2. Pollutant Load Reductions Required to Meet TMDL's

This section provides information on the pollutant load reductions needed and how they were determined. It addresses TMDL reductions needed given in the previous narratives. Nonpoint sources of pollution addressed are broken out by category quantified in the previous section. Finally, impacts on downstream waters are considered.

2.1. Total Maximum Daily Load Reductions Needed

Three separate stream assessments were conducted between April 2001 and October 2003, coinciding with historic low flow and drought conditions during 2002 for the region. The 2003 assessment was conducted during a high rainfall period with an excess of 13 inches of precipitation up to the end of the field assessment period. At least four bankfull events occurred since January 2003, beginning with a rapid snowmelt in early March 2003.

2.1.1. Methodology

The assessment methodologies and protocol used were the same as those used for the East, South and West Branches. Prior to beginning the field assessment, the Codorus Creek watershed was divided into subwatersheds. Each subwatershed was named according to the nomenclature on the U.S.G.S. topographic maps or labeled according to a landmark feature in that subwatershed. The corridor along the main stem of the Codorus from the confluence of the upper Codorus Creek and West Branch to the Susquehanna River was identified as a separate watershed and includes all first order streams that drain directly to the main stem. Drainage areas were determined at several locations within each subwatershed. This information was then plotted on U.S.G.S. 7.5' topographic quadrangles and used by the assessment crews to assist in stream type classification (Rosgen, 1994). The subwatersheds are listed by stream order (i.e., from outfall to source going down the list) by subwatershed in decreasing order, from outfall to source, in table 2-1.

All streams in each subwatershed were assessed. Stream reaches were determined either by stream type or degree of impairment. Each identified reach on the main stem of each subwatershed was identified with a two-digit number beginning with 01 at the headwaters and numbered sequentially downstream to the mouth. Each contributing tributary to the main stem was identified with a three digit number beginning with 101 following the same procedures. Field assessment crews began assessment efforts in the headwaters of each subwatershed and proceeded downstream. This identification system is a way to identify all stream reaches assessed on the forms and Watershed Assessment Map. During the assessment, photographs were taken to illustrate the various forms and degrees of impairment.

Table 2-1. Codorus Creek Watershed Drainage Areas

CODORUS CREEK	Drainage Area (Square Miles)	Drainage Area (Acres)	Municipalities
Codorus Creek (CC) Saginaw-York	40.90	14,200.62	East Manchester, Manchester Twp. Hellam, Springettsbury, Spring Garden, West Manchester, North York, West York, City of York
Trout Run (TR)	1.59	846.84	Hellam
Starview Trib (SVT)	0.97	620.80	East Manchester
Dee Run (DR)	3.13	2,003.20	Hellam
Emigsville Trib (ET)	3.73	2,387.20	Manchester Twp.
Lightners School Trib (LST)	2.89	1,849.60	Manchester Twp., City of York
Mill Creek (MC)	18.49	11,833.60	Spring Garden, Springettsbury, York Twp., Yoe, Dallastown, Red Lion
Willis Run (WR)	4.77	3,052.80	CoY, NYB, MnT, WMT
Violet Hill Trib (VHT)	4.38	2,803.20	Spring Garden, York Twp., City of York
Lincolnway Trib (LT)	5.12	3,276.80	West York, West Manchester
Leaders Heights Trib (LHT)	3.19	2,041.60	York Twp.
TOTAL	89.16	44,916.26	
EAST BRANCH			
East Branch Codorus Creek (EBCC3) SBCC	44.00	28,160.00	York Twp. Springfield
Reynolds Mill Trib (RMT)	0.23	147.20	York Twp.
Nixon Park Trib (NPT)	2.82	1,804.80	Springfield, Jacobus, Loganville
Jacobus Boro West Trib (JBWT)	0.25	160.00	Jacobus, Springfield
Leaders Heights South Trib (LHST)	0.21	134.40	York Twp.
Jacobus Boro North Trib (JBNT)	0.20	128.00	Jacobus, Springfield
I-83 Exit Four Trib (EFT)	0.45	288.00	York Twp.
Arlington Park Trib (APT)	0.97	620.80	York Twp.
Jacobus Boro East (JBET)	0.41	262.40	Jacobus, Springfield
I-83 Exit Three Trib (ETT)	0.76	486.40	Springfield
Spartan Road Trib (SRT)	0.36	230.40	York Twp.
Inners Creek (IC)	3.11	1,990.40	York Twp., Dallastown
Dunkard Valley Trib (DVT)	3.35	2,144.00	Springfield, Loganville
Barshinger	4.23	2,707.20	York Twp., North Hopewell, Red Lion
Dallastown South Trib (DST)	1.20	768.00	York Twp., Dallastown
East Branch Codorus Creek (EBCC2) SR 214	22.3	14,272.00	York Twp., Springfield, North Hopewell
Ridgeview Road Trib (RRT)	0.63	403.20	Springfield
Graydon Raod Trib (GRT)	0.86	550.40	Springfield
Winterstown Boro North Trib (WBNT)	1.46	934.40	North Hopewell, Winterstown
Seaks Run (SR)	3.22	2,060.80	Springfield
Winterstown Boro South Trib (WBST)	0.73	467.20	North Hopewell, Winterstown
East Branch Codorus Creek (EBCC1) Blymire	5.66	3,622.40	York Twp., Springfield
Blymire Hollow Trib (BHT)	6.41	4,102.40	North Hopewell, Winterstown
Hametown Trib (HT)	1.47	940.80	Springfield
Rehmeyer Hollow Trib (RHT)	0.77	492.80	Springfield, North Hopewell
Mt. Zion Trib (MZT)	0.89	569.60	Springfield
Mt. Olivet Trib (MOT)	1.30	832.00	Shrewsbury, North Hopewell, Hopewell
TOTAL	108.25	69,280.00	

SOUTH BRANCH			
South Branch Codorus Creek (SBCC)	68.00	43,520.00	North Codorus, Springfield, Seven Valleys, Glen Rock, Codorus, Railroad, New Freedom
Wangs Trib (WT)	1.02	652.80	North Codorus
Bens Trib (BT)	0.43	275.20	North Codorus
Fishel Creek (FIC)	3.74	2,393.60	Springfield
Seven Valleys North Trib (SVNT)	0.77	492.80	North Codorus
Seven Valleys South Trib (SVST)	1.07	684.80	Springfield, Seven Valleys
Zeiglers Church Trib (ZCT)	1.14	729.60	North Codorus
Stricthouser Trib (ST)	10.50	6,720.00	North Codorus, Jefferson, Codorus
Brush Valley Trib (BRVT)	2.49	1,593.60	North Codorus, Codorus
Buffalo Valley Trib (BUVT)	2.80	1,792.00	North Codorus, Codorus
Hanover Junction Trib (HJT)	0.96	614.40	North Codorus, Codorus
Cherry Run (CR)	1.66	1,062.40	Codorus
Larue Trib (LT)	0.91	582.40	Springfield
Peter & Paul Trib (PPT)	0.45	288.00	Codorus
Travis Trib (TT)	1.71	1,094.40	Springfield
Krebs Valley Trib (KVT)	4.32	2,764.80	Codorus
Centerville Creek (CC)	14.40	9,216.00	Codorus
Pierceville Run (PR)	6.70	4,288.00	Codorus
Foust Creek (FOC)	1.78	1,139.20	Springfield, Shrewsbury
Glen Rock South Trib (SGRT)	0.48	307.20	Codorus, Glen Rock
Glen Rock Valley Trib (GRVT)	3.55	2,272.00	Glen Rock, Shrewsbury, Springfield
Trout Run (TR)	3.37	2,156.80	Shrewsbury Twp. and Boro
Golf Course Trib (GFT)	0.70	448.00	Shrewsbury
New Freedom Church Trib (NFCT)	2.90	1,856.00	Shrewsbury
North Railroad Trib (NRT)	0.40	256.00	Shrewsbury, Railroad
Railroad Trib (RRT)	0.41	262.40	Shrewsbury, Railroad
Hungerford Trib (HuT)	1.07	684.80	Shrewsbury, Railroad, New Freedom
New Freedom Trib (NFT)	1.13	723.20	Shrewsbury, Railroad, New Freedom
TOTAL	138.86	88,870.40	
WEST BRANCH			
Codorus Creek (CC) IRD-Lake Marburg	30.28	19,379.20	West Manchester, North Codorus, Spring Grove, Jackson, Paradise, Heidelberg, Penn, Hanover
South Branch Codorus Creek (SBCC) IRD-Reynolds Mill	1.56	998.40	York Twp., North Codorus
New Salem Trib	2.42	1,548.80	North Codorus, York-New Salem
Old Paths Trib (OPT)	3.94	2,521.60	North Codorus, Codorus
Sunnyside Trib (ST)	1.04	665.60	Jackson, West Manchester
Nashville Trib (NT)	1.55	992.00	Jackson, Spring Grove
Stoverstown Branch (SB)	3.06	1,958.40	North Codorus
Spring Grove Trib	1.03	659.20	Jackson, Spring Grove
Lehman Trib (LHT)	3.06	1,958.40	North Codorus
Bunch Creek (BC)	5.30	3,392.00	Jackson, Paradise
Oil Creek (OC)	14.91	9,542.40	Jackson, Paradise, Heidelberg, Penn, Hanover
Gitts Run (GR)	1.89	1,209.60	Heidelberg, Penn
Lischy Church Trib (LCT)	1.44	921.60	North Codorus
Swimming Pool Trib (SPT)	1.24	793.60	North Codorus

Porters Creek (PC)	1.96	1,254.40	Heidelberg
Prospect Hill Trib (PHT)	0.53	339.20	North Codorus
West Branch Codorus Creek (WBCC)	10.37	6,636.80	Heidelberg, Penn, West Manheim, Manheim
Codorus Creek (Upper CC)	14.87	9,516.80	North Codorus, Jefferson, Codorus, Manheim
Long Run (LR)	9.81	6,278.40	West Manheim, Manheim
Furnace Creek	3.36	2,150.40	Penn, West Manheim
TOTAL	113.62	72,716.80	
CODORUS CREEK WATERSHED AGGREGATE			
Codorus Creek	89.16	44,916.26	
East Branch	108.25	69,280.00	
South Branch	138.86	88,870.40	
West Branch	113.62	72,716.80	
TOTAL	449.89	275,783.46	

2.1.2. Fluvial Geomorphic Stream Classification

Under Rosgen's stream classification method, there are eight major stream types found naturally: A, B, C, D, DA, E, F, and G (Figures 2-1 and 2-2). Each of these stream types differs with respect to degree of entrenchment, width to depth ratio, extent of floodplain area, slope, and sinuosity. Each stream type is also classified according to the average particle size or D50 of the substrate particle size as follows.

1 = bedrock
2 = boulders (80" to 10.1")
3 = cobbles (10.1" to 2.5")
4 = gravel (2.5" to 0.08")
5 = sand
6 = silt

The main stem of each subwatershed was divided into reaches according to stream types and/ or degree of impairment. Each reach on the main stem of each sub-watershed, was identified with a two-digit number beginning with 01. Each contributing tributary to the main stem was identified with a three digit number beginning with 101. Survey crews began assessment efforts in the headwaters of a particular subwatershed where the first reach of stream assessed was identified as 01. This identification system was used to identify all stream reaches assessed on the assessment forms and watershed assessment mapping.

The single most important stream channel feature used to determine stream type is the bankfull feature. The elevation or height of this channel feature is used to calculate the entrenchment ratio and the width/depth ratio. The bankfull height on stable streams is the point at which the water in a channel begins to move out over the floodplain. Stream dimensions, patterns, and bed features associated with the longitudinal stream profile are generally described as a function of channel width measured at the bankfull stage. Since streams are self-formed and self-maintained, it is important to relate measurable features

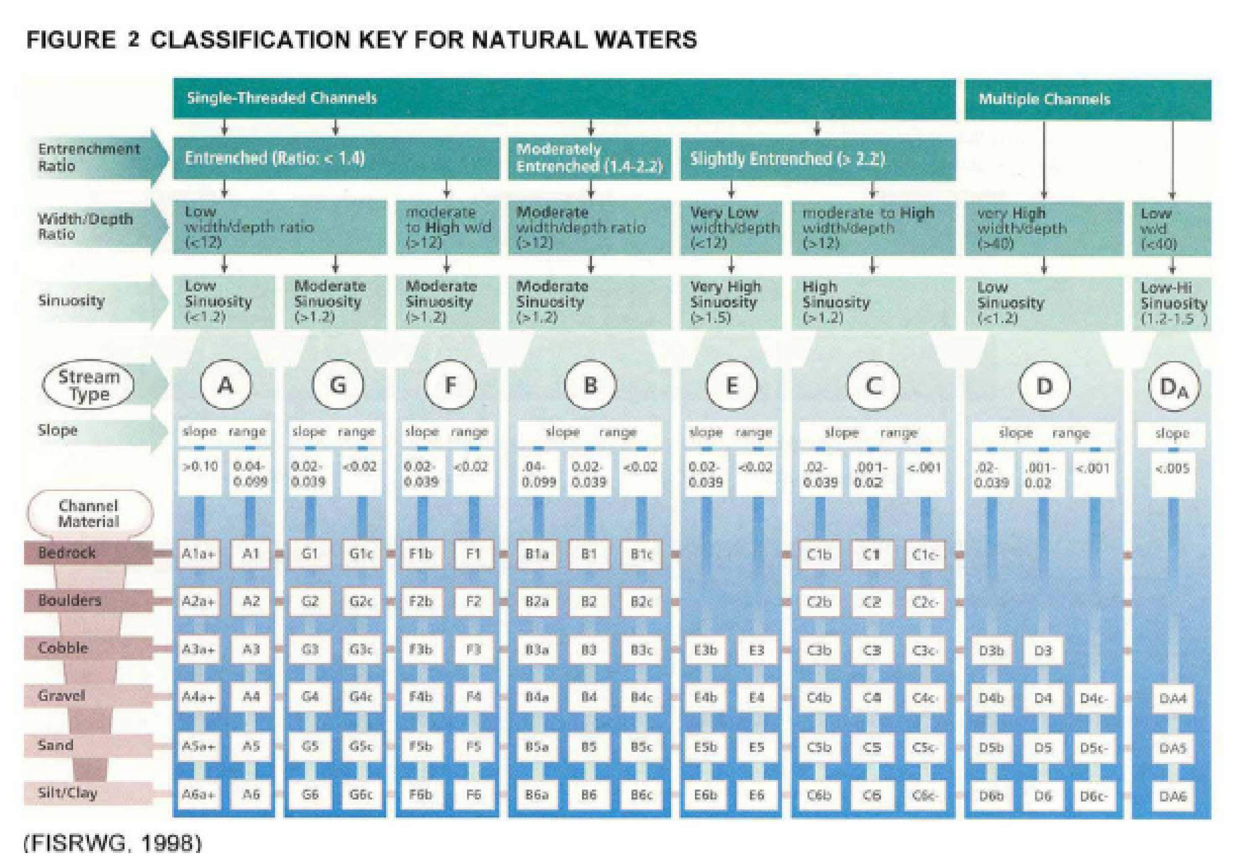

Figure 2-1. Classification Key for Natural Waters

FIGURE 8

STREAM CHANNEL EVOLUTIONARY CHANGES

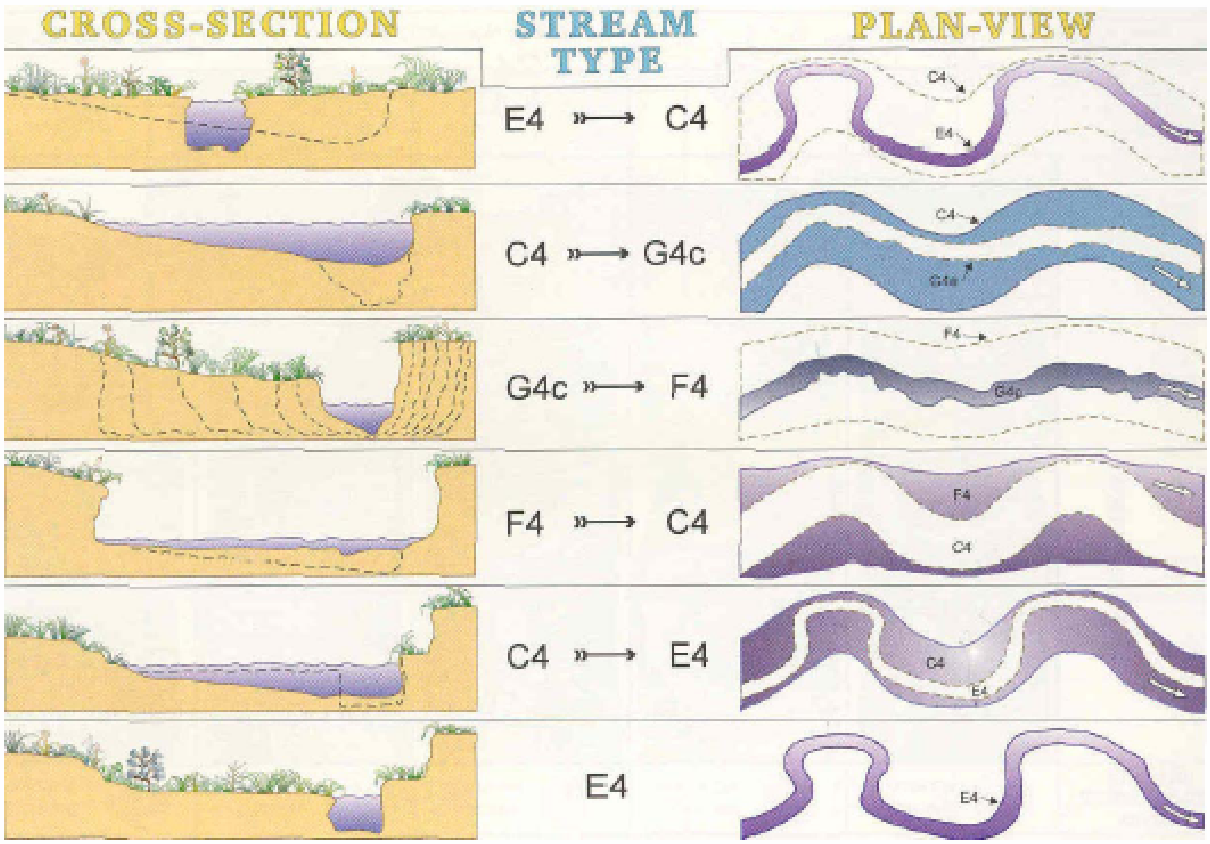

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Figure 2-2. Stream Evolution Changes

this can be identified in the field to a relatively frequent corresponding bankfull discharge. Bankfull discharge is associated with a momentary maximum flow which, on the average, has a recurrence interval of 1.5 years as determined by using a flood frequency analysis (Dunne and Leopold, 1978). Although a great deal of erosion may occur during extreme flood events, it is the smaller flow regimes which often transport the greatest quantity of sediment material over time due to the higher frequency of such events (Wolman and Miller, 1960). It is these smaller, more frequent storms that are responsible for channel formation and maintenance over a long period of time.

2.1.3. Development of a Hydraulic Geometry Curve

Leopold developed hydraulic curves for four different regions across the United States that determine the bankfull cross sectional area (bankfull width x mean bankfull depth), bankfull width, and bankfull depth based on the size of the drainage area in square miles. These regional curves were developed by gathering information from various U.S.G.S. gage stations on stable streams in different hydrophysiographic provinces across the country. From a regional perspective, the Eastern United States curve or “B” curve is the only curve presently available for use in determining stream types. This curve however is based on features found on stable streams and also covers a wide range of hydrophysiographic provinces, landform features, and many different land uses.

Data collection from gage stations representative of a watershed is important in developing regional curves. Gage stations which have been active over long periods of time (greater than ten years) are especially valuable in determining bankfull flood flow frequency (1.2 to 1.8 year return) (Leopold, Wolman & Miller, 1964). Due to the high degree of variability within any physiographic region (land use, geology, topography etc.), the curve developed to date for the Codorus Creek watershed relied on more local data collected (similar watersheds) within the regional area. In addition to these variables, the middle and lower sections of the watershed are influenced by Indian Rock Dam and unmanaged stormwater flows from urban watersheds.

Cross sectional surveys in the Codorus Creek watershed were completed at four locations along stable stream reaches where possible bankfull features were identified in order to determine consistency in the regional curve already established. All cross sections were plotted using The Reference Reach Spreadsheet program (Ohio DNR).

The regional curve is shown (Figure 2-3) includes the information collected at the four survey locations. As shown on this figure, the data points collected during the assessment are consistent with the data previously collected during other regional watershed assessments.

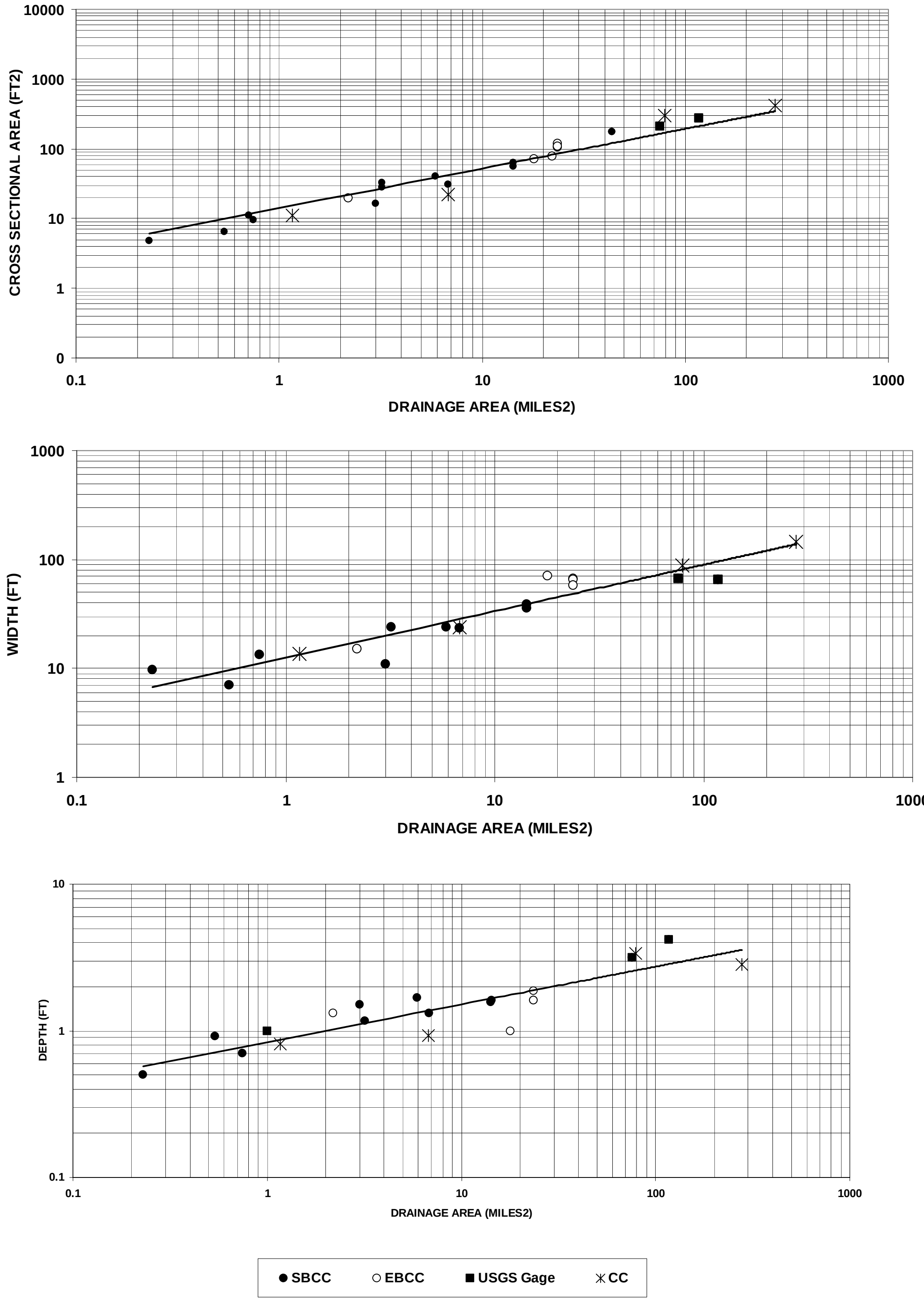

Figure 2-3. Codorus Creek Watershed Regional Curves

The bankfull cross-sectional areas, width and depth were then plotted on the hydraulic curve with the corresponding drainage area at the gage station. In addition, several cross sections were surveyed on stable stream reaches in the watershed where good bankfull indicators were evident. Likewise cross sections were surveyed in the watershed to expand the data collection efforts in order to apply the developed regional hydraulic curve to each watershed. The bankfull cross-sectional areas, width and depth at these locations were then added to the curve and plotted against the contributing drainage area (square miles) at each cross-sectional location. The locations of all reference cross sections are shown on the Watershed Assessment Maps in Figures 2-6 and 2-7.

Aquatic Resource Restoration Company has developed a regional hydraulic curve for the South Branch Codorus Creek watershed that lies within Piedmont Uplands Physiographic Province (Figure 2-11). This curve was established by collecting information at two U.S.G.S gage stations in the Codorus Creek watershed as well as surveyed stream data in the South Branch Codorus Creek watershed. This curve was then further refined with additional reference surveys completed during the assessment of the East Branch Codorus and North Branch Muddy watersheds. Information collected from the East Branch Codorus Creek was very consistent with that of the South Branch Codorus Creek. For the purpose of the Codorus Creek assessment, additional surveyed stream data was collected along four stable stream reaches in the Codorus Creek and plotted on the South Branch regional curve. The maximum drainage area plotted on South Branch curve was 117 square miles. One of the additional surveys included in this assessment was completed in the lower Codorus (CC-26) with a much larger drainage area (277 square miles).

2.1.4. Field Determination of Bankfull Features and Stream Type Classification

Stream types were classified using fluvial geomorphological (FGM) characteristics of the stream channels developed by hydrologist David Rosgen in his book entitled “Applied Fluvial Geomorphology”. Rosgen developed four levels of assessing and classifying streams that vary from a broad geomorphic characterization (Level I) to a very detailed, specific assessment (Level IV). Level I provides a geomorphic characterization of streams using topographic maps and aerial photography. A Level II assessment is more detailed and requires the actual survey and measurement of stream morphological features to classify stream types. The procedures for surveying stream cross sections are shown on Figure 2-4. Once the bankfull elevation and width (BKFw) are measured, the Floodprone Area Width (FPAw) can be determined (channel width at twice the maximum bankfull depth). Information collected includes the following:

- Bankfull Width (BKFw)
- Maximum Bankfull Depth (Thalweg or deepest part of the channel)
- Mean Bankfull Depth (BKFd)
- Floodprone Area Width (FPAw)
- Sinuosity

- Average substrate particle size

Once this information is collected, the morphological characteristics of the stream reach can be determined to identify stream type. The two most important features in determining stream types are the following.

- Entrenchment Ratio - An index value which is used to describe the degree to which a stream channel is incised or entrenched within its banks. Entrenchment = FPAw/BKFw.

- Width/Depth (W/D) Ratio - An index value which compares the width of the channel during the bankfull flow event to the average bankfull depth of the channel. W/D= BKFw/BKFd

Due to the size of the Codorus watershed (278 square miles and 447 stream miles) and the desire to collect more detailed information than that provided by a Level I assessment, a modified stream classification procedure was used for the watershed assessment. This procedure basically required the use of the regional hydraulic curve developed for the watershed to approximate the bankfull cross-sectional area at any given stream reach by using the known drainage area at that location. The approximate size of drainage areas was determined by using a 1"x1" transparent dot grid over the field mapping. Each 1-inch square equals 92 acres on the 1" = 2,000' topographic mapping.

At a minimum, each member of the stream assessment crew had completed Rosgen Level I stream classification training or were trained (in the project study area) over a three-day period on the modified assessment procedures for determining stream types and completing stream stability assessments. This pre-assessment training by the watershed assessors allowed the field team to get calibrated to stream characteristics and assessment criteria.

During the field assessment, survey crews examined stream reaches and identified the limits of each reach on the field maps. At locations where visual determinations could not promptly be made based on entrenchment or width/depth ratios or where there was a lack of bankfull indicators, channel measurements were taken using tape measures and hand levels to determine the approximate bankfull level and approximate cross sectional area. This level was determined using the regional curve whereby the known drainage area would indicate the approximate bankfull cross-sectional area. The bankfull level was chosen where it would correspond with the bankfull width to meet the approximate cross sectional area expected at that location. Generally, stream reaches were identified and plotted on the field maps where the stream type features were similar along a given reach. Along certain reaches, stream types were combined where one stream type would transition into a similar stream type or where stream types with similar features were encountered. An example of combining stream types with similar features would be C and E types, which are both slightly entrenched, or B and F types, which have moderate to high width/depth ratio. Stream reaches were also assessed separately where there was a noticeable change in the overall condition of the stream, even if the stream was of the same type.

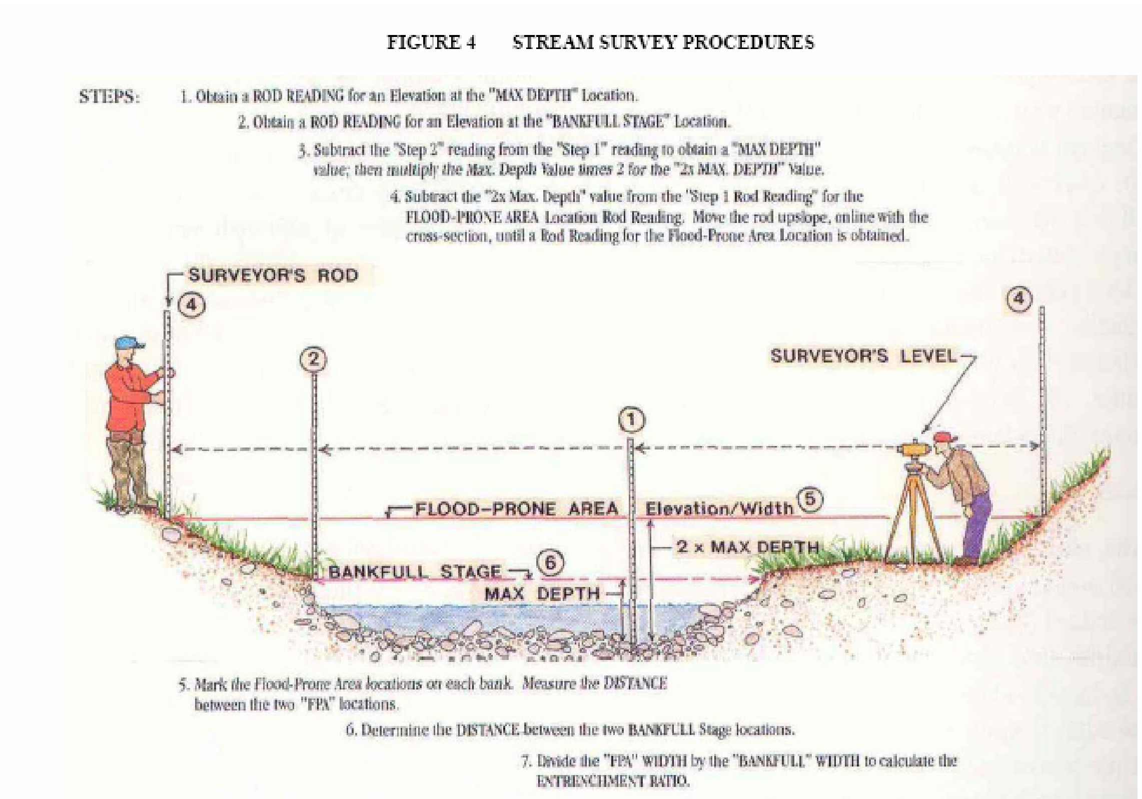

Figure 2-4. Stream Survey Procedures

2.1.5. Stream Stability Assessment and Prioritization

The stream assessments for the East, South and West Branches were conducted between March and June of 1999, 2000 and 2003, respectively. At any given time, up to four teams were in the field. During the assessment, other important watershed features were identified and mapped such as land use, important wetland areas, and any potential sources of sedimentation.

There are several accepted stream assessment procedures and protocols used to assess stream stability. Due to the size of the watershed and the extensive lineal footage of streams to be assessed, an abbreviated stream assessment form was developed to efficiently and quantitatively evaluate and prioritize stream reach conditions. This form is a modification of procedures developed by USDA (Stream Visual Assessment Protocol, Technical Note 99-1). An example of the Stream Reach Prioritization Form used for assessing stream conditions is shown in Figure 2.5. The front side of the form provides information on the stream identification, cause of impairment, and the actual assessment of stream conditions. Under the Stream Assessment portion of the form, four stream criteria were scored: bank stability, channel stability, riparian vegetation, and aquatic habitat. The evaluation consisted of visual observations and is divided into four separate categories with respect to stream feature condition: severe, moderate, minor, and stable. All references to left and right bank features were made from a view perspective looking downstream. Information from the form was then used to score each stream reach identified.

The assessment for each reach is for the overall condition of the entire reach identified. Point scores for each assessment criteria were assigned with severe rating being 1 and stable rating being 4. The degree of impairment or score for each stream reach assessed was determined from the scoring on the prioritization form as follows.

- Priority 1- Score between 4 and 8 (severely impaired, unstable)
- Priority 2 - Score between 8.1 and 12 (moderately impaired, some instability)
- Priority 3 - Score between 12.1 and 16 (minor impairment or stable)
- Other- Unassessed reaches (Piped, culverted or ponded reaches)

Other physical stream data collected on the assessment form include stream size (bankfull width) meander patterns, average size of the substrate particles, depositional features, and the extent of channel debris blockages. This information was recorded on the back of the assessment form (figure 2-5).

2.1.6. Watershed Assessment Map

A 1"=2,000' base map for each watershed area was prepared using U.S.G.S. digital mapping in GIS format (Figures 2-6 and 2-7). Information presented on the base mapping includes the following:

- Watershed limits
- Subwatershed boundaries and identification
- Stream reaches and identifiers along with stream type designation and prioritization rating
- Cross section locations
- Monitoring locations

All stream reaches in each watershed were digitized on the project base mapping. This information was used to analyze the degree of stream impairment for each subwatershed. To illustrate the degree of impairment, each of the three priority levels (severe, moderate, and minor) were color-coded to graphically show the location and extent of all impaired reaches. Stream lengths were calculated based on the digitized location of each stream reach. This information was then used to determine the total length of the various stream types and also the lengths of the prioritized reaches for each subwatershed. All stream reach length data are conservative. The length of streams shown on the U.S.G.S. base mapping does not reflect the actual and true meander patterns of the streams within each reach. By providing the mapping in a GIS format, additional GIS layers can be added in the future to conduct other watershed management and evaluation studies.

EAST BRANCH CODORUS CREEK WATERSHED ASSESSMENT
STREAM REACH PRIORITIZATION

Date: __________ **OVERALL SCORE:__________**

Assessed by: **PRIORITY RANKING: 1** (4 to 8) **2** (9 to 12) **3** (13 to 16)

STREAM IDENTIFICATION:

Watershed ID: __________ Reach ID: __________ Stream Type: __________

PREDOMINANT LAND USE: *(Circle)*: Agricultural, Rural, Open, Residential, Commercial, Industrial, Forested)

CAUSE OF IMPAIRMENT: *(Circle all that apply)*: Not impaired, stormwater runoff, pasture impacts, unstable conditions upstream, channel downcutting, , floodplain alteration, lack of riparian vegetation, high sediment loads

STREAM ASSESSMENT: *(Circle descriptive elements that apply to overall stream reach)*

Bank Stability

Priority

_____ 1 Severe *(Banks sloughing, undercut or vertical, exposed soils, evidence of property damage)*
_____ 2 Moderate *(Banks unstable, some bank sloughing, bank slopes 60 to 80 degrees)*
_____ 3 Minor *(Some bank erosion, slopes < 60 degrees,)*
_____ 4 Stable *(Well vegetated, gently sloping or low banks)*

Channel Stability

Priority

_____ 1 Severe *(numerous or large unvegetated channel bars, channel dredged, straightened or bermed, no active floodplain, downcutting and/or widening,)*
_____ 2 Moderate *(Degradation or aggradation noticeable, some evidence of over-bank flow)*
_____ 3 Minor *(Some channel scouring or sediment buildup, migration appears minor, floodplain feature present)*
_____ 4 Stable *(Channel appears natural with no evident migration, point bars well vegetated, active floodplain)*

Riparian Vegetation

Priority

_____ 1 Severe *(No woody vegetation with high banks, predominantly grasses, buffer < 10’, canopy < 20% closed)*
_____ 2 Moderate *(Sparsely vegetated banks, buffer 10' to 20' wide, canopy 20% to 40% closed)*
_____ 3 Minor *(Some woody diversity and density, buffer 20' to 60’, canopy 40% to 60% closed)*
_____ 4 Good *(Good density and diversity of woody species, or low banks with grasses, buffer > 60’, canopy > 80%)*

Aquatic Habitat (Features = riffles, runs and pools) (Cover = woody debris, large boulders, roots,)

Priority

_____ 1 Severe *(No habitat present, uniform substrate or silt, no in-stream cover, uniform stream features)*
_____ 2 Moderate (*Limited aquatic habitat, some substrate particle gradation, limited mix of stream features / cover)*
_____ 3 Minor *(Aquatic habitat noticeable throughout reach, some mix of stream features and cover but not optimal)*
_____ 4 Good *(Good in-stream cover, good mix of features, high variability of substrate particle size)*

COMMENTS:

Figure 2-5. Watershed Assessment Field Data Form

2.1.7. Permanent Bank Erosion Monitoring Locations

Prior to conducting the field assessment, one to three bank erosion monitoring locations were established in each watershed. At each monitoring station, two three-foot long metal rebar pins were placed in the banks to monitor erosion rates. A third pin was installed in the channel to monitor changes in the channel. Cross-sectional surveys were completed, and reference pins were installed for future surveying and monitoring. Additional surveys and monitoring were then completed on an annual basis up to three years from establishment.

Bank erosion hazard indices (BEHI) were recorded at all nine monitoring locations. The information recorded for the BEHI's include bank height, bank angle, root density, root depth, percentage surface protection (vegetation), soil stratification. The methodology for completing the bank profile is modeled after Rosgen's "A Practical Method of Computing Streambank Erosion Rate". This method uses measured field values, converted to prediction indices, to determine an approximate amount of streambank erosion as well as departure from stability. Using the BEHI information and the data from the continued monitoring of bank erosion in the watershed, a sediment rating curve will be developed to predict future erosion rates along impaired stream reaches.

2.1.7. Sediment and Bedload Sampling

Bedload and suspended sediment sampling was completed during high flow events in order to measure the amount of bedload and sediment transport during storm events. Three bridges were selected for sampling bedload each with similar physical features. The stream reaches selected for sampling were SBCC-020, CC-027, and SBCC-031. Cross-sectional surveys and channel profiles were completed at all three locations.

Bedload sampling was done with a Helly-Smith, cable-suspended bedload sampler with a 6"x6" orifice. Suspended sediment samples were collected using a depth-integrating cable mounted suspended sediment sampler, Model DH-76. A truck-mounted hoist was used to lower the sampling equipment into the stream.

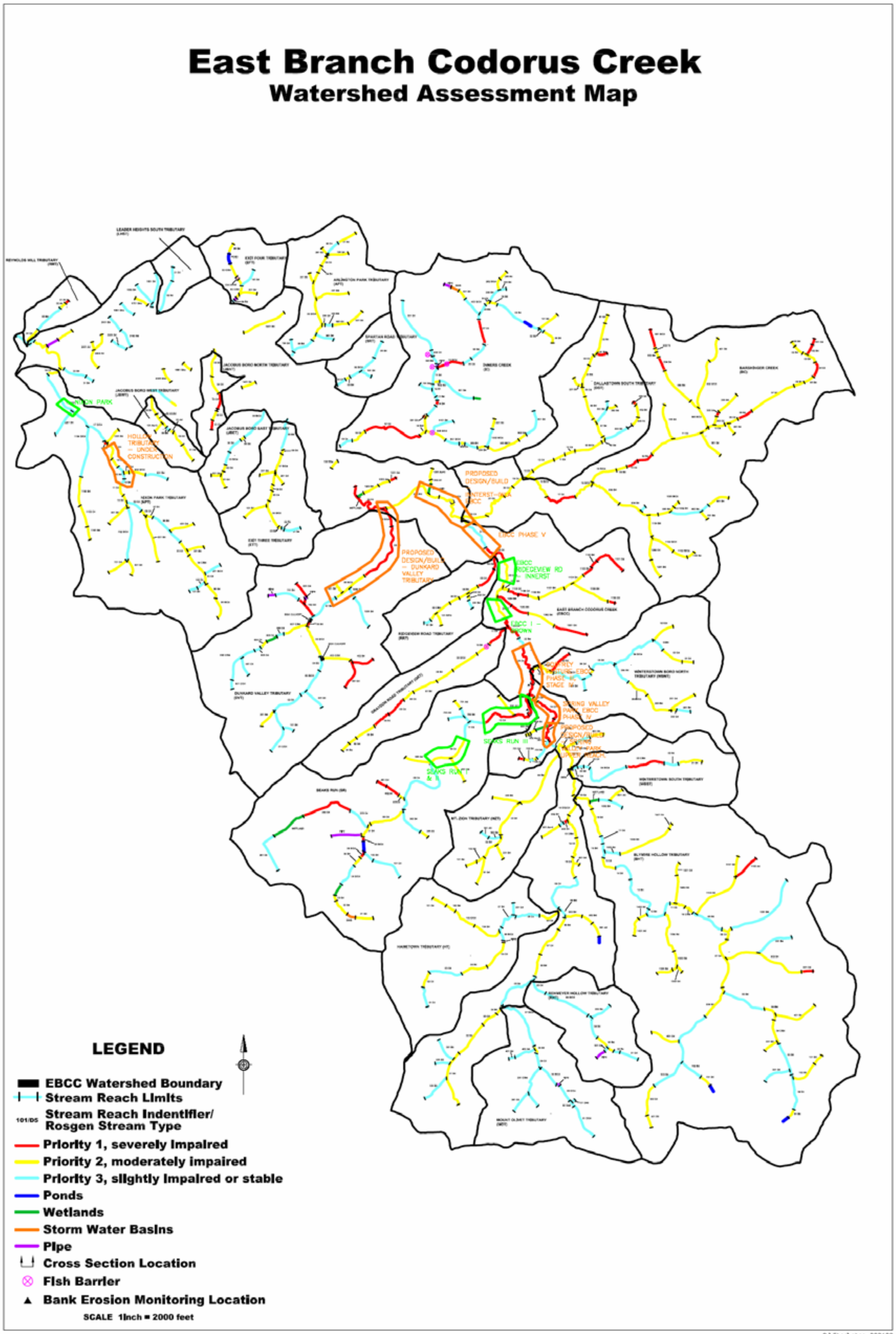

Figure 2-6. East Branch Watershed Assessment Map

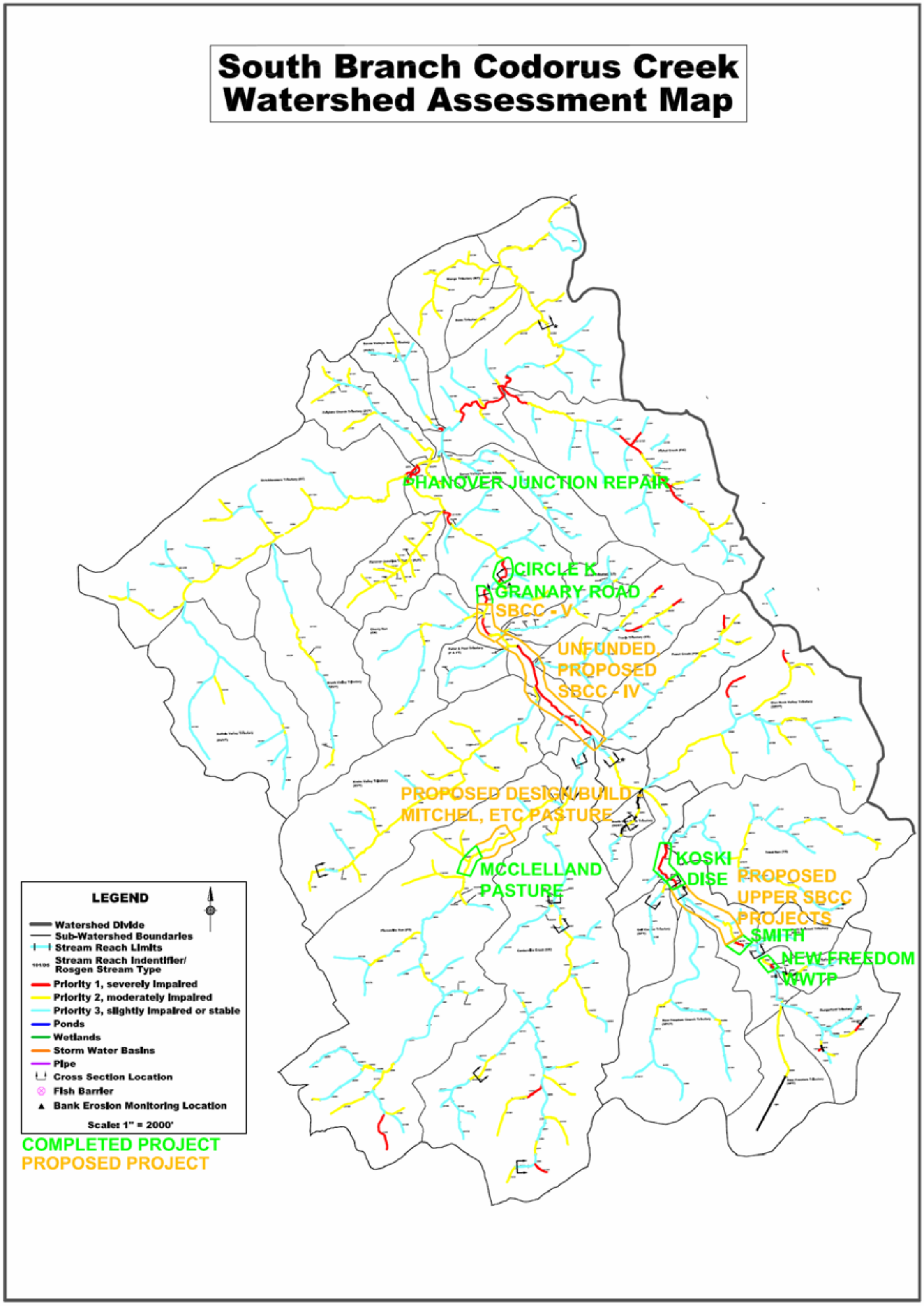

Figure 2.7. South Branch Codorus Creek Watershed Assessment Map

2.2. Watershed Assessment Findings

The East, South and West Branches of Codorus Creek were assessed between 1999 and 2003 and nonpoint sources of sediment and nutrient pollutants have been quantified by type and category, mapped and prioritized for restoration and protection management.

2.2.1. East Branch

Over the course of the watershed assessment, an estimated 552,300 feet or approximately 105 miles of stream were assessed and prioritized. Again, the total length is taken from U.S.G.S. base mapping and does not account for the actual stream meanders. It is presumed that the length of stream assessed may actually be 5% higher or another 5 miles of stream length. A total of 526 reaches were identified based on either stream type or degree of impairment.

Table 2-2 presents a summary of the assessment results and provides the lineal footage of stream and the degree of impairment (based on assessed scores) for each of the 27 subwatersheds in the project area. More than half (65%) of the lineal footage of streams in the EBCC watershed is either severely or moderately impaired. Approximately 67,912 feet of stream (13 miles) or 12% of all streams were assessed as being severely impaired. In all the severely impaired reaches, bank erosion is the primary cause of impairment. Information on all severely impaired reaches is shown on table 2-10. Another 286,634 feet of stream reaches were assessed as being moderately impaired (approximately 52% of all stream reaches). Therefore, approximately 36% of all stream reaches are slightly impaired or stable. Of the 27 subwatersheds, 14 had reaches of stream that are severely impaired and only 1 subwatershed, Leader Heights South Tributary (LHST), was found to be stable along its entire drainage course.

Of the subwatersheds that have severely impaired reaches of stream, Graydon Road Tributary (GRT) had the highest percentage (32% or 3,327 feet) of impaired stream reaches relative to the entire stream length per watershed (Table 2-9). Other sub-watersheds where more than 10% of the entire stream length is severely impaired include Barshinger Creek (BC) with 14%, Dunkard Valley Tributary (DVT) with 31%, the main stem of the East Branch Codorus Creek (EBCC) with 25%, Inners Creek (IC) with 16%, Jacobus Boro North Tributary (JBNT) with 28%, Ridgeview Road Tributary (RRT) with 30%, Seaks Run (SR) with 21%, and Winterstown Boro South Tributary (WBST) with 26%.

The streams in the upper portion of the watershed (above Spring Valley Park (EBCC-17) are in relatively good condition with only 3,960 feet of severely impaired streams. Approximately 50% of the upper watershed was assessed as moderately impaired with the remaining streams assessed as being stable. As shown on the Watershed Assessment Map, a significant amount of stream impairment is centrally located in the watershed both on the main stem and several of the smaller sub-watersheds. Much of the land use in this portion of the watershed consists of agriculture pastureland where riparian vegetation has been removed. The upper reaches of Inners Creek, Dallastown South Tributary and

Barshinger Creek watersheds drain south along the S.R. 74 corridor and most of the stream impairment is a direct result of stormwater. Only 4% of the Barshinger Creek watershed was assessed as being stable. Most of the smaller tributaries which drain directly to Lake Redman are well vegetated, but have a high percentage of impairment. Much of this impairment can be attributed to stormwater influences particularly the Jacobus Boro North Tributary. Stormwater impacts were also noted in the Dunkard Valley Tributary. Stormwater from Interstate 83 drains to a small tributary which has downcut and appears to be widening along reaches DVT-801 and 702. These reaches were assessed as severely impaired and are contributing a high sediment load to the main stem.

The York Chapter of the Izaak Walton League maintains a low head dam on the East Branch Codorus which serves as a water supply for a cooperative fish nursery. This dam restricts fish migration to the upper watershed. During the assessment, sucker spawning migrations were noted on two tributaries: Inners Creek and Dunkard Valley Tributary. Inners Creek drains directly to Lake Redman while Dunkard Valley Tributary drains to the East Branch Codorus, upstream of the confluence with Lake Redman. Although both sub-watersheds have a high percentage of stream impairment they do provide a resource to non-game fish.

The impact of sedimentation on the East Branch Codorus Creek and Lake Redman was clearly visible during the summer of 2002. An aerial photograph of Lake Redman was taken during April 2002 which shows the sediment accumulation in the upper reservoir. The watershed assessment was completed during an unseasonably dry period, with below normal rainfall. During the summer of 2002, York Water Company had to begin using the back up water supply of Lake Redman. As the lake was drawn down, these sediment deposits were exposed and reveal the degree of sedimentation.

Streambank Erosion

Bank erosion rates were documented at three monitoring locations in the watershed. All of these monitoring locations are within agricultural pastures with no riparian vegetation (SR-12, EBCC-21 and EBCC-23). At all three monitoring locations, cross-sectional surveys were completed twice over the study to document erosion rates and channel migration. The initial cross-sectional survey and installation of five foot long bank pins was completed in August 2000. Bank erosion was monitored for 20 months at SR-12 and EBCC-21 and for 22 months at EBCC-23.

During the study period no excessive flows or bankfull events occurred however, all of the bank erosion monitoring locations revealed soil loss after the second monitoring cross section data was processed. All of the cross section overlays show bank erosion and channel migration. Cross sections EBCC-21 and 23 also show channel down-cutting. A summary of the bank erosion monitoring is provided below (tables 2-3).

Table 2-2. East Branch Watershed Assessment and Restoration Priorities

		PRIORITY 1		PRIORITY 2		PRIORITY 3		OTHER*		TOTAL LENGTH
WATERSHED	Reach ID	Length (feet)	%	Length (feet)	%	Length (feet)	%	Length (feet)	%	(Feet)
APT	17	0	0%	11,078	73%	4,074	27%			15,152
BC	52	7,924	14%	45,553	82%	2,053	4%			55,530
BHT	52	1,985	3%	42,431	57%	29,482	40%	500	1%	74,398
DST	21	759	5%	13,558	81%	2,465	15%			16,782
DVT	31	11,025	31%	9,016	25%	15,728	44%	366	1%	36,135
EBCC	77	20,793	25%	45,128	54%	16,288	20%	949	1%	83,158
EBCC LAKE	17	0	0%	9,022	54%	7,564	46%			16,586
EFT	8	0	0%	3,245	63%	1,280	25%	640	12%	5,165
ETT	12	0	0%	7,028	73%	2,611	27%			9,639
GRT	11	3,327	32%	7,103	68%	0	0%			10,430
HT	15	0	0%	9,084	59%	6,262	40%	135	1%	15,481
IC	47	6,257	16%	11,255	28%	21,500	54%	1045	3%	40,057
JBET	7	0	0%	1,974	37%	3,337	63%			5,311
JBNT	5	1,176	28%	3,000	72%	0	0%			4,176
JBWT	7	0	0%	4,359	96%	198	4%			4,557
LHST	2	0	0%	0	0%	2,392	100%			2,392
MOT	13	0	0%	441	3%	12,914	95%	181	1%	13,536
MZT	10	0	0%	11,661	91%	1,119	9%			12,780
NPT	37	234	1%	21,168	54%	18,114	46%			39,516
RHT	9	0	0%	1,089	12%	7,306	82%	521	6%	8,916
RMT	4	210	7%	1,291	42%	1,548	51%			3,049
RRT	10	1,991	30%	3,902	58%	816	12%			6,709
SR	31	8,955	21%	13,471	32%	16,137	38%	3366	8%	41,929
SRT	5	0	0%	265	7%	3,646	93%			3,911
WBNT	18	1,302	7%	9,265	47%	8,965	46%			19,532
WBST	8	1,975	26%	1,247	17%	4,280	57%			7,502
TOTAL	526	67,913	12%	286,634	52%	190,079	34%	7703	1%	552,329

* Length of stream reaches within pipes, culverts underpasses or in-stream ponds which were not assessed

Table 2-3. Stream Bank Erosion Monitoring

Reach	Monitoring Period	Bank Height (Feet)	Soil Loss (Feet)	Reach Length (Feet)	Soil Volume (Cubic Feet)
SR-12	20 Months	2.3	2.5	3,940	22,655
EBCC-21	20 Months	6.6	2.2	2,391	47,829
EBCC-23	22 Months	5.8	3.24	1,533	28,808

Table 2-4. East Branch Estimated Sedimentation from Stream Erosion

SCENARIO 1

Severely impaired stream reaches

Total feet*	Avg. Eroded Bk. Ht.	Active**	Avg. annual soil loss (ft)	Total annual volume (cubic feet)	Total tons***
67,912	4.5	80%	3	733,450	36,672

Moderately impaired stream reaches

Total feet*	Avg. Eroded Bk. Ht.	Active**	Avg. annual soil loss (ft)	Total annual volume (cubic feet)	Total tons***
286,634	3	65%	1.5	838,404	41,920

Slightly impaired to stable

Total feet*	Avg. Eroded Bk. Ht.	Active**	Avg. annual soil loss (ft)	Total annual volume (cubic feet)	Total tons***
190,082	2	10%	0.5	19,008	950
			TOTALS =	*1,493,955 (CUBIC FEET)*	*74,698 (TONS)*

SCENARIO 2

Severely impaired stream reaches

Total feet*	Avg. Eroded Bk. Ht.	Active**	Avg. annual soil loss (ft)	Total annual volume (cubic feet)	Total tons***
67,912	4.5	70%	2	427,846	21,392

Moderately impaired stream reaches

Total feet*	Avg. Eroded Bk. Ht.	Active**	Avg. annual soil loss (ft)	Total annual volume (cubic feet)	Total tons***
286,634	3	40%	1	343,961	17,198

Slightly impaired to stable

Total feet*	Avg. Eroded Bk. Ht.	Active**	Avg. annual soil loss (ft)	Total annual volume (cubic feet)	Total tons***
190,082	2	5%	0.5	9,504	475
			TOTALS =	*718,371 (CUBIC FEET)*	*35,919 (TONS)*

* *Lengths of stream reaches based on EBCC Watershed Assessment and assume only one eroded bank along reaches*

The volume of soil loss presented assumes average site conditions along the entire reach and erosion occurring only along one bank. Although soil loss was only measured at one location along the reach, there is a great deal of physical variability along each of the three reaches with respect bank height and actual soil loss. Although no bankfull storm events occurred during the study significant soil loss from the stream banks was documented.

One source of soil loss occurring is the freeze/thaw of vertical unstable stream banks. This type of soil loss occurs very slowly but is continuous during the winter months. As the frozen soil thaws during the morning hours, soil particles fall into the stream or collect along the ice at the bank/water interface. This condition was observed during the study at Reach EBCC-21 and videotaped.

Based on the bank erosion measured during the watershed assessment soil loss due to bank erosion was estimated (table 2-4). More refined soil loss estimates will be made as bank erosion monitoring continues in the future. All of the reaches where bank erosion was monitored are planned for restoration. Bank erosion monitoring will continue even after restoration to document measurable results.

2.2.2. South Branch

Over the course of the watershed assessment, a total of 785,096 linear feet, or approximately 148 miles of stream, were assessed and prioritized. Again, the total length is taken from USGS base mapping and does not account for the actual stream meanders.

It is presumed that the length of stream assessed may actually be 5% higher or another 7 miles of stream length. A total of 542 reaches were identified based on either stream type or degree of impairment.

Table 2-5 lists the linear footage of stream and the degree of impairment, based on assessed BEHI scores, for each of the 28 subwatersheds. Approximately one-half (45%) of the linear footage of streams in the SBCC watershed are either severely or moderately impaired. Approximately 54,366 linear feet of stream (10 miles) or 7% of all streams were assessed as being severely impaired. In all the severely impaired reaches, bank erosion is the primary cause of impairment. Another 295,397 feet of stream reaches were assessed as being moderately impaired, approximately 38% of all streams. Therefore, approximately 54% of all stream reaches are slightly impaired or stable. Of the 28 subwatersheds, 11 had reaches of stream which are severely impaired and only 1 subwatershed, North Railroad Tributary, was found to be stable along its entire drainage length.

Of the subwatersheds which have severely impaired reaches of stream, the main stem of the South Branch Codorus Creek had the highest percentage (21%) of impaired reaches relative to the stream length per watershed. Other subwatersheds where more than 10% of the entire stream length is severely impaired includes Fishel Creek (FIC) 16%, Foust Creek (FOC) 15%, and Travis Trib (TT) 12%. The subwatershed with the most severely impaired reaches is the main stem of the South Branch with over 31,125 linear feet of stream. This correlates with DEP’s South Branch Codorus Creek TMDL for Subbasins 1 and 2.

The majority of the streams in the watershed are slightly entrenched, 348,015 linear feet or 44%, consisting of “C” and “E” stream types. A total of 217,374 linear feet (28%) of the streams are entrenched “A”, “G”, and “F” stream types. The moderately entrenched “B” stream types comprise 20% of all streams. The vast majority of all streams have a gravelly substrate.

Information pertaining to the location of all stream reaches assessed was shown on the West Branches Watershed Assessment Maps previously mentioned.

Streambank Erosion

Streanbank erosion rates were documented at two monitoring locations in the watershed. Both of these monitoring locations are within agricultural pastures with no riparian vegetation (Reach SBCC-026 and SBCC-015). At both locations, cross-sectional surveys were completed three times over the study to document erosion rates and channel migration. The initial cross-sectional survey and installation of three-foot long bank pins was completed in July 1999. In December 1999, a second cross-sectional survey was completed. During this survey, all bank pins at both monitoring locations were exposed up to 22 inches from the bank. A comparison of the first and second cross-sections at both locations revealed channel migration of up to two feet with bank erosion along the right bank and an extension of the point bar along the left bank. This channel migration is believed to be associated with the high flows experienced with Hurricane Floyd which passed over the watershed in September 1999.

Table 2-5. South Branch Watershed Assessment and Restoration Priorities

Subwatershed	DA (sq mi)	Reach Number	Priority 1 (feet)	%	Priority 2 (feet)	%	Priority 3 (feet)	%	Other * (feet)	%	Total
BeT	0.43	1			4153	1.00					4153
BRVT	2.49	11			5642	0.29	13567	0.71			19209
BUVT	2.8	9			2730	0.10	25079	0.90			27809
CC	14.4	64	2336	0.032	24163	0.31	51398	0.66			77897
CR	1.66	10			4203	0.25	12367	0.75			16570
FIC	3.74	38	7752	0.16	11220	0.23	29407	0.61			48379
FOC	1.78	15	2914	0.15	4973	0.25	12056	0.60			19944
GCT	0.7	7			626	0.13	4247	0.87			4872
GRVT	3.55	25	2735	0.07	17848	0.46	18309	0.47			38892
HJT	0.96	16			19478	1.00					19478
HuT	1.07	18	898	0.07	2204	0.16	9560	0.70	942	0.07	13604
KVT	4.32	26			33412	0.71	13893	0.29			47305
LT	0.91	17			1839	0.15	10643	0.85			12482
NFCT	2.9	13			2350	0.09	23944	0.91			26294
NFT	1.13	2			4745	0.55			3848	0.45	8593
NRT	0.4	4					2619	1.00			2619
PPT	0.45	4			254	0.05	4963	0.95			5218
PR	6.7	47	2485	0.03	33290	0.45	38529	0.52			74304
RRT	0.41	6			989	0.21	2786	0.60	845	0.19	4620
SBCC	68	79	31125	0.21	44759	0.31	68820	0.47	358	0.00	145061
SGRT	0.48	6			1437	0.25	1966	0.35	2228	0.40	5632
ST	10.5	21	940	0.02	31898	0.65	15862	0.33			48700
SVNT	0.77	10	436	0.04	2523	0.23	8244	0.74			11203
SVST	1.07	19			2291	0.14	14523	0.86			16814
TR	3.37	28	227	0.01	8421	0.25	25403	0.74	204	0.01	34255
TT	1.71	22	2518	0.12	5761	0.27	12995	0.61			21275
WT	1.02	7			13821	1.00					13821
ZCT	1.14	17			10367	0.64	5725	0.3557			16092
TOTAL	68	542	54366	0.07	295397	0.38	426907	0.54	8425	0.01	785096

*** Length of stream reaches with pipes, culverts, underpasses or in-stream ponds which were not assessed or prioritized**

Degree of Impairment	Severe	Moderate	Minor	Stable
Assessment Score	4 5 6 7 8	9 10 11 12	13 14 15 16	
Priority Ranking	Priority 1	Priority 2	Priority 3	

The monitoring stations at both locations were again examined in March 2000. All bank pins (3-feet long) were either exposed entirely or had fallen into the channel. In early May 2000, a third cross-section was surveyed at both locations and five-foot long bank pins were installed to continue to monitor future erosion rates. Figures 2-6 and 2-7 provide a comparison of the first and third (July 1999 and May 2000) surveyed cross-sections taken at both monitoring locations over a 10-month period. A comparison of these monumented cross-sections reveals that the stream at SBCC-026 had continued to migrate laterally resulting in the cumulative loss of 2.5 feet of soil along the right bank (Figure 2-6). Similarly, the stream channel at SBCC-015 had migrated laterally along the right bank with a cumulative loss of 3.3 feet of soil (Figure 2-7).

Using the data collected from these sites, the volume of soil loss at both monitoring locations was approximated using conservative estimates for eroded banks throughout these reaches. At SBCC-026, the surveyed eroded bank measures approximately 6 feet in height with a documented soil loss of up to 2.5 feet. The eroded condition of streambanks along this reach varies but extends for approximately 700 feet. Using an average eroded bank height of 4.5 feet and an average soil loss of 2 feet throughout the reach, the approximate loss of soil along the banks is 10,800 cubic feet or 540 tons (100 lbs/cubic foot) over a 10-month period or an average of 0.45 tons of soil per foot of streambank.

At reach SBCC-015, the surveyed eroded bank is approximately 5 feet in height with a documented loss of up to 3.3 feet of streambank along this 1,100-foot reach. Using an average eroded bank height of 4 feet and an average soil loss of 2.5 feet throughout this reach, the approximate volume of eroded soil along the banks is 11,000 cubic feet or 550 tons. This equates to 0.50 ton of soil loss per foot of streambank.

Based on the information collected at these two monitoring stations, bank erosion has contributed approximately 1,090 tons of soil along these two stream reaches in less than a year.

2.2.3. West Branch

Over the course of the watershed assessment, a total of 1,710,000 feet or approximately 324 miles of stream were assessed and prioritized. The total length of stream however is conservative as it only reflects stream length as provided by the U.S. Geological Survey and does not include the actual stream length and true pattern of the streams. It is estimated that an additional 5 % (approximately 16 miles) of actual stream channel may exist in the watershed. A total of 964 stream reaches were identified during the assessment. Information collected from the assessment is shown on the Watershed Assessment Map attached to this report. The results of the watershed assessment are presented on Tables 2-6.

As shown in Table 2-6 approximately 42 miles of stream were assessed as being severely impaired which represents 13% of the streams in the watershed. Another 118 miles (36%) were assessed as being moderately impaired while the balance (153 miles or 47%) was assessed as having minor impairment or were stable. 3.6 miles or 1% of the assessed stream reaches were concrete channels. All of the concrete channels in the project study area are located in the Willis Run watershed, which represents 3% of this watershed.

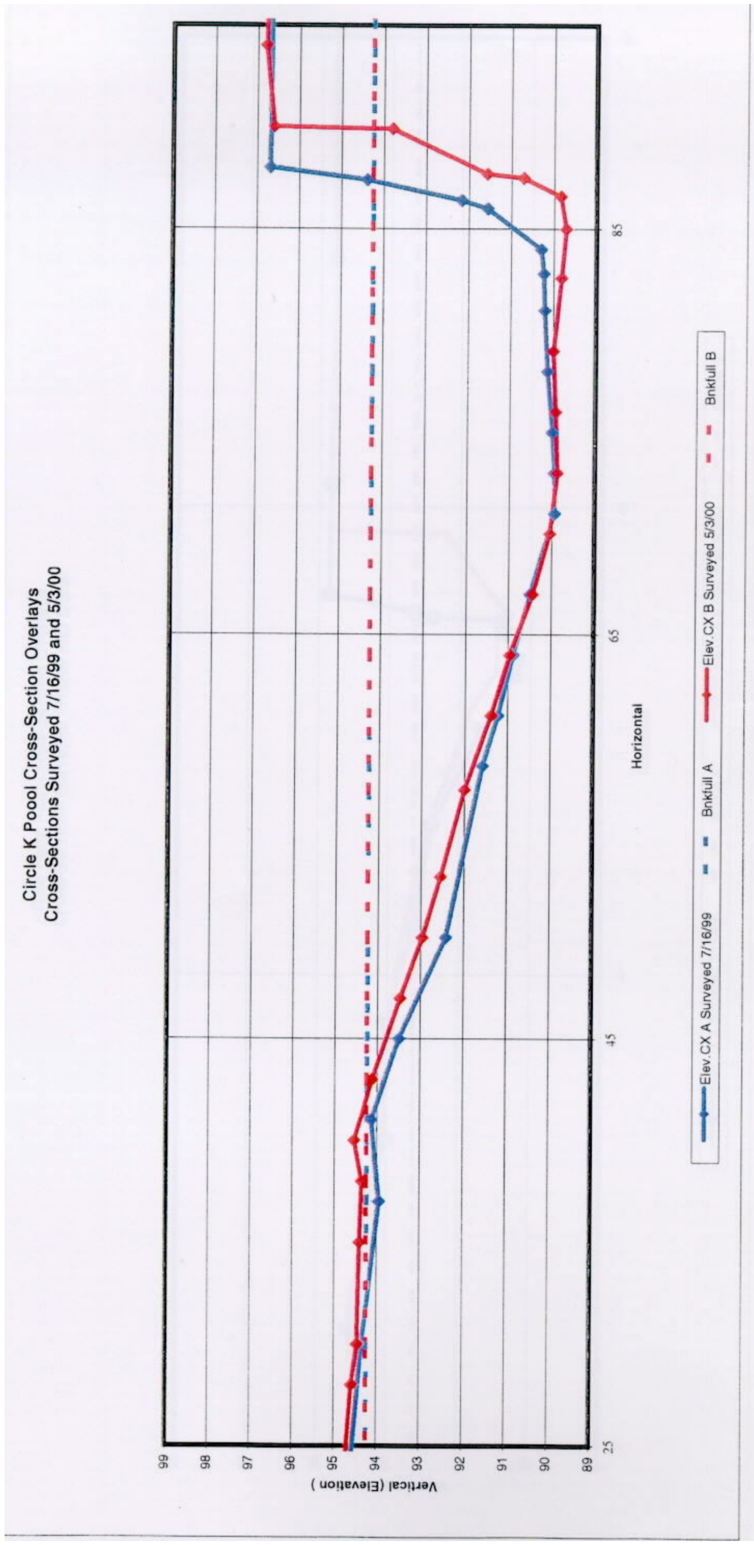

Figure 2-8. SBCC-026 Bank Erosion Monitoring

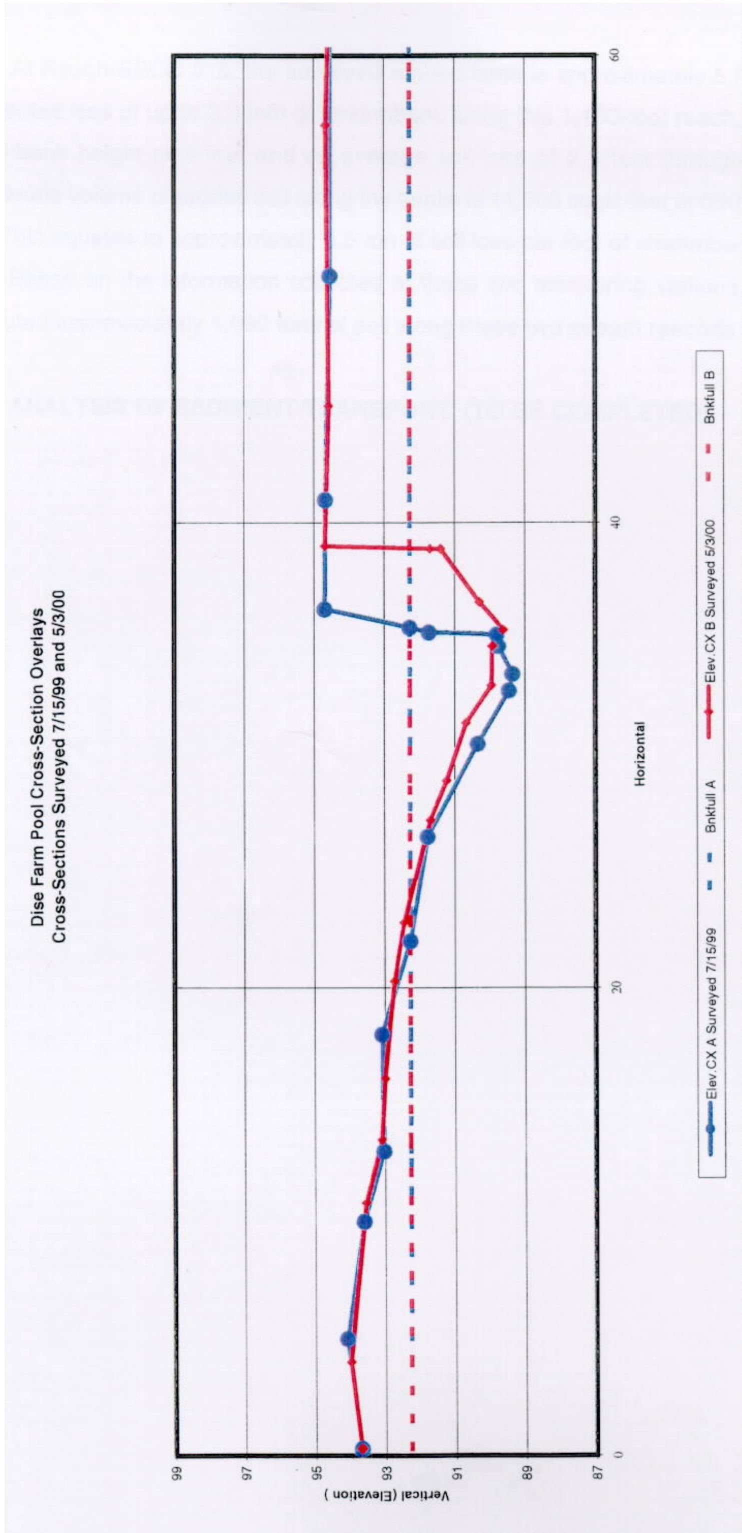

Figure 2-9. SBCC-015 Bank Erosion Monitoring

These concrete channels are primarily associated with the relocation of Willis Run around the rock quarry. Approximately 5,500 feet of piped channel or 37% of all stream reaches were mapped in the Spring Garden Park Tributary (Poorhouse Run) watershed. The length of piped or culverted channel is conservative and only noted where field conditions allowed. The true length of piped channel in this watershed and the other urban watersheds is higher, particularly in the urban and developed portions. In addition to having the highest percentage of piped channels, the Spring Garden Park Tributary has the highest percentage of severely impaired channels (53%). This subwatershed is highly urbanized. Other urban subwatersheds assessed include: Emigsville Tributary, Furnace Creek (lower watershed), Leader Heights Tributary, Lightners School Tributary, Lincolnway Tributary, Mill Creek, Violet Hill Tributary (Tyler Run), and Willis Run. Although there is considerable commercial and residential development occurring in the Emigsville Tributary, the majority of the streams (79%) were assessed as being stable.

The municipality with the most severely impaired stream reaches is Manheim Township. Approximately 9 miles of stream were assessed as severe. Manheim Township covers portions of the Upper Codorus Creek and Long Run subwatersheds, which are predominantly agriculture. York Township has approximately 6 miles of severely impaired stream. York Township is primarily an urbanized watershed and includes Mill Creek and Violet Hill Tributary (Tyler Run).

Streambank Erosion

During the watershed assessment bank erosion was measured at three sites; OC-12 #1, UCC- 18, and LR-11. Six additional monitoring locations were established to continue monitoring efforts.

Erosion rates varied between 1 cubic foot and 4 cubic feet of soil per foot of stream were recorded (table 2-7). OC-12 #1 is located along the outside of a meander bend and was monitored over a nine month period. This stream reach is approximately 3,500 feet and is located in a cattle pasture with no woody vegetation and unrestricted livestock. Based on survey data this reach of stream is eroding at rate of approximately 4 cubic feet of soil per foot of stream (one bank). The majority of the soil loss was along the top of the bank where approximately 8 inches of soil eroded. If this rate is consistent throughout the reach, approximately 700 tons of soil loss would occur annually. It would be inappropriate to assume the same erosion rate over the entire reach.

Along unstable and unvegetated streams, the outside of meanders will erode at greater rates due to the higher shear stress along the banks. In order to more accurately define erosion rates, three additional monitoring locations were established along this reach OC-12, #2L, & #2R and OC-12, #3. UCC-18 is located on a severely impaired reach along the upstream portion of an outside meander and was monitored over a one year period.

Table 2-6. West Branch Watershed Assessment Summary

TABLE 4
WEST BRANCH - MAINSTEM CODORUS CREEK WATERSHED ASSESSMENT SUMMARY

		PRIORITY 1		PRIORITY 2		PRIORITY 3		PIPED		CONCRETE		
Subwatershed Name	# of Reaches	Feet	%	Feet	%	Feet	%	Feet	%	Feet	%	Total Length
BUNCH CREEK	11	--	--	16,278	45%	20,302	55%	--	--	--	--	36,580
CODORUS CREEK	114	32,478	11%	90,252	29%	173,459	57%	7,445	2%	--	--	302,417
DEE RUN	9	--	--	16,236	63%	9,493	37%	--	--	--	--	25,729
EMIGSVILLE TRIBUTARY	31	491	1%	7,704	18%	33,174	79%	564	1%	--	--	41,733
FURNACE CREEK	36	5,518	12%	32,446	73%	6,510	15%	--	--	--	--	44,473
GITTS RUN	13	--	--	528	2%	23,037	98%	--	--	--	--	23,565
LEADER HEIGHTS TRIBUTARY	20	3,168	8%	24,468	61%	12,155	31%	--	--	--	--	39,790
LEHMAN TRIBUTARY	23	1,927	6%	5,903	18%	24,404	76%	--	--	--	--	32,234
LIGHTNERS SCHOOL TRIB	15	2,988	13%	10,555	45%	8,226	35%	1,452	6%	--	--	23,221
LINCOLNWAY TRIBUTARY	10	--	--	15,412	63%	9,203	37%	--	--	--	--	24,615
LISCHY CHURCH TRIBUTARY	11	--	--	1,352	7%	12,155	93%	--	--	--	--	18,364
LONG RUN	86	14,684	12%	58,471	47%	50,508	41%	--	--	--	--	123,663
MILL CREEK	147	44,130	22%	58,069	29%	79,084	39%	18,865	9%	--	--	200,376
NASHVILLE TRIBUTARY	5	1,431	12%	9,192	77%	1,352	11%	--	--	--	--	11,975
NEW SALEM TRIBUTARY	24	1,874	6%	13,659	44%	15,581	50%	--	--	--	--	31,115
OIL CREEK	75	16,368	12%	86,053	61%	39,362	28%	206	0%	--	--	141,990
OLD PATHS TRIB	26	3,384	6%	8,369	15%	42,383	78%	--	--	--	--	54,136
PORTERS CREEK	15	4,404	26%	6,051	36%	6,574	39%	--	--	--	--	17,028
PROSPECT HILL TRIBUTARY	7	1,151	18%	2,798	44%	2,445	38%	--	--	--	--	6,394
SOUTH BRANCH CODORUS CREEK	4	4,990	21%	--	--	18,601	79%	--	--	--	--	23,591
SPRING GARDEN PARK TRIBUTARY	7	7,883	53%	1,367	8%	412	3%	5,449	37%	--	--	14,911
SPRING GROVE TRIBUTARY	5	--	--	7,096	86%	1,356	14%	--	--	--	--	8,052
STARVIEW TRIBUTARY	9	--	--	3,316	23%	11,972	77%	--	--	--	--	14,288
STOVERSTOWN BRANCH	30	5,057	12%	12,597	31%	23,105	57%	--	--	--	--	40,656
SUNNYSIDE TRIB	3	--	--	2,867	48%	3,347	52%	--	--	--	--	6,014
SWIMMING POOL TRIB	14	703	5%	11,236	58%	7,392	37%	--	--	--	--	19,731
TROUT RUN	2	--	--	--	--	8,806	100%	--	--	--	--	8,506
UPPER CODORUS CREEK	98	39,021	21%	52,694	29%	91,122	50%	--	--	--	--	181,838
VIOLET HILL TRIBUTARY	40	6,262	11%	31,896	57%	18,144	32%	--	--	--	--	55,773
WEST BRANCH CODORUS CREEK	56	3,319	7%	34,357	36%	56,881	57%	--	--	--	--	94,538
WILLIS RUN	18	20,528	48%	5,449	13%	--	--	855	2%	16,252	38%	42,768
Total	964	221,760	13%	626,671	37%	810,545	47%	34,837	2%	16,252	1%	1,710,065

The survey results show an annual soil loss of one cubic foot per foot of stream. LR-11 was established on a severely impaired reach of Long Run and is located on the outside of the meander. The second monitoring survey was completed nine months after the initial survey and revealed a 0.77 cubic foot of soil loss per stream foot or 1.03 cubic feet per stream foot annually. A second monitoring cross section (LR-11 #2) was established on this reach downstream of LR-11 #1. At LR-11 #1 the right bank collapsed over the toe pin and the channel is actively migrating down valley. LR-11 #2 was established to measure bank erosion downstream where it appears that significant erosion and channel adjustments will occur.

Table 2-7. West Branch Streambank Erosion Monitoring

BANK EROSION MONITORING SUMMARY

SITE	DATE ESTABLISHED	MONITORING DATE	FT^3/YEAR SOIL LOSS (1)	BEHI NUMERICAL RATING (2)	BEHI ADJECTIVE RATING (3)	NBS ADJECTIVE RATING (4)
East Long Run (LR-11/BM#1)	2/11/2002	11/13/2003	1.03	30.3	High	Low
East Long Run (LR-11/BM#2)	11/13/2003			40.9	Very High	High
Mill Creek MC-09	11/13/2003			39.8	High	Very High
Mill Creek MC-10	11/13/2003			26.2	Moderate	Low
Oil Creek (OC-12/ Furhmans BM#1)	2/11/2003	11/22/2003	4.00	36.8	High	High
Oil Creek (OC-12/ Furhmans BM#2-Left Bank)	11/12/2003			30.0	Moderate	Low
Oil Creek (OC-12/ Furhmans BM#2-Right Bank)	11/12/2003			26.8	Moderate	Low
Oil Creek (OC-12/ Furhmans BM#3)	11/12/2003			37.5	High	High
Upper Codorus Creek (UCC-18/Frazier BM#1)	11/26/2002	11/13/2003	1.00	29.5	Moderate	Moderate

(1) Cubic feet of soil loss per linear foot of stream
(2) BEHI- Bank Erosion Hazard Index
(3) BEHI Ajective Rating- Indicates erodibility based on BEHI scores.
(4) NBS Abjective Rating- Near Bank Shear Stress indicator.

2.3. Consider impacts on downstream waters

Disturbances that bring changes to stream corridors and associated ecosystems are natural events or human induced activities that occur separately or simultaneously. Either individually or in combination, disturbances place stresses on the stream corridor that have the potential to alter its structure and impair its ability to perform key ecological functions. The true impact of these disturbances can best be understood by how they affect the ecosystem structure, processes, and functions.

A disturbance occurring within or adjacent to a corridor typically produces a causal chain of effects, which may permanently alter one or more characteristics of a stable system. A view of this chain is illustrated in Figure 2-8 (Wesche 1985). This view can be applied in many stream corridor restoration initiatives with the ideal goal of moving back as far as feasible on the cause-effect chain to plan and select restoration alternatives. Otherwise, chosen alternatives may merely treat symptoms rather than the source of the problem.

Using this broad goal along with the thoughtful use of a responsive evaluation and design process will greatly reduce the need for trial-and-error experiences and enhance the opportunities for successful restoration.

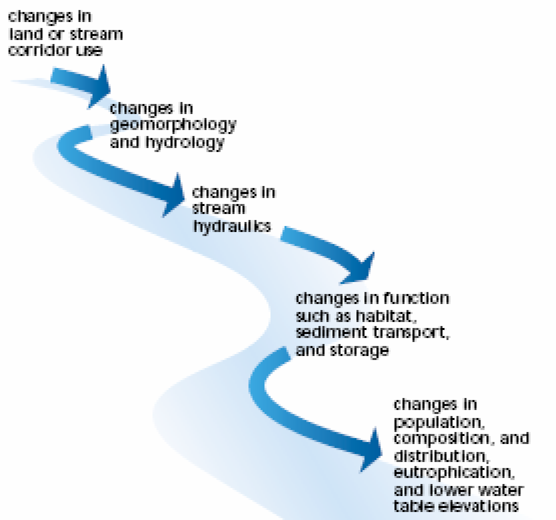

Figure 2-10. Chain of Events Due to Disturbance.

Disturbances can occur anywhere within the stream corridor and associated ecosystems and can vary in terms of frequency, duration, and intensity. A single disturbance event may trigger a variety of disturbances that differ in frequency, duration, intensity, and location. Each of these subsequent forms of direct or indirect disturbance should be addressed in restoration planning and design for successful results.

This plan focuses on understanding how various disturbances affect the stream corridor and associated ecosystems. We can better determine what actions are needed to restore stream corridor structure and functions by understanding the evolution of what disturbances are stressing the system, and how the system responds to those stresses.

Natural disturbances as a multitude of potential events that cover a broad range of temporal and spatial scales. Often the agents of natural regeneration and restoration, natural disturbances are part of the dynamic system and evolutionary process at work in stream corridors.

Traditionally the use and management of stream corridors have focused on the health and safety or material wealth of society. Human-induced forms of disturbances and resulting effects on the ecological structure and functions of stream corridors are, therefore, common.

In either case, if existing stream bank and channel erosion is left unaddressed then the consequences will be continued ecosystem, environmental and water quality degradation, and increasing impairment of waterbody designated and protected uses, throughout the Codorus Creek Watershed.

Therefore, natural stream channel restoration design is considered to be the best hope and the most cost-effective and efficient solution for encouraging and implementing environmental stewardship and watershed protection measures in the Codorus Creek Watershed.

2.4 Watershed Restoration and Protection Priorities

The results of the Codorus Creek Watershed Assessments were fairly consistent between and among the East, South and West Branches with respect to degree of stream impairment and source of impairment (table 2-8).

Table 2-8. Summary of Watershed Assessments

Watershed	Severely Impaired (Miles0	Percent of Total (%)	Moderately Impaired (Miles)	Percent of Total (%)
East Branch Codorus Creek	13	12	54	51
South Branch Codorus Creek	10	7	56	38
West Branch Codorus Creek	42	13	118	36
Total	65		228	

The assessment of the South Branch Codorus included 148 miles of stream, while the East Branch involved 105 miles of stream. The assessment of the West Branch and main stem of the Codorus included another 324 miles of stream for a total of 577 miles of stream in the Codorus Creek watershed. Of this total, 66 miles were assessed as severely impaired or 11.5% of all streams. Another 40% or 230 miles of stream in the entire watershed were assessed as moderately impaired. The upper section of the watershed has a higher percentage of agriculture and forest land while the lower watershed in the vicinity of York has substantially more urban development including residential, commercial, and industrial land uses. As in the other completed watershed assessments, the primary sources of impairment in the watershed appears to be stream bank erosion and sedimentation, lack of adequate, woody riparian buffers, and unrestricted livestock access to the streams. Bank erosion monitoring will be continued to develop a sediment rating curve to help predict future erosion rates.

Overall the water quality of the Codorus Creek is good and supports a good diversity of benthic macroinvertebrates and fin fish. Although Codorus Creek and its tributaries have been impaired for many years, there is potential for enhancement and restoration. The upper Codorus supports a unique and productive coldwater fishery. The portion of the South Branch included in the assessment supports a productive warm water fishery despite obvious impairment.

Mill Creek was a stocked trout stream in the past and has great potential to be restored as a coldwater fishery. There appears to be significant groundwater recharge to the stream and the stream appears to have good water quality. With regional stormwater management planning, sediment load reduction through bank stabilization and habitat improvements, this urban stream could be restored to a viable fishery.

With the water quality improvements completed by Glatfelter and the initiatives being implemented by the U.S Army Corps of Engineers (ACOE), there is tremendous restoration momentum. The identified watershed partners have pursued a number of restoration and habitat enhancements over the last several years. With the completion of the watershed assessment and prioritization of restoration, funding and property owner support will be a critical to implementing any restoration. A general stream restoration plan has been prepared and is presented in subsequent sections of this watershed implementation plan to help guide future stream restoration efforts. Priority watershed restoration activity by subwatershed and aggregate for the watershed as a whole is given below (table 2-9).

Table 2-9. Watershed of Priority Restoration Activity By Subwatershed and Aggregate for the Watershed as a Whole

EAST BRANCH CODORUS CREEK WATERSHED	Reaches	Priority 1	Priority 2	Priority 3	Other	Total
Stream Priority		(Feet)	(Feet)	(Feet)	(Feet)	(Feet)
1. East Branch CC-3 (Lower)	EBCC-77	20,793	45,128	16,288	949	83,158
2. Dunkard Valley Trib	DVT-31	11,025	9,016	15,728	366	36,135
3. Seaks Run	SR-31	8,995	13,471	16,137	3,366	41,969
4. Barshinger Creek	BC-52	7,924	45,553	2,053	0	55,530
5. Inners Creek	IC-47	6,257	11,255	21,500	1,045	40,057
6. Graydon Road Trib	GRT-11	3,327	7,103	0	0	10,430
7. Ridgeview Road Trib	RRT-10	1,991	3,902	816	0	6,709
8. Blymire Hollow Trib	BHT-52	1,985	42,431	29,482	500	74,398
9.Winterstown Boro S Trib	WBST-8	1,975	1,247	4,280	0	7,502
10.Winterstown Boro N Trib	WBNT-18	1,302	9,265	8,965	0	19,532
11. Jacobus Boro N. Trib	JBNT-5	1,176	3,000	0	0	4,176
12. Dallastown South Trib	DST-21	759	13,558	2,465	0	16,782
13. Nixon Park Trib	NPT-37	234	21,168	18,114	0	39,516
14. Reynolds Mill Trib	RMT-4	210	1,291	1,548	0	3,049
15. Mt. Zion Trib	MZT-10	0	11,661	1,119	0	12,780
16. Arlington Park Trib	APT-17	0	11,078	4,074	0	15,152
17. Hametown Trib	HT-15	0	9,084	6,262	135	15,481
18. East Branch CC-2 (Mid)	EBCC-17	0	9,022	7564	0	16,586
19. I-83 Exit Three Trib	ETT-12	0	7,028	2,611	0	9,639
20. Jacobus Boro W. Trib	JBWT-7	0	4,359	198	0	4,557
21. I-83 Exit Four Trib	EFT-8	0	3,245	1,280	640	5,165
22. Jacobus Boro E.	JBET-7	0	1,974	3,337	0	5,311
23. Rehmeyer Hollow Trib	RHT-9	0	1,089	7,306	521	8,916
24. Spartan Road Trib	SRT-5	0	265	3,646	0	3,911
25. Mt. Olivet Trib	MOT-13	0	41	12,914	181	13,136
26. Leaders Heights S. Trib	LHST-2	0	0	2,392	0	2,392
27. East Branch CC-1	EBCC-1	0	0	0	0	0
TOTAL		67,953	286,234	190,079	7,703	551,969
SOUTH BRANCH CODORUS CREEK WATERSHED	Reaches	Priority 1	Priority 2	Priority 3	Other	Total

Stream Priority		(Feet)	(Feet)	(Feet)	(Feet)	(Feet)
1. South Branch CC	SBCC	31,125	44,759	68,820	358	145,062
2. Fishel Creek	FIC-38	7,752	11,220	29,407	0	48,379
3. Foust Creek	FOC-15	2,914	4,973	12,056	0	19,943
4. Glen Rock Valley Trib	GRVT-25	2,735	17,848	18,309	0	38,892
5. Travis Trib	TT-22	2,518	5,761	12,995	0	21,274
6. Pierceville Run	PR-47	2,485	33,290	38,529	0	74,304
7. Centerville Creek	CC-64	2,336	24,163	51,398	0	77,897
8. Stricthouser Trib	ST-21	940	31,898	15,862	0	48,700
9. Hungerford Trib	HuT-18	898	2,204	9,560	942	13,604
10. Seven Valleys N. Trib	SVNT-10	436	2,523	8,244	0	11,203
11. Trout Run	TR-28	227	8,421	25,403	204	34,255
12. Krebs Valley Trib	KVT-26	0	33,412	13,893	0	47,305
13. Hanover Junction Trib	HJT-16	0	19,476	0	0	19,476
14. Wangs Trib	WT-7	0	13,821	0	0	13,821
15. Zeiglers Church Trib	ZCT-17	0	10,367	5,725	0	16,092
16. Brush Valley Trib	BRVT-11	0	5,642	13,567	0	19,209
17. New Freedom Trib	NFT-2	0	4,745	0	0	4,745
18. Cherry Run	CR-10	0	4,203	12,367	0	16,570
19. Bens Trib	BeT-1	0	4,153	0	0	4,153
20. Buffalo Valley Trib	BUVT-9	0	2,730	25,079	0	27,809
21. New Freedom Ch Trib	NFCT-13	0	2,350	23,944	0	26,294
22. Seven Valleys S. Trib	SVST-19	0	2,291	14,523	0	16,814
23. Larue Trib	LT-17	0	1,839	10,643	0	12,482
24. Glen Rock South Trib	GRST-6	0	1,437	1,966	2,228	5,631
25. Railroad Trib	RRT-6	0	989	2,786	845	4,620
26. Golf Course Trib	GCT-7	0	626	4,247	0	4,873
27. Peter & Paul Trib	PPT-4	0	254	4,963	0	5,217
28. North Railroad Trib	NRT-4	0	0	2,619	0	2,619
TOTAL		54,366	295,395	426,905	4,577	781,243

WEST BRANCH CODORUS CREEK WATERSHED	Reaches	Priority 1	Priority 2	Priority 3	Other	Total
Stream Priority		(Feet)	(Feet)	(Feet)	(Feet)	(Feet)
1. Mill Creek	MC-147	44,130	58,069	79,084	18,865	200,148
2.Upper Codorus Creek	UCC-98	39,021	52,694	91,122	0	182,837
3. Codorus Creek	CC-114	32,478	90,252	173,459	7,445	303,634
4. Willis Run	WR-18	20,528	5,449	0	0	25,977
5. Oil Creek	OC-75	16,368	86,053	39,362	206	141,989
6. Long Run	LR-86	14,684	58,471	50,508	0	123,663
7. Spring Garden Park Trib	SGPT-7	7,883	1,367	412	5,449	15,111
8. Violet Hill Trib	VHT-40	6,262	31,896	18,144	0	56,302
9. Furnace Creek	FUC-36	5,518	32,446	6,510	0	44,474
10. Stoverstown Branch	SB-30	5,057	12,597	23,105	0	40,759
11. South Branch CC	SBCC-4	4,990	0	18,601	0	23,591
12. Porters Creek	PC-15	4,404	6,051	6,574	0	17,029
13. Old Paths Trib	OPT-26	3,384	8,369	42,383	0	54,136
14. West Branch CC	WBCC-56	3,319	34,357	56,881	0	94,557
15. Leaders Hieghts Trib	LHT-20	3,168	24,468	12,155	0	39,791
16. Lightners School Trib	LST-15	2,988	10,555	8,226	1,452	23,221

17. Lehman Trib	LHT-23	1,927	5,903	24,404	0	32,234
18. New Salem Trib	NST-24	1,874	13,659	15,581	0	31,114
19. Nashville Trib	NT-5	1,431	9,192	1,352	0	11,975
20. Prospect Hill Trib	PHT-7	1,151	2,798	2,445	0	6,394
21. Swimming Pool Trib	SPT-14	703	11,236	7,392	0	19,331
22. Emigsville Trib	ET-31	491	7,704	33,174	564	41,933
23. Bunch Creek	BC-11	0	16,278	20,302	0	36,580
24. Dee Run	DR-9	0	16,236	9,493	0	25,729
25. Lincolnway Trib	LT-10	0	15,412	9,203	0	24,615
26. Spring Grove Trib	SGT-5	0	7,096	1,356	0	8,452
27. Starview Trib	SVT-9	0	3,316	11,972	0	15,288
28. Sunnyside Trib	ST-3	0	2,867	3,347	0	6,214
29. Lischy Church Trib	LCT-11	0	1,352	12,155	0	13,507
30. Gitts Run	GR-13	0	528	23,037	0	23,565
31. Trout Run	TR-2	0	0	8,806	0	8,806
TOTAL		221,759	626,671	810,545	33,981	1,692,956