Red Creek East Watershed Assessment

2017 – 2018

Wayne County Soil & Water Conservation District

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Red Creek East is a Class C stream with impacts that needs verification to determine the extent of possible stress to aquatic life. The suspected source of the stress is agriculture. Historic water quality is scarce, but Wayne County Soil & Water Conservation District (SWCD) previously examined Red Creek East at a single outfall location. For this assessment, water quality samples were collected at eleven locations from May 2017 to June 2018. The samples were analyzed for total phosphorus, total nitrogen, nitrate + nitrite, and total suspended solids. Total Kjeldahl Nitrogen was determine by finding the difference between total nitrogen and nitrate + nitrite. Total phosphorus and total Kjeldahl Nitrogen concentrations observed in Red Creek East were noticeably elevated throughout the stream system. A comparison between non-event and event conditions suggests that some constituents can be diluted during intense precipitation events. A majority of the soils in the watershed have moderate infiltration rates and moderately low runoff potential. Approximately 89% of the Red Creek East watershed is composed of agricultural land use. There is approximately 2,245 acres of protected wetlands in the watershed that play an important role in water filtration and nutrient recycling. There are two entities that have SPDES permitted discharges in the watershed. Agricultural livestock operations have been a staple of remediation efforts by SWCD. Water quality impacts to Red Creek East by such operations could be attributed to improper grazing practices and runoff from animal feeding systems. Runoff from cropland was observed as a potential source of nonpoint source pollution. Municipal and commercial properties in the watershed have the potential to implement green infrastructure practices to manage stormwater runoff. Ortho-imagery was used as a tool to identify onsite wastewater treatment systems near waterbodies or that have a number of systems in a concentrated area. Habitat modification in the watershed was observed to be channel modification that has changed and continues to alter the rates of erosion and sedimentation in the stream system.

INTRODUCTION AND BACKGROUND

A watershed can be defined as any land area in which water drains to a common point. When beginning to look at how land is managed and the resulting impacts upon water quality, it becomes increasingly clear that what is done on the land will ultimately affect the receiving waterbody. The concept of *Watershed Management* is to look broadly at the multiple land uses (agriculture, development, etc.) to determine the impacts and to find ways to mitigate those impacts to protect these waterbodies.

Through a combination of field work, resource evaluation and mapping, an assessment of the watershed can help determine and outline upland actions that affect water quality. This *Watershed Assessment* then serves as the basis for prioritizing corrective measures and finding appropriate funding opportunities to address sources of pollution within the watershed.

The resulting document will expectantly serve as a guideline for restoration and improvements within the watershed, which will ultimately improve the water quality and ecology.

STREAM AND WATERSHED CHARACTERISTICS

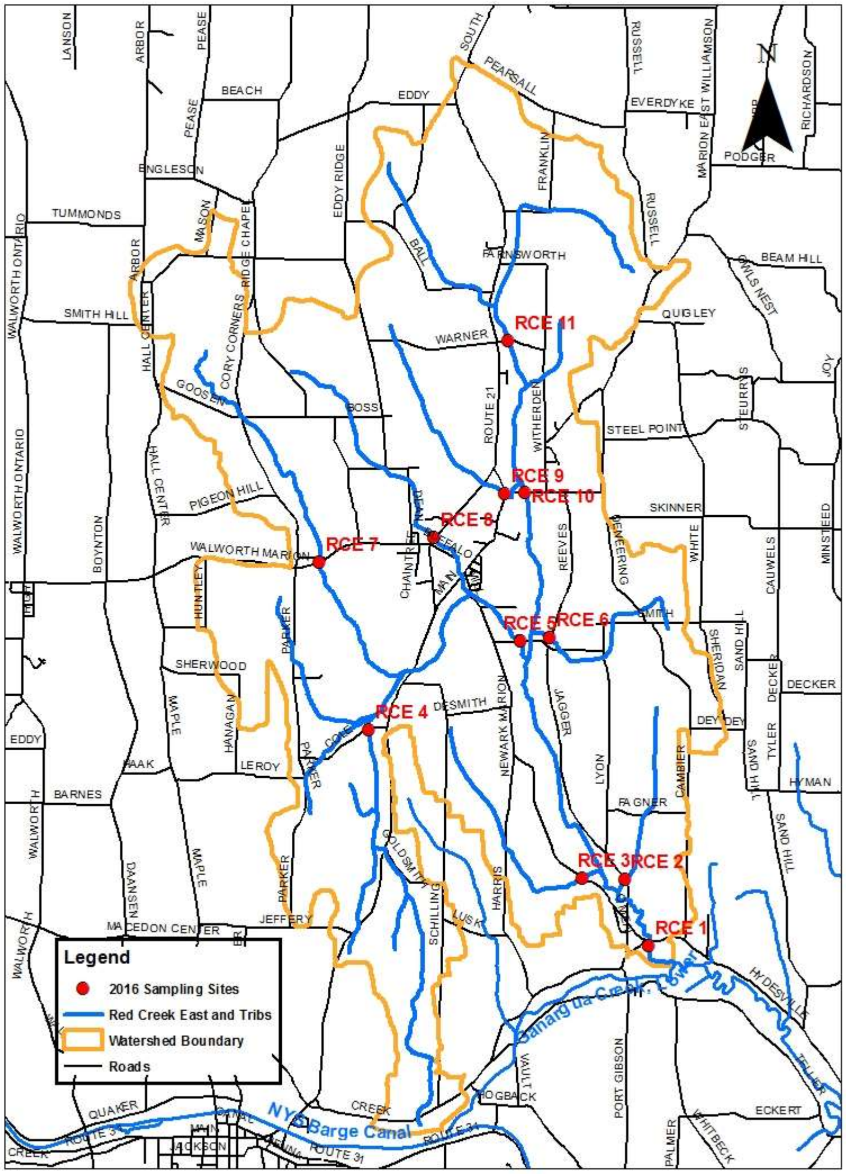
Red Creek East's (0704-0015) headwaters originate in the southern portion of the Town of Williamson along the Route 21 corridor. A larger tributary stream that outfalls into Red Creek East (near the Hamlet of Marion) has headwaters that originate along the town boundaries of Marion and Palmyra. The stream system flows south through the Town of Marion into the Town of Palmyra where it outfalls into Lower Ganargua Creek near Creek and Hydesville Rd. Red Creek East and its tributaries are approximately 40 miles in length. Red Creek East's watershed is approximately 21,750 acres in size.

STREAM MORPHOLOGY AND CLASSIFICATION

The section of Red Creek East that lies within the Town of Palmyra is a third order stream. Using USGS StreamStats, Red Creek East has the following approximate bankfull statistics:

Bankfull area: 142 $ft.^2$
Bankfull depth: 2.88 ft.
Bankfull streamflow: 490 $ft.^3/s$
Bankfull width: 50.6 ft.

Using USGS Quadrangle topographic maps (Palmyra and Williamson, NY, 7.5-minute series), the slope of the main channel of Red Creek East was found to be approximately 0.12 percent. The slopes of the tributaries to this stream range from approximately 0.12 to 0.57 percent.



Red Creek East Sampling Sites

New York State Department of Environmental Conservation (NYSDEC) *2008 Oswego River/Finger Lakes Basin Waterbody Inventory/Priority Waterbodies List* Report (WI/PWL) classified Red Creek East as a C stream with impacts that *NEED VERIFICATION* to determine the extent of possible stress on *AQUATIC LIFE* (Appendix I). For class C waters, the best usage is fishing. “These waters shall be suitable for fish, shellfish, and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes” (Chapter X – Division of Water, Section 701.8). Waterbodies with impacts that *NEED VERIFICATION* are “waterbodies that are thought to have water quality problems or impact, but for which there is not sufficient or definitive documentation.” “Such waterbodies require additional monitoring to determine whether uses are restricted or threatened.”

The Waterbody Inventory Data Sheet for Red Creek East states that the pollutant(s) type is suspected to be *D.O./OXYGEN DEMAND, NUTRIENTS*. **The Data Sheet states that the major, suspected source of the pollutants is *AGRICULTURE* and possibly (or unconfirmed) *Industrial*.** The Data Sheet indicates the resolvability of the impairment requires the evaluation of possible solutions and/or the development of management action (*NEEDS VERIFICATION/STUDY*). The Resolution Potential noted is *MEDIUM*, meaning the resources necessary to address the problem are beyond what are currently available. The 'Further Details' section of the Data Sheet continues discussing that Red Creek East may experience minor impacts due to nutrients and Biological Oxygen Demand (BOD) loading from agricultural activities and a food processing plant discharge. The food processing facility is no longer in operation. Concerns had previously raised with NYSDEC regarding the impact of runoff from high application amounts of apple pomace to agricultural fields. As previously stated, Red Creek East is classified as a C stream, but the waters of the stream are Class C/D

WATER QUALITY

Red Creek East historical water quality data is rare. This stream was included in a watershed characterization projects in 2009 and 2010 (Makerawicz et al. 2010 and 2011) that examined a single sample site located near the outfall of the watershed. The data previously collected by SWCD will be compared to the data collect for this project. This watershed assessment was designed to evaluate and further identify potential sources of pollution that impact the stream. The eleven (11) sampling sites were chosen based on location along the main channel, at the outlet of sub-watersheds, and safety/ease of access (See map above). Samples were collected at the 11 locations from May 2017 to June 2018. A total of 14 sampling efforts were completed between the previously stated dates. Sampling was completed to reflect random seasonal variations in water quality. Samples were collected during what could be classified as 'Event' conditions (i.e. noticeable precipitation runoff). Water samples were not collected during winter months. Samples were transported, on ice, to the water chemistry laboratory at Upstate Freshwater Institute in Syracuse, NY, for water chemistry analysis of total phosphorus (TP), nitrate + nitrite (NO_x), total nitrogen (TN), and total suspended solids (TSS). Total Kjeldahl Nitrogen (TKN) was determined by finding the difference between TN and NO_X. Variability existed in the concentrations of nutrients from the 11 sampling sites. This is due to differences in land uses as well as point and nonpoint sources across the watershed.

Table 1a. Mean, Non-event concentrations for Red Creek East from 5/22/17 to 6/26/18 and Mean, Non-event concentrations from various Wayne County tributaries.

RED CREEK 2017-18 NON-EVENT					
SITE ID	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (µg/L)	TSS (mg/L)
RCE 1	269.5	1.018	0.161	856.4	5.1
RCE 2	74.5	1.127	0.654	473.5	5.6
RCE 3	93.8	0.796	0.122	673.8	9.3
RCE 4	68.3	0.848	0.245	599.7	5.9
RCE 5	216.6	1.533	0.884	786.3	8.8
RCE 6	134.6	0.967	0.284	682.9	4.6
RCE 7	108.1	1.171	0.270	901.0	8.9
RCE 8	54.5	0.749	0.175	574.3	12.6
RCE 9	57.2	1.408	0.777	631.3	7.01
RCE 10	151.1	1.397	0.720	677.8	11.3
RCE 11	151.5	1.594	0.946	647.8	3.3
WAYNE COUNTY TRIBUTARIES NON-EVENT					
Waterbody	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (µg/L)	TSS (mg/L)
Canandaigua Outlet 09-10	47.8	N/A	1.032	590.2	3.0
Glenmark Creek 09-10	39.2	N/A	0.774	535.9	3.2
Crusoe Creek 09-10	103.5	N/A	0.110	1201.9	3.4
Black Brook 09-10	55.3	N/A	0.464	848.7	11.0
Red Creek East 09-10	127.7	N/A	0.282	939.9	4.4
Red Creek West 09-10	98.5	N/A	0.238	710.4	3.2
Red Creek West 16-17	70.0	1.198	0.222	976.4	9.4
Salmon Creek West 10	N/A	N/A	N/A	N/A	N/A
Maxwell Creek 10	252.3	N/A	0.340	754.0	2.0
Ganargua Creek Lower 12-13	61.4	N/A	0.790	448.2	11.2

Table 1b. Mean, Event concentrations for Red Creek East from 5/22/17 to 6/26/18 and Mean, Non-event concentrations from various Wayne County tributaries.

RED CREEK EAST 2017-18 EVENT					
SITE ID	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (µg/L)	TSS (mg/L)
RCE 1	181.9	1.053	0.311	667.7	15.4
RCE 2	85.6	1.789	0.443	1346.0	5.6
RCE 3	97.3	0.713	0.133	580.8	5.2
RCE 4	96.1	0.963	0.276	687.2	6.7
RCE 5	172.9	1.413	0.468	1137.8	7.2
RCE 6	123.0	1.087	0.293	794.0	9.8
RCE 7	112.8	0.959	0.182	777.7	5.0
RCE 8	82.0	1.340	0.208	1131.8	7.3
RCE 9	58.8	1.300	0.731	804.4	10.5
RCE 10	114.2	1.707	0.823	884.5	6.6
RCE 11	127.2	4.193	1.291	2902.8	9.4
WAYNE COUNTY TRIBUTARIES EVENT					
Waterbody	TP (µg/L)	TN (mg/L)	Nitrate (mg/L)	TKN (µg/L)	TSS (mg/L)
Canandaigua Outlet 09-10	72.3	N/A	1.795	1449.0	13.6
Glenmark Creek 09-10	91.4	N/A	0.793	800.8	20.5
Crusoe Creek 09-10	138.5	N/A	0.170	1067.9	7.5
Black Brook 09-10	70.3	N/A	0.828	968.6	17.7
Red Creek East 09-10	132.6	N/A	0.489	842.4	9.8
Red Creek West 09-10	110.5	N/A	0.348	743.0	7.1
Salmon Creek West 10	162.2	N/A	2.130	990.0	4.6
Maxwell Creek 10	222.4	N/A	1.260	802.0	8.4
Ganargua Creek Lower 12-13	106.3	N/A	0.907	430.0	33.9

Total Phosphorus (TP)

Phosphorus as phosphate is one of the major nutrients required for plant growth and is often considered the 'limiting' nutrient in New York freshwaters. Sources of phosphorus include animal wastes, sewage, detergent, fertilizer and disturbed land. U.S. Environmental Protection Agency recommended water quality standard for flowing waters entering a lake is 50 µg/L and 100 µg/L for all other streams (USEPA, 2012). Wisconsin Department of Natural Resources established a phosphorus water quality standard for flowing waters entering lakes at 75 µg/L and 100 µg/L for all other streams and rivers (Wisconsin, 2010). The NYSDEC Stream Biomonitoring Team, in conjunction with the University of Albany, Department of Biological Sciences, suggests a phosphorus threshold limit of 65 µg/L between mesotrophic and eutrophic conditions in flowing streams (Smith et al., 2006). During non-precipitation event conditions, 9 of the 11 Red Creek East sampling sites had mean concentrations of TP exceeding 65 µg/L. Sites RCE 1 and RCE 5 had the highest observed mean concentration at 269.5 µg/L and 216.6 µg/L, respectively (Table 1a). Compared to other streams assessed in Wayne County, Red Creek East's TP results were found to be quite high. From the 2009 and 2010 studies of a single, watershed-outfall site, mean, non-event TP concentration was 127.7 µg/L. Site RCE 1 of this study was at the same location of the previous studies (2009 and 2010) with a mean concentration twice as much as previously observed.

During precipitation event conditions, 10 of 11 sampling sites exceeded 65 µg TP/L. Sites RCE 1 and RCE 5 had the highest observed TP concentrations at 181.9 µg/L and 172.9 µg/L, respectively (Table 1b). The event concentrations observed in Red Creek East were fairly similar to those of other tributaries in Wayne County. The sampling site for Red Creek East in 2009 and 2010 is the same location for RCE 1 of this study. There is a slight increase in TP concentrations from the previous studies.

Total Kjeldahl Nitrogen (TKN)

Total Kjeldahl Nitrogen is the combination of organically bound nitrogen and ammonia. Sources of these forms of nitrogen include sewage effluent and runoff from land where manure has been applied or stored. U.S. Environmental Protection Agency water quality criteria recommendations for New York State region provided data that un-impacted waterbodies have a TKN concentration of 200.0 µg/L (USEPA, 2000). For this report, TKN was calculated by finding the difference between the concentrations of Total Nitrogen (TN) and Nitrate + Nitrite (NO_x). All 11 sample sites exceeded 200.0 µg/L for both non-event conditions, although sites RCE 2 and RCE 8 could be considered low for waterbodies with some level of land use impact. Sites RCE 7 and RCE 1 had the highest observed non-event TKN concentration for this assessment (Table 1a). Red Creek East TKN non-event concentrations for this report are fairly comparable to other streams in Wayne County. The equivalent sample site for the studies in 2009 and 2010 and RCE 1 of this report had similar TKN non-event concentrations.

During event conditions, all 11 sampling sites exceeded 200.0 µg/L. Site RCE 3 could be considered low for having some level of impact in its drainage basin. Sites RCE 11, RCE 2, RCE 5 and RCE 8 all exceeded 1000 µg/L. RCE 11 TKN concentration was more than double of the next highest amount. Besides this outstanding number, other mean event concentrations were fairly similar to others seen throughout Wayne County. The replica sampling site from previous Red Creek East assessments compared to this one displayed a decrease in TKN concentrations during event induced stream flows.

Nitrate + Nitrite (NO_x)

Nitrate is the form of nitrogen that is most readily available for plant uptake. It is more easily detected as Nitrate + Nitrite, or NO_x (Nitrite is not commonly found in surface waters but is created as nitrate converts to nitrogen gas during denitrification). Nitrate sources include soil, animal wastes (including birds and fish), sewage and septic systems, fertilizers and decaying vegetation. The NYSDEC water quality standard for nitrate in drinking water is 10 mg/L. The

United States Geological Survey (USGS) states that background nitrate concentrations for undeveloped watersheds is 0.6 mg/L (USGS, 1999). Five of the 11 sites sampled during non-event conditions surpassed 0.6 mg/L, with the highest being RCE 11 at mean concentration of 0.946 mg/L. The six other sampling sites had concentrations below 0.3 mg/L. There is a wide variation among non-event NO_x concentrations in Wayne County's streams and the same could be said for different drainage basins in Red Creek East. Site RCE 1 displayed a slight decrease compared to results for the same location from 2009 and 2010.

Mean NO_x concentrations observed under event conditions were relatively low to moderate with the exception of RCE 9, RCE 10, and RCE 11. RCE 11 had the highest mean concentration 1.291 mg/L. Compared to other Wayne County streams, Red Creek East display lower concentrations during precipitation events. Site RCE 1 displayed a decrease in mean event concentrations compared to results for the same location from 2009 and 2010.

Total Suspended Solids (TSS)

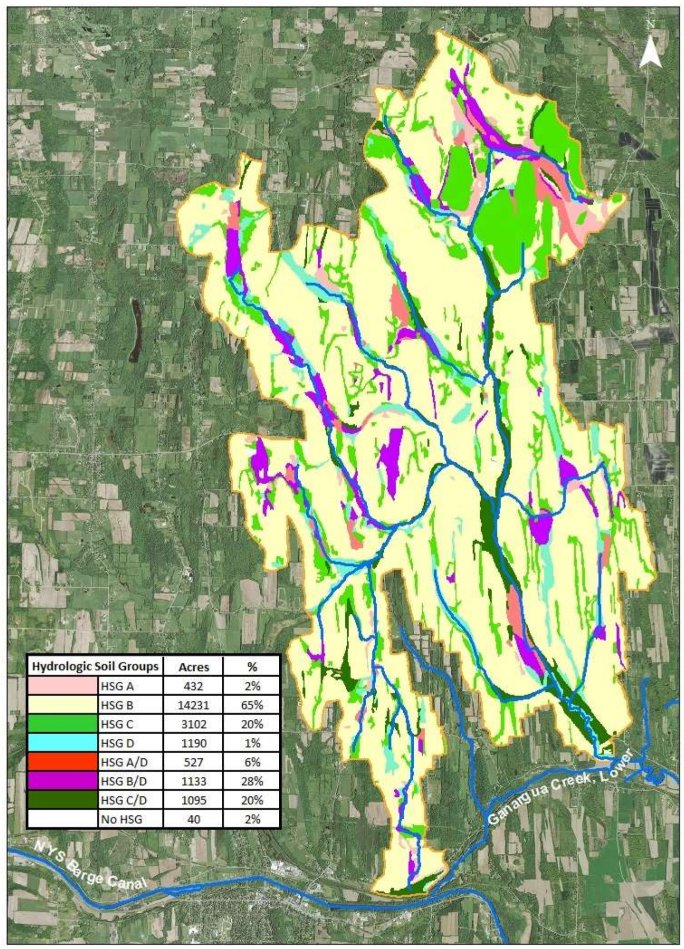
Total suspended solids is a measure of soil particles and other materials suspended in water. Water-borne sediments act as an indicator, facilitator and agent of pollution (Makerawicz et al. 2011). As an indicator, TSS adds hue to water. As a facilitator, sediments transport other pollutants such as nutrients and toxic substances. As an agent, sediments smother organisms and cover habitats used by some species for spawning (Makerawicz et al. 2011). Mean non-event concentration of TSS ranged from 3.3 mg/L at site RCE 11 to 12.6 mg/L at RCE 8. The concentration observed throughout Red Creek East during baseline flows were somewhat higher than a number of other Wayne County streams. The identical sampling site from previous Red Creek East assessments to this one displayed an increase in TSS concentrations at base stream flows.

Mean event concentrations of TSS in Red Creek East ranged from 5.0 mg/L at RCE 7 to 15.4 at site RCE 1. TSS concentrations observed during event conditions were generally lower than those observed in other Wayne County streams. Site RCE 1 of this study was at the same location of the previous studies (2009 and 2010) with a mean concentration noticeably elevated from previously observed.

When comparing non-event conditions to that of event conditions, a common observation is that samples collected during event conditions will have higher concentrations. This is due to increases in overland runoff and erosion. There were noticeable exceptions to this during this assessment, suggesting that some constituents can be diluted during intense precipitation events.

HYDROLOGIC SOIL GROUPS

Hydrologic soil group (HSG) is a group of soils having similar runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. Wetness characteristics, water transmission after prolonged wetting and depth to slowly permeable layers are properties that influence runoff potential. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. Hydrologic soil groups are important in the planning watershed-protection and flood-prevention projects as well as for planning or designing structures for the use, control and disposal of water. The four hydrologic soil groups (HSGs) are described as:



Red Creek East Hydrologic Soil Groups

Group A—Soils in this group have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hour).

Group B—Soils in this group have moderately low runoff potential and moderate infiltration rates when thoroughly wetted. They consist of 10 – 20 percent clay and 50 – 90 percent sand. These soils have a moderate rate of water transmission (0.15-0.30 in/hour).

Group C—Soils in this group have moderately high runoff potential and low infiltration rates when thoroughly wetted. These soils have a low rate of water transmission (0.05-0.15 in/hour).

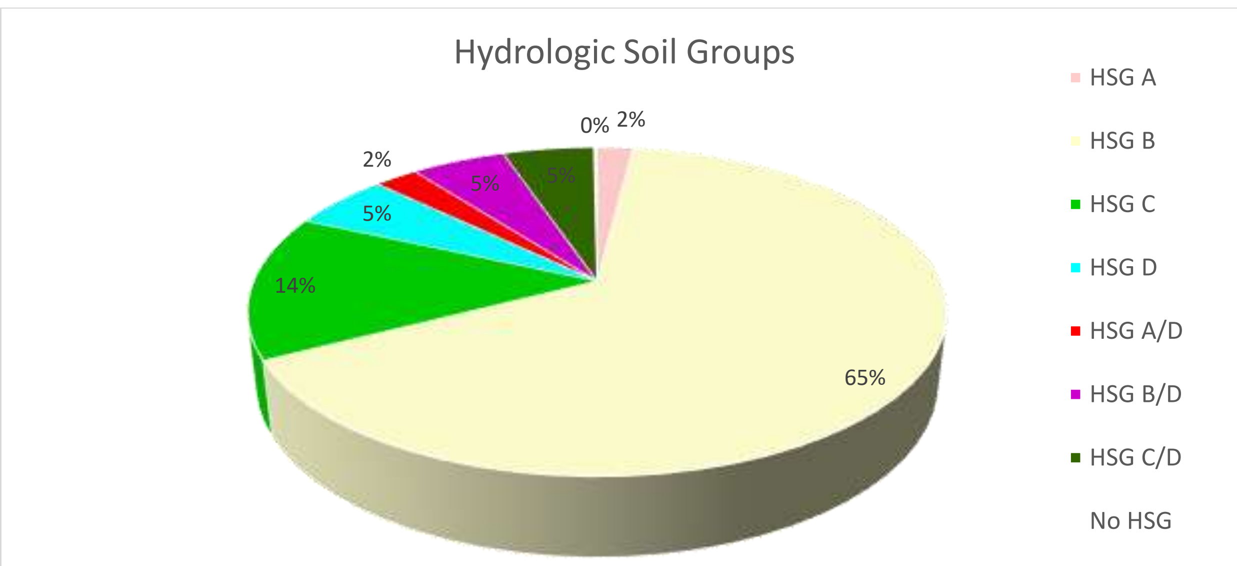
Group D—Soils in this group have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hour).

Dual hydrologic soil groups—Certain wet soils are placed in group D based solely on the presence of a water table within 24 inches of the surface even though the ease with which pores of a saturated soil permit water movement may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D and C/D) based on their ability to allow water movement and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition.

Table 2. Hydrologic soil groups for the Red Creek East.

Hydrologic Soil Groups		Acres	%
	HSG A	432	2%
	HSG B	14231	65%
	HSG C	3102	14%
	HSG D	1190	5%
	HSG A/D	527	2%
	HSG B/D	1133	5%
	HSG C/D	1095	5%
	No HSG	40	0%
	TOTAL	21750	

Figure 1. Percent acreage of hydrologic soil groups for the Red Creek East.



As evident in Table 2, a majority of the watershed area is soil that has moderate infiltration rates when saturated. These soils also have moderately low runoff potential. As a result of any soil disturbance, the soil profile can be changed from its natural state and listed soil groups may no longer apply. The map above displays the distribution of the HSGs in the Red Creek East watershed. It should be noted that groups with moderate to high runoff potential are located in close proximity to the stream itself. Any land disturbances in these areas has a greater chance of impacting the water quality of the stream.

High infiltration rates can pose an increased risk for groundwater and surface water contamination. Soil straining or filtration usually removes suspended solids and particulate phosphorus, but dissolved phosphorus (phosphates) can remain untreated. Fine- to medium-textured soils have a larger capacity to hold phosphate, while coarse-textured soils do not (Busman et al, 2002). The same can be stated for nitrate-N. Water-soluble nitrate leaches below root zones with excess water. This nitrogen form has the potential to enter ground and surface water in areas of coarse-textured soils (Lamb et al, 2014).

LAND USE

The land use and land cover patterns (permeability) in a watershed have a significant impact on the overall quality of the receiving waterbody. Knowing the extent of development in a watershed and where the development is located can play a key role in the contaminant loading to a waterbody. In general, as land uses occur, stream systems and overall waterbody health can become diminished through changes in runoff and other human impacts.

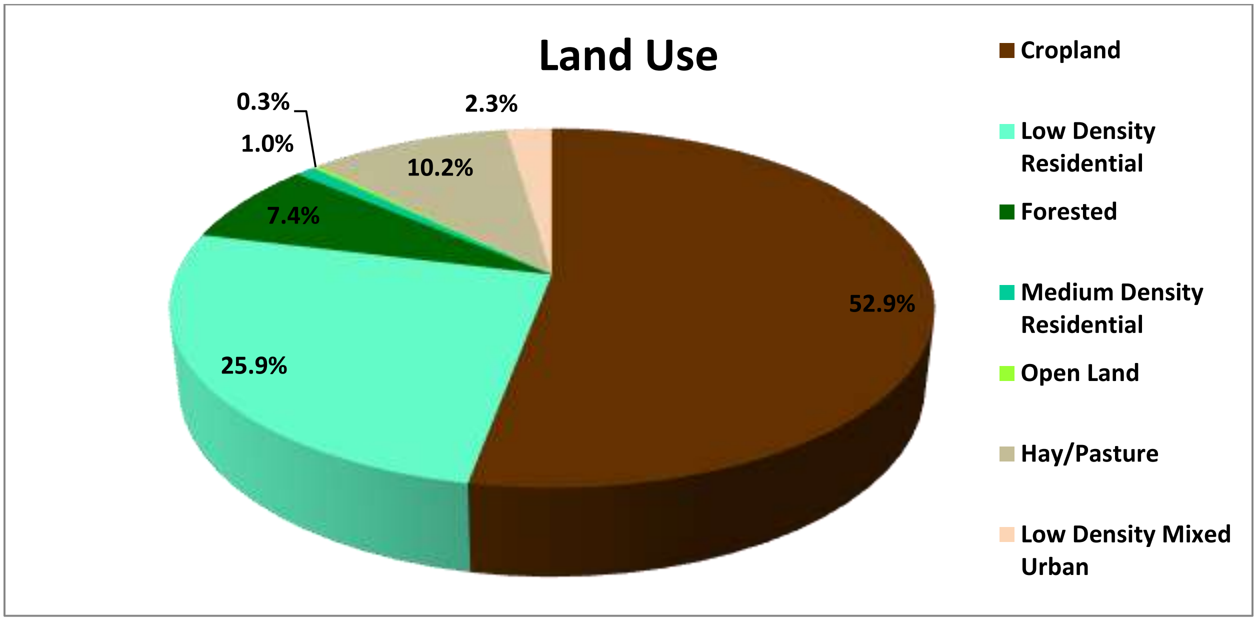
Land use categories observed in the Red Creek East watershed are categorized as:

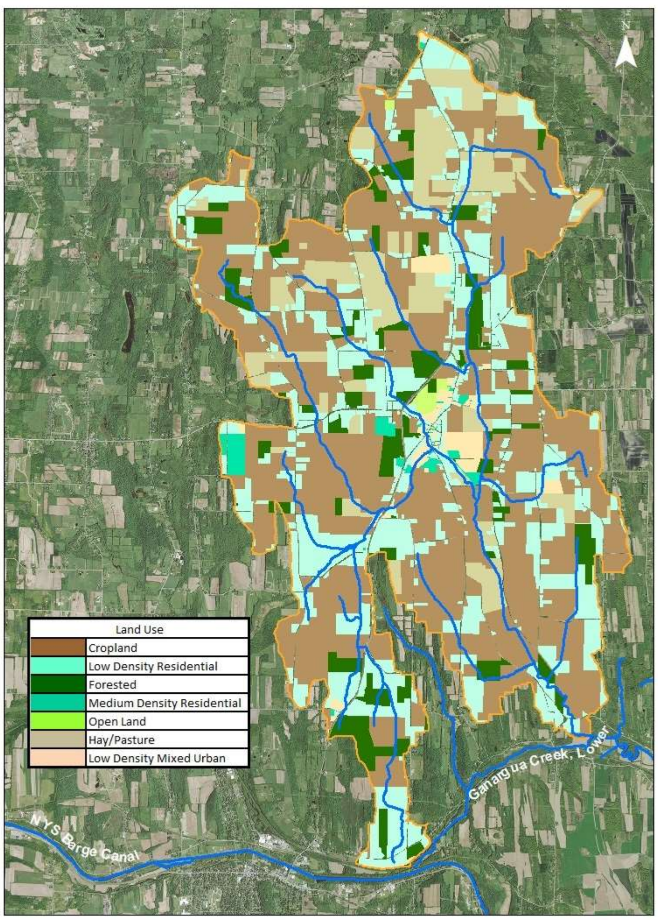
- *Hay/Pasture* – includes plant and tree nurseries, fruit orchards, livestock grazing areas
- *Cropland* – includes mucklands, field crops and dairy products
- *Forest* – includes various vacant lands, wooded public parks and private forests
- *Open Land* – includes outdoor recreation facilities, skiing center, cemeteries, landfill
- *Low Density Residential* – includes rural, primary residence with acreage including agricultural land
- *Medium Density Residential* – includes multi-family residence, mobile homes and residence with commercial uses
- *Low Density Mixed Urban* – includes small commercial operations and mobile home parks

Table 3. Land uses of the Red Creek East watershed and acreages

Land Use		Acres	%
	Cropland	11510	52.9%
	Low Density Residential	5635	25.9%
	Forested	1620	7.4%
	Medium Density Residential	215	1.0%
	Open Land	60	0.3%
	Hay/Pasture	2210	10.2%
	Low Density Mixed Urban	500	2.3%

Figure 2. Percent acreage of land uses for Red Creek West watershed.





Red Creek East Land Use

Figure 2 provides a fairly accurate representation of current land uses within the Red Creek East watershed. It is important to note that the Low Density Residential category has a high likelihood of containing Agricultural Lands. With that in mind, in combination with Cropland and Hay/Pasture, approximately 89% of the watershed is made up of some form of agricultural land.

Land use information can be used in conjunction with adjacent water quality data to determine potential areas of concern and aide in prioritizing implementation efforts to reduce pollution loading. Using Stressed Stream Analysis, an approach developed by Dr. Joseph Makarewicz, priority subwatersheds can be systematically sampled to locate point and nonpoint sources (Makarewicz, 1993).

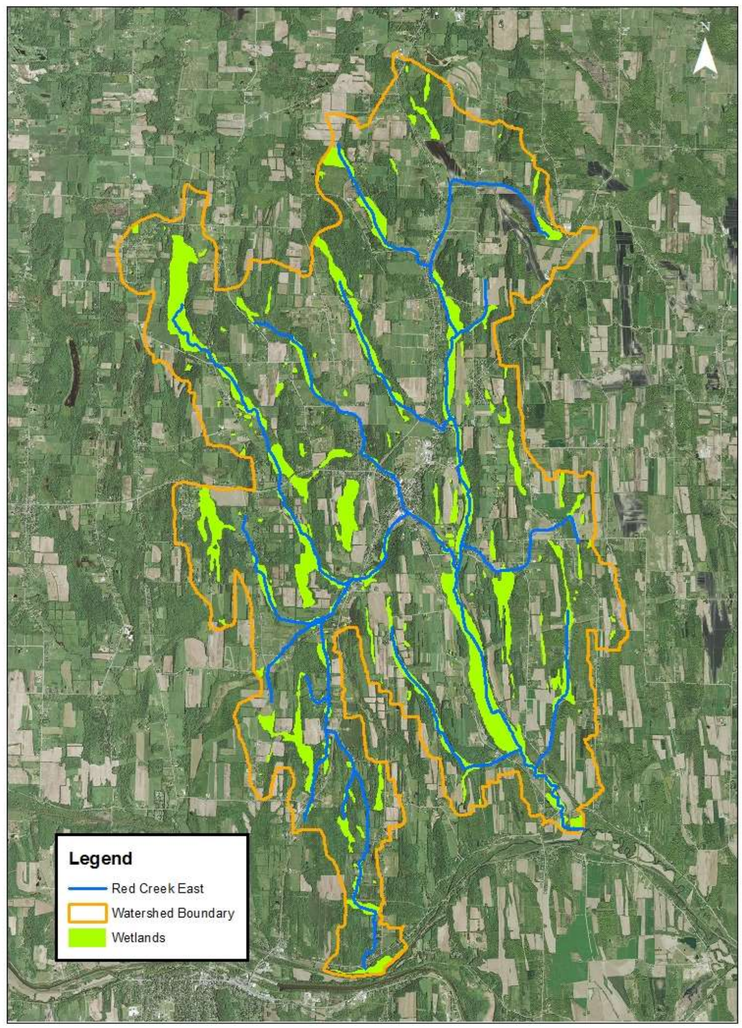
WETLANDS

Wetlands are defined as "areas saturated by surface or ground water sufficient to support distinctive vegetation adapted for life in saturated soil conditions." Wetlands provide flood and storm water control by absorbing, storing and slowing the movement of runoff. They provide erosion control by slowing water velocity, filtering sediment and by buffering streambanks and shorelines. Wetlands treat pollution and cycle nutrients back into the environment by filtering out natural and manmade pollutants, which are then broken down or immobilized. Wetlands provide important habitat for feeding, nesting and spawning fish and wildlife including rare and endangered species. Lastly, wetlands give humans areas for recreation, education and research opportunities.

Wetlands may act as a sink for nutrients and sediment, meaning they act as filters. The biological and chemical process of the nitrogen cycle in wetlands causes up to 90% to be removed.

Phosphorus enters wetlands as dissolved phosphorus or attached to suspended solids. Its removal occurs through uptake by plants, and chemical reactions with soil and soil components. However, wetlands can become saturated with phosphorus and may release it from the system. This loss of phosphorus from wetlands occurs in late summer, early fall and winter as organic matter decomposes causing low oxygen conditions.

Wetlands filter suspended solids from water that comes into contact with wetland vegetation. The plants also create friction on water flow, slowing movement, thus allowing suspended material to settle.



Red Creek East Wetlands

The Red Creek East watershed has approximately 2,245 acres of NYSDEC regulated wetlands consisting of forest/shrub wetlands, ponds, lakes, emergent wetlands, and riverine wetlands. Wetlands in NYS are protected by the Freshwater Wetlands Act (1975) "with the intent to preserve, protect and conserve freshwater wetlands and their benefits, consistent with the general welfare and beneficial economic, social and agricultural development of the state."

WATER QUALITY ISSUES AND RECOMMENDATIONS

Point Sources

State Pollution Discharge Elimination System (SDPES) permit is designed to control point source discharges to groundwaters and surface waters.

Wastewater


Town of Marion WWTP

Town of Marion operates a SPDES-permitted wastewater treatment plant in the Red Creek East watershed. The facility is located on Smith Road in the Town of Marion. Due to aging of the facility and the infrastructure, the Town of Marion has entered an intermunicipal agreement with the Wayne County Water and Sewer Authority, Town of Macedon and the Village of Palmyra to explore options and funding opportunities for the establishment of a Regional Wastewater Treatment Plant that would serve the three communities. The new facility would be located adjacent to the existing Palmyra WWTP. This would eliminate any adverse impacts that the Marion facility may have had on the water quality of Red Creek East. Water quality data from site RCE 5, located south of the WWTP, had significantly elevated concentrations of TP and TKN during both non-event and event conditions. Results from monitoring sites upstream of RCE 5 (RCE 4, RCE 7, RCE 8) also had elevated levels of TP and TKN, suggesting that the WWTP is not the only source contributing to the stream at RCE 5.

There is mobile home park located of the Huntley Rd. in the Town of Marion that submitted a request for renewal of a SPDES permits in January 2006. No current information could be found on this facility. The facility is described as 'Sanitary services' with a flow rate of 0.0370 million gallons per day. This facility is located immediately adjacent to a state regulated wetland, therefore any deficiencies to the systems performance would have a negative effect on water quality and the wetland itself.

Nonpoint Sources

Agriculture Nonpoint Source Pollution

Livestock

Livestock production is an important component of the agricultural economy of Wayne County, comprising 24% of the county's 179,000 acres of farmland. Depending on management, livestock operations can either degrade or contribute to the quality of natural resources. Livestock situations that can contribute nutrients and sediment to Red Creek East include grazing, animal feeding operation and animal waste.

Overgrazing of livestock exposes soils, increases erosion, encourages invasive species colonization, destroys aquatic habitat and destroys streambank and floodplain vegetation. Animals with direct access to streams can degrade water quality by dropping manure directly into the stream and by disturbing streambank stability. Vegetation along a stream corridor is necessary for wildlife habitat and water quality filtration. To reduce the negative impacts of overgrazing on water quality, farmers can adjust grazing intensity, exclude livestock from sensitive areas, provide alternative sources of water and shade and promote the revegetation of damaged areas.

Confined animal systems for beef and dairy cattle, swine and poultry have greatly increased farm production efficiency, but this concentration of animals can bring about water resource concerns. Contaminated runoff from these operations can contain excessive amounts of nutrients, pathogens and sediment. Such operations have to manage manure in the confinement areas and utilize/dispose of manure in an appropriate way.

Pollution of surface waters is not the only concern associated with livestock manure. Manure applied to agricultural land can be beneficial because of its nutrients and soil building characteristics, but over-application may lead to groundwater contamination, especially nitrate and fecal coliform bacteria. This is a significant concern to rural areas where residential drinking water comes from wells.

Livestock operations including beef, dairy, poultry and horses are found in various parts of Red Creek East's Watershed. These farms can be found in the subwatersheds of sampling sites RCE 3, RCE 5, RCE 6, RCE 7, RCE 8 and RCE 11. The water quality results observed during this report may be a result of activities associated with livestock production. Most, if not all, of the operations in the Red Creek East watershed have a level of involvement in conservation programs with Wayne County SWCD or USDA-NRCS. If that is not the case, the District may use the information acquired from this report to gauge landowner interest in becoming involved in the conservation programs available.

Farm operations identified during the course of this assessment will not be identified by name in this publication to maintain producer privacy but will be contacted through the SWCD.

The following sections of this publication briefly describe best management practices (BMP) for activities associated with livestock operations. Some the farms in this watershed have already implemented a variety of these practices.

Managing livestock grazing land to protect water quality and aquatic and riparian habitat should include the following measures:

- Improving and/or maintaining the health of a stable and desired forage plant community that at the same time stabilizes soil and improves water quality;
- Ensure adequate residual vegetative cover;
- Provide adequate regrowth time and rest for plants;
- Excluding livestock from riparian zones and wetlands using fencing and, where necessary, providing stable stream crossings;
- Determining a grazing system for each individual farm;
- Providing water facilities away from streams; and
- Stabilizing heavily used areas.

Animal feeding operations (AFOs) should be managed to minimize impacts on water quality and public health. To meet this goal, management of AFOs should address the following:

- Divert clean water away from feedlots and holding pens, animal manure and manure storage systems;
- Prevent seepage of contaminated effluent into ground and surface water;
- Provide adequate, safe storage of animal manure;
- Apply manure to farmland in accordance with a nutrient management plan;
- Land receiving manure should be managed to minimize the movement of nutrients and organic material and buffer/treat runoff;
- Operators should document the quantity of waste produced and its utilization/disposal; and
- Deceased animals should be managed so to not adversely affect ground and surface waters.


Barnyard Management System

Numerous BMPs can be implemented to achieve the management efforts stated above. The most recent practices used by Wayne County SWCD include:

- Roof runoff management;
- Diversions channels;
- Heavy use area protection;
- Waste storage facility; and
- Vegetated filter strips.

The livestock operations observed during this watershed assessment exhibited varying degrees of water resource concerns. These farms could strongly benefit from the management practices stated above.


Level Spreader for a Vegetated Treatment Area

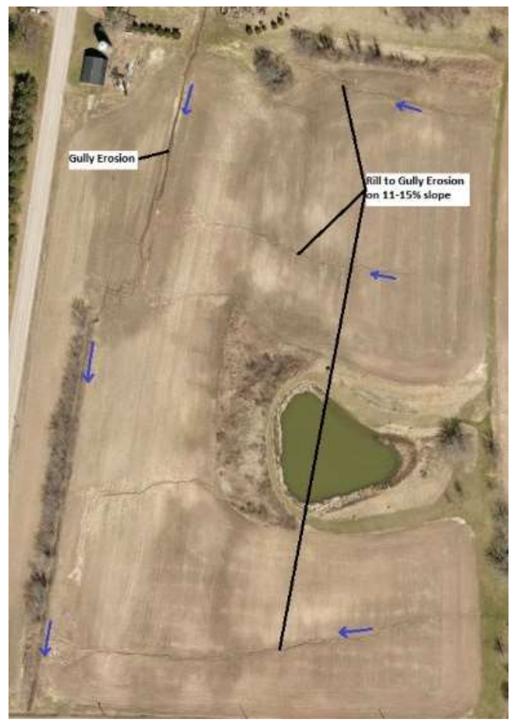
Cropland

Cropland in the Red Creek East watershed consist of 11,510 acres, roughly 53% of the total watershed (21,750 acres). There are two subcategories of cropland recognized in New York State: cultivated and non-cultivated. Cultivated cropland involve row crops or close-grown crops. Non-cultivated cropland includes permanent hay land and horticultural cropland (fruit, nut, vineyard crops and nurseries). “Cropland” used above in “Land Use” is composed of only cultivated cropland. Orchards and Nursery are bundled with “Hay/Pasture” land use category.

Cultivated cropland is the dominant land use in the Red Creek East watershed. By no means does this prove that it is solely responsible for degradation of water quality. It means that significant consideration should be made regarding conservation practices.

Cropland activities have the potential to contribute to nonpoint source pollution. Application of commercial fertilizer to cropland can introduce nitrogen and phosphorous to surface or groundwater. When excess nutrients are introduced to natural waterbodies through runoff, they can potentially increase the "productivity" of the water system, referred to as eutrophication.

Pesticides and herbicides can be transported to surface and groundwater through runoff and/or soil infiltration. Chemicals that are resistant to degradation can persist in natural waterbodies and can bioaccumulate in aquatic organisms. This can result in chemicals biomagnifying through the food chain. As noted above, the water quality data collected for this report did not include the analysis of pesticide or herbicide components.



The cultivation of croplands destabilizes soils and can lead to excess soil erosion and sedimentation. Soils eroded from cropland often contain nutrients which further impact water quality in the receiving waterbodies. Salts produced from natural weathering of soil can also be transported in runoff, which can negatively affect water quality.

Where manure is applied to cropland, there is a possibility of excessive concentrations of pathogens and nutrients entering adjacent waterbodies through surface or ground water. Soil characteristics, soil types, crops grown, amount of manure applied, rate of application and seasonal timing of application determine the potential for adverse impacts to water quality.

To address pollutants caused by cropland activities, BMPs can be designed to initially prevent runoff or to treat polluted runoff before it reaches a waterbody. The simplest BMP to use for cropland activities is sound farm administration and planning. Whole farm planning is the holistic approach to farm management used to identify and prioritize issues on a farm without compromising the farm business.

Often for administrative BMPs to be successful, they require the implementation of structural BMPs. Structural BMPs for cropland have the goal of improving water quality in waterbodies adjacent to cropland by preventing excessive erosion and intercepting and filtering possibly contaminated runoff. Cropland BMPs that can be used to meet this goal includes:


Diversion

- Crop rotation;
- Strip cropping;
- Contour farming;
- Cover cropping;
- Residue management;
- Vegetated filter strips;
- Grassed swales;
- Riparian buffers;
- Diversions;
- No-till/conservation tillage;
- Water and sediment control basin; and
- Grade stabilization structures.


No-till Seeding

In many situations, the use of multiple BMPs may be needed to reduce nonpoint source pollution on agricultural operations. The appropriate BMP(s) to implement can be dependent on numerous onsite factors (climate, topography, installation costs, etc.) and may require management from a natural resource professional. Management and conservation plans should contain BMPs that are most applicable to the farm location, with each practice functioning with all others to achieve the operation's goals.

NYS Department of Agriculture and Market's *Agricultural Environmental Management* (AEM) program is a specific program that addresses nonpoint source pollution associated with agriculture. AEM is a voluntary, incentive-based program that provides farmers with technical assistance to help plan and implement conservation practices to meet business objectives and that address natural resource concerns. Wayne County SWCD, the local AEM resource professional, has over 300 agricultural operations enrolled in the program since 2005. Twenty-one farms within the Red Creek East watershed are enrolled in the AEM 5-tier approach. By participating in AEM, agricultural


Water and Sediment Control Basin

operations can document environmental stewardship and further improve contributions to the community, economy, and environment.

More detailed information regarding AEM can be found at:

http://www.agriculture.ny.gov/SoilWater/aem/index.html

During the preparation of this report, it become apparent the some of the farm operations' information is out of date and/or the farm has changed owners. The SWCD has committed to improving the number of operations enrolled in the AEM program by filling a position that focuses on the program.

Stormwater Runoff

Stormwater runoff as a nonpoint source in the Red Creek East watershed pertains to impervious surfaces and opportunities for Green Infrastructure (GI). As more and more natural areas are developed for commercial or residential uses, natural stormwater conveyance systems are disrupted therefore affecting the receiving waterbody. GI uses practices that mimic natural systems to manage stormwater. Examples of GI practices include:

- Rain gardens;
- Green roofs;
- Vegetative swales;
- Bioretention areas;
- Rain barrels; and
- Pervious pavement

Two separate dates (Top- 6/15/17, Bottom- 10/30/17), stormwater drain discharging turbid water at RCE 9. Possible source is material stockpiles at Marion Highway Department.

Green Infrastructure (GI) practices would prove to be very beneficial in the hamlet of Marion. This is where the most impervious surfaces occur in the watershed. GI practices could become community pride events involving all ages of residents. Town buildings and parks provide numerous opportunities to install practices that are appealing, educational and benefit water quality. Commercial properties could be seen as taking a vested interest in the residential community by implementing GI and they could use the event as a team building exercise.

Educating the public on the importance of GI and how they can use certain practices for their own benefit will improve to overall appeal of the community, while also protecting water resources.

> For example: A rain garden can be installed to collect and absorb runoff from rooftops, sidewalks, and streets, while increase the 'curb appeal' of a home. The water-tolerant plants of the rain garden also act as habitat and food for birds and pollinators. Neighborhood associations and community groups could be used to promote, coordinate and implement GI practice in the residential neighborhoods. Potential stormwater runoff from the commercial properties in the downtown area of Marion and the Marion Central School District would result from impervious land cover (parking lots, roofs). Those location with close proximity to surface waterbodies should provide adequate buffer space. Potentially contaminated runoff could also be rerouted away from sensitive areas to locations where it could be absorbed and filtered into the ground. The school district could offer many opportunities for student-led GI projects as part of a curriculum or as a 'capstone' project.

Onsite Wastewater Systems (Septic)

By the time this report was published, it was not known how many properties are served by the Town of Marion sanitary sewer system. It can safety be assumed that the more populated areas of downtown Marion and sections NYS Route 21 corridor are connected to sanitary sewer. This may demonstrate that the household residences outside of these areas have onsite wastewater treatment systems, or septic systems. Sewage is a source of both phosphorus and nitrogen. As stated above concentrations of this nutrients were found at elevated and varying levels throughout the watershed. Thus, the importance of septic management should not be overlooked.

Septic system failure can be attributed to a number of causes including damaged distribution pipes, saturated soils, improper location and poor design/installation. A system could be perfectly designed but still contribute excess nutrients to a waterbody simply by being in close a proximity to said waterbody. NYS regulations require that septic leach/absorption fields have to be a minimum of 100 feet away from a waterbodies mean high water mark. These septic systems would pose the immediate attention in identifying contributing sewage sources. Researchers at SUNY College of Brockport and Cornell University have evaluated the use of aerial imagery in identifying and mapping septic fields in NYS watersheds (Richards et al. 2016). Under optimal conditions (no canopy cover or shadows), the researchers were able to identify over 80% of the systems in an observed watershed. They were able to

identify systems that were located less than 100 feet from surface waters and produced maps of septic field "hotspots", or areas of high septic system concentration.

Use of aerial imagery can be very valuable when the conditions are appropriate. A small number of systems were identified along the riparian corridors of Red Creek East. Of those observed, the drainfields appeared to be in conformance with minimum separation distant for a waterbody. More use of this technique and improvements in aerial imaging will ultimately advance the user's ability and confidence with it.

The lack of an adequate system, lack of routine maintenance, increased density of homes served by septic systems, undersized/overused systems and the installation on unacceptable land conditions can lead to onsite system failure and water quality impacts.

A typical septic system consists of a septic tank and a drainfield, or soil absorption field. The following are signs that a septic system is failing:

- Wastewater backing up into household drains;
- Bright green, spongy grass on the drainfield, even during dry weather;
- Pooling water or muddy soil around your septic system or in your basement; and
- A strong odor around the septic tank and drainfield.

Successful upkeep of a septic system should include:

- Inspect and pump frequently: The average household septic system should be inspected at least every three years by a septic service professional and is typically pumped every three to five years.
- Water efficiency: Efficient water use can improve the operation of a septic system and reduce the risk of failure.
- Proper waste disposal: Septic systems are designed to process only human waste and bath tissue. Disposing of chemicals and/or pharmaceuticals via toilets or drains can damage the living organisms that digest and treat septic system waste.
- Drainfield maintenance: Avoid driving across or parking on the drainfield. Avoid planting trees near the leach lines. Keep roof drains, sump pumps, and other rainwater drainage systems away from the drainfield area.

Hydrologic Modification

Hydrologic Modification is the alteration of natural flow of water through a landscape. NYSDEC includes habitat modification in its description of hydrologic modification. Although not stated on the NYSDEC PWL data sheet, hydrologic modification was observed in the Red Creek East watershed in the form of channel modification

Channel modification, sometime referred to as channelization, is stream channel engineering done for the purpose of flood control, navigation, drainage improvement and reduction of channel migration potential (EPA, 2007). This includes activities such as straightening, widening, deepening, or relocating stream channels, clearing or snagging operations. These types of hydrologic modification typically result in a more uniform channel cross sections, steeper stream gradients and reduced average pool depths (EPA, 1993). Hydrologic modification also reduces groundwater recharge (EPA, 2007).

Channel modification changes the ability of a natural systems to both absorb hydraulic energy and filter pollutants from surface waters (EPA, 2007). It also alters the rate and pathway of sediment erosion, transport and deposition (EPA, 1993). Channel modification often results in diminished instream and riparian habitat for fish and wildlife. Channelization accelerates the movement of NPS pollutants to the receiving waterbody.

A typical longitudinal profile of a stream is curved with steep slopes near the headwaters and a gentle slope near the mouth. In the headwaters, the smaller streams are steeper to transport its naturally eroding sediment. As often observed in the headwater and intermediate streams of Wayne County, the slope is altered by drainage practices to make the land more usable. The velocity of the stream then changes, causing significant changes in erosion and sedimentation throughout the stream.

Physical and chemical characteristics of surface waters that may be influenced by channel modification include sedimentation, turbidity, temperature, nutrients, dissolved oxygen, oxygen demand and contaminants. Channelization observed in Red Creek East were mostly associated with agricultural drainage practices with little to no buffer filter strip between the crop and the waterbody. The stream has been straightened and will take sharp turns along property lines or field edges.

CONCLUSION

Water is one of our most precious natural resources. As populations increase and development expands, it places a negative strain on our waterbodies. It is imperative that these natural systems are maintained in a way where they can continue to support their ecosystem. Watershed management is a tool to evaluate and address how a waterbody responds to human activities.

A majority of Red Creek East's watershed is composed of agricultural land use, making the management of agricultural nonpoint sources of pollution important. Managing runoff from grazing land, animal feeding lots and cultivated cropland would prove beneficial to the ecology of the stream. The remediation of aging infrastructure of the Marion WWPT would eliminate any adverse impacts the facility may have of water quality. Stormwater runoff from Municipal and commercial properties in the watershed have the potential to corrected through the use of green infrastructure practices. Channel modification of the stream for drainage purposes can accelerate the rates of erosion and sedimentation in the stream system.

Land development and agricultural operations within the Red Creek East watershed are not likely to end in the near future. Therefore it is extremely important to manage the land uses in the best interest of the stream. Irresponsible management of lands can further degrade the water quality and aquatic ecosystem of Red Creek East and its tributaries. Protection of water resources is dependent on not just a single entity but an entire watershed community. This assessment is intended to summarize water resource issues within the watershed and to improve awareness of them. It is the duty of landowners within the watershed to be stewards of this stream so that future generations may enjoy it.

REFERENCES

Busman, Lowell., John Lamb, Gyles Randall, George Rehm, Michael Schmitt. 2002. The Nature of Phosphorus in Soils. University of Minnesota: Extentsion. Nutrient Management. Link.

Lamb, John A., Fabian G. Fernandez, Daniel E. Kaiser. 2014. Understanding Nitrogen in Soils. University of Minnesota: Extension. Nutrient Management. Link.

Makarewicz, Joseph C., Theodore W. Lewis. 2010. Characterization of Six Watersheds of Wayne County, New York. The Department of Environmental Science and Biology, The College at Brockport State University of New York.

Makarewicz, Joseph C., Theodore W. Lewis, Blake J. Snyder. 2011. Characterization of Eight Watersheds of Wayne County, New York, 2010-2011. The Department of Environmental Science and Biology, The College at Brockport State University of New York.

Makarewicz, Joseph C. 1993. Stressed Stream Analysis. Waterworks. 9: 5-12.

New York State Department of Environmental Conservation. 1992. New York State Register and Official Compilation of Codes, Rules and Regulations of the State of New York, Division of Water.

New York State Department of Environmental Conservation. 2008. Oswego River/Finger Lake Basin Waterbody Inventory/Priority Waterbodies List.

Smith, A.J., R.W. Bode, and G.S. Kleppel. 2006. A Nutrient Biotic Index (NBI) for Use with Benthic Macroinvertebrate Communities. Elsevier Science.

United States Geological Survey. 1999. The Quality of Our Nation's Waters, Circular 1225, Nutrients and Pesticides.

United State Environmental Protection Agency, U.S. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. Office of Water. EPA-840-B-92-002.

United States Environmental Protection Agency, U.S. 2007. National Management Measures to Control Nonpoint Source Pollution from Hydromodification. Office of Water. EPA 841-B-07-002

United States Environmental Protection Agency. 2012. Chapter I, Subchapter D – Water Programs, Part 131 – Water Quality Standards.

Wisconsin Department of Natural Resources. 2010. Water Quality Standards for Wisconsin Surface Waters, NR 102.0

APPENDIX I. NYS DEC PRIORITY WATERBODY LIST DATA SHEET

Red Creek and tribs (0704-0015)

Need Verific

Waterbody Location Information

Revised: 08/09/2007

Water Index No:	Ont 66-12-52-23-17			**Drain Basin:**	Oswego-Seneca-Oneida
Hydro Unit Code:	04140201/230	**Str Class:**	C		Seneca/Clyde Rivers
Waterbody Type:	River			**Reg/County:**	8/Wayne Co. (59)
Waterbody Size:	39.1 Miles			**Quad Map:**	PALMYRA (I-12-4)
Seg Description:	entire stream and tribs				

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	**Severity**	**Problem Documentation**
Aquatic Life	Stressed	Possible

Type of Pollutant(s)

Known: - - -
Suspected: D.O./OXYGEN DEMAND, NUTRIENTS
Possible: - - -

Source(s) of Pollutant(s)

Known: - - -
Suspected: AGRICULTURE
Possible: Industrial

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 1 (Waterbody Nominated, Problem Not Verified)
Lead Agency/Office: DOW/BWAM **Resolution Potential:** Medium
TMDL/303d Status: n/a

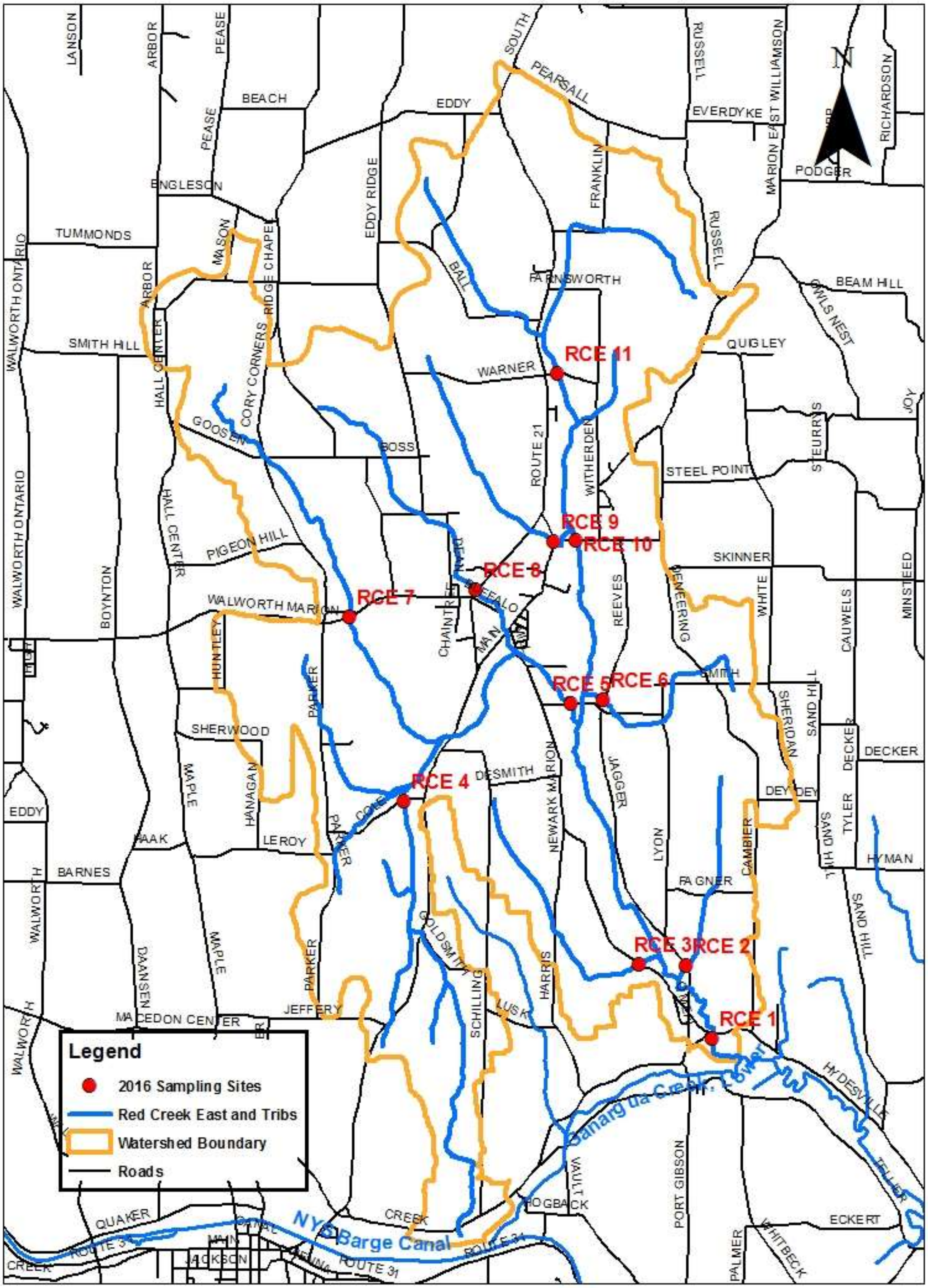
Further Details

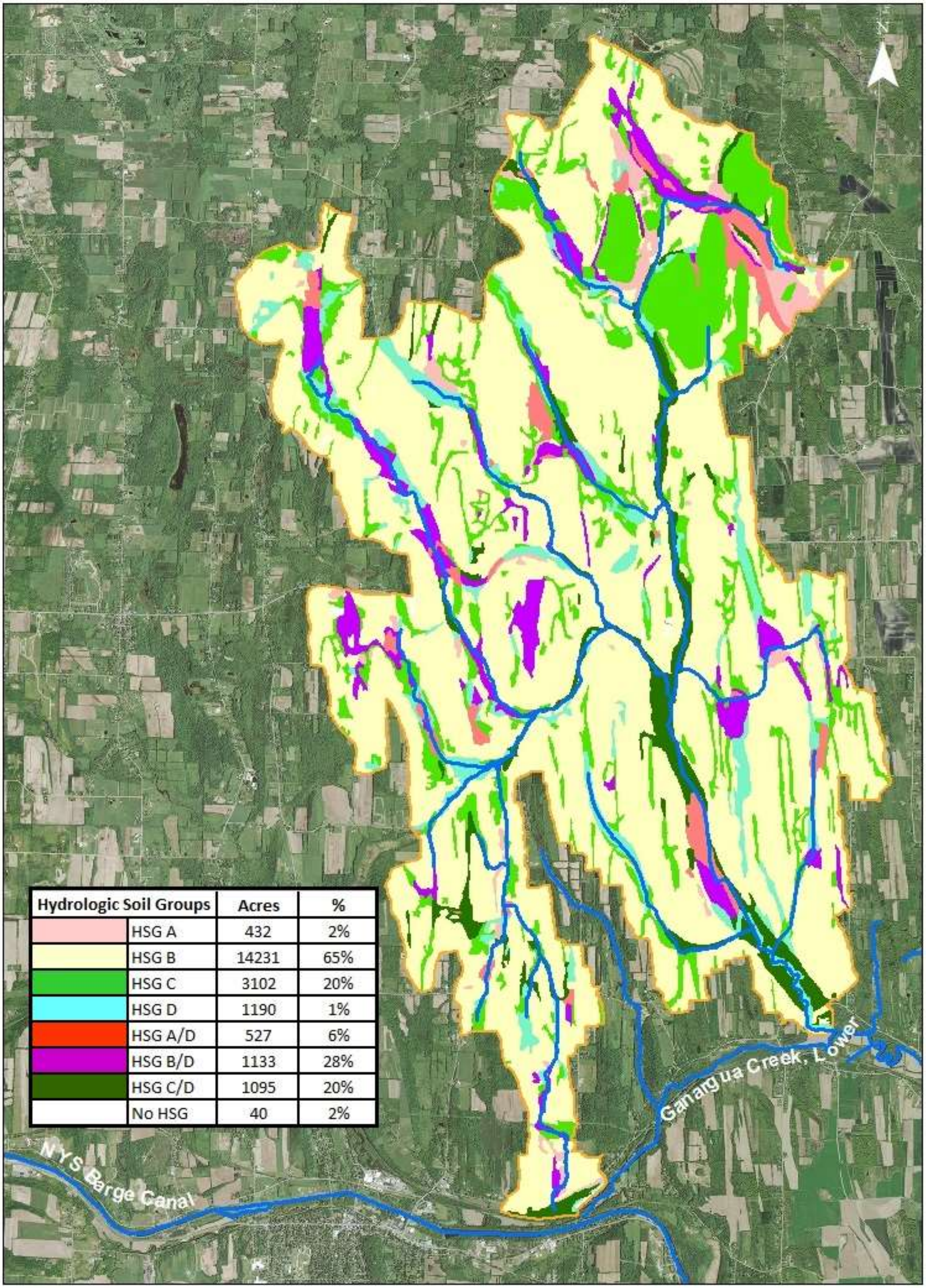
Aquatic life support in Red Creek may experience minor impacts due to nutrients and BOD loading from agricultural activities and a food processing discharge.

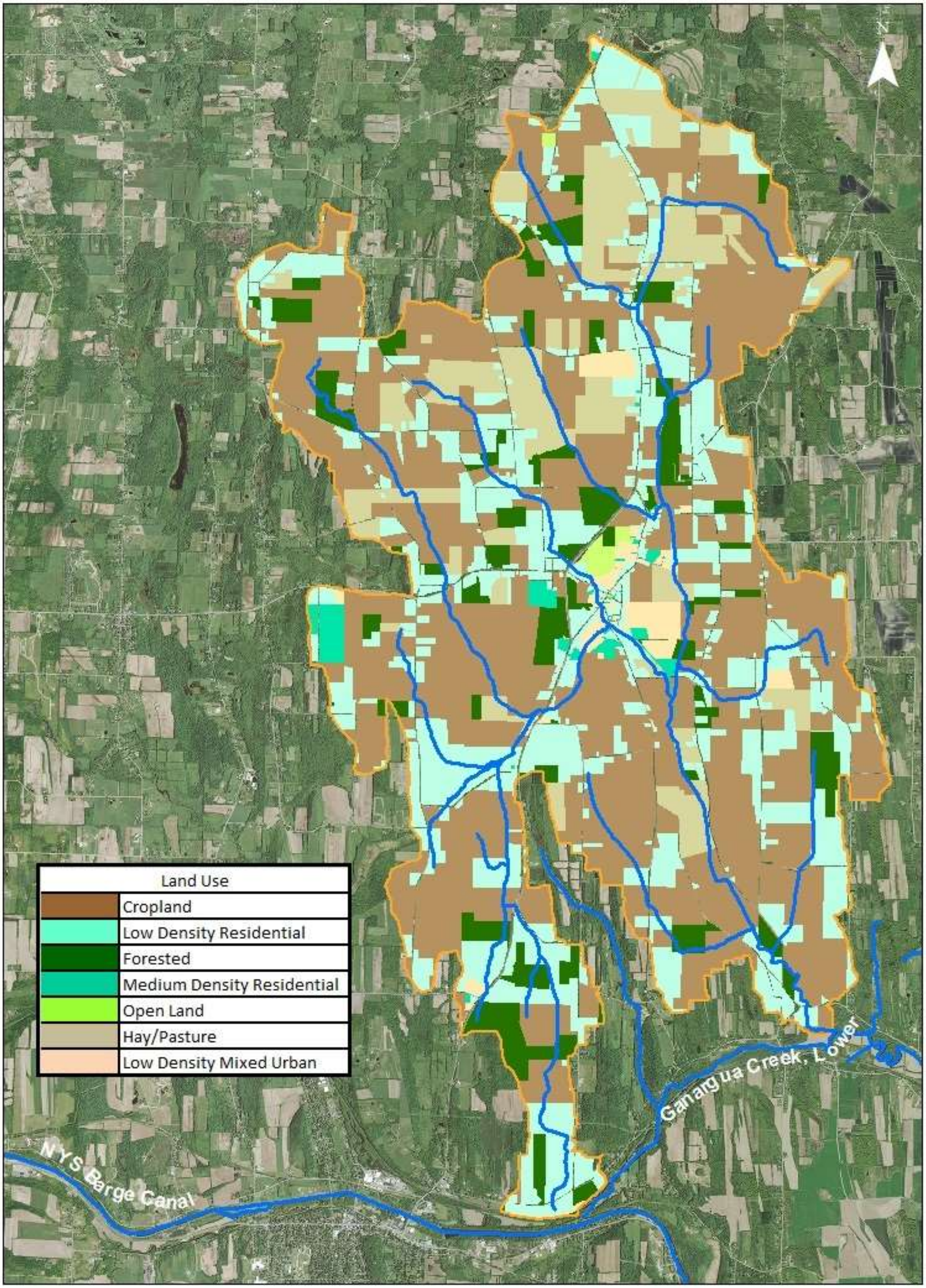
Previously, concerns were raised regarding the impact of nonpoint runoff from agricultural fields with high application rates of apple pomace. A food processing plant discharge was although thought to be contributing to the loading in the stream. Sampling to verify the actual level of impact in the stream is recommended. (DEC/DOW, BWAM/RIBS, June 2005)

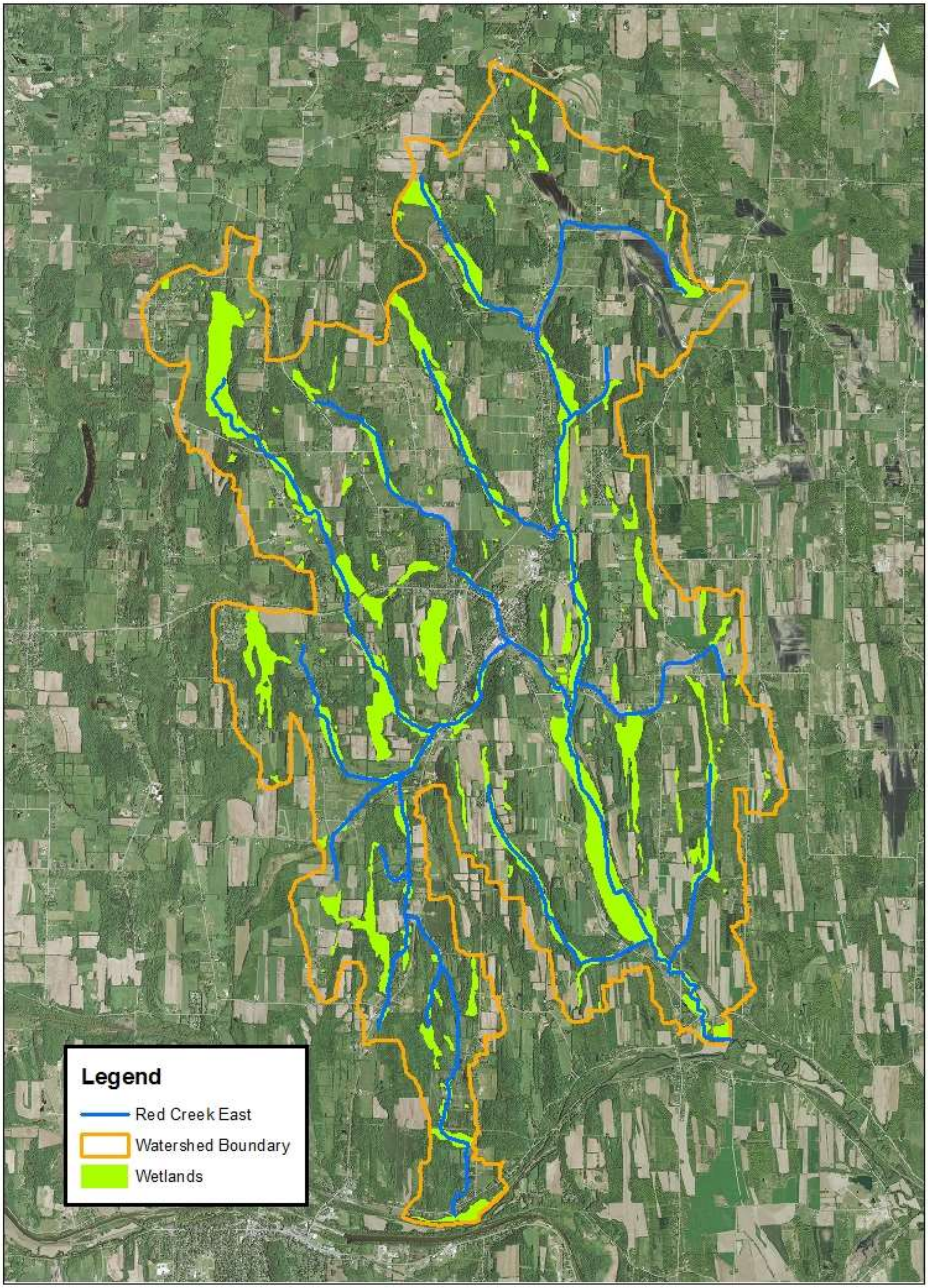
This segment includes the entire stream and all tribs. The waters of the stream are Class C/D. Tribs to this reach/segment are also Class C/D.

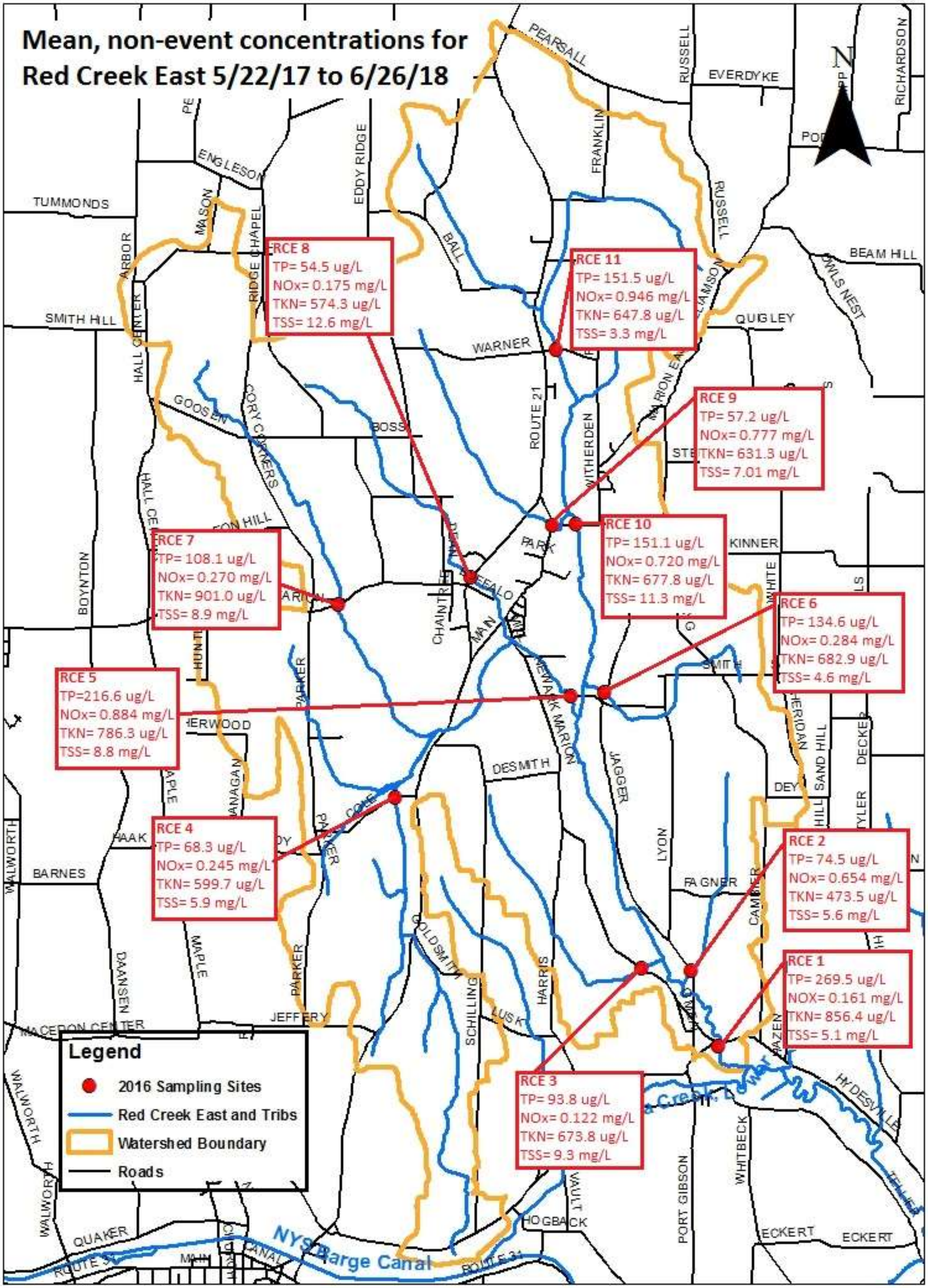
APPENDIX II. DETAILED MAPS




Hydrologic Soil Groups
Acres
%
HSG A 432 2%
HSG B 14231 65%
HSG C 3102 20%
HSG D 1190 1%
HSG A/D 527 6%
HSG B/D 1133 28%
HSG C/D 1095 20%
No HSG 40 2%
Ganargua Creek, Lower
NYS Barge Canal

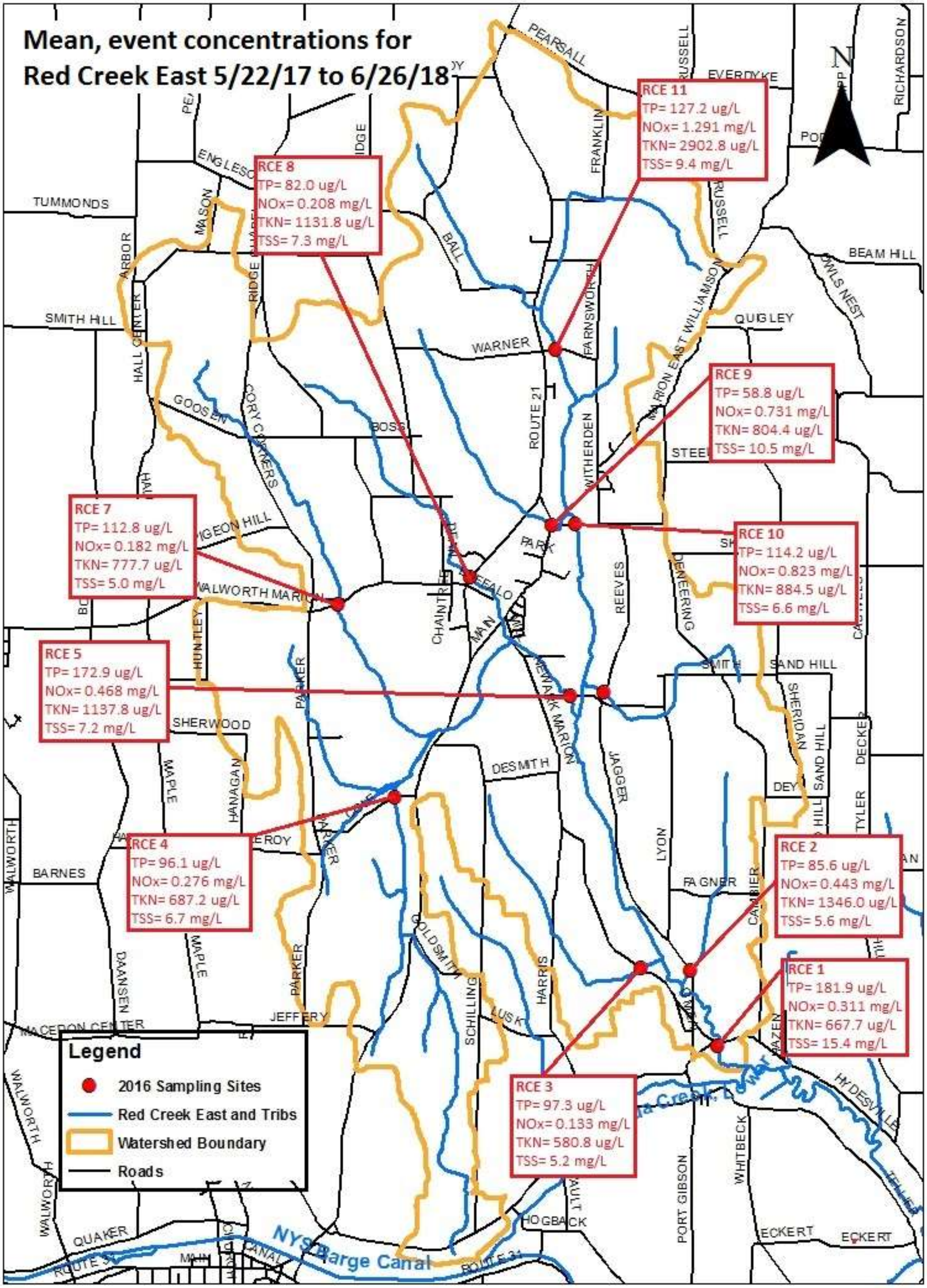

Land Use
Cropland
Low Density Residential
Forested
Medium Density Residential
Open Land
Hay/Pasture
Low Density Mixed Urban
N
Ganargua Creek, Lower
NYS Barge Canal


N
Legend
Red Creek East
Watershed Boundary
Wetlands



Mean, non-event concentrations for
Red Creek East 5/22/17 to 6/26/18
RCE 1
TP= 269.5 ug/L
NOX= 0.161 mg/L
TKN= 856.4 ug/L
TSS= 5.1 mg/L
RCE 2
TP= 74.5 ug/L
NOx= 0.654 mg/L
TKN= 473.5 ug/L
TSS= 5.6 mg/L
RCE 3
TP= 93.8 ug/L
NOx= 0.122 mg/L
TKN= 673.8 ug/L
TSS= 9.3 mg/L
RCE 4
TP= 68.3 ug/L
NOx= 0.245 mg/L
TKN= 599.7 ug/L
TSS= 5.9 mg/L
RCE 5
TP=216.6 ug/L
NOx= 0.884 mg/L
TKN= 786.3 ug/L
TSS= 8.8 mg/L
RCE 6
TP= 134.6 ug/L
NOx= 0.284 mg/L
TKN= 682.9 ug/L
TSS= 4.6 mg/L
RCE 7
TP= 108.1 ug/L
NOx= 0.270 mg/L
TKN= 901.0 ug/L
TSS= 8.9 mg/L
RCE 8
TP= 54.5 ug/L
NOx= 0.175 mg/L
TKN= 574.3 ug/L
TSS= 12.6 mg/L
RCE 9
TP= 57.2 ug/L
NOx= 0.777 mg/L
TKN= 631.3 ug/L
TSS= 7.01 mg/L
RCE 10
TP= 151.1 ug/L
NOx= 0.720 mg/L
TKN= 677.8 ug/L
TSS= 11.3 mg/L
RCE 11
TP= 151.5 ug/L
NOx= 0.946 mg/L
TKN= 647.8 ug/L
TSS= 3.3 mg/L
Legend
2016 Sampling Sites
Red Creek East and Tribs
Watershed Boundary
Roads
N
PEARSALL
RUSSELL
EVERDYKE
RICHARDSON
ENGLESON
EDDY RIDGE
FRANKLIN
TUMMONDS
MASON
RIDGE CHAPEL
ARBOR
BALL
BEAM HILL
OWLS NEST
SMITH HILL
HALL CENTER
WARNER
QUIGLEY
GOOSEN
CORY CORNERS
BOSS
ROUTE 21
WITHERDEN
PARK
KINNER
BOYNTON
CHAINTREE
MAIN
PARKER
SMITH
NEWARK MARION
DESMITH
JAGGER
DEY
SAND HILL
DECKER
TYLER
WALWORTH
BARNES
LYON
FAGNER
GOLDSMITH
MAPLE
DAANSEN
SCHILLING
HARRIS
LUSK
JEFFERY
WHITBECK
HYDESVILLE
VAULT
HOGBACK
PORT GIBSON
ECKERT
QUAKER
MAIN
CANAL
NYS Barge Canal
ROUTE 31

Mean, event concentrations for Red Creek East 5/22/17 to 6/26/18



APPENDIX III. WATER QUALITY DATA

Non-event Concentrations for Red Creek East

17RCE01					
Date	TP (µg P/L)	TN (µg N/L)	Nitrate (µg N/L)	TKN (µg P/L)	TSS (mg/L)
6/2/2017	189	944	144	800	3.7
6/15/2017	412.8	1089	274	815	3.2
7/20/2017	308.4	1470	118	1352	2.4
8/3/2017	286.6	857	119	735	2.7
8/30/2017	253.4	770	117	653	5.7
4/18/2018	47.3	1020	355	665	2.7
5/23/2018	232	1070	91	979	17
6/26/2018	426.6	923	71	852	3.3

17RCE02					
Date	TP (µg P/L)	TN (µg N/L)	Nitrate (µg N/L)	TKN (µg P/L)	TSS (mg/L)
6/2/2017	48	1198	547	651	1.9
6/15/2017	77.9	808	493	315	4.9
7/20/2017	111.3	1344	886	458	1.7
8/3/2017	117.3	1027	613	414	4.5
8/30/2017	N/A	N/A	N/A	N/A	N/A
4/18/2018	17.1	1430	1070	360	1.8
5/23/2018	75.3	955	312	643	18.7
6/26/2018	N/A	N/A	N/A	N/A	N/A

17RCE03					
Date	TP (µg P/L)	TN (µg N/L)	Nitrate (µg N/L)	TKN (µg P/L)	TSS (mg/L)
6/2/2017	104.7	676	18.95	657	2
6/15/2017	145.3	1039	104	935	16.6
7/20/2017	101.4	758	121	637	4.2
8/3/2017	108.4	647	122	525	17.8
8/30/2017	N/A	N/A	N/A	N/A	N/A
4/18/2018	24.3	814	319	495	2.5
5/23/2018	78.6	842	48	794	12.4
6/26/2018	N/A	N/A	N/A	N/A	N/A

17RCE04					
Date	TP (µg P/L)	TN (µg N/L)	Nitrate (µg N/L)	TKN (µg P/L)	TSS (mg/L)
6/2/2017	42.2	1119	236	883	2.2
6/15/2017	64.1	907	356	551	4.8
7/20/2017	76.6	904	326	637	4.2
8/3/2017	76.8	670	252	418	11.3
8/30/2017	21.6	457	87	370	3.5
4/18/2018	28.2	936	364	572	2.5
5/23/2018	168.6	920	94	826	7.2
6/26/2018	N/A	N/A	N/A	N/A	N/A

Non-event Concentrations for Red Creek East

17RCE05					
Date	TP (µg P/L)	TN (µg N/L)	Nitrate (µg N/L)	TKN (µg P/L)	TSS (mg/L)
6/2/2017	133.3	1455	709	746	6.4
6/15/2017	203.4	1297	793	504	24.8
7/20/2017	101.4	2288	645	1643	5.2
8/3/2017	313.2	1296	1607	N/A	5.6
8/30/2017	420.5	1600	1186	414	2.9
4/18/2018	48.0	994	382	612	3.4
5/23/2018	155.3	1290	335	955	17.7
6/26/2018	357.4	2040	1410	630	4.2

17RCE06					
Date	TP (µg P/L)	TN (µg N/L)	Nitrate (µg N/L)	TKN (µg P/L)	TSS (mg/L)
6/2/2017	88.3	904	154	750	2.5
6/15/2017	234.5	925	337	588	4.5
7/20/2017	66.7	1111	449	662	3.5
8/3/2017	160.2	964	399	565	4.3
8/30/2017	88.8	575	237	338	2.9
4/18/2018	66	967	328	639	3.0
5/23/2018	143.6	1190	134	1056	8.5
6/26/2018	228.6	1100	235	865	7.4

17RCE07					
Date	TP (µg P/L)	TN (µg N/L)	Nitrate (µg N/L)	TKN (µg P/L)	TSS (mg/L)
6/2/2017	62.9	979	80	899	2.8
6/15/2017	112.3	1032	244	788	23.8
7/20/2017	166.6	1648	281	1367	8.5
8/3/2017	151.4	1470	356	1114	9.4
8/30/2017	139.7	1000	492	508	12.7
4/18/2018	23	818	190	628	1.8
5/23/2018	93.6	1100	122	978	6.7
6/26/2018	115.6	1320	394	926	5.4

17RCE08					
Date	TP (µg P/L)	TN (µg N/L)	Nitrate (µg N/L)	TKN (µg P/L)	TSS (mg/L)
6/2/2017	28.9	742	18.95	723.05	2.3
6/15/2017	102.4	690	101	589	21.0
7/20/2017	43.2	740	232	508	8.4
8/3/2017	40.0	703	162	541	4.6
8/30/2017	57.8	454	205	249	21.1
4/18/2018	43.1	858	265	593	4.3
5/23/2018	70.3	884	89	795	29.9
6/26/2018	50.4	920	324	596	9.2

Non-event Concentrations for Red Creek East

17RCE09					
Date	TP (µg P/L)	TN (µg N/L)	Nitrate (µg N/L)	TKN (µg P/L)	TSS (mg/L)
6/2/2017	24.1	1369	848	521	2.5
6/15/2017	104	1651	1175	476	23.6
7/20/2017	87.4	1657	1212	445	6.1
8/3/2017	43.3	1774	186	1588	5.2
8/30/2017	19.0	870	588	282	1.5
4/18/2018	17.8	965	526	439	2.3
5/23/2018	118.6	1380	561	819	11.5
6/26/2018	43.6	1600	1120	480	3.4

17RCE010					
Date	TP (µg P/L)	TN (µg N/L)	Nitrate (µg N/L)	TKN (µg P/L)	TSS (mg/L)
6/2/2017	147.4	1871	994	877	8.6
6/15/2017	224.5	1566	814	752	30.7
7/20/2017	126.9	1453	842	611	6.2
8/3/2017	202.9	1238	501	737	22.7
8/30/2017	120.8	1150	704	446	5
4/18/2018	57	1520	856	664	1.9
5/23/2018	153.6	1170	339	831	12.2
6/26/2018	175.5	1210	706	504	2.7

17RCE010					
Date	TP (µg P/L)	TN (µg N/L)	Nitrate (µg N/L)	TKN (µg P/L)	TSS (mg/L)
6/2/2017	152.4	2735	1621	1114	3.9
6/15/2017	141.8	2004	1621	383	2.5
7/20/2017	160.8	1472	980	492	0.7
8/3/2017	191.5	989	469	520	1.4
8/30/2017	97.3	498	148	350	0.8
4/18/2018	116.4	1990	1340	650	1.8
5/23/2018	126.9	1550	618	932	14.1
6/26/2018	224.8	1510	769	741	1.4

Event Concentrations for Red Creek East

17RCE01					
Date	TP (µg P/L)	TN (mg N/L)	Nitrate (mg N/L)	TKN (µg P/L)	TSS (mg/L)
5/22/2017	117.0	0.822	0.254	568	2.5
7/14/2017	280.7	1.291	0.755	536	75.4
9/6/2017	57.8	1.160	0.113	1047	3.1
10/30/2017	155.3	0.722	0.217	505	5.3
3/28/2018	48.5	1.150	0.410	740	2.4
6/26/2018	431.9	1.170	0.115	1055	3.6

17RCE02					
Date	TP (µg P/L)	TN (mg N/L)	Nitrate (mg N/L)	TKN (µg P/L)	TSS (mg/L)
5/22/2017	38.4	0.665	0.258	407	3.4
7/14/2017	116.2	5.849	0.375	5474	6.4
9/6/2017	96.6	0.751	0.390	361	4.3
10/30/2017	195.7	0.937	0.513	424	15.7
3/28/2018	28.8	1.050	0.610	440	2.2
6/26/2018	97.8	1.480	0.510	970	1.3

17RCE03					
Date	TP (µg P/L)	TN (mg N/L)	Nitrate (mg N/L)	TKN (µg P/L)	TSS (mg/L)
5/22/2017	86.1	0.472	0.019	453	6.7
7/14/2017	142.0	0.545	0.082	463	7.8
9/6/2017	106.5	0.936	0.034	902	1.9
10/30/2017	58.8	0.633	0.327	306	6.6
3/28/2018	27.2	0.554	0.259	295	2.0
6/26/2018	162.9	0.114	0.074	1066	5.9

17RCE04					
Date	TP (µg P/L)	TN (mg N/L)	Nitrate (mg N/L)	TKN (µg P/L)	TSS (mg/L)
5/22/2017	31.3	0.646	0.209	437	3.0
7/14/2017	109.6	0.914	0.183	731	7.8
9/6/2017	71.4	0.710	0.102	608	3.5
10/30/2017	278.2	0.967	0.440	527	13.1
3/28/2018	17.4	1.110	0.506	604	6.4
6/26/2018	68.7	1.430	0.214	1216	4.3

17RCE05					
Date	TP (µg P/L)	TN (mg N/L)	Nitrate (mg N/L)	TKN (µg P/L)	TSS (mg/L)
5/22/2017	110.6	1.333	0.736	597	2.8
7/14/2017	169.1	1.410	0.421	989	8.3
9/6/2017	223.4	0.674	0.691	N/A	6.8
10/30/2017	N/A	0.960	0.373	587	17.5
3/28/2018	56.6	1.050	0.465	585	1.2
6/26/2018	304.7	3.050	0.116	2934	6.5

17RCE06					
Date	TP (µg P/L)	TN (mg N/L)	Nitrate (mg N/L)	TKN (µg P/L)	TSS (mg/L)
5/22/2017	65.5	0.904	0.369	535	2.0
7/14/2017	31.7	0.976	0.267	709	5.7
9/6/2017	203.8	1.240	0.126	1114	6.6
10/30/2017	190.8	1.100	0.424	676	34.9
3/28/2018	71.4	0.874	0.369	505	3.4
6/26/2018	174.9	1.430	0.205	1225	6.3

Event Concentrations for Red Creek East Cont.

17RCE07					
Date	TP (µg P/L)	TN (mg N/L)	Nitrate (mg N/L)	TKN (µg P/L)	TSS (mg/L)
5/22/2017	62.9	0.706	0.093	613	1.2
7/14/2017	135.4	1.075	0.151	924	6.9
9/6/2017	139.1	1.130	0.266	864	8.3
10/30/2017	200.5	0.849	0.141	708	8.2
3/28/2018	27.2	0.755	0.222	533	1.5
6/26/2018	111.5	1.240	0.216	1024	3.8

17RCE08					
Date	TP (µg P/L)	TN (mg N/L)	Nitrate (mg N/L)	TKN (µg P/L)	TSS (mg/L)
5/22/2017	46.8	1.202	0.243	959	2.9
7/14/2017	66.0	3.079	0.227	2852	8.0
9/6/2017	74.4	1.220	0.090	1130	5.0
10/30/2017	209.5	0.731	0.181	550	12.8
3/28/2018	48.5	0.707	0.255	452	12.7
6/26/2018	46.5	1.100	0.252	848	2.2

17RCE09					
Date	TP (µg P/L)	TN (mg N/L)	Nitrate (mg N/L)	TKN (µg P/L)	TSS (mg/L)
5/22/2017	18.4	1.218	0.915	303	1.6
7/14/2017	97.7	2.560	0.885	1675	24.9
9/6/2017	57.8	N/A	1.239	N/A	11.9
10/30/2017	57.8	0.909	0.217	692	15.5
3/28/2018	38.6	1.030	0.508	522	3.0
6/26/2018	82.4	1.450	0.620	830	6.1

17RCE010					
Date	TP (µg P/L)	TN (mg N/L)	Nitrate (mg N/L)	TKN (µg P/L)	TSS (mg/L)
5/22/2017	96.1	1.480	1.174	306	4.7
7/14/2017	120.2	2.704	0.663	2041	7.5
9/6/2017	107.8	1.590	0.695	895	7.6
10/30/2017	96.6	1.560	0.942	618	13.0
3/28/2018	55.0	1.330	0.819	511	2.9
6/26/2018	209.3	1.580	0.644	936	4.0

17RCE010					
Date	TP (µg P/L)	TN (mg N/L)	Nitrate (mg N/L)	TKN (µg P/L)	TSS (mg/L)
5/22/2017	61.0	2.334	2.031	303	1.4
7/14/2017	173.0	14.066	1.166	12900	20.1
9/6/2017	117.3	1.050	0.218	832	2.8
10/30/2017	106.5	3.840	2.950	890	24.7
3/28/2018	123.7	1.830	0.395	1435	4.7
6/26/2018	181.9	2.040	0.983	1057	2.9