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Conesus Lake 2008: Baseline Data on the Stream Bank Restoration Project, Update on Water Quality of USDA Monitored Watersheds

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Conesus Lake 2008

Baseline Data on the Stream Bank Restoration Project

Update on Water Quality of USDA Monitored Watersheds

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State University of New York

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Executive Summary

1. Pre-remediation or baseline data on suspended solids were collected during the summer of 2008 from several stream reaches of Densmore and North McMillan Creeks and Wilkins and North Gully. The intention is to use these baseline data to evaluate the effectiveness of the stream remediation project on stream bank erosion when completed.

2. The erosion data collected suggest that during the summer period of 2008, erosion was more evident (from highest to lowest) at Densmore Creek, North McMillan, Wilkins, and the least at North Gully.

3. The second aspect of the study was to continue monitoring the USDA streams (Graywood Gully, Cottonwood Gully, Long Point Gully, Sand Point Gully, Southwest Creek, North McMillan Creek, and Sutton Point Gully) to further develop the data base as a tool for evaluation of the health of these watersheds, to determine if management practices were maintained during the summer after the USDA project ended, and to determine if new land use practices that may be affecting water quality were underway. This unique data set provides a picture of the current status of the environmental health of these watersheds. It shows where management practices were introduced and how successful these efforts were.

4. The results of the continuation of the monitoring of the USDA watersheds indicate that where management practices were implemented, major decreases in losses of nutrients and soil from various watersheds were realized; that is, soil and nutrients were being maintained on these watersheds and not being lost to Conesus Lake. In general, these reductions observed from 2003 to 2007 were maintained into 2008 after the USDA project had ended. The exception, however, was Long Point Gully where major increases in phosphorus, soils, and organic nitrogen were observed in

the stream draining this watershed. New or changing farming practices and/or land usage are suggested in the Long Point watershed.

Recommendations

1. When the stream remediation project is completed, a follow-up study is recommended to determine the effectiveness of efforts to reduce stream bank erosion.

2. The follow-up monitoring of the USDA study creeks should be continued. The County has a unique data base that now extends over a 6-year period. Such a data base provides an opportunity to determine if water quality conditions are improving or deteriorating in seven of Conesus Lake's watersheds. These data provide an opportunity to critically evaluate land use practices in watersheds and could be used to provide direction to management practices in these watersheds as part of the Conesus Lake Watershed Plan.

3. If such monitoring were to continue, North Gully is suggested as an additional site as some USDA data also exists for this location.

Introduction

Conesus Lake is fed by 18 tributaries and a number of smaller streams and rivulets (Forest *et al.* 1978). The terrain in the watershed is characterized by gentle slopes at the northern outlet and southern inlet areas. Steep hilly slopes characterize the flanks and southern portion of the watershed. For example, from the middle third of the lake to the southern end of the watershed, the lake and valley are flanked by steep slopes exceeding 45 percent. The soils of the Conesus Lake watershed are mostly derived from locally-occurring shale and sandstone bedrock material that has been reworked by glacial action (Bloomfield 1978). Towards the north of the watershed, limestone materials transported by the glaciers from the central NY limestone belt influence the soil. This influence is less as one moves south, and in general, soils are more agriculturally productive to the north of the watershed compared with the south

(Stout 1970). The soils vary widely in other properties of significance to land use management and water quality impacts. Many of the soils are highly susceptible to erosion, presenting the risk of sediment or sediment-borne nonpoint source pollution. Other soils are poorly drained, which make them likely to be important surface runoff generation areas. They are also risk zones for generation of nonpoint source pollution. Overall, the soils of this watershed present a diverse and complicated mosaic of management imperatives – they prescribe land use decisions at the field scale.

Mitigation of soil and nutrient loss from agricultural land continues to be a concern within watersheds of the United States and indeed worldwide. There are a number of reasons for this concern. First, depletion of agricultural soil is counterproductive to good farming practices and crop productivity. And perhaps more importantly, overfertilization and concomitant nutrient loss to downstream aquatic ecosystems may produce undesirable effects including increased numbers of bacteria, algae, and macrophytes, increased siltation, and decreased aesthetics – in general, a deterioration in both surface (streams) and groundwater quality downstream resulting in cultural eutrophication of lakes and streams.

Research completed in 1990, 1999, and 2000 identified several Conesus Lake watersheds as being the primary sources of nutrient and soil loss. This research indicated that nonpoint losses (kg/ha/day) of soil, soluble phosphorus, nitrate and organic nitrogen (animal wastes) are considerably higher during hydrometeorologic events from sub-watersheds in agriculture compared to other land uses (Makarewicz *et al.* 1999, 2001). In general, erosion from various stream reaches contribute a large amount of sediment each year to Conesus Lake. The Conesus Lake watershed Management Plan (SOCL 2001) was published in 2003 and recommended that streams in the watershed be stabilized and/or restored. In August 2005 Stantec Consulting Services (2005) was contracted to evaluate stream erosion and to develop plans for the remediation of selected stream banks in the Conesus Lake watershed. This report indicated that most of the “12 stream reaches visited were in an unstable state due to the heavy sediment supplies of the past and the related geomorphic adjustment.” In

March 2008 the Livingston County Planning Department chose to do a preliminary study of several of the stream reaches to develop baseline data on suspended solids in high-priority impacted streams prior to the restoration project. These data would serve as a baseline to determine the effectiveness of the restoration projects contemplated in the future. Information on total suspended solids (sediment and soil) in stream water was collected from Wilkins Creek, Densmore Creek, North Gully, and North McMillan Creek (Fig. 1). In addition, water chemistry data were collected for almost seven years on many streams that were part of the USDA Study (Makarewicz 2009)(Fig. 2). This monitoring was continued through the summer to determine if the agricultural community was maintaining Best Management Practices implemented six years ago.

Methods

For both the stream remediation sites and the former USDA sites of Makarewicz (2009), samples were generally taken every Tuesday morning from 25 May to 28 August 2008 irregardless of stage height; that is, water samples were taken on a Tuesday during hydrometeorologic events or nonevents. Water samples were taken above and below six reaches of Wilkins Creek (Fig. 3; Upper Middle Reach, Upper Reach), Densmore Creek (Fig. 4; Lower Middle Reach, Upper Middle Reach), North Gully (Fig. 5; Middle Reach), and North McMillan Creek (Fig. 6; Lower Reach). Water samples were also taken at the former USDA monitoring sites at the base of the Graywood Gully, Long Point Gully, Sand Point Gully, Cottonwood Gully, Sutton Point Gully, and North McMillan Creek sub-watersheds.

Water samples were taken, preserved, and analyzed using approved standard methodologies (USEPA 1979, APHA 1999). Samples were analyzed for TP (APHA Method 4500-P-F), TKN (USEPA Method 351.2), NO_2+ NO_3 (APHA Method 4500-NO_3-F), and TSS (APHA Method 2540D). Except for TSS, all analyses were performed on a Technicon AutoAnalyser II. Method Detection limits were as follows: SRP (0.48 µg P/L), TP (0.38 µg P/L), NO_2+ NO_3 (0.005 mg N/L), TKN (0.15 µg N/L), and TSS (0.2 mg/L). Sample water for dissolved nutrient analysis (SRP, NO_2+ NO_3) was filtered immediately on site with 0.45-µm MCI Magna Nylon 66 membrane filters and held at 4°C until analysis the following day.

All water samples were analyzed at the Water Chemistry Laboratory at The College at Brockport, State University of New York (NELAC – EPA Lab Code # NY01449) within 24 h of collection. In general, this program includes biannual proficiency audits, annual inspections and documentation of all samples, reagents and equipment under good laboratory practices. All quality control (QC) measures are assessed and evaluated on an on-going basis. As required by NELAC and New York's ELAP certification process, method blanks, duplicate samples, laboratory control samples, and matrix spikes are performed at a frequency of one per batch of 20 or fewer samples. Field blanks (events and nonevents) are routinely collected and analyzed. Analytical data generated with QC samples that fall within prescribed acceptance limits indicate the test method was in control. For example, QC limits for laboratory control samples and matrix spikes are based on the historical mean recovery plus or minus three standard deviations. QC limits for duplicate samples are based on the historical mean relative percent difference plus or minus three standard deviations. Data generated with QC samples that fall outside QC limits indicate the test method was out of control. These data are considered suspect and the corresponding samples are reanalyzed. As part of the NELAC certification, the lab participates semi-annually in proficiency testing program (blind audits, Table 1) for each category of ELAP approval. If the lab fails the proficiency audit for an analyte, the lab director is required to identify the source and correct the problem to the certification agency.

Results and Discussion

Stream Reaches – Erosion Study

Total suspended solids are a measure of suspended particles in water. This indicator is a measure of soil and sediment being carried by the water at a given location. Although there are some things that may be learned from the data set generated, the main purpose of the data is to have "baseline" data prior to the implementation of the restoration and remediation at identified sites. After implementation, a similar study should determine the effectiveness of the soil erosion management practices. These data do suggest that during the summer period of 2008, erosion was more evident (from highest to lowest) at Densmore Creek, North McMillan, Wilkins, and the least at North Gully. Raw data are presented in the Appendix.

Wilkins Creek (Figure 7)

Upper Reach Concentrations of total suspend solids (TSS) were generally higher in the upstream portion of the reach than in the downstream portion of the reach. For example on 28 May 2008 in Fig. 7, the "Upper Reach" of Wilkins Creek, the TSS concentration at the upstream location was 6 mg/L while the TSS concentration a few hundred yards downstream was <1 mg/L. We interpret this as meaning that TSS (soil) were being sequestered or stored as sediment within this reach of the stream bed. Only on 14 July, when 0.43 inches of rain fell in the Conesus Lake watershed, the TSS value was higher at the lower end of this reach, indicating that sediment was being transported downstream due to erosion.

Middle Reach Similar to the "Upper Reach", TSS concentrations were generally higher at the upstream rather than at the downstream sampling site. On two dates, 11 and 23 June 2008, two days when rain fell (Appendix Table E), TSS concentrations were very high (>15 mg/L) at the upstream location of the "Middle Reach' compared to the downstream site (< 2 mg/L) of the "Upper Reach" of Wilkins Creek. This suggests that some erosion of stream banks occurred between the "Upper" and "Middle" reaches - that is, outside the boundaries defined here.

Densmore Creek (Figure 8)

Upper Middle Reach On four dates (17 June, 7 July ,14 July , 21 July),TSS concentrations were higher at the downstream location than at the upstream location. On these dates, soil/sediment was being lost from the upstream site and deposited downstream. These dates were associated with rainfall (17 June: 0.26"of rain, 23 June: 0.09", 14 July: 0.43", Table E) in the Conesus Lake watershed. On other dates, TSS concentrations were higher upstream than downstream, indicating that soil/sediment transported into the "Upper Middle Reach" was sequestered within the reach. These “legacy” sediments will likely be transported during the next large rain event downstream toward and into Conesus Lake.

Lower Middle Reach TSS concentrations ranged from 0.5 to 8 mg/L (average 1.9 mg/L for the downstream location) and were generally lower than at the “Upper Reach” (range <0.2 to 18 mg/L, average of 3.8 mg/L for the downstream location). On four occasions, TSS concentrations were higher at the downstream location than at the upstream site, indicating that soil/sediment was being lost from the watershed. These dates (17 June: 0.26” of rain, 23 June: 0.09”, 14 July: 0.43”, were associated with rainfall in the Conesus Lake watershed (Appendix, Table E).

North Gully (Figure 9)

Middle Reach Concentrations of TSS were generally higher in the upstream portion or nearly the same concentration than in the downstream portion of the reach. Average concentrations of the upstream and downstream were not significantly different ($p>0.05$, t-test). This result suggests that soil/sediment was not being transported from the upstream to the downstream location during the sampling times.

North McMillan Creek (Figure 10)

On 9 of the 14 sampling days, TSS concentrations were substantially higher at the downstream site. For example, on 2 June (0.34” of rain), 23 June (0.09” of rain) , 7 July (0.00”), 14 July (0.43”), 18 July (0.67”) and 8 August (0.40”), downstream TSS concentrations ranged as high as 1000% more than at the upstream location. At times, large amounts of material are being lost from the North McMillan watershed.

Stream Watershed Monitoring (USDA Watersheds)

Starting in September of 2002, the Conesus Lake Watershed Project monitored the chemistry of stream water in several creeks of the Conesus Lake watershed (Makarewicz *et al*. 2009). Six small, predominantly agricultural (>70%) watersheds (<325 ha) in the Conesus Lake catchment of New York State were selected to test the impact of Best Management Practices (BMPs) on mitigation of nonpoint nutrient sources and soil loss from farms to downstream aquatic systems. The streams were monitored for the nutrients total phosphorus, soluble reactive phosphorus, and nitrate. These are all measures that indicate how much “fertilizer” is in the water. Total Kjeldahl nitrogen provides an indication of the amount of organic matter, such as manure, that is present in the water. Total suspended solids provides a measure of the amount of erosion either from stream banks or from upland areas. Sodium is a measure of how much salt is in the water. Increases in these concentrations over a period of time would indicate that materials are being lost from the watersheds as a result of land use practices. Decreases in these concentrations would suggest improvements within a watershed; that is, materials are being kept within the watershed.

Over a 5-year period, intensive stream water monitoring and analysis of covariance provided estimates of marginal means of concentration and loading for each year weighted by covariate discharge (Makarewicz *et al.* 2009). In general, significant reductions in total phosphorus (TP), soluble reactive phosphorus (SRP), nitrate +nitrite (NO_3+NO_2), total Kjeldahl nitrogen (TKN) and total suspended solids (TSS) concentration and flux occurred by the second year and third year of implementation. At Graywood Gully for example, where Whole Farm Planning was practiced and a myriad of structural and cultural BMPs were introduced, we observed the greatest percent reduction (average = 55.8%, range 47% to 65%) and the largest number of significant reductions in analytes (4 out of 5). In general, both structural and cultural BMPs were observed to have profound effects on nutrient and soil loss. Where fields were left fallow or planted in a vegetative type crop (alfalfa), reductions, especially in NO_3, were observed. Where structural implementation occurred, reductions in total fractions were particularly evident. Where both were applied, major reductions in nutrients and soil occurred. Taking significant portions of the watersheds out of crop production or by removing dairy cows had a similar effect; nutrients and soil were maintained on the watershed, and significant reductions in nutrient and soil loads and concentrations to downstream systems were evident.

We have selected the summer portions (May through August) of the Makarewicz *et al*. (2009) data set from 2003 to 2007 (Table 2) for comparison to the summer 2008 data collected. Since Makarewicz *et al.* (2009) generally took samples on every Tuesday of the year, the 2008 data is directly comparable, as samples were generally taken on Tuesday during the summer of 2008. The Makarewicz *et al.* (2009) event data, which was taken based on rainfall amount and occurred on random dates, was not included in the data in Table 2. Also the data presented in Table 2 is not adjusted for discharge from each creek as Makarewicz *et al.* (2009) did in his analysis. Nevertheless, the data set developed in summer 2008 does provide a trend analysis over time of the status of each watershed. What follows is a watershed by watershed review.

Graywood Gully (Table 2, Fig. 2): The Maxwell Farm occurs in this watershed and a myriad of Best Management Practices were introduced here. In the Graywood Gully watershed where row crops and dairy farming were present, application of a full spectrum of management practices (fertilizer reduction, cover crops, contour strips, reduction in fall and winter manure spreading, various grass filters for runoff from bunker storage of silage and milk house wastes, cows and heifers fenced from the creek and pond) were implemented. Reductions in the limiting nutrient phosphorus (whether it be the dissolved fraction or the total fraction) decreased by over 50% since the implementation of BMPs. The loss of soil from the land has also decreased by ~ 50% and nitrate by 75%, while organic nitrogen as TKN decreased by 40%. Clearly, management practices have lead to a decrease in the amount of soil and nutrients being lost from the land and a reduction of such being delivered to Conesus Lake. After the USDA project had ended, this reduction observed from 2003 to 2007 was maintained into 2008 for nitrate, TKN and TSS, but there appeared to be a slight increased in TP and SRP in 2008.

Cottonwood Gully (Table 2, Fig. 2): In Cottonwood Gully where row crops predominate, BMPs were limited to two: construction of three water and sediment control basins (gully plugs) and strip cropping designed to retain soils. Previous to BMP introduction in this small watershed (98.8 ha), soil loss was high and conservatively estimated in the 1990s at 130 tons (metric) per year (Makarewicz *et al.* 2001). As in Graywood Gully, significant impacts from management practices were observed in the second year after introduction of BMPs. Unlike Graywood Gully, retention of soil and nutrients was recorded for only three of five analytes (TKN, TSS, and NO_3). With the exception of TSS (71% reduction), the magnitude of reduction was low relative to Graywood Gully [e.g., NO_3 concentration: 32% (Cottonwood) versus 58% (Graywood)]. This trend was maintained into 2008 after the USDA project had ended.

Long Point Gully (Table 2, Fig. 2): Dairy cattle were removed from the Long Point Gully watershed in 2003, and a 37% reduction (76.7 ha) in crop acreage occurred by 2004. Here major reductions in NO_3 (42%), TP (36%), and SRP (53%) concentrations were observed by 2007, 3 years after removal of cropland from production (Table 2). As expected, removing land from crop production reduced nonpoint nutrient sources and led to major reductions of nutrients from the watershed. Somewhat surprisingly, concentrations of all parameters, except nitrate, increased dramatically in the summer of 2008. For example, SRP values had been steadily falling from ~40 µg/L in 2003 to ~15 µg/l in 2007. In 2008, SRP concentrations jumped back to 44.8 µg/L, exceeding concentrations observed in 2003. Some type of new land use activities occurred in this watershed during the summer of 2008.

Sutton Point Gully (Table 2, Fig. 2): Significant reductions in NO_3 (39%), TSS (72%), and TKN (33%) occurred at Sutton Point (Table 2) within 1, 3, and 4 years, respectively, after 2003. No physical infrastructure improvements were implemented in this watershed until 2007 when gully plugs were added. However, a significant and increasing portion of the watershed has been placed in alfalfa/grass production since 2003 (37% in 2005 to 60.3 % in 2007). As in Cottonwood Gully, the conversion of portions of this watershed to a long-term vegetative type crop (alfalfa-grass hay), a cultural BMP, would indicate that no nitrogen fertilizer was added to these fields (N. Herendeen, Personal Communication, Cornell Cooperative Extension). Also during this period, manure slurry was not added to fields (P. Kanouse, Personal Communication, Livingston County Soil and Water Conservation District). Both practices, reduction in manure spreading and the establishment of increasing acreage of a vegetative crop, likely led to the observed decrease in NO_3 and TKN to the downstream system. As with the other watershed where management practices were implemented, these reductions were maintained into 2008 after the USDA project had ended.

Sand Point Gully (Table 2): At Sand Point Gully rotational grazing pens and water troughs were installed, and cattle were fenced out of the creek starting in May of 2003. Two gully plugs and tiles were also installed in a small portion of the watershed in November 2002 prior to the beginning of this project. We did not expect a large impact of management practices here, especially since the major management area, rotational grazing and the “gully plugs”, accounted for less than 9.5% of the entire watershed. Also, manure-spreading operations continued in large portions of the watershed throughout the study (P. Kanouse, Personal Communication, Livingston County Soil and Water Conservation District), which theoretically could cause elevated levels of NO_3 and TP. Despite these expectations, a significant 44% reduction in NO_3 concentration was observed (Table 2) by 2004 with no further significant changes over the study period, except for 2008. A reduction in other analytes, with the exception of sodium was not observed. Discussion on why the decrease in nitrate may have occurred may be found in Makarewicz *et al*. (2009).

Southwest Gully (Table 2, Fig. 2): This creek was not reported on by Makarewicz *et al.* (2009). Inspection of Table 2 suggests that major reductions in nitrate, TSS, and TKN occurred over the 6-year period. This may be related to the construction of a manure pit within this watershed by the USDA project.

North McMillan Creek (Table 2, Fig. 2): This watershed was the reference watershed for the USDA Study. No BMPs were introduced here. No significant changes were observed in stream concentrations for any of the parameters.

In summary, where management practices were implemented, major decreases in losses of nutrients and soil from various watersheds were realized; that is, soil and nutrients were being maintained on these watersheds and not being lost to Conesus Lake. In general, these reductions observed from 2003 to 2007 were maintained into 2008 after the USDA project had ended. The exception was Long Point Gully where major increases in phosphorus (SRP and TP), soils (TSS), and organic nitrogen (TKN) were observed. New or changing farming practices and use are suggested in the Long Point watershed.

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Table 1. Proficiency audit of the Water Quality Laboratory at The College at Brockport.

NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

Lab 11439

SUNY BROCKPORT
WATER LAB LENNON HALL
BROCKPORT, NY 14420
USA

EPA Lab ID NY01449

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Shipment: 315 Non Potable Water Chemistry
Shipment Date: 14-Jul-2008

Analyte	Sample ID	Result	Mean/Target	Acceptance Limits	Method	Score
Approval Category : **Non Potable Water**						
Sample: **Residue**						
Solids, Total Suspended 208 passed out of 213 reported results.	1502	58.8	59.9	47.5 – 67.8	SM18-20 2540D (97)	Satisfactory
Sample: **Organic Nutrients**						
Kjeldahl Nitrogen, Total 86 passed out of 87 reported results.	1504	18.5	16.8	11.1 – 21.7	EPA 351.2 Rev. 2.0	Satisfactory
Phosphorus, Total 100 passed out of 108 reported results.	1504	4.06	3.99	3.26 – 4.78	SM18-20 4500-PF	Satisfactory
Sample: **Inorganic Nutrients**						
Nitrate (as N) 110 passed out of 115 reported results.	1507	2.32	2.37	1.87 – 2.88	SM18-20 4500-NO3 F (00)	Satisfactory
Orthophosphate (as P) 98 passed out of 101 reported results.	1507	3.78	3.95	3.25 – 4.68	SM18-20 4500-PF	Satisfactory
Sample: **Minerals II**						
Sodium, Total 79 passed out of 83 reported results.	1537	48.77	47.6	40.4 – 54.7	SM 18-20 3111B (99)	Satisfactory
Sample: **Nitrite**						
Nitrite as N 106 passed out of 110 reported results.	1541	0.95	0.926	0.742 – 1.11	SM 18-20 4500-NO2 B	Satisfactory

Table 2. Average summer concentration (May through September only) of stream water draining the Graywood, Sand Point, Long Point, Sutton Point, Southwest and North McMillan Creek watersheds of Conesus Lake. Data from 2003 to 2007 are derived from the annual data of Makarewicz *et al*. 2009. See text for further explanation.

		TP (µg P/L)		Nitrate (mg N/L)		TSS (mg/L)		TKN (µg N/L)		Sodium (mg/L)		SRP (µg P/L)	
	Year	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean
Graywood	2003	247.9	71.5	8.09	1.21	8.8	1.4	539	42	65.53	5.15	116.6	15.4
	2004	241.9	25.2	8.14	1.20	14.8	2.7	558	35	52.58	2.12	120.8	13.1
	2005	163.3	10.6	3.63	.40	9.1	2.4	555	54	59.04	4.67	104.7	8.9
	2006	173.8	19.7	1.87	.19	7.1	1.5	384	52	70.72	4.82	105.5	13.5
	2007	96.3	21.1	2.22	.31	5.3	1.2	376	77	99.58	10.98	59.2	13.3
	2008	123.8	19.9	1.21	.31	5.4	1.0	303	44	102.03	5.26	99.1	16.2
Sand Point	2003	59.6	4.2	2.00	.50	5.5	1.3	569	75	44.01	3.38	39.2	5.0
	2004	111.4	44.4	.97	.13	46.8	41.1	719	217	23.74	1.72	37.0	9.1
	2005	75.5	8.7	1.65	.36	5.0	1.6	466	76	19.48	.95	50.3	6.8
	2006	86.8	13.5	1.17	.14	3.8	.6	539	104	16.95	.87	43.5	4.5
	2007	70.4	8.4	1.57	.66	2.5	.3	477	59	17.75	1.13	48.5	8.0
	2008	79.6	3.6	0.66	.04	4.5	1.1	505	40	21.48	1.83	54.3	4.0
Long Point	2003	102.3	22.6	4.99	.97	10.6	4.4	775	116	58.65	2.16	39.7	7.1
	2004	219.4	129.3	4.41	1.11	132.6	124.0	832	199	33.04	2.89	40.4	7.7
	2005	69.8	17.8	2.58	.58	8.7	4.2	568	54	31.04	1.09	34.4	8.5
	2006	60.7	14.9	2.23	.55	8.1	3.8	552	95	40.61	2.08	29.5	7.7
	2007	41.0	15.3	2.40	.96	3.4	.7	515	90	36.20	3.91	14.8	8.3
	2008	75.7	15.5	1.97	0.31	16.5	13.1	771	265	57.75	3.75	44.8	7.9
Sutton Point	2003	45.5	4.7	1.93	.36	11.6	3.2	415	50	24.51	1.30	28.4	2.6
	2004	216.6	160.6	1.15	.10	13.7	7.3	413	56	18.09	1.37	26.5	3.7
	2005	46.6	5.0	1.28	.26	4.2	.7	318	38	15.87	.62	30.9	3.9
	2006	48.6	2.9	.98	.09	2.8	.9	352	86	21.14	1.18	28.9	2.9
	2007	38.0	3.2	1.57	.21	1.0	.1	305	83	19.40	1.21	25.0	4.1
	2008	46.6	2.1	1.32	.28	3.7	1.1	221	36	18.51	1.65	31.2	3.0

Table 2 Continued .

		TP (µg P/L)		Nitrate (mg N/L)		TSS (mg/L)		TKN (µg N/L)		Sodium (mg/L)		SRP (µg P/L)	
	Year	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean
Cottonwood	2003	68.0	6.0	2.83	.48	3.6	1.1	468	65	37.97	3.26	51.1	5.7
	2004	143.2	66.0	2.35	.60	69.4	58.3	568	86	18.16	1.01	53.0	6.6
	2005	97.3	23.3	2.30	.44	10.5	4.5	424	38	17.48	.50	57.5	6.0
	2006	68.8	6.4	1.64	.17	1.0	.3	393	37	21.46	.75	43.4	3.9
	2007	63.8	3.5	1.48	.13	2.5	.8	433	76	19.27	.33	45.8	3.7
	2008	84.7	9.9	1.12	.13	2.6	.8	381	46	25.02	2.34	57.7	3.9
Southwest	2003	83.2	5.0	3.54	.74	5.7	1.5	1054	527	37.01	1.26	63.1	7.2
	2004	179.1	47.9	1.63	.24	46.2	34.6	796	204	30.01	1.52	78.1	10.2
	2005	124.2	7.7	1.28	.39	10.8	3.5	486	61	32.28	1.02	69.1	7.7
	2006	97.9	6.4	1.03	.17	4.6	1.7	456	63	44.95	1.85	61.8	4.9
	2007	116.1	10.3	1.09	.11	7.1	3.6	469	100	35.02	.56	76.4	5.0
	2008	100.4	3.6	1.17	.14	3.0	0.8	297	33	45.50	2.67	69.5	5.3
North McMillan	2003	10.9	2.3	.26	.05	2.7	1.3	265	41	35.05	1.77	4.4	.6
	2004	39.6	26.6	.14	.02	33.3	30.0	365	85	28.36	2.02	5.1	1.4
	2005	11.4	2.0	.24	.03	3.5	.8	276	39	30.04	.99	4.8	.6
	2006	10.5	1.5	.13	.03	1.7	.5	229	30	36.63	.65	3.7	.9
	2007	7.6	.9	.14	.02	2.0	.5	246	64	36.63	1.04	2.5	.3
	2008	13.8	7.0	.11	.02	2.3	.4	220	34	50.72	1.17	2.9	.5

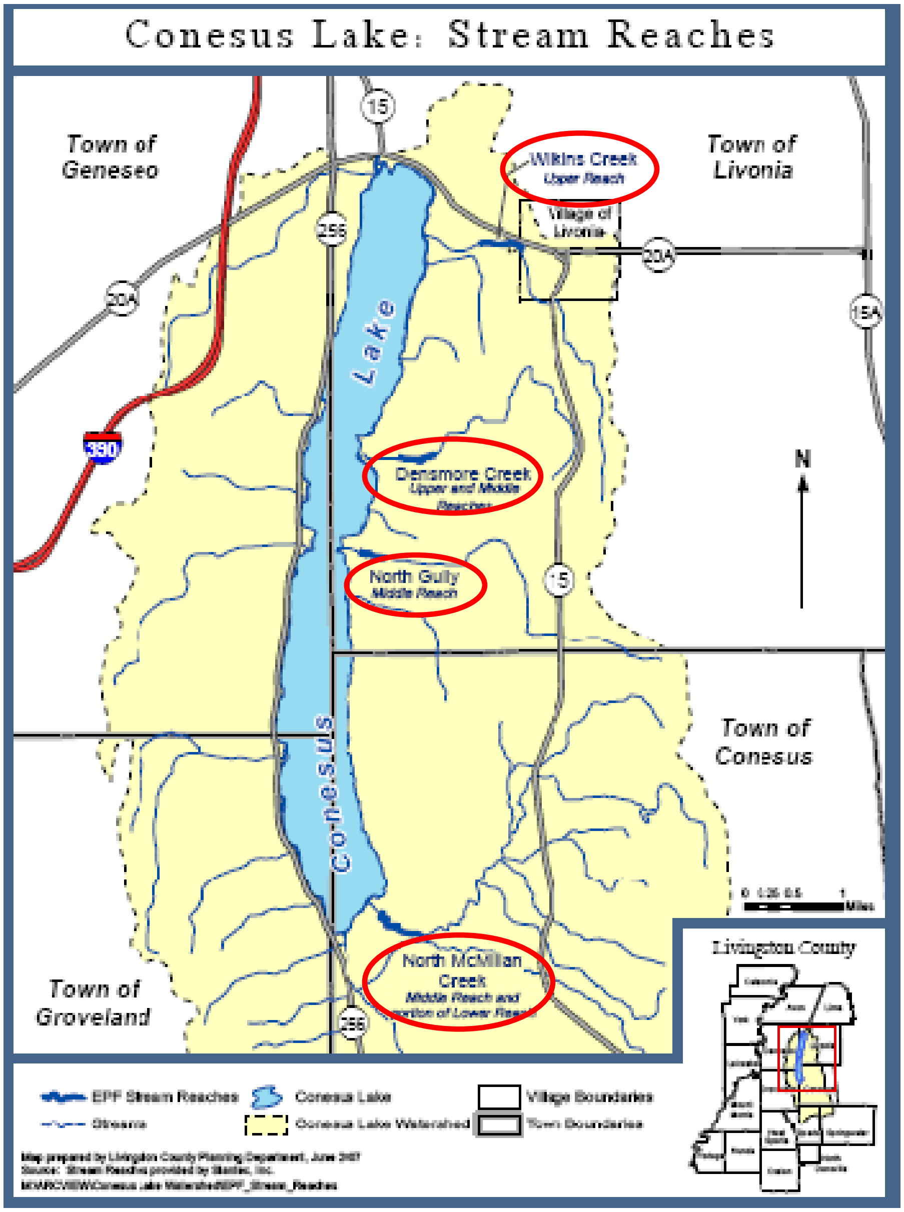

Figure 1. Location of stream remediation sites at Wilkins Creek, Densmore Creek, North Gully, and North McMillan Creek. Also shown are streams monitored during the summer of 2008 as a continuation of the USDA project (Makarewicz 2009).

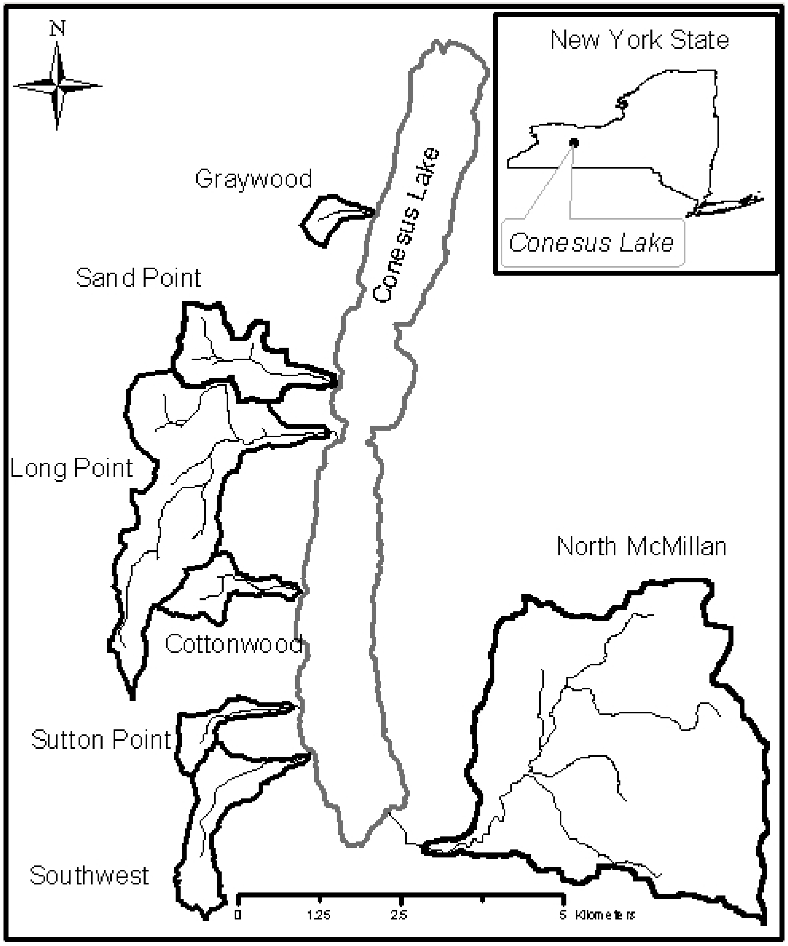

Figure 2. USDA sampling sites of Makarewicz (2009) sampled during the summer of 2008.

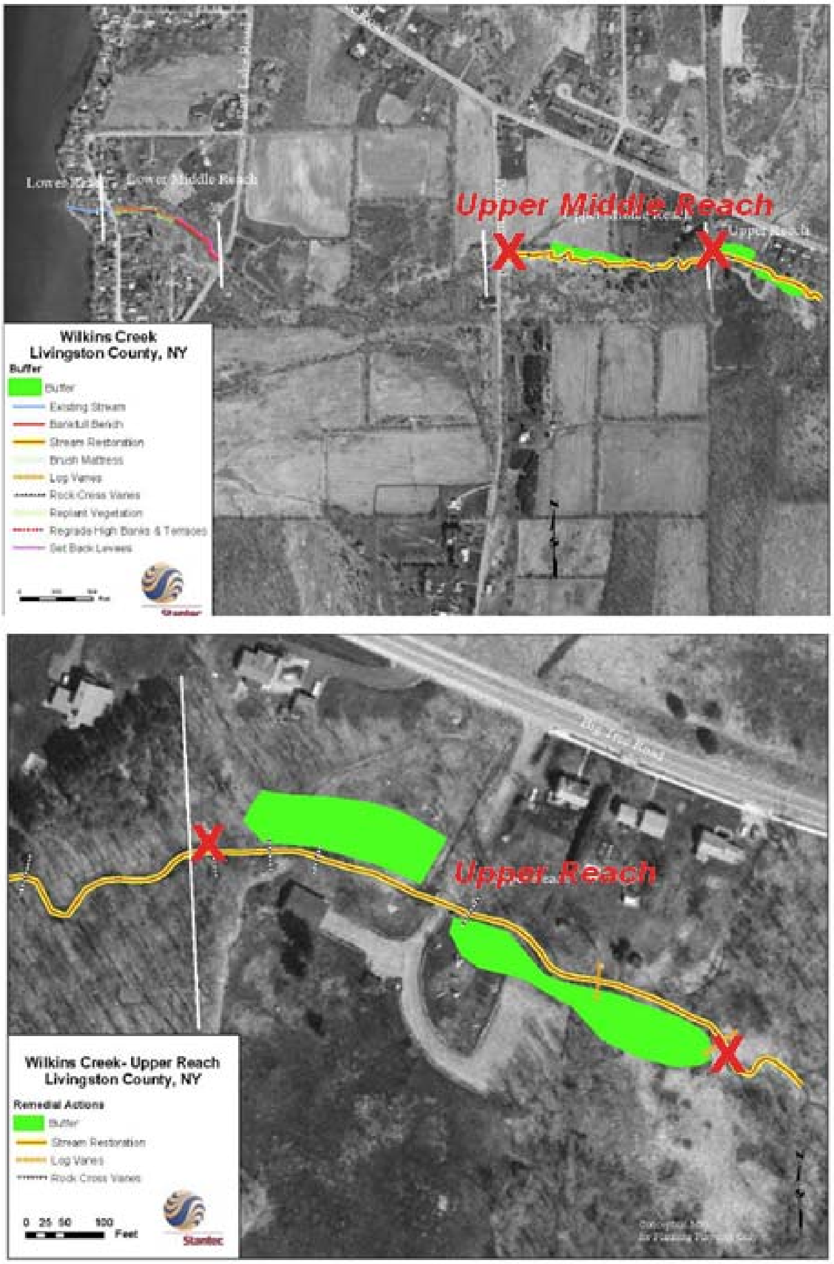

Figure 3. Sampling sites at Wilkins Creek. The “X’ denotes the actual sampling sites.

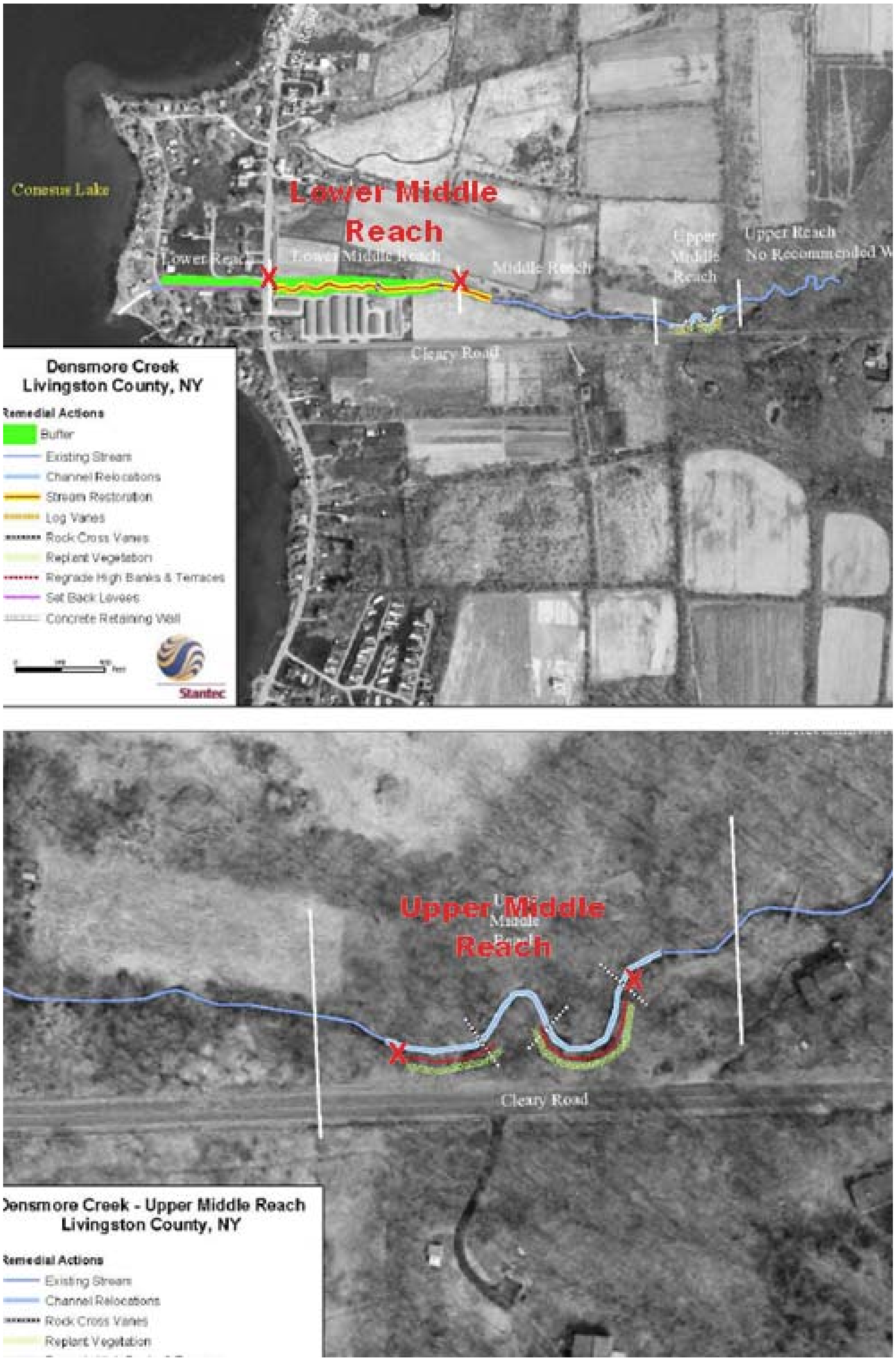

Figure 4. Sampling sites at Densmore Creek. The “X’ denotes the actual sampling sites.

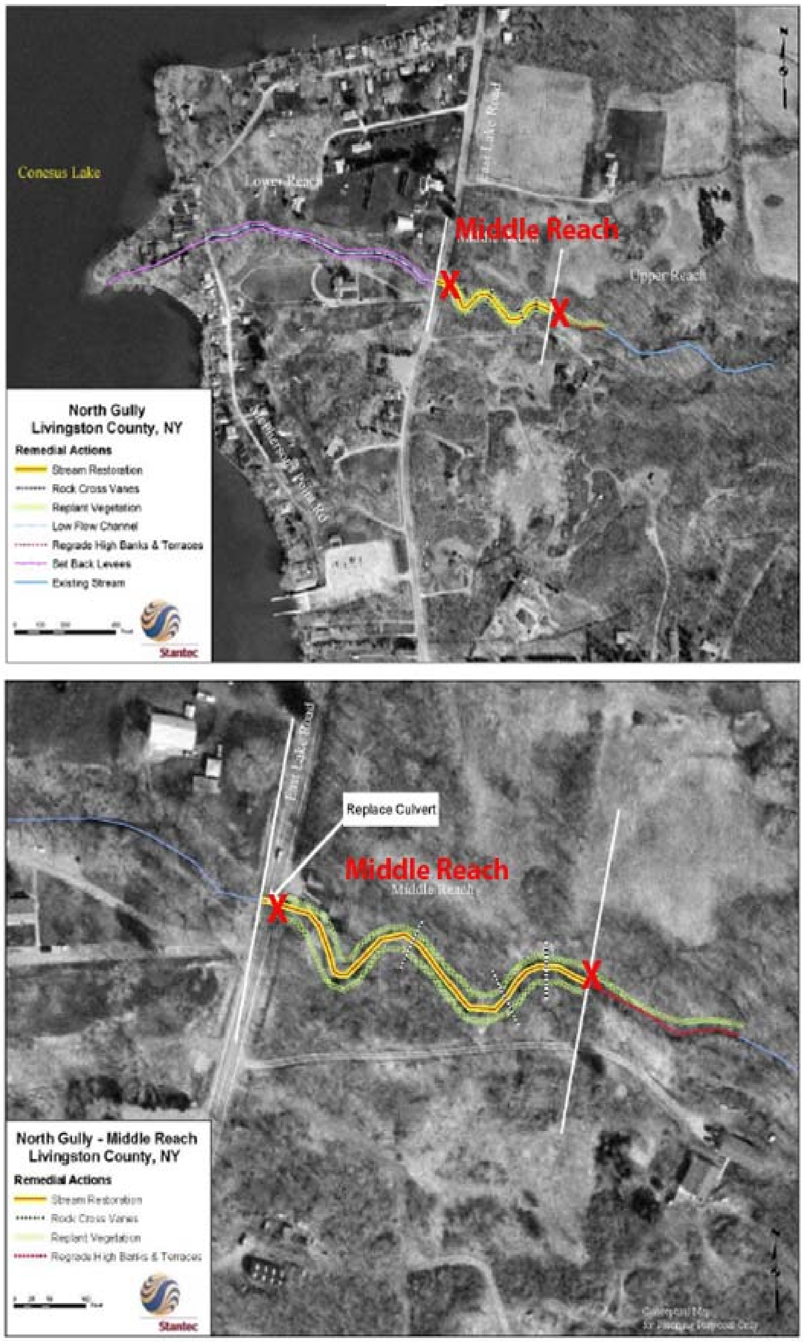

Figure 5. Sampling sites at North Gully. The “X’ denotes the actual sampling sites.

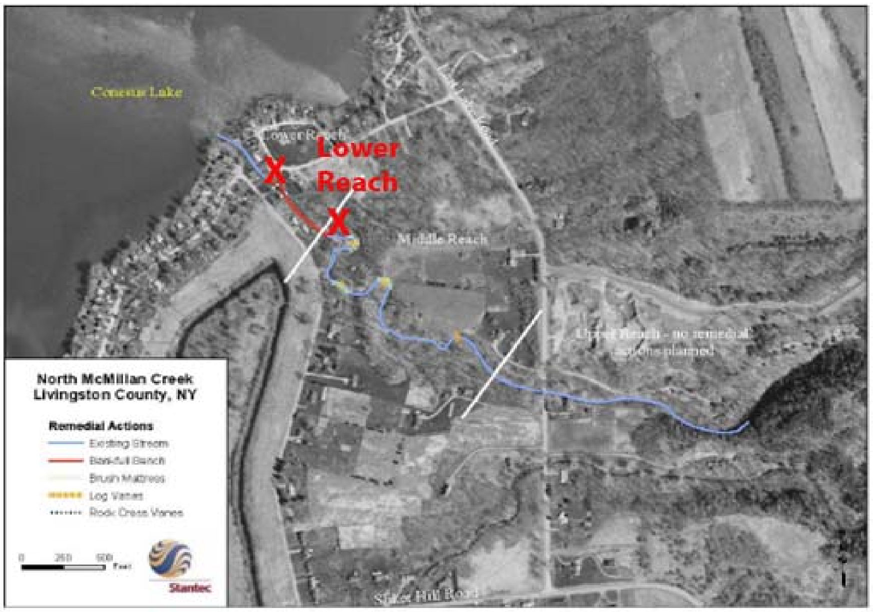

Figure 6. Sampling sites at North McMillan Creek. The “X’ denotes the actual sampling sites

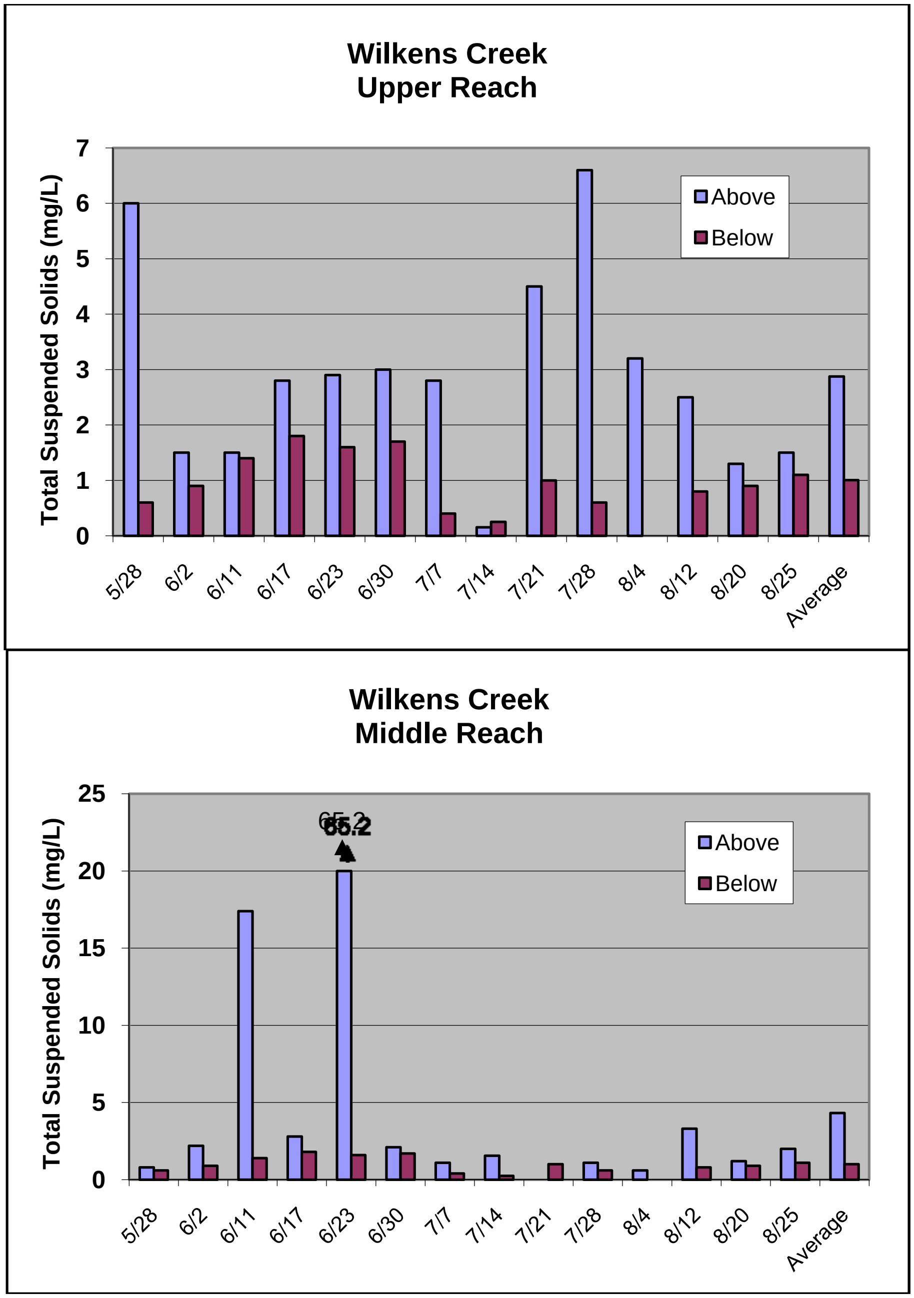

Figure 7. Total suspended solid concentrations above and below the “Upper and Middle Reach” of Wilkins Creek (See Fig. 1 for site location), 2008.

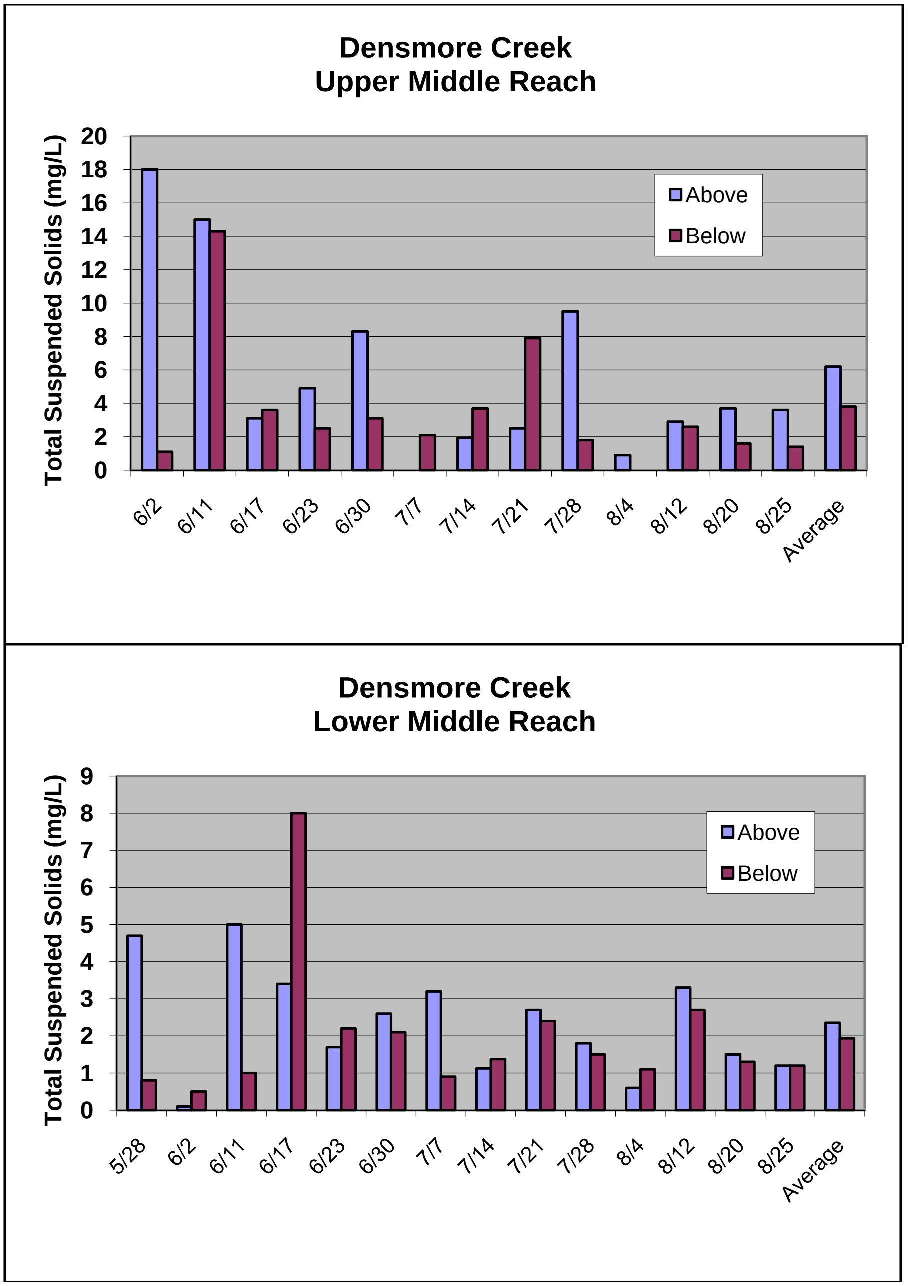

Figure 8. Total suspended solid concentrations above and below the “Middle Reach” and “Lower Reach” of Densmore Creek (See Fig. 1 for site location), 2008.

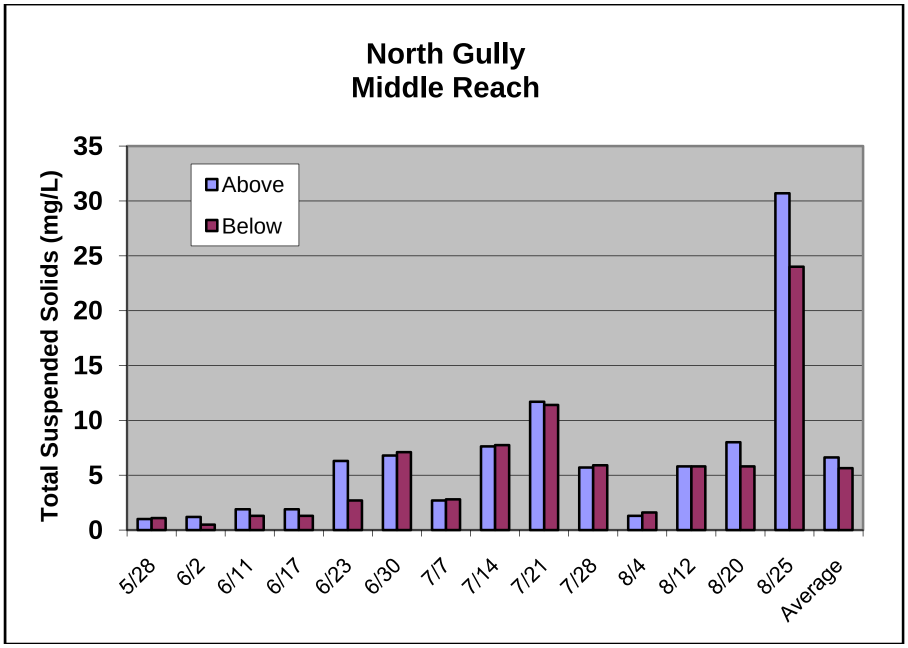

Figure 9. Total suspended solid concentrations above and below the “Middle Reach” of North Gully (See Fig. 1 for site location), 2008.

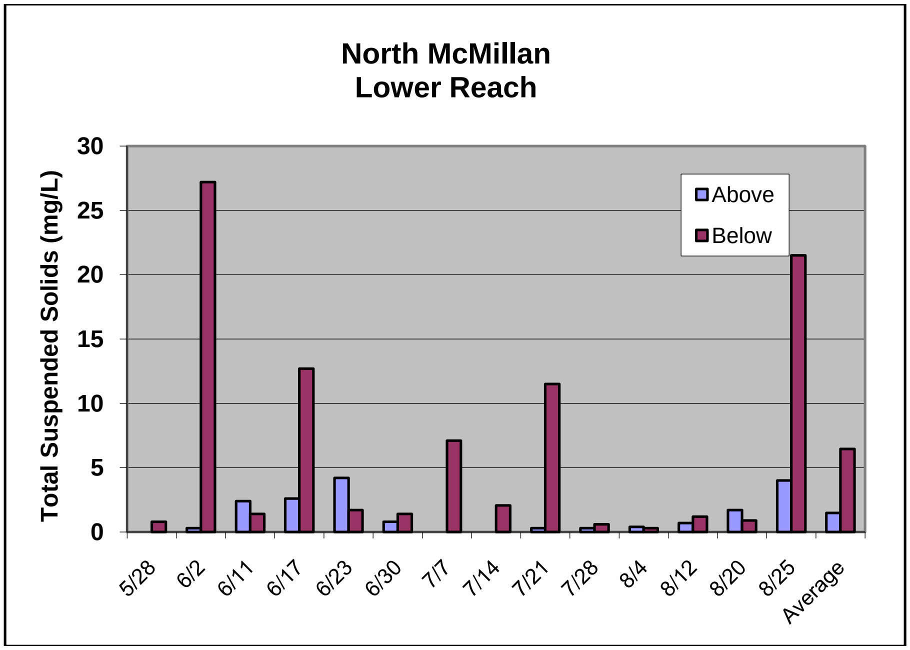

Figure 10. Total suspended solid concentrations above and below the “Lower Reach” of North McMillan Creek (See Fig. 1 for site location), 2008.

Appendix A

Table A. Total suspended solids (mg/L) in stream water from Wilkins Creek. See Figures 1 and 3 for location.

	Upper Reach		Middle Reach	
	Upper	Lower	Upper	Lower
5/28/2008	6.0	0.6	0.8	0.6
6/2	1.5	0.9	2.2	0.9
6/11	1.5	1.4	17.4	1.4
6/17	2.8	1.8	2.8	1.8
6/23	2.9	1.6	20.0	1.6
6/30	3.0	1.7	2.1	1.7
7/7	2.8	0.4	1.1	0.4
7/14	0.2	0.3	1.5	0.3
7/21	4.5	1.0	Bottle Broke	1.0
7/28	6.6	0.6	1.1	0.6
8/4	3.2	ND	0.6	ND
8/12	2.5	0.8	3.3	0.8
8/20	1.3	0.9	1.2	0.9
8/25	1.5	1.1	2.0	1.1
Average	2.9	1.0	4.3	1.0

Table B. Total suspended solids (mg/L) in stream water from Densmore Creek. See Figures 1 and 4 for location. NS=No sample. Dry= no water in the stream. ND=Non-detectable.

	Upper Middle Reach		Lower Middle Reach	
	Upper	Lower	Upper	Lower
5/28/2008	NS	NS	4.7	0.8
6/2	18.0	1.1	<0.1	0.5
6/11	15.0	14.3	5.0	1.0
6/17	3.1	3.6	3.4	8.0
6/23	4.9	2.5	1.7	2.2
6/30	8.3	3.1	2.6	2.1
7/7	Dry	2.1	3.2	0.9
7/14	1.9	3.7	1.1	1.4
7/21	2.5	7.9	2.7	2.4
7/28	9.5	1.8	1.8	1.5
8/4	0.9	ND	0.6	1.1
8/12	2.9	2.6	3.3	2.7
8/20	3.7	1.6	1.5	1.3
8/25	3.6	1.4	1.2	1.2
Average	6.2	3.8	2.4	1.9

Table C. Total suspended solids (mg/L) in stream water from North Gully. See Figures 1 and 5 for location.

	Upper	Lower
5/28	1.0	1.1
6/2	1.2	0.5
6/11	1.9	1.3
6/17	1.9	1.3
6/23	6.3	2.7
6/30	6.8	7.1
7/7	2.7	2.8
7/14	7.6	7.8
7/21	11.7	11.4
7/28	5.7	5.9
8/4	1.3	1.6
8/12	5.8	5.8
8/20	8.0	5.8
8/25	30.7	24.0
Average	6.6	5.6

Table D. Total suspended solids (mg/L) in stream water from North McMillan Creek. See Figures 1 and 6 for location. NS=No sample. Dry= no water in the stream. ND=Non-detectable.

	Upper	Lower
5/28	ND	0.8
6/2	0.3	27.2
6/11	2.4	1.4
6/17	2.6	12.7
6/23	4.2	1.7
6/30	0.8	1.4
7/7	ND	7.1
7/14	ND	2.1
7/21	0.3	11.5
7/28	0.3	0.6
8/4	0.4	0.3
8/12	0.7	1.2
8/20	1.7	0.9
8/25	4.0	21.5
Average	1.5	6.5

Table E. Rainfall data from Conesus Lake (collected J. Meeken). Precipitation data from Rochester, NY (National Weather Service). Values are in inches. Precip= All precipitation including snowfall.

May			June			July			August		
	Rainfall	Precip		0.00	Precip		Rainfall	Precip		Rainfall	Precip
5/1/2008	none	0.01	6/1/2008	0.34	0.00	7/1/2008	0.06	0.00	8/1/2008	none	0.00
5/2/2008	0.04	0.13	6/2/2008		0.00	7/2/2008	none	0.00	8/2/2008	0.27	0.34
5/3/2008	0.05	0.42	6/3/2008	0.00	0.19	7/3/2008	none	0.27	8/3/2008	0.03	T
5/4/2008	0.41	0.03	6/4/2008	1.07	T	7/4/2008	0.45	0.00	8/4/2008	none	0.00
5/5/2008	none	T	6/5/2008	0.00	0.12	7/5/2008	none	0.00	8/5/2008	none	1.07
5/6/2008	none	T	6/6/2008	0.00	0.01	7/6/2008	none	0.00	8/6/2008	0.57	0.00
5/7/2008	none	0.26	6/7/2008	0.40	0.00	7/7/2008	none	0.00	8/7/2008	none	0.00
5/8/2008	0.09	0.00	6/8/2008	0.46	T	7/8/2008	0.03	0.00	8/8/2008	ND	0.40
5/9/2008	0.02	0.00	6/9/2008	0.33	0.00	7/9/2008	none	0.06	8/9/2008	ND	0.46
5/10/2008	trace	0.00	6/10/2008	T	0.24	7/10/2008	none	0.00	8/10/2008	ND	0.33
5/11/2008	none	0.13	6/11/2008	0.00	0.00	7/11/2008	trace	0.05	8/11/2008	ND	T
5/12/2008	none	0.02	6/12/2008	T	0.00	7/12/2008	0.37	T	8/12/2008	ND	0.00
5/13/2008	none	0.00	6/13/2008	0.01	0.22	7/13/2008	0.06	0.23	8/13/2008	ND	T
5/14/2008	none	0.19	6/14/2008	T	0.15	7/14/2008	0.43	T	8/14/2008	ND	0.01
5/15/2008	0.03	0.01	6/15/2008	0.00	0.16	7/15/2008	none	0.00	8/15/2008	ND	T
5/16/2008	0.01	0.00	6/16/2008	0.00	0.43	7/16/2008	none	0.16	8/16/2008	ND	0.00
5/17/2008	0.02	0.02	6/17/2008	0.26	0.08	7/17/2008	none	0.09	8/17/2008	ND	0.00
5/18/2008	none	0.20	6/18/2008	0.03	0.15	7/18/2008	0.67	0.00	8/18/2008	ND	0.26
5/19/2008	0.17	T	6/19/2008	0.00	0.03	7/19/2008	none	0.00	8/19/2008	ND	0.03
5/20/2008	trace	T	6/20/2008	0.00	0.02	7/20/2008	0.39	1.01	8/20/2008	ND	0.00
5/21/2008	0.02	0.09	6/21/2008	0.00	0.02	7/21/2008	0.47	0.04	8/21/2008	ND	0.00
5/22/2008	0.04	0.02	6/22/2008	0.00	T	7/22/2008	0.39	0.04	8/22/2008	ND	0.00
5/23/2008	0.02	0.00	6/23/2008	0.01	0.09	7/23/2008	0.87	1.32	8/23/2008	ND	0.00
5/24/2008	none	0.00	6/24/2008	0.00	0.00	7/24/2008	0.94	0.37	8/24/2008	ND	0.01
5/25/2008	none	0.00	6/25/2008	0.00	0.00	7/25/2008	0.63	0.00	8/25/2008	ND	0.00
5/26/2008	trace	0.00	6/26/2008	0.00	0.05	7/26/2008	none	0.01	8/26/2008	ND	0.00
5/27/2008	trace	0.06	6/27/2008	0.00	0.00	7/27/2008	0.11	0.00	8/27/2008	ND	0.00
5/28/2008	none	0.00	6/28/2008	0.04	0.24	7/28/2008	0.09	0.00	8/28/2008	ND	0.04
5/29/2008	none	0.00	6/29/2008	0.02	0.39	7/29/2008	none	0.00	8/29/2008	ND	0.02
5/30/2008	none	T	6/30/2008	T	T	7/30/2008	none	0.26	8/30/2008	ND	T
5/31/2008	0.12	0.95				7/31/2008	0.03	T	8/31/2008	ND	0.00