of locations.

Water Quality

Clay exposures and sediment from stream bank and channel erosion pose a potential threat to water quality in West Kill Creek. Clay and sediment inputs into a stream may increase *turbidity* and act as a carrier for other pollutants and pathogens. There was one significant clay exposure documented in this management unit, which should be further investigated for its causes and severity.

Stormwater runoff can also have a considerable impact on water quality. When it rains, water falls on roadways and flows untreated directly into West Kill Creek. The cumulative impact of oil, grease, sediment, salt, litter and other unseen pollutants found in road runoff can significantly degrade water quality. There are 2 stormwater culverts in this management unit, and thirteen percent of the stream (364 ft.) lies within 50 ft. of a road. Opportunities should be explored for improving natural buffering of these stormwater sources before they join the main channel. The intensive subdivision of Tumble Ranch Road is unique in the West Kill watershed, and its associated stormwater drainages should be investigated for potential hydrological and water quality impacts.

Nutrient loading from failing septic systems or livestock manure is another potential source of water pollution. Leaking septic systems can contaminate water making it unhealthy for swimming or wading. There are no houses located in close proximity to the stream channel in this management unit.

The New York City Watershed Memorandum of Agreement (MOA) allocated 13.6 million dollars for residential septic system repair and replacement in the West-of-Hudson Watershed through 2002. Eligible systems included those that were less than 1,000-gallon capacity serving one- or two-family residences, or home and business combinations. No homeowners in this management unit made use of this program to replace or repair a septic system.

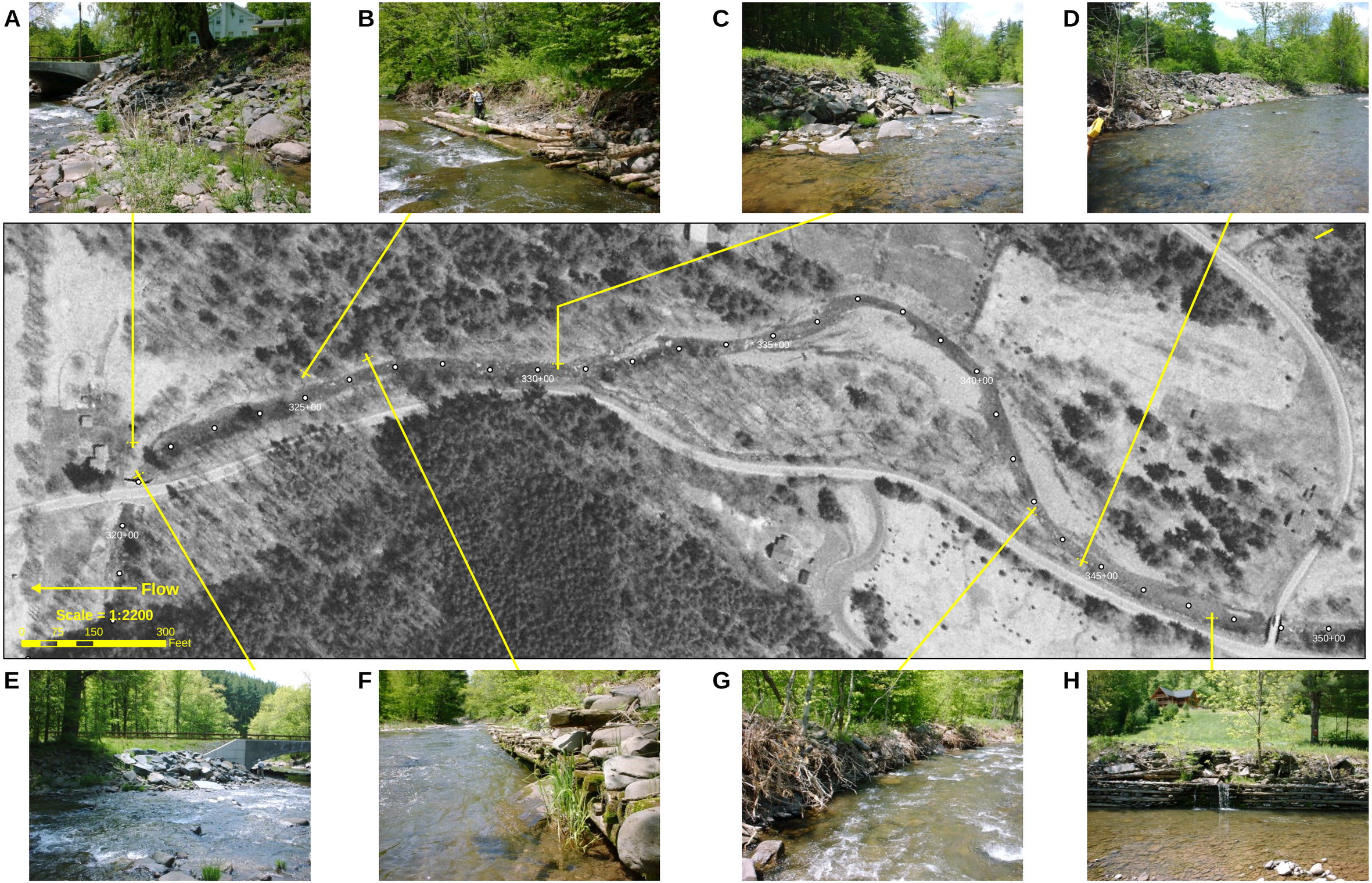


Figure 4.9.2 Management Unit 9 - 2004 aerial photography