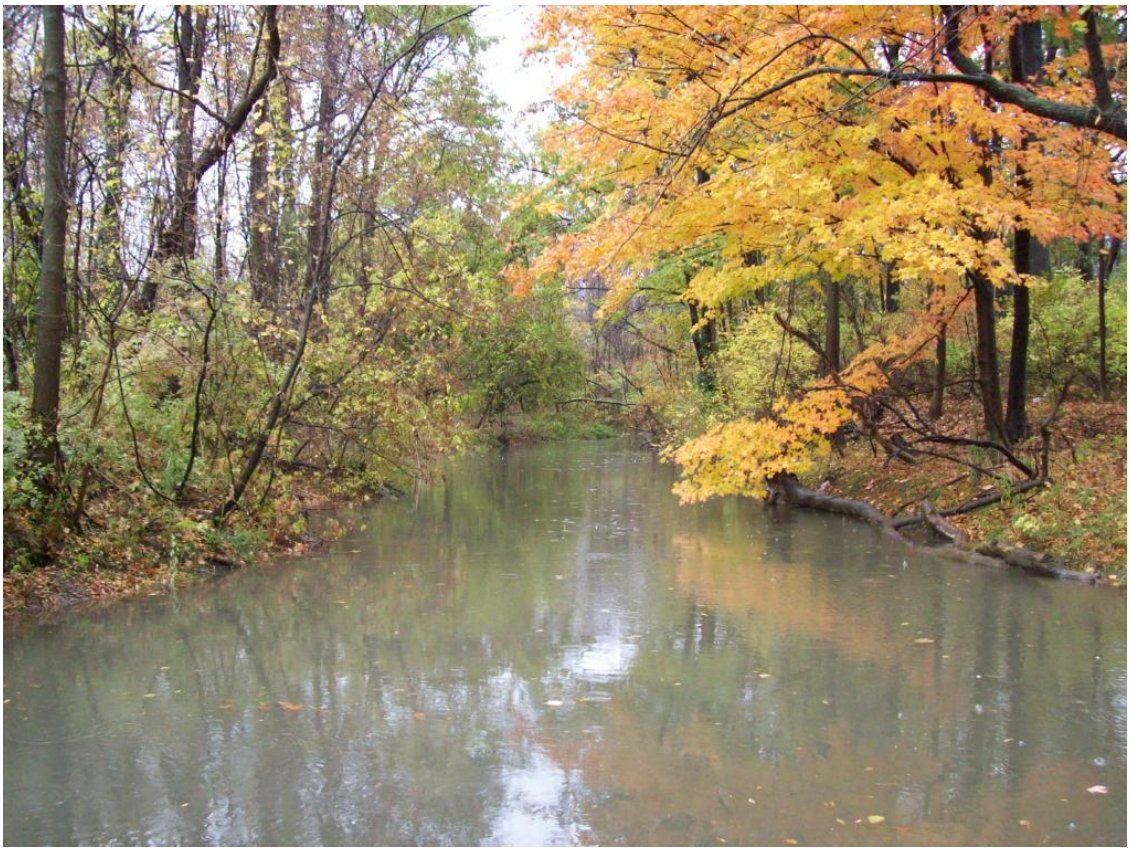
Cayuga Creek Watershed
Stream Visual Assessment Protocol (SVAP)



Prepared By: Watershed Analysis Team
Dr. Kelly M. Frothingham, Course Instructor, GEG 421/521
Michael Draganac, Alexander Sowyrda, Jessica Bakert, Alexis Carroll, Nicholas Conwall, Brent Laspada, Jason Pantano, Victoria Pollard, Joseph, Skowronski

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INTRODUCTION

In the Fall of 2008, as part of a class project for Watershed Analysis 421/521, students from Buffalo State College conducted a study using the NRCS Stream Visual Assessment Protocol (SVAP) (Natural Resources Conservation Service (NRCS), 1998) to assess the current geomorphological, water quality, and ecological conditions of Cayuga Creek in Niagara County, New York.

The objective of this project was to use a qualitative assessment tool (i.e., the SVAP) to describe the current conditions of Cayuga Creek. The purpose of this report is to provide a document to be used by planners and various stakeholders to identify potential rehabilitation areas within Cayuga Creek for possible project implementation.

Cayuga Creek in Niagara County, New York is a tributary to the upper Niagara River (Figure 1). The Niagara River was designated as one of 43 Areas of Concern (AOCs) in the Great Lakes Basin because of impaired beneficial uses (U.S. Environmental Protection Agency (USEPA), 2009). Environmental problems in the Niagara River AOC include: inactive hazardous waste sites, contaminated sediment, combined sewer overflows, habitat degradation, and nonpoint source pollution, including urban and rural runoff (USEPA, 2009).

The focus of this study is on the main-stem of Cayuga Creek. The headwaters of the 10-mile long Cayuga Creek start in the Town of Lewiston and from that point the creek flows south through the Tuscarora Nation and the Town of Wheatfield. The creek then crosses under Walmore Road onto the Niagara Falls International Airport and Air National Guard Base complex and continues south through the Town of Niagara, and the City of Niagara Falls where it joins the Little River adjacent to Cayuga Island (Figure 1).

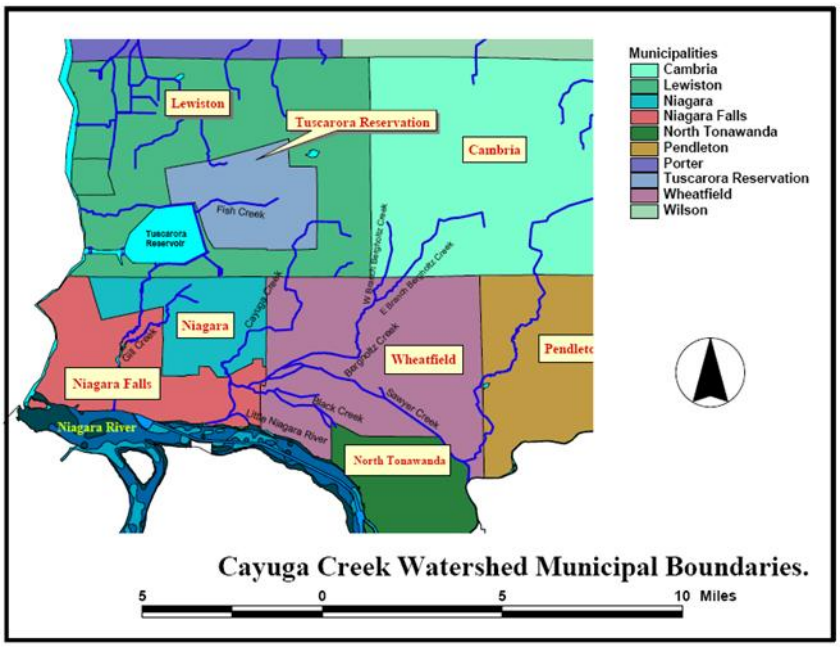

Figure 1. Map of the Cayuga Creek watershed municipal boundaries.

Land use in the Cayuga Creek watershed varies from rural, residential, agricultural, to commercial and industrial. North of the Airport and Air Base complex in the Town of Lewiston, the Tuscarora Nation, and the Town of Wheatfield, land uses consist of mixed residential and agriculture with some pockets of open land. In the southern portion of the watershed much of the land in the Town

of Niagara and the City of Niagara Falls are mainly suburban, residential, and commercial development. Industrial activities are concentrated in the City of Niagara Falls.

Most of the watershed topography is relatively flat. Elevations range from approximately 625 feet at the headwaters to approximately 560 feet at the Niagara River confluence in the City of Niagara Falls. Fluctuations in the water levels of Cayuga Creek are directly affected by water levels in the Niagara River (U.S. Army Corps of Engineers (USACE), 2002). Water levels are also affected by the daily draw down of the New York Power Authority (NYPA) and Ontario Power Generation (OPG) (USACE, 2002). Other factors such as wind, natural flow variations and ice conditions, water levels of Lake Erie and Lake Ontario, also affect water levels of the creek (USACE, 2002).

The characteristic bedrock units underlying the basin are the Lockport Dolomitic Limestone and the Queenston and Rochester Shales. These are buried along much of Cayuga Creek, with the stream flowing through a clay-lined channel. The U.S. Department of Agriculture Soil Conservation Service has mapped these soils and classified them as to permeability (drainage) (Higgins et al., 1972). Most of the soils in the Cayuga Creek basin are derived from glacial lake sediments and are characterized by high density, poor tilth (tillability), and very poor drainage.

Historically, the primary function of Cayuga Creek has been that of flood control, as evident by human induced channel alterations, specifically channelization. An existing flood control structure located between Porter Road and Niagara Falls Boulevard consists of an earthen berm built along the creek to control flood waters and protect homes and structures in and around the Cayuga Village Trailer Park in the Town of Niagara (USACE, 2002).

METHODS

STREAM VISUAL ASSESSMENT PROTOCOL

The Stream Visual Assessment Protocol (SVAP) is a qualitative field reconnaissance technique that assesses channel and floodplain conditions, riparian areas, water quality and aquatic habitat (NRCS, 1998). The SVAP elements assessed for this project consider fluvial geomorphological, water quality, and biological conditions (Table 1). The following elements were assessed: channel condition, bank stability, riparian zone, water appearance, nutrient enrichment, barriers to fish movement, instream fish cover, presence of pools in the stream, and canopy cover (Table 1).

Table 1. Description of SVAP Elements (after NRCS, 1998)

SVAP Element	Description
Channel Condition	Evidence of channelization or alteration of the stream and existence of dikes, levees, etc.
Bank Stability	Existence of or the potential for detachment of soil from the upper and lower stream banks and its movement into the stream.
Riparian Zone	Width of the natural vegetation zone from the edge of the active channel out onto the flood plain.
Nutrient Enrichment	Reflected by the types and amounts of aquatic vegetation in the water.
Water Appearance	Compares turbidity, color, and other visual characteristics with a healthy or reference stream.
Barriers to Fish Movement	Barriers that block the movement or deny access to fish or any other aquatic organism to other parts of the stream.
Instream Fish Cover	Measures availability of physical habitat for fish.
Pools	Pool abundance and diversity are evaluated.
Canopy Cover	Evaluates shading of the water surface area throughout the entire stream reach.

Cayuga Creek was divided into sections by road intersection (between Saunders Settlement Road and Niagara Falls Boulevard) and reaches were defined within each section. The sections of the stream that flow through the Tuscarora Nation and the Niagara Falls International Airport and Air National Guard Base complex were not assessed. Based on the SVAP protocol, a reach should be twelve times the active (i.e., bankfull) channel width and it should be representative of the stream through an area (NRCS, 1998). Within each reach, the elements outlined in Table 1 were individually ranked on a scale of 1 to 10, using the qualitative descriptions in the SVAP manual (NRCS, 1998). The mean of the individual scores was used to determine the overall condition of each reach. Reaches with an overall score of 6 or less are Poor; overall scores in the range of 6.1-7.4 are Fair; overall scores between 7.5-8.9 are Good; and overall scores greater than 9 are Excellent (NRCS, 1998).

In the field, a general description of each reach was documented and sketched. Channel width (lowflow and bankfull), depth (lowflow and bankfull), reach length, dominant substrate type, and GPS

coordinates were recorded. A Manning's n roughness coefficient was estimated and digital photographs were taken at each reach.

STABILITY THRESHOLD ANALYSIS

Stability Threshold Analysis (STA) was used to determine what methods of bank stabilization techniques could be used to stabilize streambanks in reaches that had Poor bank stability element scores. In particular, the applicability of biotechnical bank stabilization techniques was considered. Biotechnical techniques use vegetation to stabilize streambanks. STA compares reach-averaged shear stress and velocity values to permissible shear stress and velocity values (Fischenich 2001) and it can be used to determine a range of possible bank stabilization solutions (Frothingham, 2008). Thus, STA is valuable in the planning stage of watershed management, as it is relatively easy and cost-effective to collect the data needed for the analysis.

Reach-averaged velocity for both low- and bankfull flow conditions were calculated using Manning's equation:

$$V = (1.49/n)\, D^{2/3} * S^{1/2}$$

where D=depth, S=slope, and n= Manning's number. Reach-averaged shear stress values for both low- and bankfull flow conditions were also calculated:

$$\tau = \gamma DS$$

where γ=specific weight of water, D=depth, and S=slope.

The calculated reach-averaged velocity and shear stress values in Poor bank stability score reaches were compared to permissible velocity and shear stress values for a variety of boundary conditions (Table 2).

Table 2. Permissible Velocity and Shear Stress Values for Different Bank Stabilization Techniques (after Fischenich 2001)

Boundary category	Boundary type	Permissible shear stress (lb/ft^2)	Permissible velocity (ft/s)
Biotechnical streambank stabilization	Reed fascines	0.6-1.25	5
	Coir roll	3-5	8
	Vegetated coir mat	4-8	9.5
	Live brush mattress (initial)	0.4-4.1	4
	Live brush mattress (grown)	3.9-8.2	12
	Brush layering (initial/grown)	0.4-6.25	12
	Live fascine	1.25-3.10	6-8
	Live willow stakes	2.10-3.10	3-10
Non-degradable RECPs	Unvegetated	3.0	5-7
	Partially established	4.0-6.0	7.5-15
	Fully vegetated	8.0	8-21

RESULTS

A total of 67 reaches were assessed between Saunders Settlement Road and Niagara Falls Boulevard. The following contains a general description, including the number of reaches assessed, predominate land use, and the major impairments, by road intersection. Appendix A contains the individual SVAP scores for each reach and Appendix B contains the photo index of each reach.

Saunders Settlement Rd. to Walmore Rd.

This section included 20 reaches (Reach 1-20). The surrounding land use was a mix of residential and agricultural fields, with the latter being of the majority. Overall SVAP scores ranged from 3.3-6.6 (Poor, to the low end of Fair). Impairments included lack of pools, water appearance, nutrient enrichment, bank stability, and instream fish cover. Bank stability scores ranged from 1.5 to 7.5 (Poor to Good).

Walmore Rd. to Cory Rd.

This section included Reaches 21 through 24, with surrounding land use being a mix of residential and agricultural. The overall SVAP rating for all four reaches in this section was Poor. There was a large amount of bank erosion throughout this section and it lacked a significant riparian zone.

Cory Rd. to Walmore Rd.

This section was from Reach 25 through Reach 30, and it was a mix of residential and industrial land uses. The first two reaches (Reaches 25-26) in this section were industrial, flowing through a concrete mixing facility. The impairments in both reaches included lack of riparian zone and Reach 25 was overgrown with reeds to the point of becoming a complete barrier to fish movement. The remainder of this section (Reaches 27-30) was residential and impairments included lack of a riparian zone and there was some evidence of stream channelization. There also were reaches where there was little to no instream fish cover. It should also be noted that a resident of this section commented about concrete sediment washing downstream during and after storm events.

Walmore Rd. to Lockport Rd.

This section was from Reach 31 through Reach 44, and was combination of farmland, forest, and residential. This section was highly agricultural, and had a range of overall SVAP scores. For the most part this section was rated Fair to Good, with some reaches that are scored as Very Good. In the reaches that had Poor ratings, there were issues with bank stability, instream fish cover, and lack of riparian zone.

Lockport Rd. to Walmore Rd.

This section covered Reaches 45 through 52, and was a combination of forest, residential, commercial, and industrial land use. The first three reaches had Good overall SVAP scores. Reaches 48through 50 were surrounded by commercial/industrial land uses and impairments included channel condition, bank stability, riparian zone, barriers to fish movement, nutrient enrichment, and pools.

Porter Road to Niagara Falls Boulevard

A total of 15 reaches (Reaches 53-67) were assessed in this section of Cayuga Creek. All reaches fell within the boundary between Porter Road and Niagara Falls Boulevard and at no time did the creek cross under any roadway or structure; thus, several reaches with similar characteristics are described together.

Reaches 53-55

Reaches 53 through 55 were primarily surrounded by former agricultural lands that are currently forested. This section has been channelized from Porter Rd. to the Cayuga Village Trailer Park. Overall SVAP ratings for these reaches ranged from Poor to Fair. This section has some bank erosion, but overall it had an extensive riparian corridor and good canopy cover. The canopy cover has resulted in some large woody debris falling into the creek.

Reaches 56-58

Reaches 56 through 58 are in the Cayuga Village Trailer Park. Land use in this section is primarily residential on the left bank with forest on the right bank. This section of the creek has also been channelized to provide flood protection for the Cayuga Village Trailer Park. Overall SVAP ratings for these reaches are Poor and impairments include channel condition, riparian zone, bank stability, in-stream fish cover, and water appearance. At the beginning of Reach 56 the creek makes a 45-degree bend and slabs of concrete previously used for bank stabilization have fallen into the creek. The remaining portions of this ad hoc bank stabilization are in immediate danger of failure.

Reaches 59-62

Reaches 59 through 62 also run through and just downstream of the Cayuga Village Trailer Park. Land use in this section is primarily residential on both the left and right banks. Overall SVAP ratings for these reaches range from Poor to Fair. Impairments in this section are lack of a riparian zone, channel condition, bank stability, and water appearance. This section includes a tight bend (approximately 90 degrees) and additional ad hoc bank stabilization with no uniformity of material or construction.

Reaches 63-65

Reaches 63 through 65 are surrounded by primarily residential land use on the left bank with some wooded areas that have been partially cleared by property owners and heavily wooded land use on the right bank. Overall SVAP ratings for these reaches are Fair. These reaches the creek follow what appears to be a "natural" meandering course roughly paralleling Tuscarora Road.

Reaches 66-67

Reaches 66 through 67 are immediately upstream of Niagara Falls Boulevard. Land use in this section is primarily wooded on the left bank and commercial on the right bank. Overall SVAP ratings for these reaches are Fair. The right bank has been heavily armored with small stone to protect a capped "dump" site. In this section there is little to no riparian corridor and no canopy cover.

Stability threshold analysis (STA) was used to determine what methods of bank stabilization techniques could be used to stabilize streambanks in reaches that had Poor bank stability element scores. A total of 38 reaches had Poor bank stability scores. STA results indicate that biotechnical bank stabilization techniques could be used in all of those reaches (Tables 4 and 4); however, more detailed reach-scale analysis must occur before recommendations for specific bank stabilization techniques can be made. Based on STA results, we recommend further reach-scale study of the 38 reaches for several reasons:

1. Largely due to the shallow slope (0.0016) of Cayuga Creek, maximum calculated velocities rarely exceeded 8 ft/sec and maximum shear stress never exceeded 1.0 lbs/sq. ft. Biotechnical bank stabilization methods are recommended for use in streams with velocities ranging from 0 to 8 ft/sec, depending on which method is applied (Fischenich, 2001) (see Table 2).

2. Using biotechnical bank stabilization also addresses other problems observed in the reaches. Other problems that were common in the reaches included lack of fish cover, lack of pools, and poor general channel conditions (e.g., evidence of channelization). Biotechnical bank stabilization methods offer enhancement of channel condition by providing habitat, as well as bank stabilization.

3. Biotechnical bank stabilization methods are generally less expensive to install than traditional hard engineering methods. Traditional hard engineering methods, such as adding rock riprap, concrete, or cobble/gravel, do not usually enhance the in-stream fish cover, canopy cover, or habitat space for micro or macro invertebrates along the bank.

4. Most biotechnical bank stabilization methods, such as coir rolls, joint plantings, fascines, live brush mattresses, and RECPs, do not require the use of machinery and heavy equipment. The installation of these methods can be performed by hand using manual labor, which in turn is less damaging to the riparian and buffer zones. The clearing of trees and brush to make room for such equipment is not necessary for this process. A lack of heavy equipment also means less or no compaction of the surrounding soils, minimizing disturbance and excess sedimentation. On a scale such as that of Cayuga Creek, most of the possible biotechnical bank stabilization options could be accomplished with no more than a single truck and a few wheel barrows brought close to the streambank to deliver materials.

Table 3. Low Flow STA Results in Reaches with Poor Bank Stability Scores

Rd. Intersection	Reach number	Shear stress (lb/sq ft)	Velocity (ft/sec)	Applicable biotechnical techniques
Saunders Settlement. Rd to Walmore	1	0.02	0.61	any
	2	0.03	0.76	any
	3	0.06	1.30	any
	4	0.08	1.54	any
	5	0.06	1.12	any
	8	0.01	0.44	any
	9	0.03	0.68	any
	10	0.02	0.57	any
	11	0.02	0.52	any
	12	0.03	0.81	any
	13	0.05	1.34	any
	14	0.04	1.08	any
	17	0.01	0.20	any
Walmore Rd. to Cory Dr.	21	0.15	2.23	any
	22	0.05	1.07	any
	23	0.08	1.41	any
	24	0.10	1.70	any
Cory Dr. to Walmore Rd.	25	0.20	0.85	any
	26	0.08	0.44	any
	27	0.20	2.70	any
	30	0.10	1.70	any
Walmore Rd. to Lockport Rd.	31	0.10	2.06	any
	32	0.10	2.06	any
	38	0.08	0.95	any
	42	0.08	0.95	any
Lockport Rd. to Walmore Rd	48	0.15	0.70	any
	49	0.15	1.20	any
	50	0.15	1.66	any
	51	0.20	1.46	any
Porter Rd. to Niagara Falls Blvd.	54	0.20	2.70	any
	56	0.15	2.23	any
	57	0.30	2.96	any
	58	0.10	1.42	any
	60	0.20	3.26	any
	61	0.25	3.79	any
	62	0.30	3.54	any
	63	0.30	3.54	any
	64	0.20	2.70	any

Table 4. Bankfull flow STA Results in Reaches with Poor Bank Stability Scores

Rd. Intersection	Reach number	Shear stress (lb/sq ft)	Velocity (ft/sec)	Applicable biotechnical techniques
Saunders Settlement. Rd to Walmore	1	0.30	4.13	any except initial live brush mattress
	2	0.28	3.82	any
	3	0.25	3.43	any
	4	0.28	3.70	any
	5	0.28	3.20	any
	8	0.24	3.05	any
	9	0.26	3.22	any
	10	0.19	2.86	any
	11	0.28	3.38	any
	12	0.28	3.38	any
	13	0.22	3.60	any
	14	0.26	3.64	any
	17	0.17	1.13	any
Walmore Rd. to Cory Dr.	21	0.28	3.34	any
	22	0.40	4.30	any except initial live brush mattress
	23	0.30	3.54	any
	24	0.40	4.29	any except initial live brush mattress
Cory Dr. to Walmore Rd.	25	0.45	1.45	any
	26	0.45	1.45	any
	27	0.50	4.50	any except initial live brush mattress
	30	0.40	4.29	any except initial live brush mattress
Walmore Rd. to Lockport Rd.	31	0.60	6.79	any except initial live brush mattress and reed facines
	32	0.50	6.01	any except initial live brush mattress and reed facines
	38	0.35	2.64	any
	42	0.21	1.82	any
Lockport Rd. to Walmore Rd	48	0.35	1.23	any
	49	0.90	4.26	any except initial live brush mattress
	50	0.35	2.92	any
	51	0.80	3.67	any
Porter Rd. to Niagara Falls Blvd.	54	0.50	4.98	any except initial live brush mattress and reed facines
	56	0.80	6.82	any except initial live brush mattress and reed facines
	57	0.60	4.69	any except initial live brush mattress and reed facines
	58	0.50	4.15	any except initial live brush mattress
	60	0.80	8.23	any except initial live brush mattress and reed facines
	61	0.80	8.23	any except initial live brush mattress and reed facines
	62	0.90	7.38	any except initial live brush mattress and reed facines
	63	0.80	6.82	any except initial live brush mattress and reed facines
	64	0.60	5.63	any except initial live brush mattress and reed facines

CONCLUSIONS

Streambank and channel erosion and the resulting suspension of sediment are significant and recognized problems throughout the watershed, particularly within the City of Niagara Falls. The constriction and concentration of creek flows, channel modification, concentrated point source discharges, loss of woody riparian vegetation, and altered hydrologic characteristics, and fluctuations in water levels associated with Power Authority of the State of New York management of the Niagara River are contributing causes to this problem. Streambank erosion continues to reduce the quantity and quality of the shoreline, the water column, vegetated shallows and the riparian corridor and overhanging trees and shrubs, which is subject to undercutting and deadfall (USACE, 2002).

Results from this study indicate that Cayuga Creek is generally in poor condition. The average SVAP score of all sixty-seven reaches analyzed is 5.7, and the median score is 5.8, which amounts to a Poor overall SVAP rating. Documented problems include: lack of riparian and buffer zones, eroding streambanks, lack of in stream habitat, mowed lawns right to the streambanks, lack of pools/riffles, commercial dumping, and nutrient enrichment.

Streambank erosion was documented in many of the reaches in Cayuga Creek Results of this study showed that biotechnical streambank stabilization methods are appropriate to use to remedy almost every instance of bank erosion. Biotechnical stream bank stabilization methods are appropriate and worth future study for four reasons: 1. The low energy nature of the stream; 2. The ability of biotechnical methods to address the habitat concerns in this watershed; 3.The cost of biotechnical methods are generally less than traditional heavy engineering; 4. The impact of installation on the stream corridor is less than that of traditional heavy engineering techniques.

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APPENDIX A – SVAP RESULTS FOR CAYUGA CREEK

	Cayuga Creek Stream Assessment (November 2008)																				
Rd. Intersection	**Reach #**	**GPS Coordinates**	**Reach Length (ft)**	**Active (bankfull) Channel Width (ft)**	**Active (bankfull) Channel Depth (ft)**	**Low flow Channel Width (ft)**	**Low flow Channel Depth (ft)**	**Dominant Bed Substrate**	**Channel Condition**	**Riparian Zone**	**Bank Stability**	**Water Appearance**	**Nutrient Enrichment**	**Barriers to Fish Movement**	**In stream Fish Cover**	**Pools**	**Canopy Cover**	**Overall Score**	**Overall Rating**	**Land Use**	**Comments**
Saunders Settlement Rd to Walmore Rd.	1	43° 08′ 35.02″ N 78° 55′ 34.6″ W	220	25	3	6.5	0.17	silt/clay	3	6.5	4.5	1	1	8	5	1	7	4.1	Poor	Commercial, Residential, Pasture	No water in channel, garbage in ditch, channelization, school bus development close to banks.
	2	43° 08′ 32.8″ N 78° 55′ 35.1″ W	240	16	2.75	7	0.25	silt/clay	4	7	4	1	2	8	5	1	7	4.3	Poor	Commercial, Residential, cultivated field, lawn	Overabundance of plants, tree and grass clippings on top of bank.
	3	43° 08′ 30.5″ N 78° 55′ 34.6″ W	380	22	2.5	5	0.58	silt/clay	1	4	1.5	3	2	8	5	2	3	3.3	Poor	Commercial, Cultivated field, lawn	Channelization, some dumping but less than reach 1, not enough water in channel to support aquatic organisms
	4	43° 08′ 26.6″ N 78° 55′ 34.5″ W	180	17	2.8	12.5	0.75	silt/clay	1	8	3.5	5	4	8	4	3	8	4.9	Poor		Grass cuttings, branches and logs cut down and left on bank. Pipe running into stream from cultivated fields.
	5	43° 08′ 25.0″ N 78° 55′ 36.5″ W	280	16	2.8	11	0.58	silt/clay	2	8.5	4	4	3	8	7	3	9	5.4	Poor	Forest, Cultivated field	Extremely high density of vegetation in channel, saturated soil, somewhat marshy. No obvious signs of dumping or interference apart from channelization (present throughout stream).
	6	43° 08′ 22.2″ N 78° 55′ 38.4″ W	245	11	2.3	8.5	0.58	silt/clay	2	7.5	7.5	3	3	7	5	2	8	5	Poor	Pasture, cultivated field	Two large pipes that separate the stream, big boulders on sides for stabilization. Barrier to fish movement & no water, just saturated bog.
	7	43° 08′ 20.5″ N 78° 55′ 39.8″ W	210	21	3.2	9.5	0.58	silt/clay	2	8	7.5	3	3	8	6	2	5	4.9	Poor		Over vegetated, good coverage, still minimum amounts of water in stream.
	8	43° 08′ 19.1″ N 78° 5′ 42.1″ W	230	11	2.4	5.3	0.13	boulder	5	6	4	4	7	7	6	1	9	5.4	Poor		Open channel, very small stream running through, large bed load, well covered.
	9	43° 08′ 17.4″ N 78° 55′ 43.3″ W	210	14	2.6	7	0.25	boulder/ cobble	6	8	6	5	7	8	3	3	7	5.8	Poor	Forest, Cultivated field	More water than previously, very well sheltered and gentle banks, not very stable due to mass vegetation.
	10	43° 08′ 15.0″ N 78° 55′ 44.3″ W	140	12	1.9	5	0.17	boulder	5	9	3.5	6	7	10	3	1	8	5.8	Poor	Forest	Overhanging vegetation, leaves cover water surface, good riparian zone, no barriers to fish movement.
	11	43° 08′ 16.2″ N 78° 55′ 44.0″ W	110	13	2.8	4.5	0.17	silt/clay	6	9	5	8	7	9	3	3	7	6.3	Fair	Cultivated field, Forest	No barriers to fish movement, riparian zone still very good. Open channel, gentle banks.
	12	43° 08′ 14.0″ N 78° 55′ 44.27″	105	12	2.8	7.5	0.33		6	7.5	4	8	8	9	5	4	7	6.5	Fair	Cultivated, Forest	Hardly any barriers to fish movement, water appearance and nutrient enrichment considerably better.
	13	43° 08′ 13.29″ N 78° 55′ 45.39″	140	7.5	2.2	6	0.5	gravel / sand	6	7	2.5	7	8	10	5	7	5	6.4	Fair	Cultivated field	Large tunnel like tube, increasing barrier to fish movement.
	14	43° 08′ 11.7″ N 78° 55′ 46.9″ W	285	15	2.5	10.5	0.42	boulder / cobble	5	9	5	9	8	8	5	3	7	6.6	Fair	Pasture, cultivated field	Highest scoring section, less canopy cover but vegetation along banks, and water appearance good.
	15	43° 08′ 08.7″ N 78° 55′ 47.1″ W	200	13	2	9.5	0.21	boulder / cobble	7	8	7	5	3	7	5	2	3	5.2	Poor	Cultivated field, Residential	Bank stability good, lack of coverage, abundance of fallen vegetation causes barrier to fish movement.
	16	43° 08′ 06.6″ N 78° 55′ 46.9″ W	220	15	1.5	7	0.38	silt / clay	8	9	7	3	3	7	5	2	3	5.2	Poor		Hardly any sign of a channel, completely over vegetated, runs through cultivated field with residency on each side, very close to banks.
	17	43° 08′ 04.4″ N 78° 55′ 47.01″	275	13	1.7	7	0.13	silt / clay	8	9	6	3	3	7	5	2	3	5.1	Poor		
	18	43° 08′ 02.3″ N 78° 55′ 49.0″ W	135	10	1.8	6	0.13	silt / clay	7	9	6.5	3	3	7	5	2	3	5.1	Poor	Cultivated field, Road, Residential	Boggy, saturated soil, water appearance very low, no canopy, over vegetated, riparian zone poor.
	19	43° 08′ 00.9″ N 78° 55′ 49.0″ W	350	14	1.5	8	0.21	silt / clay	7	8.5	6.5	4	3	5	3	2	3	4.6	Poor		
	20	43° 07′ 57.3″ N 78°55′ 48.7″ W	255	21	2.5	15.5	0.5	cobble / gravel	7	7.5	6.5	4	5	9	3	3	9	6.1	Fair	Cultivated field, residential, Industrial	Large open channel, water appearance good, no barriers to fish movement, no barriers to fish movement.

Rd. Intersection	Reach #	GPS Coordinates	Reach Length (ft)	Active (bankfull) Channel Width (ft)	Active (bankfull) Channel Depth (ft)	Low flow Channel Width (ft)	Low flow Channel Depth (ft)	Dominant Substrate	Channel Condition	Riparian Zone	Bank Stability	Water Appearance	Nutrient Enrichment	Barriers to fish movement	In stream Fish Cover	pools	canopy cover	Overall Score	Overall Rating	Land Use	Comments
Walmore Rd. to Cory Dr.	21	43° 07' 55.8" N 78° 55' 52" W	168	15	2.75	7	1.5	silt/clay	2	1	4	5	8	5	1	1	7	3.8	poor	Residential, Agricultural	Severe mass wasting/undercutting caused by 90 deg. bend 3-4 feet high.
	22	43° 07' 55.4" N 78° 55' 53.9" W	134	14	4	6.5	0.5	silt/clay	4	2	5	3	4	?	?	?	6	3.5	poor		25 ft. section on both sides of bank with mass wasting/undercutting 3 to 4 feet high
	23	43° 07' 54.4" N 78° 55' 54.2" W	171	12	3	8	0.75	silt/clay	4	2	3	4	6	10	1	1	5	4	poor		Medium bank erosion w/ undercutting throughout the entire length, 2-3 ft above water. Also weedy barriers to fish movement.
	24	43° 07' 52.4" N 78° 55' 54.3" W	310	16	4	7	1	silt/clay	6	5	6	6	5	10	3	1	4	5.2	poor		Medium bank erosion w/ undercutting throughout the entire length, 2-3 ft above water.
Cory Dr. to Walmore Rd.	25	43° 07' 48.9" N 78° 55' 54.0" W	235	10	4.5	11	2	silt/clay	1	1	1	1	1	2	1	1	1	1	poor	Industrial, Residential, Agricultural	(Industrial section though concrete plant) Extremely dense weeds/reeds blocking fish movement. Minor erosion along entire reach 2-3 ft high
	26	43° 07' 46.4" N 78° 55' 53.2" W	213	25	4.5	14	0.75	silt/clay	6	1	1	7	2	8	2	5	1	3.6	poor		Industrial area, no buffer or riparian zone whatsoever
	27	43° 07' 44.3" N 78° 55' 54.3" W	295	15	5	8	2	silt/clay	4	2	4	7	8	9	1	1	4	4.2	poor		No buffer/riparian zone, transition from industrial to residential w/ mowed lawns right to stream bank edge
	28	43° 07' 41.8" N 78° 55' 53.7" W	235	9	2.5	6	1	silt/clay	7	5.5	8	7	7	4	1	1	8	6.7	fair		No fish cover, channelized stream w/o pools or meanders. Residential properties w/o buffers.
	29	43° 07' 39.2" N 78° 55' 55.3" W	140	20	5.5	8	0.75	silt/clay	6	3	7	6	8	9	2	2	7	5.6	poor		No fish cover, channelized stream w/o pools or meanders. Residential properties w/o buffers.
	30	43° 07' 37.8" N 78° 55' 55.8" W	285	15	4	10	1	silt/clay	6	4.5	4.5	7	7	4	1	1	2	6.1	fair		No fish cover, signs of poor bank stability, but minimal erosion at this point. Residential properties with minimal buffers. No shade over this section
Walmore Rd. to Lockport Rd.	31	43° 07' 37.0" N 78° 55' 51.5" W	300	23	6	14	1	silt/clay	8	5	5	8	8	6	2	1	3	5.1	poor	Residential, Agricultural	No fish cover, signs of poor bank stability, but minimal erosion at this point. Residential properties with minimal buffers. No shade over this section
	21	43° 07' 36.6" N 78° 55' 47.6" W	300	15	5	8	1	silt/clay	6	4	5	7	8	9	2	1	7	5.4	poor		residential properties with minimal buffer and no riparian zone, medium to minor erosion on R bank 1-2 feet above water, along entire reach. Channelized stream, no pools or fish cover
	33	43° 07' 37.0" N 78°55' 44.0" W	300	14	3	7	0.75	graded silts/cobbles	9	7.5	9	9	9	6	6	7	8	7.8	good		Good pools riffles, excellent bank stability, beautiful section of stream
	34	43° 07' 38.7" N 78° 55' 41.8" W	300	15	3	7	0.75	graded	9	7.5	9	9	9	6	6	7	8	7.8	good		
	35	43° 07' 35.2" N 78° 55' 33.6" W	275	18	3	7.5	0.75	graded silts/cobbles	7	9	8	8	9	9	6	2	10	7.5	good		No pool/riffle development
	36	43° 07' 34.2" N 78° 55' 32.8" W	300	16.5	4	4	0.25	graded silts/cobbles	7.5	8	7.5	8	9	9	6	5	8	7.5	good		Medium to heavy - 10 feet of erosion on R bank, 40 feet of erosion on L, both 1-2 feet high. Lack of pools/riffles
	37	43° 07' 32.9" N 78° 55' 39.2" W	257	15	3	8	1.25	silt/clay	6	7	8	5	9	10	3	2	7	6.3	fair		10 feet of major erosion on R bank, 40 feet of minor erosion on L, both 1-2 feet high
	38	43° 07' 30.2" N 78° 55' 32.9" W	300	17	3.5	10	0.75	graded silts/cobbles	8	8.5	5	4	10	10	2	7	9	7	good		30 ft of minor erosion on L bank
	39	43° 07' 28.8" N 78° 55' 33.5" W	300	21	4.5	10	2	graded	8	7.5	7	4	10	10	6	3	8	7	good		
	40	43° 07' 26.3" N 78° 55' 32.0" W	290	16	3	11	1	gravel/cobble 1+ in.	8	7	9	4	8	7	3	2	8	6.2	fair		Overall pretty good reach w/ come concerns about fish cover, lack of pools and poor water appearance due to tractor crossing.
	41	43° 07' 23.9" N 78° 55' 30.7" W	280	18	3	10	0.75	gravel/cobble 1+ in.	10	7	9	6	10	10	6	3	8	7.7	good		Good reach, lacks pools
	42	43° 07' 21.4" N 78° 55' 29.8" W	285	16	2	10	0.75	gravel/cobble 1+ in.	8	3	6	7	10	10	2	2	7	6.1	fair		Mass wasting 25-30ft long and 4-5 feet high on R bank at 90 deg bend. Lawn comes right to stream edge w/o buffer or any riparian zone. Lack of fish cover
	43	43° 07' 20.8" N 78° 55' 27.2" W	300	17	2.5	10	0.75	graded silts/cobbles	6	3	7	7	10	10	2	4	3	5.8	poor		Lawn comes right to stream edge w/o buffer or any riparian zone. Lack of fish cover
	44	43° 07' 19.1" N 78° 55' 24.5" W	320	20	6	9	1.5	graded silts/cobbles	7	4	8	8	10	4	2	9	5	6.3	fair		Lawn comes right to stream edge w/o buffer or any riparian zone. Lack of fish cover. Weedy blockage to fish movement

Rd. Intersection	Reach #	GPS Coordinates	Reach Length (ft)	Active (bankfull) Channel Width (ft)	Active (bankfull) Channel Depth (ft)	Low flow Channel Width (ft)	Low flow Channel Depth (ft)	Dominant Substrate	Channel Condition	Riparian Zone	Bank Stability	Water Appearance	Nutrient Enrichment	Barriers to fish movement	In stream Fish Cover	pools	canopy cover	Overall Score	Overall Rating	Land Use	Comments
Lockport Rd. to Walmore Rd	45	43° 07′ 16.5″ N 78° 55′ 22.6″ W	285	22.5	3.5	9	0.75	gravel/cobble 1+ in.	7	8	9	9	9	7	2	7	6	7.1	good	Residential, Agricultural, Commercial, Forest	good section
	46	43° 07′ 14.5″ N 78° 55′ 23.7″ W	325	18	2	16	0.75	gravel/cobble 1+ in.	8	9	10	8	10	9	4	6	8	8	very good		
	47	43° 07′ 10.7″ N 78° 55′ 24.3″ W	275	15-50+	4	20	3.5	graded silts/cobbles	8	9	10	8	8	9	4	8	7	7.9	very good		
	48	43° 07′ 09.2″ N 78° 55′ 27.3″ W	290	22	3.5	7.5	1.5	silt/clay	6	5	4	5	2	5	3	3	5	4	poor		Heavy rubble due to construction debris affecting bank stabilization and water appearance, heavy weeds and algae development blocking fish movement, channelized stream w/o pools.
	49	43° 07′ 06.1″ N 78° 55′ 32.4″ W	285	45	10	8	1.5	silt/clay	6	5	4	5	2	5	3	3	5	4	poor		Heavy rubble due to construction debris affecting bank stabilization and water appearance, heavy weeds and algae development blocking fish movement, channelized stream w/o pools. Riparian zone is an commercial dumping ground on R bank.
	50	43° 07′ 02.7″ N 78° 55′ 32.9″ W	305	30	3.5	13	1.5	silt/clay	6	5	4	5	2	5	3	3	5	4	poor		
	51	43° 07′ 00.0″ N 78° 55′ 34.3″ W	250	30	8	6	2	graded silts/cobbles	7	3	5	8	9	5	5	7	8	6.3	fair		Residential and commercial properties come right to stream bank on R side
	52	43° 06′ 57.3″ N 78° 55′ 33.9″ W	220	8	2.5	7	1.5	silt/clay	3	1.5	5	2	8	2	3	5	8	4.2	poor		Channelized stream. Water had an oily sheen. Minimal to no buffer from residential properties, banks were muddy and non-cohesive
Porter Road to Niagara Falls Boulevard	53	43° 06′ 02.7″ N 78° 57′ 26.6″ W	350	30	7	15	1	Silt/Clay	8	9	6.5	3	7	7	7	NA	NA	6.8	Fair	Forest/Residential	Water appears cloudy/murky, likely due to sediment, Previous channel straightening. Erosion and exposed roots along both banks. Good canopy cover. Bank stabilization recommended.
	54	43° 05′ 58.8″ N 78° 57′ 29.6″ W	500	25	5	19	2	Silt/Clay	2	9	3	2	7	9	6			5.4	Poor		
	55	43° 05′ 58.8″ N 78° 57′ 29.6″ W	400	24	7	15	2	Silt/Clay	7	9	6.5	2	6	9	3			6.1	Fair	Forest	Unknown substance causing film along the water surface
	56	43° 05′ 52.2″ N 78° 57′ 38.5″ W	300	28	8	15	1.5	Silt/Clay	3	4.5	5.5	3	7	4	7			4.9	Poor		Large pieces of concrete laying inside stream; former bank stabilization.
	57	43° 05′ 51.9″ N 78° 57′ 43.3″ W	500	26	6	19	3	Cobble	1	1	3	2	6	9	2			3.4	Poor	Forest/Residential	Cantilever found along section of left bank. Unknown substance causing film along the water surface.
	58	43° 05′ 52.1″ N 78° 57′ 49.1″ W	300	28	5	16	1	Cobble	2	5.5	4.5	3	7	5	7			4.9	Poor	Residential	Mass failure, and undercutting found along sections of left bank.
	59	43° 05′ 52.0″ N 78° 57′ 53.1″ W	400	20	4.4	15	1	Silt/Clay	3	5.5	8	2	7	10	6			5.9	Poor	Forest/Residential	Mowed grass on right bank, to the top of channel. Riprap along both banks.
	60	43° 05′ 50.8″ N 78° 57′ 59.2″ W	350	25	8	20	2	Gravel/Silt/Clay	5	4.5	4.5	5	8	8	8			6.1	Fair	Residential	Bank stabilization along right bank.
	61	43° 05′ 46.8″ N 78° 57′ 59.2″ W	200	18	8	15	2.5	Silt/Clay	4	4.5	4	5	8	7	6			5.5	Poor	Forest/Residential	Mowed grass, and houses directly along right bank. Previous stabilization along right bank. Erosion along right bank.
	62	43° 05′ 45.5″ N 78° 57′ 57.5″ W	500	16	9	11	3	Gravel/Silt/Clay	4	4.5	6	5	8	7	7			5.9	Poor		Previous bank stabilization. Residential land use along right bank
	63	43° 05′ 42.6″ N 78° 57′ 50.8″ W	304	13	8	8	3	Silt/Clay	2	7.5	4.5	5	8	8	7			6.0	Poor	Forest	Mass wasting along left bank. Evidence of previous bank stabilization.
	64	43° 05′ 40.1″ N 78° 57′ 53.0″ W	277	36	6	25	2	Silt/Clay	5	9	4	5	8	7	8			6.6	Fair		Mass wasting along right bank. Erosion and exposed roots along left bank
	65	43° 05′ 38.8″ N 78° 57′ 49.2″ W	500	24	5	18	1.5	Silt/Clay	5	8	7	5	8	9	5			6.7	Fair	Forest/Residential	Good Section
	66	43° 05′ 35.2″ N 78° 57′ 52.6″ W	428	22	6.3	17	2.5	Gravel/Silt/Clay	4	6.5	9	5	8	8	8			6.9	Fair		Previous channel alteration including a 90 degree turn. Riprap along right bank.
	67	43° 05′ 34.2″ N 78° 57′ 47.2″ W	294	18	6.5	14	2	Silt/Clay	5	5	7	5	8	8	7			6.4	Fair		Previous channel straightening. Little riprap along right bank.
	End Point	43° 05′ 31.7″ N 78° 57′ 45.1″ W																			

APPENDIX B – REACH PHOTO INDEX FOR CAYUGA CREEK

Reach #: 1 Reach Length: 220 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 2 Reach Length: 240 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 3 Reach Length: 380 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 4 Reach Length: 180 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 5 Reach Length: 280 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 6 Reach Length: 245 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 7 Reach Length: 210 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 8 Reach Length: 230 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 9 Reach Length: 210 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 10 Reach Length: 140 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 11 Reach Length: 110 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 12 Reach Length: 105 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 13 Reach Length: 140 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 14 Reach Length: 285 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 15 Reach Length: 200 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 16 Reach Length: 220 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 17 Reach Length: 275 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 18 Reach Length: 135 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 19 Reach Length: 350 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 20 Reach Length: 255 ft.

Road Intersection: Saunders Settlement Rd. to Walmore Rd.

Reach #: 21 Reach Length: 168 ft.

Road Intersection: Walmore to Cory Dr.

Reach #: 22 Reach Length: 134 ft.

Road Intersection: Walmore to Cory Dr.

Reach #: 23 Reach Length: 171 ft.

Road Intersection: Walmore to Cory Dr.

Reach #: 24 Reach Length: 310 ft.

Road Intersection: Walmore to Cory Dr.

Reach #: 25 Reach Length: 235 ft.

Road Intersection: Cory Dr. to Walmore

Reach #: 26 Reach Length: 213 ft.

Road Intersection: Cory Dr. to Walmore

Reach #: 27 Reach Length: 295 ft.

Road Intersection: Cory Dr. to Walmore

Reach #: 28 Reach Length: 235 ft.

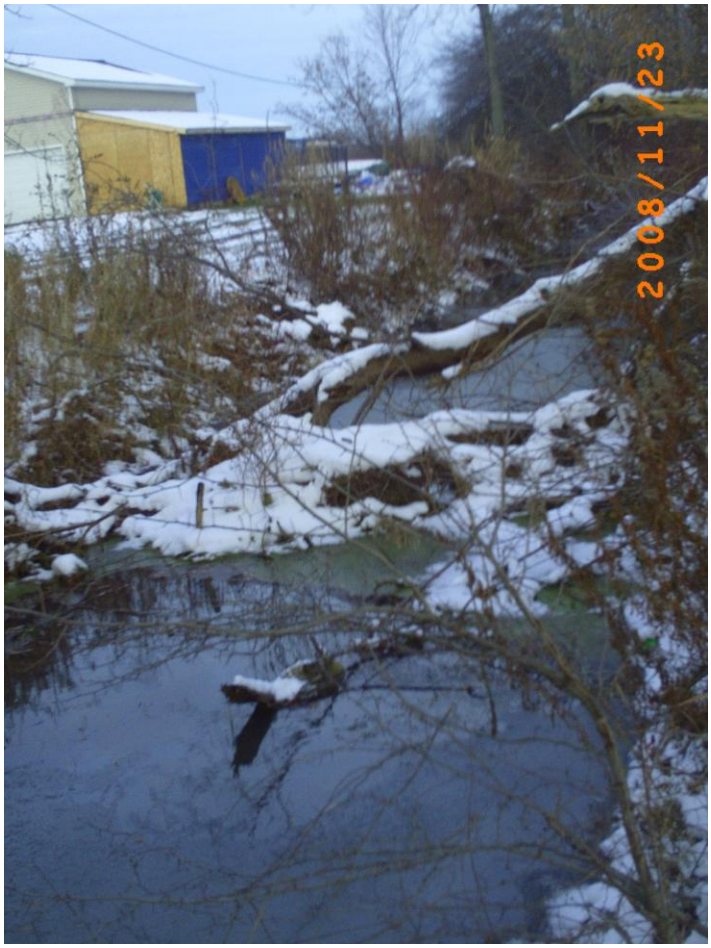
Road Intersection: Cory Dr. to Walmore

Reach #: 29 Reach Length: 140 ft.

Road Intersection: Cory Dr. to Walmore

Reach #: 30 Reach Length: 285 ft.

Road Intersection: Cory Dr. to Walmore

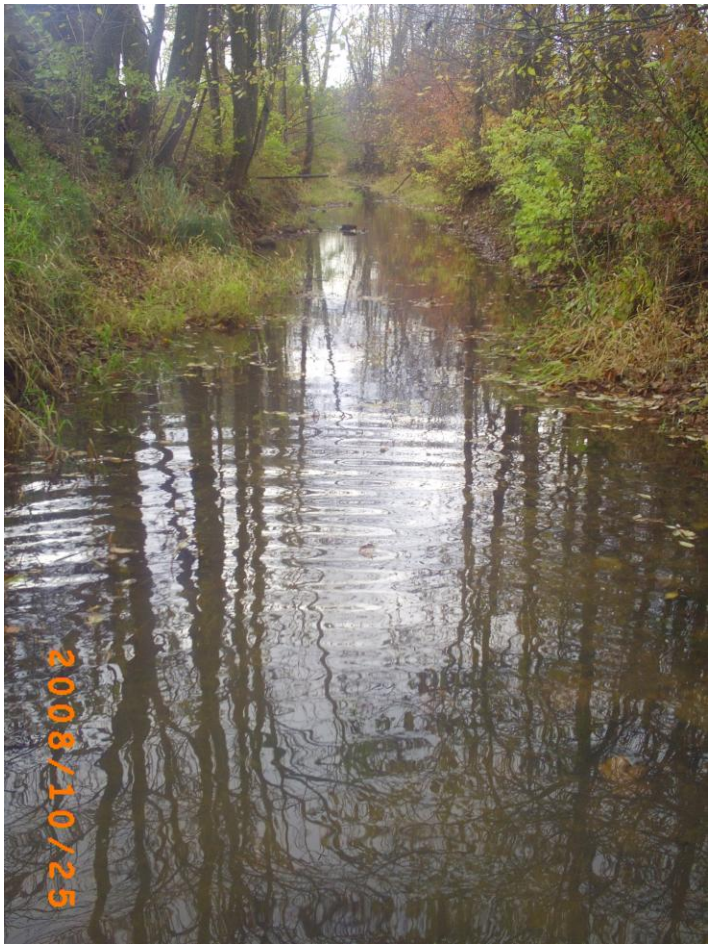


Reach #: 31 Reach Length: 300 ft.

Road Intersection: Walmore to Lockport Rd.

Reach #: 32 Reach Length: 300 ft.

Road Intersection: Walmore to Lockport Rd.



Reach #: 33 Reach Length: 300 ft.

Road Intersection: Walmore to Lockport Rd.

Reach #: 34 Reach Length: 300 ft.

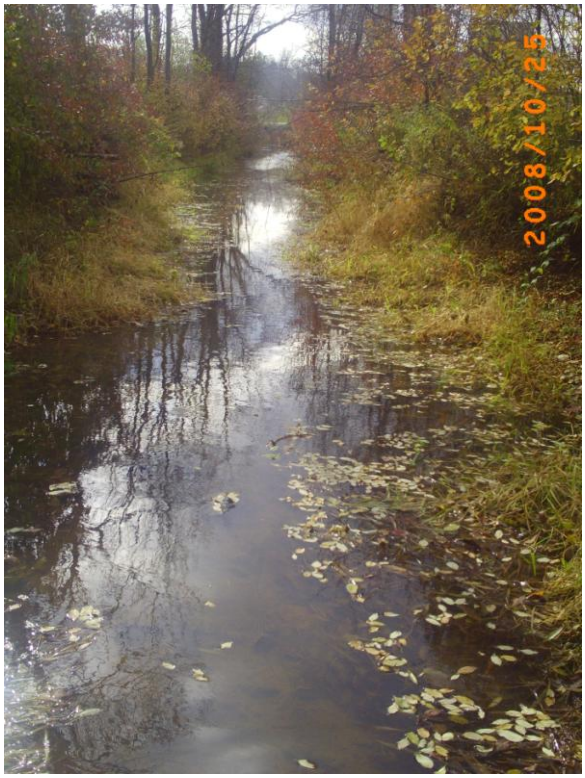
Road Intersection: Walmore to Lockport Rd.

Reach #: 35 Reach Length: 275 ft.

Road Intersection: Walmore to Lockport Rd.

Reach #: 36 Reach Length: 300 ft.

Road Intersection: Walmore to Lockport Rd.

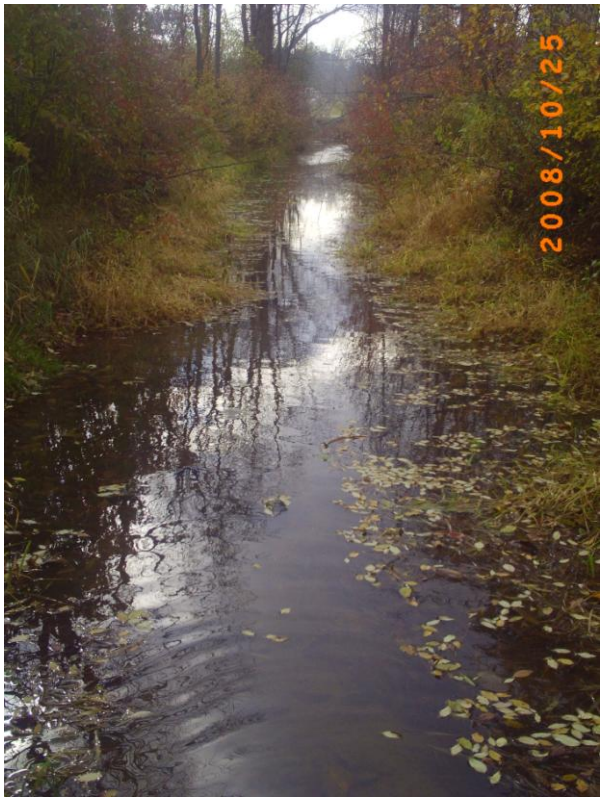


Reach #: 37 Reach Length: 257 ft.

Road Intersection: Walmore to Lockport Rd.

Reach #: 38 Reach Length: 300 ft.

Road Intersection: Walmore to Lockport Rd.



Reach #: 39 Reach Length: 300 ft.

Road Intersection: Walmore to Lockport Rd.

Reach #: 40 Reach Length: 290 ft.

Road Intersection: Walmore to Lockport Rd.

Reach #: 41 Reach Length: 280 ft.

Road Intersection: Walmore to Lockport Rd.

Reach #: 42 Reach Length: 285 ft.

Road Intersection: Walmore to Lockport Rd.

Reach #: 43 Reach Length: 300 ft.

Road Intersection: Walmore to Lockport Rd.

Reach #: 44 Reach Length: 320 ft.

Road Intersection: Walmore to Lockport Rd.

Reach #: 45 Reach Length: 285 ft.

Road Intersection: Lockport Rd. to Walmore Rd.

Reach #: 46 Reach Length: 325 ft.

Road Intersection: Lockport Rd. to Walmore Rd.

Reach #: 47 Reach Length: 275 ft.

Road Intersection: Lockport Rd. to Walmore Rd.

Reach #: 48 Reach Length: 290 ft.

Road Intersection: Lockport Rd. to Walmore Rd.

Reach #: 49 Reach Length: 285 ft.

Road Intersection: Lockport Rd. to Walmore Rd.

Reach #: 50 Reach Length: 250 ft.

Road Intersection: Lockport Rd. to Walmore Rd.

Reach #: 51 Reach Length: 250 ft.

Road Intersection: Lockport Rd. to Walmore Rd.

No Photo Available

Reach #: 52 Reach Length: 220 ft.

Road Intersection: Lockport Rd. to Walmore Rd.

Reach #: 53 Reach Length: 350 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 54 Reach Length: 500 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 55 Reach Length: 400 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 56 Reach Length: 300 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 57 Reach Length: 500 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 58 Reach Length: 300 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 59 Reach Length: 400 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 60 Reach Length: 350 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 61 Reach Length: 200 ft.

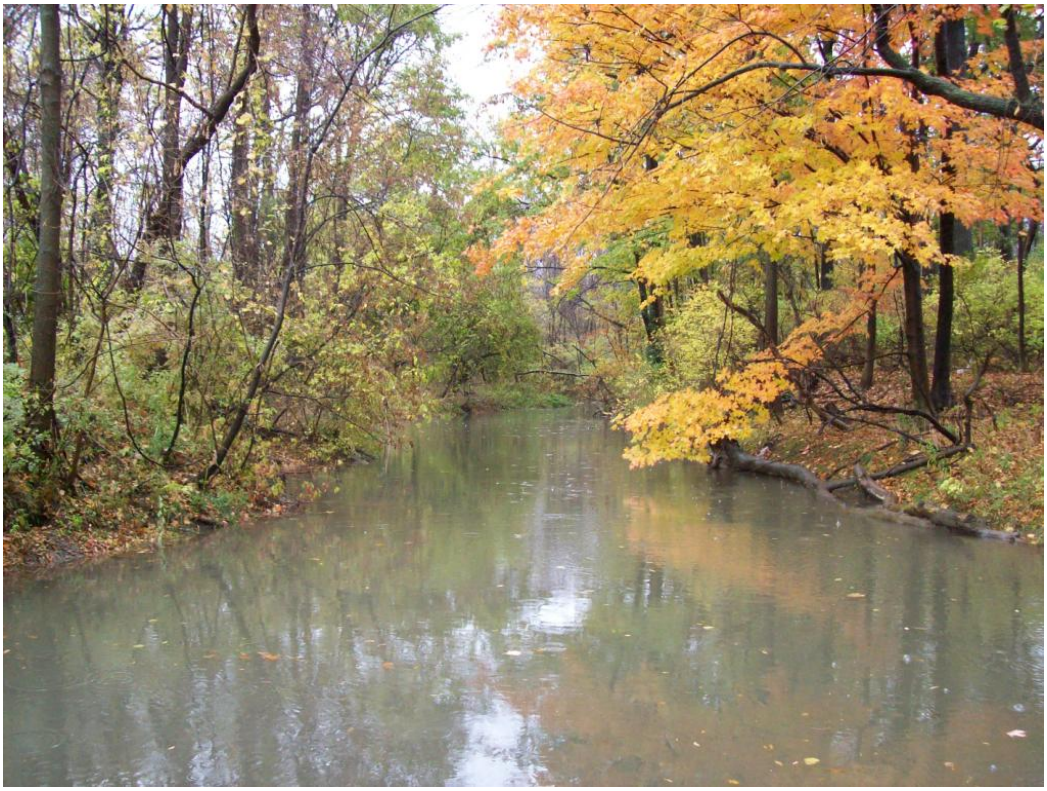
Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 62 Reach Length: 500 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 63 Reach Length: 304 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.



Reach #: 64 Reach Length: 277 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 65 Reach Length: 500 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 66 Reach Length: 428 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.

Reach #: 67 Reach Length: 294 ft.

Road Intersection: Porter Rd. to Niagara Falls Blvd.