SEGMENT ANALYSIS OF
Oatka Creek

The Location of Sources of Pollution

Wyoming and Genesee Counties

Joseph C. Makarewicz and Theodore W. Lewis

Center for Applied Aquatic Science and Aquaculture
Department of Environmental Science and Biology, State University of New York at Brockport
Funded by the Soil and Water Conservation Districts of Genesee and Wyoming Counties

August 2004

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SUMMARY

Oatka Creek flows approximately 58 miles and drains approximately 215 square miles (557 km^2) of Wyoming, Genesee, Livingston and Monroe counties of western New York State. The 2002 Oatka Creek "State of the Basin Report" recommended water quality monitoring during non-event and precipitation events to further identify sources of pollution. The Soil and Water Conservation Districts of Wyoming and Genesee Counties contracted with the Water Quality Laboratory at SUNY Brockport to systematically identify, during baseline and hydro-meteorological events, the sources of nutrients, soils and salts within the Oatka Creek watershed. With this report, we provide evidence based on 188 samples taken during eight sampling days that suggest the location and the intensity of pollution sources in the Oatka Creek watershed. The following sources of nutrient and soil loss from non-point and point sources are suggested. Detailed evaluations may be found in the "Results" section of this report.

- **Headwater stream of Oatka Creek (Warner Creek - Site 1 and upstream, Fig. 1):** Elevated levels of phosphorus (soluble reactive and total phosphorus), total Kjeldahl nitrogen and total suspended solids were observed on 23 September 2003. Subsequently, additional sampling sites were added to further characterize the sources in this reach of Oatka Creek. There was a source of total phosphorus, nitrate, total Kjeldahl nitrogen and total suspended solids between sites 1B/C on Oatka Road downstream to site 1A on Mungers Mills Road. In addition, a source of soluble reactive phosphorus was found between site 1A downstream to site 1 on Evans Road. The sources were attributed to agricultural operations in those areas.

- **Stony Creek (Sites 6 to 7):** The area of Stony Creek from site 6 on Liberty Street in Warsaw upstream to site 7A on Hermitage Road contained several areas that were sources of nutrients and soil to Oatka Creek. The entire area is dominated by agriculture including dairy operations and row crop farming. There were sources of nutrients identified between Hermitage Road (site 7A) and Route 20A (site 7), between Route 20A and Dick Road (site 6B) and between Dick Road and Buck Road (site 6A). Losses of total phosphorus, soluble reactive phosphorus, total Kjeldahl nitrogen, nitrate and total suspended solids were observed.

- **The Warsaw Sewage Treatment Plant (Fig. 1)** is a point source of nutrients to Oatka Creek. Sampling above (upstream) and below (downstream) the sewage treatment plant at Warsaw, NY indicated that major increases in SRP (71% increase), TP (188% increase), nitrate (30% increase) and TKN (27% increase) occurred within a few hundred feet of its discharge.

- **The Pearl Creek sub-watershed (site 12A Cluster, Fig. 1)** is a source of nitrate and total Kjeldahl nitrogen to Oatka Creek. The area between Taylor Road (site 12C) and Old

State Road (12B1) was identified as a source of nitrate during one event on 27 October 2003 and a source of total Kjeldahl nitrogen, soluble reactive phosphorus, total phosphorus and total suspended solids during the 21 May 2004 event. There is a cattle operation in the small reach between site 12C downstream to site 12B1. During this same event, nitrate increased 170% from site 12D1 on LaGrange Road (0.43 mg N/L) downstream to site 12D on Morrow Road (1.16 mg N/L). Nitrate increased 170% from site 12D1 on LaGrange Road (0.43 mg N/L) downstream to site 12D on Morrow Road (1.16 mg N/L) on 21 May 2004. The land use in this area is predominantly agriculture.

- **The area between sites 12 on Route 19 and 13 on Crossman Road** (Fig. 1) is an area of intense agriculture. Manure, as well as cows having access to Oatka Creek, was observed on tilled land. Results from the water quality testing show that this area possessed sources of soluble reactive phosphorus, total phosphorus, total Kjeldahl nitrogen, nitrate and total suspended solids.

- **The LeRoy sewage treatment plant** is a source of nutrients to Oatka Creek. On 27 October 2003, for example, nutrient levels increased from just upstream to just downstream the discharge pipe by the following amount: total phosphorus (450% increase), nitrate (34% increase) and total Kjeldahl nitrogen (221% increase).

- **The Oatka Trail (sites 24 through 27, Fig. 1):** In the Oatka Trail area, the ditch (site 25B) along Gully Road flows into the flood plain of Oatka Creek. The ditch receives surface runoff, as well as subsurface drainage from the area above Gully Road. On Gully Road, there are three major cattle operations that may be source(s) of nutrients. The remarkably high concentrations at site 25B are evident when compared to the main stem of Oatka Creek at the upstream site 25A. For example on 2 April 2004, total phosphorus was 2,420.6 µg P/L at site 25B versus 29.0 µg P/L at site 25A (similarly, SRP 359.0 versus 4.6 µg P/L, nitrate 10.49 versus 3.80 mg N/L, TKN 6,020 versus 500 µg N/L, TSS 483.8 versus 7.2 mg/L). Throughout the entire study, site 25B had the highest concentrations observed for nitrate (29.52 mg N/L), TKN (6,020 µg N/L), TP (2,420.6 µg P/L), TSS (483.8 mg/L). The high concentrations observed at site 25B, however, were not translated as having a major impact on the main stem of Oatka Creek during sampling. The much higher volume of the main steam of the Oatka dilutes the high levels of nutrients observed in the site 25B ditch. Also, the wetlands between site25B and the main creek may remove nutrients from the 25B tributary before it reaches Oatka Creek. However, during the flash flood event of 21 May 2004, it was evident that the ditch (site 25B) had overflowed its banks and ran directly into Oatka Creek. Undoubtedly, this event sent a large slug of polluted water into Oatka Creek.

  Other high concentrations of note on the Oatka Trail occurred in the small tributary sampled at site 24 which had a nitrate concentration of 9.07 mg N/L on 2 April 2004 and a TKN concentration of 1100 on 21 May 2004.

- **The area between sites 15 and 16 (Fig . 1)**. During the first sampling event on 17 September 2003, soluble reactive phosphorus increased between sites 15 and 16. This may have been an anomaly, as that magnitude of increase has not been repeated.

- **Tributary in Pavilion, NY:** A small tributary to Oatka Creek in Pavilion near site 14 was sampled on two dates. Site (14A) on Woodrow Road near the Town of Pavilion garage yielded higher nitrate (6.62 versus 2.02 mg N/L), TP (257.6 versus 213.6 µg P/L), SRP (57.3 versus 36.4 µg P/L), TKN (1,320 versus 1020 µg N/L) and sodium (40.50 versus 21.42 mg/L) concentrations on site 14 on the main branch of Oatka Creek on 2 April 2004. This tributary flows through the York Central School district property and behind residences along Route 63.

RECOMMENDATIONS

1. Likely locations of sources of elevated levels of nutrients and soil loss are identified. A visual inspection of these areas with landowners is suggested to pinpoint potential sources.
2. In general, control of water movement can be a means of significantly reducing non-point source pollution, whether it be nutrients or soil. Since water must come in contact with the nutrient or soil source and then be transported to the surface (or subsurface) water body, the nutrients in our streams and lakes are functions of land use practices, soil fertility and quantities of transporting water. Management practices, which reduce surface runoff, are recommended to decrease the magnitude of soil and chemical losses from land areas.
3. Identified point and non-point sources of nutrients and solids can be remediated using Best Management Practices (BMP). For example between sites 12 and 13 on Starr Road, cows appear to have access to the stream. Buffer strips near the stream and rotational grazing pens are examples of how these effects can be minimized. Also, it was quite clear that the location of farming operations between sites 12C and 12B1 are not properly contained as large losses of nutrients were observed during one event. Better education of members of the community on construction practices is warranted.
4. Farm and land management programs (e.g., Agricultural Environmental Management) already exist and are ably sponsored through county Soil and Water Conservation Districts and Cornell Cooperative Extension. Efforts, if not already in place, should be made to contact and implement existing programs to reduce/remediate areas identified in this study.
5. Two different sewage treatment plants (Leroy and Warsaw) clearly are delivering elevated levels of nutrients, especially phosphorus and nitrates, to Oatka Creek. Although these STPs are functioning within current guidelines, they will, with expanding human population, contribute a larger amount of nutrients to a creek of finite assimilatory capacities. An open discussion, workshop format, on the impacts of these STPs might be useful.

INTRODUCTION

Oatka Creek flows approximately 58 miles and drains approximately 215 square miles (557 km^2) of Wyoming, Genesee, Livingston and Monroe counties of western New York State (Figure 1). Oatka Creek discharge is continuously monitored at the USGS (United States Geological Survey) stations in the City of Warsaw in the southern portion of the watershed and in the Hamlet of Garbutt in the northern section of the watershed. An excellent consolidation and review of monitoring history of the Oatka Creek basin is presented in the "State of the Basin Report" (Tatakis 2002). Benthic macroinvertebrate populations, which are often used to assess the 'health' of a stream, suggest that lower portions (downstream of LeRoy) of Oatka Creek are "slightly impacted" by undefined sources of pollution (Tatakis 2002). Elevated levels of nitrate and nitrite, total suspended solids and total phosphorus especially during runoff events suggest possible sources of non-point pollution on Oatka Creek near Garbutt, NY (Tatakis 2002). Two of the several recommendations of the "State of the Basin Report" include water quality sampling throughout the year and during both baseline and elevated stream level conditions. The Soil and Water Conservation Districts of Wyoming and Genesee Counties contracted with the Water Quality Laboratory at SUNY Brockport to systematically identify the sources of nutrients, soils and salts during baseline and hydrometeorlogical events within the Oatka Creek watershed. To accomplish this, point and non-point sources were identified through a process called stressed stream analysis or segment analysis (Makarewicz 1999). With this report, we provide evidence based on 188 samples taken on eight different days that suggest the location and the intensity of pollution sources in the Oatka Creek watershed.

The Segment Analysis Approach:

Point and non-point sources of nutrients, soils and salts within a watershed may be identified through a process called "segment analysis" or in its fullest development "stressed stream analysis" (Makarewicz 1999). Stressed stream analysis is an integrative, comprehensive approach for determining the environmental health of a watershed and its constituent streams. Within a sub-watershed, stressed stream analysis is an approach for determining how and where a stream and its ecological community are adversely affected by a pollution source or other disturbances. It is a technique that identifies the sources, extent, effects and severity of pollution in a watershed. In its fullest use, it combines elements of the sciences of hydrology, limnology, ecology, organismal biology and genetics in an integrated approach to analyze cause and affect relationships in disturbed stream ecosystems.

Within a sub-watershed, the stream is used to monitor the "health" of the watershed. Because nutrients are easily transported by water, they can be traced to their source by systematic geographic monitoring of the stream. Segment analysis is a technique that divides the impacted sub-watershed into small distinct geographical units. Samples are taken at the beginning and end of each unit of the stream to determine if a nutrient source occurs within that reach. For example, high levels of a nutrient at the down-stream portion of a segment indicates a source within that segment. By systematically narrowing the size of the segment, a source can be identified. At completion, the cause and extent of pollution have been identified. If needed, the severity of the pollution within the impacted sub-watershed and or the entire watershed can then be evaluated by spatial analysis of the quantity and quality of biological indicators, such as fish and invertebrates, and by biological examination of structural and functional changes in individual organisms and populations in affected communities. Once identified, sources of chemical pollutants may be corrected using "Best Management Practices" (BMP). In this report, stressed stream analysis is limited to a spatial analysis of chemical sources of Oatka Creek. Examples of the successful application of the segment analysis process in identifying impacted sub-watersheds and their associated streams may be found in the following Makarewicz and Lewis (1993, 2000, 2001, 2001a, 2002, 2002a) and Makarewicz *et al*. (1994).

DEFINITIONS

Total Phosphorus (TP) - A measure of all forms of the element phosphorus. Phosphorus is an element required for plant growth on land or in water. In lakes, phosphorus is often the limiting factor of phytoplankton growth and is the cause of eutrophication, or overproduction, of lakes. Phosphorus may enter a watershed in soluble or organic form from several sources including sewage, heavy-duty detergents, fertilizer and agricultural waste. Some forms of phosphorus are more available to, and cause more immediate activity in, plants.

Soluble Reactive Phosphorus (SRP) - A measure of the most available and active form of phosphorus.

Nitrate + Nitrite (NO_3) - A measure of the soluble forms of nitrogen used readily by plants for growth. Sources of nitrates in the environment are many and include barnyard waste and fertilizer.

Total Kjeldahl Nitrogen (TKN) - The Kjeldahl method is a convenient method of analysis for nitrogen but cannot be used for all types of nitrogen compounds. It is, however, a good measure of organic nitrogen, including ammonia. Manure, for example, contains a large amount of organic nitrogen.

Sodium (Na) - A measure of the mineral, most commonly found as sodium chloride (NaCl), dissolved in water. NaCl naturally occurs in deep layers of local bedrock. Mined, it is stored and spread as a de-icing agent on roads and other pavements.

Total Suspended Solids (TSS)- A measure of the loss of soil and other materials suspended in the water from a watershed. Water-borne sediments act as an indicator, facilitator and agent of pollution. As an indicator, they add color to the water. As a facilitator, sediments often carry other pollutants, such as nutrients and toxic substances. As an agent, sediments smother organisms and clog pore spaces used by some species for spawning.

SAMPLING AND ANALYTICAL METHODS

Segment analysis was performed on eight dates on Oatka Creek (17 September, 23 September, 27 October, 20 November 2003, and 3 March, 2 April, 13 April and 21 May 2004). Sampling locations are shown on Figure 1. All samples were analyzed for nitrate, soluble reactive phosphorus, total phosphorus, total Kjeldahl nitrogen, sodium, and total suspended solids. During the initial stressed stream analysis on 17 September 2003, twenty-three stations were sampled under baseline conditions covering the major segments of the tributary (Figure 1, Table 2). The same stations were sampled on 23 September 2003 during a hydrometeorological event. On subsequent sampling dates, sampling was expanded in sub-watersheds or segments in which elevated levels of nutrients or soil were observed in the previous sampling efforts. All samples were generally taken within five hours. Specific locations of all sampling sites are shown in Figures 2-49 with road and latitude and longitude presented in Table 2.

All sampling bottles were pre-coded so as to ensure exact identification of the particular sample. All sample bottles were routinely cleaned with phosphate free RBS between sampling dates. Containers were rinsed prior to sample collection with the water being collected. In general, all procedures followed EPA standard methods (1979) or Standard Methods for the Analysis of Water and Wastewater (APHA 1999). Sample water for dissolved nutrient analyses (SRP, nitrate + nitrite) was filtered immediately with 0.45-µm MCI Magna Nylon 66 membrane and either frozen or analyzed within 24 hours of collection.

Nitrate+Nitrite: Dissolved nitrate+nitrite nitrogen was performed by the automated (Technicon autoanalyser) cadmium reduction method (APHA 1999).

Soluble Reactive Phosphorus: Sample water was filtered through a 0.45-µm membrane filter. The filtrate was analyzed for orthophosphate using the automated (Technicon) colorimetric ascorbic acid method (APHA 1999). The formation of the phosphomolybdeum blue complex was read colorimetrically at 880nm.

Total Phosphorus: The persulfate digestion procedure was used prior to analysis by the automated (Technicon autoanalyser) colorimetric ascorbic acid method (APHA 1999).

Total Kjeldahl Nitrogen: Analysis was performed using a modification of the Technicon Industrial Method 329-74W/B. The following modifications were made:

- In the sodium salicylate-sodium nitroprusside solution, sodium nitroprusside was increased to 0.4 gm/L.
- The reservoir of the autoanalyser was filled with 2M H_2SO_4 instead of distilled water.
- Other reagents were made fresh prior to analysis.

Sodium: Sodium analysis was performed by Atomic Absorption Spectrophotometry (APHA 1999).

Total Suspended Solids: APHA (1999) Method 2540D was employed for this analysis.

QUALITY CONTROL

The Water Chemistry Laboratory at SUNY Brockport is certified through the New York State Department of Health's Environmental Laboratory Approval Program (ELAP - # 11439). This program includes bi-annual proficiency audits, annual inspections and good laboratory practices documentation of all samples, reagents and equipment (Table 1).

RESULTS

Chronological Account of Stressed Stream Analysis:

17 September 2003 (Figures 2-7, Table 3)

The initial sampling event occurred during baseline conditions of 17 September 2003. The purpose was to initiate the program and to determine the variability of nutrient concentrations along the major sections of Oatka Creek. Twenty-three stations were sampled in the Oatka Creek watershed and results are presented in Table 2 and Figures 2-7. The headwater stations (sites 1 through 5) sampled in Oatka Creek, south of Warsaw, were all relatively low in nutrients and soil loss. Stony Creek was sampled at site 6 on Liberty Street and showed elevated levels of soluble reactive phosphorus (36.2 µg/L) and total phosphorus (39 µg/L) but not other analytes. Both forms of phosphorus had a lower concentration upstream from site 6 at site 7 on Stony Creek at Route 20 indicating that the source of phosphorus observed at Site 6 is between these two sites.

It the mile between site 8 on Court Street in Warsaw and site 9 on Buffalo Road, a major source on nutrients in that reach of Oatka Creek was evident. Soluble reactive phosphorus (SRP) increased over 3800% between sites 8 and 9, while total phosphorus (TP) and nitrate increased over 1600% and 50%, respectively. Total phosphorus and perhaps soluble reactive phosphorus concentrations appeared to be elevated the entire length of Oatka Creek downstream of site 9. The sewage treatment plant (STP) for the City of Warsaw is located in this segment of stream.

SRP, but not total phosphorus, increased from 24.4 µg P/L at site 12 to 105.4 µg P/L at site 13 and to 140.8 µg P/L at site 14. Soluble reactive phosphorus increased >100% between site 15 (25.7 µg P/L) and site 16 (52.9 µg P/L). SRP also increased 997% from site 21A to site 21B while TP increased 143% between the same two stations. The sewage treatment plant for the Village of Leroy is located in this segment.

Concentrations of nitrate varied from a low of 0.51 mg N/L near the headwaters (site 5) of Oatka Creek to levels generally around 1.30 to 1.60 mg N/L. The highest concentration of nitrate (3.97 mg N/L) during non-event conditions on 17 September 2003 was found at Site 12A on Pearl Creek.

Total Kjeldahl nitrogen (TKN) concentrations (Fig. 5) were low in the headwaters (e.g., 360 µg N/L at Site 2) of Oatka Creek and generally increased downstream. However, there was a 77% increase in TKN from site 9A on Route 19 north of Warsaw to site 10. Total suspended solids (TSS) and sodium, an indicator of salt, were generally low in the headwaters of Oatka Creek variable but generally increasing downstream (Figs. 6 and 7). Total suspended solids increased from 4.9 to 29.5 mg/L, an increase of >500%, from site 10 to site 12 suggesting a source of soil loss within the segment.

23 September 2003 (Figures 8-13, Table 4)

With the exception of sites 21B and 18 (no flow), the one-inch rain event of 22 September 2003 sampled the same twenty-three stations as on 17 September. In general, sources of nutrients were similar to patterns observed on the 17 September 2003. The headwaters of Oatka Creek were once again low in nutrients and soil loss with the exception of site 1. Here elevated levels of total phosphorus (TP), soluble reactive phosphorus (SRP), total Kjeldahl nitrogen and total suspended solids (TSS) were observed compared to other headwater sites. This suggests a source above site 1.

As on 17 September, site 6 (Stony Creek) had elevated levels of total phosphorus, soluble reactive phosphorus and total Kjeldahl nitrogen (TKN) compared to the headwater stations (sites 1 through 5). Further downstream, there was a major source of nutrients in the segment of Oatka Creek between site 8 on Court Street in Warsaw and site 9 on Buffalo Road. Soluble reactive phosphorus (SRP) increased from 12.4 µg P/L at site 8 to 85.6 µg P/L at site 9 (Figure 9), while total phosphorus (TP) and nitrate increased 303% and 86%, respectively. The phosphorus increases were not as dramatic as the baseline samples taken on 17 September 2003 suggesting that there may be a dilution of the source due to precipitation. This may indicate a point rather than a non-point source as the cause. The City of Warsaw sewage treatment plant is located in this segment.

Similar to 17 September 2003, SRP increased from 53.3 µg P/L at site 12 to 71.0 µg P/L at site 13 but unlike the previous sampling date, levels decreased slightly to site 14.

Once again, the highest concentration of nitrate (2.16 mg N/L) and elevated levels of total Kjeldahl nitrogen (610 µg/L) were found at Site 12A on Pearl Creek on Route 19 (Figure 10 and 11). A source of nitrate and TKN exists in this sub-watershed. An increase of 135% in TKN levels also occurred from site 16 to 19 (Figure 11). Levels continued to increase slightly northward to sites 20 and 21 near LeRoy.

27 October 2003 (Figure 14-19, Table 5)

Additional sample sites were added in response to segments previously identified as potential sources of nutrients and soil during the rain event (0.66 inches Warsaw) of 24 October 2003. Sample sites were added 100 feet above (upstream) and below (downstream) the discharges of the sewage treatment plants (STP) in Warsaw and Leroy as a result of elevated levels observed in segments containing the STP. Results of 27 October 2003 indicated that the STP in Warsaw was a source of SRP (71% increase), TP (188% increase), nitrate (30% increase) and TKN (27% increase) to Oatka Creek. The sewage treatment plant in the Town of Leroy was a source of TP (450% increase), nitrate (34% increase) and TKN (221% increase) to Oatka Creek on 27 October 2003.

Site 6A was added on Buck Road between sites 6 and 7. The source of nutrients (SRP – 154% increase, TP – 94% increase, nitrate – 33% increase and TKN – 37% increase) in this segment of Stony Creek on 27 October 2003 was between site 6A and site 7 on Route 20. An additional site will be added to further pinpoint the source.

Two additional sites (12B and 12C) were added on Pearl Creek (site 12A) to further pinpoint the source of nitrate in that stream. Results from 27 October 2003 indicated that the major source of nitrate in this segment was between site 12C on Taylor Road (0.88 mg N/L) and Site 12B on Silver Lake Road (2.64 mg N/L). A farm with cattle is located just downstream from the Taylor Road site (site 12C). Elevated TKN and total suspended solids in this segment was probably due to agricultural practices in the area.

As on previously sampling dates, both total phosphorus and soluble reactive phosphorus increased between sites 12 and 13 once again. A large cattle operation exists on Starr Road where animals are allowed access to the stream and where manure is spread over land with no cover crops (Photo 1 and 2).

20 November 2003 (Figures 20-25, Table 6)

A heavy rain (1.39 inches at Warsaw, NY) on 19 November 2003 prompted a sampling event on 20 November 2003. An additional site (6B) was added between sites 6A and 7 on Stony

Photo 1. Agricultural field adjacent to Oatka Creek and Starr Road.

Photo 2. Agricultural operation adjacent to Starr Road and Oatka Creek. The creek is located along the tree line behind the cows.

Creek, site 6B is on Dick Road. Results suggest that the majority of the soluble reactive phosphorus entered the stream between site 7 and site 6B. Total Kjeldahl nitrogen was elevated along the entire segment of Stony Creek. The highest levels were observed above site 7 (1,570 µg N/L) (Figure 23). Further sampling upstream of site 7 is required.

An increase in phosphorus (TP and SRP) from site 12 to site 13 was not observed as in previous events. However, there was an increase in TKN (9% increase), nitrate (88% increase) and total suspended solids (80% increase) from site 12 to 13. The increase in nitrate observed from sites 12 to 13 appeared to be caused by water from Pearl Creek, which enters upstream of site 13.

Nitrate was high once again on Pearl Creek (sites 12A – 4.82 mg N/L, 12B – 3.55 mg N/L and 12C – 5.07 mg N/L). However, the highest concentration of nitrate on 20 November 2003 was observed upstream of the farm identified as the source of nitrate on 27 October 2003. This may mean that there are multiple sources of nitrate in this reach of the stream. It is possible that the agricultural fields or a silage storage area upstream from site 12C are the source. Further investigation is warranted in this area.

Total suspended solids were elevated at several locations (sites 9, 12, 13-16 and 25).

Mud Creek, sampled at site 26, was running for the first time during this study. Elevated levels of nutrients were observed. This site will continue to be monitored.

3 March 2004 (Figures 26-31, Table 7)

Thirty-four sites were sampled during a snowmelt event on 3 March 2004. Sites were added upstream from Sites 1 and 7 as well as in the Site 12A cluster on Pearl Creek. A source of phosphorus, nitrogen and total suspended solids was discovered between Site 1B on Oatka Road and Site 1A on Mungers Mills Road. Within this reach of the stream soluble reactive phosphorus increased 183%, total phosphorus increased 156%, total Kjeldahl nitrogen increased 24% nitrate increased 105% and total suspended solids increased 434%. Additional sites will be added in subsequent sampling events to further characterize this source.

The newly added site 7A on Hermitage Road clarified the sources previously found in this predominantly agricultural area of Oatka Creek. There was a source of total Kjeldahl nitrogen (680 to 830 µg N/L), nitrate (0.86 to 1.50 mg N/L), total suspended solids (29.3 to 46.5 mg/L) and total phosphorus (47.9 to 65.6 µg P/L) between site 7A and site 7 on Route 20A. The stream runs through a small farm in this segment. In the reach from site 7 to site 6B on Dick Road, soluble reactive phosphorus increased 200%, total phosphorus increased 51% and nitrate increased 24% due to the agricultural activity in this area. Nitrate and total Kjeldahl nitrogen continued to increase downstream from site 6B to site 6A on Buck Road.

Total suspended solids decreased by over a factor of two from site 9A to 10 as the creek overflowed its banks, and the velocity decreased allowing the suspended material to settle out.

The Pearl Creek area (site 12A cluster) was sampled heavily during this event. Between sites 12B on Silver Lake Road and site 12A on Route 19 (Photo 3), small increases in nitrate (19%) and TKN (18%) and large increases in TP (68%), SRP (49%) and TSS (405%) were observed.

Photo 3. Manure spread on bare ground in Site 12B cluster adjacent to Silver Lake and Old State Roads

There were also elevated concentrations of total Kjeldahl nitrogen (1,270 µg N/L), total phosphorus (109.5 µg P/L), nitrate (2.98 mg N/L) and total suspended solids (96.9 mg/L) at site 12E on Morrow Road. Additional sites will be added upstream of site 12E during the next event. Nitrate also increased from sites 12 D (1.98 mg N/L) and 12E downstream to site 12C (3.39 mg N/L), an area dominated by agricultural land use (Photo 4).

Photo 4. Agricultural land upstream from Site 12C.

The runoff and flooding of agricultural land adjacent to Site 13 on Crossman Road caused sizable increases of total suspended solids, total Kjeldahl nitrogen and total phosphorus (Photo 5).

Photo 5. Flooded agricultural land upstream from Site 13 on Crossman Road

Site 14 in Pavilion, as well as site 17 on Transit Road, had slightly elevated levels of nitrate and soluble reactive phosphorus.

The highest concentration of sodium (75.14 mg/L) observed during this study was observed at site 23 on 3 March 2004. Deicing salt that had accumulated in snow pack from adjacent Route 19 is the likely source.

2 April 2004 (Figures 32-37, Table 8)

A heavy rain event (1.04 inches at Warsaw, NY) prompted 23 sites to be sampled on 2 April 2004. Additional sites were sampled in the 1A area, the 12 D and12E area, the site 14 area, the 17 area and the area along the Oatka trail.

The source of phosphorus in the site 1A area has been isolated to the branches of Warner Creek between site 1A upstream to sites 1B and 1C. Additional reconnaissance of this agricultural area will be conducted.

In the site 12A cluster of Pearl Creek, additional samples were taken upstream of sites 12E and 12D. There was a source of nitrate between sites 12E1 (0.98 mg N/L) on LaGrange Road downstream to site 12E (6.62 mg N/L) on Morrow Road. As identified previously, the segment of Pearl Creek between site 12B and 12A contained a source of nitrate, total phosphorus, total Kjeldahl nitrogen, and total suspended solids.

An additional site was added on a tributary to Oatka Creek in Pavilion near site 14. That site (14A) on Woodrow Road near the Town of Pavilion garage yielded higher nitrate (6.62 vs. 2.02 mg N/L), TP (257.6 vs. 213.6 μg P/L), SRP (57.3 vs. 36.4 μg P/L), TKN (1320 vs. 1020 μg N/L) and sodium (40.50 vs. 21.42 mg/L) concentrations versus site 14 on the main branch of Oatka Creek. A source exists in this tributary.

In the site 17 (Transit Road) area, three additional sites were added: site 17A on Route 63, site 17B on Transit Road and site 17C on Route 20. In segments between sites 17A and B and site 17 significant increases of all parameters measured except nitrates were observed.

Site 25B, a ditch along Gully Road on the Oatka Trail (sites 25-27) had the highest concentrations of nitrate (29.52 mg N/L), total phosphorus (409.1 μg P/L), soluble reactive phosphorus (195.7 μg P/L) and sodium (183.3 mg/L) observed throughout the Oatka Creek watershed on 2 April 2004. However, concentrations in the main stem of Oatka Creek appear not to be affected downstream of site 25B. Discharge from site 25B was low compared to flow rates of the main tributary of Oatka Creek.

The small tributary sampled at site 24 had the second-highest nitrate concentration at 9.07 mg N/L. Additional investigation of the Oatka Trail will take place in future events.

13 April 2004 (Figures 38-43, Table 9)

The Oatka Trail area was sampled during a rain event (0.69 inches measured at Rochester, NY) on 13 April 2004. Site 25B, once again, proved to be an important source of nutrients to Oatka Creek. The site 25B tributary is a ditch that runs along Gully Road and into the flood plain of Oatka Creek. The tributary is comprised of surface runoff as well as a large percentage of subsurface drainage from the area above Gully Road. On Gully Road, there are three major cattle operations that may be the source of nutrients to the tributary. The high concentrations of nutrients observed at the site 25B ditch compared to the main branch of Oatka Creek at site 25A upstream was striking. For example, total phosphorus was 2,420.6 µg P/L at site 25B (ditch on Gully Road) versus 29.0 µg P/L at site 25A (main branch of Oatka Creek). Similar contrasts were obtained between site 25B versus site 25A for soluble reactive phosphorus (359.0 vs. 4.6 µg P/L), total suspended solids (483.8 vs. 7.2 mg/L), nitrate (10.49 vs. 3.80 mg N/L) and total Kjeldahl nitrogen (6,020 vs. 500 µg N/L). Despite the high concentrations found at site 25B, a measurable effect on the main branch of Oatka Creek was not observed. The volume of water flowing from the ditch is small compared to the flow in the main stem of Oatka Creek. Thus dilution of the high levels of nutrients observed in the ditch is likely. Also, the ditch at site 25B flows into a wetland before entering the main branch of Oatka Creek. Wetland plants can reduce nutrients concentrations in water by assimilation.

21 May 2004 (Figures 44-49, Table 10)

A full-scale segment analysis was undertaken during the height of the spring agricultural season on 21 May 2004 after 0.95 inches of rain (Warsaw, NY) to confirm sources that had been previously identified, to determine if additional sources were evident during a different season, and to expand sampling in targeted segments of the watershed.

Sources of nutrients and soil were confirmed in the site 1A and upstream area, the site 6 to 7 area, site 12A and upstream area, and the areas around the two sewage treatment plants. An additional site was added upstream from sites 14A in Pavilion to better understand the elevated levels observed on previous occasions.

A source of total phosphorus, nitrate, total suspended solids, and a minor source of total Kjeldahl nitrogen was confirmed in the site 1 area between site 1A and sites 1B and 1C. TP increased 69% from site 1B to 1A, while TP increased 165% from site 1C to 1A. Nitrate increased 225% from sites 1B and 1C downstream to site 1A. A cattle operation in this segment is the likely source of nutrients and soil loss in this segment of Oatka Creek (Photo 6). Also in this segment, there was a continued increase of soluble nutrients (SRP 32% increase, nitrate 127% increase) from site 1A downstream to site 1. There was evidence of tilled agricultural fields adjacent to the stream in this area (Photo 7).

Photo 6. Agricultural operation between sites 1B, 1C downstream to site 1A

Photo 7. Agricultural activity adjacent to stream at site 1

Two areas of the site 6 to site 7 cluster were re-confirmed as sources of nutrients to Oatka Creek. In the upper reaches of this cluster from site 7A downstream to site 7, nitrate increased 156% from 0.43 to 1.10 mg N/L while TKN increased a more modest 12%. Another source of nutrients in this cluster was from site 7 downstream to site 6B where SRP increased 141%, TP increased 47% and TKN increased 62% in this agricultural area.

Despite the large portion of agricultural land use in the Oatka Valley portion of the watershed (sites 9A to 10), the valley did not appear to be a major source of nutrients to downstream locations of Oatka Creek. With rising stream levels, the Oatka valley becomes a large flood plain where water velocity decreases as creek water spreads laterally. As a result, erosive action of the flowing water and soil loss is minimized. In addition, water overflowing its banks in the valley is trapped in a series of ponds that increase the residence time of the water after the stream recedes allowing siltation and thus reduction of suspended solids in the creek.

However, on the 21 May 2004 rain event, there were losses of nutrients and soil from the Oatka Valley of the watershed. Total phosphorus, total Kjeldahl nitrogen and total suspended solids, parameters often associated with soil loss, all increased more than 57% from site 9A downstream to site 10. We believe the high loss of soil and associated nutrients on this sampling day, and not previous sampling days, is a consequence of recently tilled land and the burst of heavy rain prior to this sampling day.

Further confirmation that the two sewage treatment plants were contributing nutrients to Oatka Creek on 21 May 2004 was obtained. In the segment of stream that contains the Warsaw STP, total phosphorus increased 84% and soluble reactive phosphorus increased 157% from 15.6 to 40.1 µg P/L. TP increased 48%, total Kjeldahl nitrogen increased 42% and SRP increased 249% in the reach of Oatka Creek that contains the Village of Leroy STP.

In the Pearl Creek (site 12A) cluster, several sources have been confirmed. Nitrate increased 170% from site 12D1 on LaGrange Road (0.43 mg N/L) downstream to site 12D on Morrow Road (1.16 mg N/L). The land use in this area is predominantly agriculture.

On 21 May 2004, TKN increased 84%, SRP increased 326%, TP increased 377% and TSS increased 891% between sites 12C and 12B1. The cattle operation in the small segment between site 12C downstream to site 12B1 (Photo 8) is the likely source. Note the close proximity of the cattle operation to the creek (Photo 8).

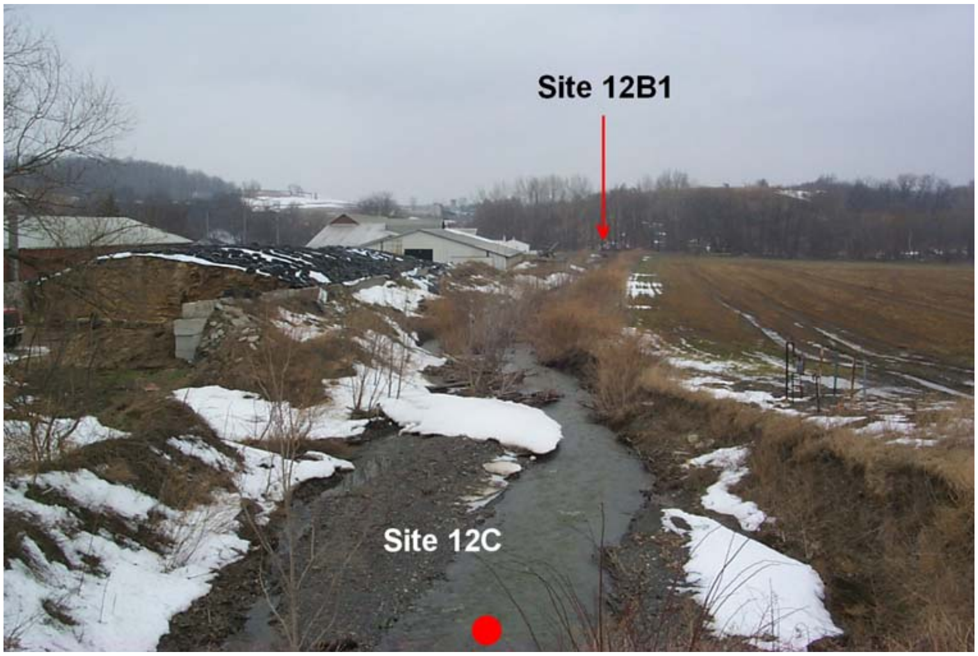

Photo 8. The reach of Pearl Creek that flows from site 12C down to site 12B1.

There were sources of phosphorus (both TP and SRP) in the area of site 14 in Pavilion. An additional site was added (site 14B on Route 19) on the small tributary entering the main branch of Oatka Creek at Pavilion. Both small tributary sites (14A and 14B) had greater than twice the levels of SRP and TP found at site 14 on the main branch of Oatka Creek. This tributary flows through the York Central School district property and behind residences along Route 63.

DISCUSSION

The quality and quantity of runoff from a watershed into a stream are ultimately influenced by people. The amount of runoff is determined by the amount of excess precipitation, that which neither sinks into the ground nor is stored at the surface. Precipitation excess is determined primarily by climate, vegetation, infiltration capacity, surface storage and land use by people. Impervious landscapes (e.g., parking lots), removal of wetlands and vegetation in general, storm sewers, blockage of streams by debris, etc., all contribute to rapid rises in stream level and potential flooding. Similarly, land usage contributes to the quality of the water in the stream. For example, deicing salt spread on roads is easily dissolved and accumulates in streams raising the concentration of sodium in water. Another example is the spreading of manure on the land. If done properly, this can be a reasonable practice enriching the soil. If not, the result may be elevated levels of fecal coliform bacteria and increased levels of phosphorus, organic nitrogen and nitrates that cause health concerns or cause eutrophication of downstream systems. Land use practices initiated by people can and do affect stream water quality and stream discharge. If we can identify the sources of pollution, remedial action plans and best management plans can be initiated that mitigate downstream effects.

Best Management Practices:

Identified point and non-point sources of nutrients and solids can be remediated using Best Management Practices (BMP). Whether or not management practices include a reduction of cropland or fertilization, control of water movement can be a means of significantly reducing non-point source pollution. Since water must come in contact with the nutrient source and then be transported to the surface (or subsurface) water body, the nutrients in water bodies are functions of soil fertility and quantities of transporting water. Management practices, which reduce surface runoff, have been shown to dramatically decrease the magnitudes of sediment and chemical losses from land areas (Haith 1975).

Agriculture: Haith (1975) and the Morton (1985, 1982) recommend use of buffer strips of forest or grass between the pollutant source and a stream to intercept the runoff, resulting in removal by deposition or filtering by the vegetative cover. Other cropland management practices include diversions, terraces contour cropping, strip cropping, waterways, minimum and no tillage. Livestock operation controls include barnyard runoff management, manure storage facilities and livestock exclusion from woodlands. They may also include structural devices such as grassed waterways, sediment retention basins, erosion control weirs and animal waste holding tanks. BMP's are designed to reduce sediment and nutrient transport to streams and lakes. They may benefit the farmer in the long term by decreasing fuel and fertilizer costs and by improving soil productivity. Furthermore, the advent of Concentrated Animal and Feed Operations (CAFO) permits, regulatory control of farms with large numbers of animals may be inevitable.

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Table 1. Results of the semi-annual New York State Environmental Laboratory Assurance Program (ELAP Lab # 11439, SUNY Brockport) Non-Potable Water Chemistry Proficiency Test, July 2003. Score Definition: 4 (Highest) = Satisfactory, 3 = Marginal, 2 = Poor, 1 = Unsatisfactory.

WADSWORTH CENTER
NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

Proficiency Test Report

Lab 11439 SUNY BROCKPORT EPA Lab Code NY01449 Page 1 of 1
WATER LAB LENNON HALL
BROCKPORT, NY 14420 USA

Shipment 265 Non Potable Water Chemistry Shipment Date: 21-Jul-2003

Analyte	Sample ID	Result	Mean/Target	Warning Limits	Method	Score
Sample: **Water Residue**						
Solids, Total Suspended 293 passed out of 304 reported results. EPA Code: 0072	6502	47.7	44.5	39.3-49.7	SM 18-20 2540D	Satisfactory
Sample: **Organic Nutrients**						
Kjeldahl Nitrogen, Total 102 passed out of 108 reported results. EPA Code: 0034	6504	14.37	14	11.5-16.5	EPA 351.3	Satisfactory
Phosphorus, Total 119 passed out of 132 reported results. EPA Code: 0035	6504	5.59	5.31	4.56-6.06	SM18-20 4500-P E	Satisfactory
Sample: **Inorganic Nutrients**						
Nitrate (as N) 123 passed out of 128 reported results. EPA Code: 0032	6507	34.10	34.7	30.2-39.3	SM18-20 4500-NO3 F	Satisfactory
Orthophosphate (as P) 88 passed out of 94 reported results. EPA Code: 0033	6507	3.96	4.15	3.73-4.56	SM18-20 4500-P F	Satisfactory
Sample: **Metals I and II**						
Sodium, Total 106 passed out of 120 reported results. EPA Code: 0025	6511	25.24	24.1	22.3-26	SM 18-20 2450D	Satisfactory

Table 2. Location of all stations sampled in the Oatka Creek watershed as determined by Global Positioning System (GPS). STP = sewage treatment plant.

Station	Road	Latitude	Longitude
1	Evans Road	42° 41.071'	78° 06.076'
1A	Mungers Mill Road	42° 42.383'	78° 05.390'
1B	Oatka Road	42° 43.031'	78° 04.662'
1C	Oatka Road	42° 43.026'	78° 05.384'
2	Route 19	42° 40.649'	78° 07.115'
3	Mungers Mill Road	42° 42.330'	78° 07.521'
4	Route 19	42° 42.766'	78° 07.814'
5	Keeney Road	42° 42.926'	78° 07.689'
6	Liberty Street	42° 44.013'	78° 44.013'
6A	Buck Road	42° 43.683'	78° 09.717'
6B	Dick Road	42° 44.013'	78° 10.566'
7	Route 20A - Halls Corner	42° 44.371'	78° 11.094'
7A	Route 238	42° 44.868'	78° 11.793'
8	Court Street - Warsaw	42° 44.560'	78° 08.258'
Warsaw STP		42° 45.030'	78° 08.207'
9	Buffalo Road	42° 45.658'	78° 08.491'
9A	Route 19	42° 46.383'	78° 07.458'
10	Lamb Road	42° 49.337'	78° 04.886'
12	Route 19	42° 50.901'	78° 03.605'
12A	Route 19	42° 50.909'	78° 02.592'
12B	Silver Lake Road	42° 50.779	78° 01.638'
12B1	Old State Road	42° 50.371	78° 00.503'
12C	Taylor Road	42° 50.184'	78° 00.502'
12D	Morrow Road	42° 49.044'	78° 00.496'
12D1	LaGrange Road	42° 49.109'	78° 00.895'
12E	Morrow Road	42° 49.047'	78° 00.273'
12E 1	LaGrange Road	42° 48.101'	78° 00.351'
13	Crossman Road	42° 51.804'	78° 02.786'
14	Route 63 and River Road	42° 52.853'	78° 01.769'
14A	Woodroe Road - Pavilion	42° 52.644	78° 01.587
14B	Route 19 - Pavilion	43° 12.759	77° 56.759
15	Route 20 and Creek Road	42° 54.522'	78° 01.751'
16	Junction Road	42° 55.724'	78° 02.304'
17	Transit Road	42° 55.989'	78° 04.448'
17A	Ellicott Street Road	42° 55.531'	78° 05.544'
17B	Transit Road	42° 54.954'	78° 04.450'
17C	Route 20	42° 54.378'	78° 04.333'
18	Hawks Road	42° 55.983'	78° 04.284'
19	Covell Road	42° 56.646'	78° 02.421'
20	Cole Road	42° 57.475'	78° 01.427'
21	Clay Street - Leroy	42° 58.447'	77° 59.535'
21A	Mill Street - Leroy	42° 58.951'	77° 59.413'
Leroy STP	Red Mill Road	42° 59.463'	77° 59.150'
21B	North Street	43° 00.254'	77° 58.584'
23	Parmalee Road	43° 00.891'	77° 58.242'
24	Oatka Trail Road	43° 00.849'	77° 56.744
25	Circular Hill Road	43° 00.834'	77° 57.304'
25A	Wilcox Road	43° 00.703'	77° 56.709'
25B	Gully Road	43° 00.762'	77° 56.329'
25C	Oatka Trail Road	43° 00.628'	77° 56.412'
26	Gulf Road - Mud Creek	42° 59.531'	77° 55.674'
27	Route 383	42° 59.767'	77° 51.731'

Table 3. Water chemistry results for the segment analysis on 17 September 2003. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen and SRP = soluble reactive phosphorus.

Sample	Date Collected	TP (µg P/L)	Nitrate (mg N/L)	TSS (mg/L)	TKN (µg N/L)	Sodium (mg/L)	SRP (µg P/L)
Oatka 1	9/17/2003	17.0	1.16	1.2	480	11.71	5.4
Oatka 2	9/17/2003	10.5	0.75	2.2	360	21.46	2.5
Oatka 3	9/17/2003	8.7	0.59	2.8	460	21.95	4.9
Oatka 4	9/17/2003	10.5	0.67	6.6	290	15.84	6.9
Oatka 5	9/17/2003	8.1	0.51	1.2	320	22.37	5.2
Oatka 6	9/17/2003	39.0	0.55	1.0	480	21.03	36.2
Oatka 7	9/17/2003	21.2	1.08	2.6	530	20.31	7.9
Oatka 8	9/17/2003	13.8	1.26	3.8	450	27.39	2.5
Oatka 9	9/17/2003	242.3	1.95	2.7	510	31.11	97.7
Oatka 9a	9/17/2003	156.8	1.50	5.0	530	29.40	45.2
Oatka 10	9/17/2003	111.9	1.32	4.9	940	25.72	63.7
Oatka 12	9/17/2003	135.9	1.70	29.6	1000	57.62	24.4
Oatka 12a	9/17/2003	31.3	3.97	1.8	780	37.90	22.7
Oatka 13	9/17/2003	140.8	1.82	12.3	660	32.66	105.4
Oatka 14	9/17/2003	150.3	1.63	8.1	870	31.51	140.8
Oatka 15	9/17/2003	111.6	1.34	4.4	650	33.25	25.7
Oatka 16	9/17/2003	82.6	1.34	4.3	720	33.02	52.9
Oatka 19	9/17/2003	72.2	1.23	3.8	570	32.97	49.3
Oatka 20	9/17/2003	53.8	1.08	3.0	560	33.80	7.9
Oatka 21	9/17/2003	41.0	0.80	2.9	730	34.78	23.7
Oatka 21a	9/17/2003	41.3	0.88	5.2	690	36.84	3.2
Oatka 21b	9/17/2003	103.0	0.85	3.0	590	37.54	35.1
Oatka 25	9/17/2003	84.6	0.97	2.5	480	36.67	13.8

Table 4. Water chemistry results for the segment analysis on 23 September 2003. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen and SRP = soluble reactive phosphorus.

Sample	Date Collected	TP (µg P/L)	Nitrate (mg N/L)	TSS (mg/L)	TKN (µg N/L)	Sodium (mg/L)	SRP (µg P/L)
Oatka 1	9/23/2003	28.9	1.19	14.1	650	11.26	10.3
Oatka 2	9/23/2003	16.6	0.96	3.1	340	26.42	7.9
Oatka 3	9/23/2003	13.7	1.22	6.1	370	20.34	4.0
Oatka 4	9/23/2003	11.6	0.84	3.8	400	13.69	9.0
Oatka 5	9/23/2003	9.6	0.88	3.9	350	22.74	4.5
Oatka 6	9/23/2003	54.7	0.67	4.0	650	21.14	40.4
Oatka 7	9/23/2003	44.1	0.36	3.0	670	19.49	14.2
Oatka 8	9/23/2003	28.3	0.73	5.2	450	23.62	12.4
Oatka 9	9/23/2003	114.0	1.36	5.3	420	26.35	85.6
Oatka 9a	9/23/2003	129.0	0.94	10.6	410	31.71	53.6
Oatka 10	9/23/2003	131.3	1.01	6.7	510	28.51	82.2
Oatka 12	9/23/2003	103.8	1.26	9.8	470	32.61	53.3
Oatka 12a	9/23/2003	26.6	2.16	2.0	610	36.66	14.4
Oatka 13	9/23/2003	86.3	1.87	5.1	530	28.26	71.0
Oatka 14	9/23/2003	86.0	1.36	6.0	520	35.04	59.2
Oatka 15	9/23/2003	76.0	1.20	3.4	450	31.45	50.9
Oatka 16	9/23/2003	75.7	1.27	4.5	240	34.04	44.2
Oatka 17	9/23/2003	58.2	0.12	6.2	1270	47.99	15.5
Oatka 19	9/23/2003	62.9	1.10	1.8	510	33.56	48.3
Oatka 20	9/23/2003	57.0	0.97	2.4	600	31.44	41.5
Oatka 21	9/23/2003	49.4	0.77	4.6	680	33.98	25.4
Oatka 21a	9/23/2003	38.6	0.46	3.0	170	47.58	12.7
Oatka 25	9/23/2003	27.4	1.12	1.3	440	26.81	15.8

Table 5. Water chemistry results for the segment analysis on 27 October 2003. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen and SRP = soluble reactive phosphorus.

Sample	Date Collected	TP (µg P/L)	Nitrate (mg N/L)	TSS (mg/L)	TKN (µg N/L)	Sodium (mg/L)	SRP (µg P/L)
Oatka 6	10/27/2003	63.8	1.03	7.9	660	17.52	12.5
Oatka 6A	10/27/2003	74.6	1.00	14.0	710	16.56	27.7
Oatka 7	10/27/2003	38.5	0.75	125.0	520	13.36	10.9
Oatka 8	10/27/2003	53.0	1.05	15.6	710	24.46	14.8
Oatka 9	10/27/2003	113.8	1.24	13.8	650	28.72	42.6
Oatka 12	10/27/2003	79.4	1.12	1.2	450	28.62	31.0
Oatka 12A	10/27/2003	51.1	2.99	13.8	840	30.77	10.8
Oatka 12B	10/27/2003	38.0	2.64	38.3	750	33.74	3.0
Oatka 12C	10/27/2003	38.2	0.88	8.8	520	41.08	12.3
Oatka 13	10/27/2003	87.6	1.52	6.0	580	26.19	59.7
Oatka 14	10/27/2003	83.7	1.46	3.6	460	28.11	75.3
Oatka 15	10/27/2003	74.5	1.40	2.1	430	32.59	25.9
Oatka 16	10/27/2003	62.2	1.34	2.4	410	32.03	39.6
Oatka Above Warsaw STP	10/27/2003	43.1	0.93	11.4	510	23.51	13.6
Oatka Below Warsaw STP	10/27/2003	124.2	1.21	11.2	650	26.02	23.3
Oatka Above Leroy STP	10/27/2003	67.1	1.01	22.6	330	38.30	42.3
Oatka Below Leroy STP	10/27/2003	368.8	1.35	22.9	1060	39.62	38.8

Table 6. Water chemistry results for the segment analysis on 20 November 2003. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen and SRP = soluble reactive phosphorus.

Sample	Date Collected	TP (µg P/L)	Nitrate (mg N/L)	TSS (mg/L)	TKN (µg N/L)	Sodium (mg/L)	SRP (µg P/L)
Oatka 6	11/20/2003	44.6	2.75	5.0	690	9.98	32.0
Oatka 6A	11/20/2003	52.8	2.61	2.9	1220	12.09	25.2
Oatka 6B	11/20/2003	47.7	2.60	6.1	940	11.57	23.5
Oatka 7	11/20/2003	31.7	2.12	5.9	1570	12.24	10.2
Oatka 9	11/20/2003	103.0	2.41	43.2	1520	17.47	34.0
Oatka 10	11/20/2003	236.1	1.42	16.7	610	12.80	109.4
Oatka 12	11/20/2003	286.3	1.08	54.2	670	22.71	155.3
Oatka 12A	11/20/2003	111.8	4.82	16.3	390	27.14	66.9
Oatka 12B	11/20/2003	96.7	3.55	8.4	400	30.98	57.3
Oatka 12C	11/20/2003	53.4	5.07	7.1	330	32.93	37.9
Oatka 13	11/20/2003	250.5	2.03	97.6	730	19.75	129.5
Oatka 14	11/20/2003	224.2	2.29	49.2	<150	20.06	120.2
Oatka 15	11/20/2003	248.6	3.24	63.0	750	19.57	105.4
Oatka 16	11/20/2003	271.2	3.33	73.6	180	21.63	116.3
Oatka 25	11/20/2003	333.4	3.53	59.5	180	25.18	119.7
Oatka 26	11/20/2003	155.7	4.26	10.0	180	15.80	52.5

Table 7. Water chemistry results for the segment analysis on 3 March 2004. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen and SRP = soluble reactive phosphorus.

Sample	Date Collected	TP (µg P/L)	Nitrate (mg N/L)	TSS (mg/L)	TKN (µg N/L)	Sodium (mg/L)	SRP (µg P/L)
Oatka Creek SSA 1	3/3/2004	90.9	1.76	16.3	810	7.47	38.2
Oatka Creek SSA 1A	3/3/2004	98.4	1.60	34.7	880	7.16	28.0
Oatka Creek SSA 1B	3/3/2004	38.5	0.78	6.5	710	2.03	9.9
Oatka Creek SSA 2	3/3/2004	49.0	1.81	32.3	620	18.21	9.2
Oatka Creek SSA 3	3/3/2004	67.6	1.85	30.8	680	13.07	18.9
Oatka Creek SSA 4	3/3/2004	51.8	1.32	40.4	530	3.76	20.1
Oatka Creek SSA 5	3/3/2004	70.1	2.09	37.0	720	10.36	18.8
Oatka Creek SSA 6	3/3/2004	113.9	2.08	60.2	750	20.62	20.9
Oatka Creek SSA 6A	3/3/2004	84.8	2.01	34.3	700	20.08	22.4
Oatka Creek SSA 6B	3/3/2004	99.2	1.86	45.6	650	21.93	27.3
Oatka Creek SSA 7	3/3/2004	65.6	1.50	46.5	830	21.00	9.1
Oatka Creek SSA 7A	3/3/2004	47.9	0.86	29.3	680	14.19	8.6
Oatka Creek SSA 8	3/3/2004	90.0	1.73	62.7	780	12.59	19.7
Oatka Creek SSA 9	3/3/2004	109.2	1.71	84.6	1060	19.03	26.0
Oatka Creek SSA 9A	3/3/2004	110.0	1.65	70.2	820	20.10	29.6
Oatka Creek SSA 10	3/3/2004	108.3	2.08	28.6	840	18.44	49.2
Oatka Creek SSA 12	3/3/2004	120.3	1.76	19.0	860	18.96	52.6
Oatka Creek SSA 12A	3/3/2004	116.7	3.22	43.9	980	27.99	41.8
Oatka Creek SSA 12B	3/3/2004	69.3	2.70	8.7	830	32.39	28.1
Oatka Creek SSA 12B1	3/3/2004	54.9	3.41	30.2	790	26.97	33.5
Oatka Creek SSA 12C	3/3/2004	44.3	3.39	28.5	800	25.55	20.0
Oatka Creek SSA 12D	3/3/2004	28.9	1.98	21.0	640	24.43	11.7
Oatka Creek SSA 12E	3/3/2004	109.5	2.98	96.9	1270	30.16	23.7
Oatka Creek SSA 13	3/3/2004	144.7	1.98	69.2	1150	21.55	44.7
Oatka Creek SSA 14	3/3/2004	158.0	2.16	70.5	1110	22.58	66.6
Oatka Creek SSA 15	3/3/2004	134.3	1.90	52.3	1500	24.73	52.5
Oatka Creek SSA 16	3/3/2004	149.8	2.28	60.6	1450	27.18	54.9
Oatka Creek SSA 17	3/3/2004	144.4	2.15	55.6	1290	19.79	72.4
Oatka Creek SSA 19	3/3/2004	163.7	2.24	67.1	1470	26.62	55.8
Oatka Creek SSA 21A	3/3/2004	146.6	2.23	41.1	1320	27.09	62.8
Oatka Creek SSA 21B	3/3/2004	161.3	2.12	42.9	1330	23.10	74.0
Oatka Creek SSA 23	3/3/2004	15.2	0.63	2.5	840	75.14	5.0
Oatka Creek SSA 25	3/3/2004	171.6	2.28	43.6	1160	28.39	71.4
Oatka Creek SSA 26	3/3/2004	71.6	2.38	12.3	860	16.83	36.8

Table 8. Water chemistry results for the segment analysis on 2 April 2004. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen and SRP = soluble reactive phosphorus.

Sample	Date	TP	Nitrate	TSS	TKN	Sodium	SRP
	Collected	(µg P/L)	(mg N/L)	(mg/L)	(µg N/L)	(mg/L)	(µg P/L)
Oatka 1	4/2/2004	60.1	1.36	4.8	730	7.85	20.9
Oatka 1A	4/2/2004	52.7	0.76	4.7	530	7.35	18.6
Oatka 1B	4/2/2004	23.8	0.22	2.9	390	4.09	8.3
Oatka 1C	4/2/2004	31.6	0.41	2.9	320	5.16	9.5
Oatka 12A	4/2/2004	116.0	5.02	30.7	730	22.82	21.1
Oatka 12B	4/2/2004	77.7	3.90	5.2	530	25.00	28.7
Oatka 12B1	4/2/2004	58.6	3.36	11.2	500	28.13	6.5
Oatka 12C	4/2/2004	66.7	4.62	25.2	500	26.95	8.4
Oatka 12D	4/2/2004	76.8	3.67	20.2	570	28.52	11.3
Oatka 12D1	4/2/2004	69.6	3.47	16.2	530	8.93	8.1
Oatka 12E	4/2/2004	44.7	6.62	14.7	630	24.69	5.0
Oatka 12E1	4/2/2004	39.9	0.98	4.0	550	36.52	5.1
Oatka 14	4/2/2004	213.6	2.02	60.3	1020	21.42	36.4
Oatka 14A	4/2/2004	257.6	6.62	55.4	1320	40.50	57.3
Oatka 17	4/2/2004	226.1	1.68	64.0	1530	20.99	71.4
Oatka 17A	4/2/2004	116.7	1.15	22.2	750	5.04	17.8
Oatka 17B	4/2/2004	125.0	1.57	28.7	810	19.19	25.5
Oatka 17C	4/2/2004	117.3	1.26	25.4	780	14.53	28.7
Oatka 24	4/2/2004	183.3	9.07	35.4	800	69.32	14.6
Oatka 25A	4/2/2004	174.9	5.79	47.6	930	52.55	31.9
Oatka 25B	4/2/2004	409.1	29.52	25.0	1050	39.53	195.7
Oatka 25C	4/2/2004	167.8	1.53	55.3	1070	35.58	20.1
Oatka 27	4/2/2004	137.5	1.56	36.7	920	37.81	22.7

Table 9. Water chemistry results for the segment analysis on 13 April 2004. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen and SRP = soluble reactive phosphorus.

Sample	Date	TP	Nitrate	TSS	TKN	Sodium	SRP
	Collected	(µg P/L)	(mg N/L)	(mg/L)	(µg N/L)	(mg/L)	(µg P/L)
Oatka 24	4/13/2004	19.1	2.74	5.5	570	96.60	5.0
Oatka 25A	4/13/2004	29.0	3.80	7.2	500	31.83	4.6
Oatka 25A1	4/13/2004	52.2	0.26	30.7	570	25.38	5.0
Oatka 25A2	4/13/2004	19.7	1.98	8.1	490	32.92	2.7
Oatka 25B	4/13/2004	2420.6	10.49	483.8	6020	56.18	359.0
Oatka 25C	4/13/2004	26.7	2.54	6.7	410	29.97	8.1
Oatka 27	4/13/2004	68.4	2.49	10.5	530	33.87	22.8

Table 10. Water chemistry results for the segment analysis on 21 May 2004. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen and SRP = soluble reactive phosphorus.

Sample	Date Collected	TP (µg P/L)	Nitrate (mg N/L)	TSS (mg/L)	TKN (µg N/L)	Sodium (mg/L)	SRP (µg P/L)
Oatka Creek SSA 1	5/21/2004	167.5	1.18	23.5	1090	7.77	54.4
Oatka Creek SSA 1A	5/21/2004	170.5	0.52	29.7	1000	7.36	41.1
Oatka Creek SSA 1B	5/21/2004	100.8	0.10	14.0	910	4.31	18.9
Oatka Creek SSA 1C	5/21/2004	64.4	0.16	11.0	810	4.32	49.1
Oatka Creek SSA 2	5/21/2004	121.0	1.14	32.0	1150	18.05	34.8
Oatka Creek SSA 3	5/21/2004	118.1	1.43	36.7	970	14.73	20.9
Oatka Creek SSA 4	5/21/2004	72.6	0.69	35.7	890	7.93	15.9
Oatka Creek SSA 5	5/21/2004	98.4	1.20	34.3	1020	13.74	18.2
Oatka Creek SSA 6	5/21/2004	69.9	1.41	12.0	840	12.57	29.2
Oatka Creek SSA 6A	5/21/2004	70.2	1.29	6.0	1050	12.74	30.2
Oatka Creek SSA 6B	5/21/2004	71.4	1.27	10.0	1330	12.71	34.2
Oatka Creek SSA 7	5/21/2004	48.5	1.10	8.7	820	13.88	14.2
Oatka Creek SSA 7A	5/21/2004	49.4	0.43	9.0	730	8.81	15.7
Oatka Creek SSA 8	5/21/2004	91.1	1.29	37.7	1040	16.09	15.6
Oatka Creek SSA 9	5/21/2004	167.5	1.37	68.7	1080	16.55	40.1
Oatka Creek SSA 9A	5/21/2004	171.9	1.27	54.0	1090	16.57	43.5
Oatka Creek SSA 10	5/21/2004	277.7	1.20	87.0	1710	14.52	31.8
Oatka Creek SSA 12	5/21/2004	114.9	1.41	16.5	740	23.57	73.7
Oatka Creek SSA 12A	5/21/2004	106.1	2.03	6.0	670	32.14	28.9
Oatka Creek SSA 12B	5/21/2004	67.3	1.80	11.2	880	33.78	18.9
Oatka Creek SSA 12B1	5/21/2004	101.1	0.96	10.9	1070	30.05	19.6
Oatka Creek SSA 12C	5/21/2004	21.2	1.66	1.1	580	32.59	4.6
Oatka Creek SSA 12D	5/21/2004	40.3	1.16	9.5	680	31.02	8.6
Oatka Creek SSA 12D1	5/21/2004	35.9	0.43	7.2	720	39.93	3.0
Oatka Creek SSA 12E	5/21/2004	43.8	1.26	8.0	960	31.10	15.9
Oatka Creek SSA 12E1	5/21/2004	49.7	0.77	16.3	930	11.29	21.9
Oatka Creek SSA 13	5/21/2004	70.2	1.40	11.3	620	24.51	41.1
Oatka Creek SSA 14	5/21/2004	67.0	1.86	5.8	550	28.16	26.0
Oatka Creek SSA 14A	5/21/2004	174.9	1.72	2.9	550	55.18	140.9
Oatka Creek SSA 14B	5/21/2004	182.2	2.01	4.0	500	55.26	142.6
Oatka Creek SSA 15	5/21/2004	115.7	1.91	9.5	800	29.03	74.3
Oatka Creek SSA 16	5/21/2004	68.5	1.73	7.2	720	27.74	47.1
Oatka Creek SSA 17	5/21/2004	55.2	1.07	5.2	880	35.30	21.2
Oatka Creek SSA 17A	5/21/2004	35.3	0.20	18.2	810	11.53	12.1
Oatka Creek SSA 17B	5/21/2004	80.5	2.94	6.0	800	35.27	34.2
Oatka Creek SSA 17C	5/21/2004	69.0	1.55	10.4	690	24.49	45.1
Oatka Creek SSA 19	5/21/2004	60.4	1.68	2.6	640	27.91	41.8
Oatka Creek SSA 20	5/21/2004	55.2	1.48	1.8	630	25.98	45.5
Oatka Creek SSA 21	5/21/2004	89.7	1.36	14.0	960	26.12	38.8
Oatka Creek SSA 21A	5/21/2004	72.8	1.24	10.6	620	31.25	21.2
Oatka Creek SSA 21B	5/21/2004	107.6	1.33	4.6	880	28.13	74.0
Oatka Creek SSA 23	5/21/2004	20.2	1.14	1.8	850	78.93	20.9
Oatka Creek SSA 24	5/21/2004	100.7	1.78	25.3	1100	96.84	40.8
Oatka Creek SSA 25	5/21/2004	81.1	1.54	7.0	660	33.01	52.1
Oatka Creek SSA 25C	5/21/2004	77.1	1.66	8.0	470	34.84	66.4