Characterization and Prioritization of the Watersheds of Niagara County, New York

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Summary

1. Monthly from February 2006 thru December 2007 the Niagara County Soil & Water Conservation District, in conjunction with the Department of Environmental Science and Biology at The College at Brockport, surveyed Four Mile Creek, Twelvemile Creek East, Twelvemile Creek West, Eighteenmile Creek, Bergholtz Creek, Bull Creek, Cayuga Creek, Gill Creek, Hopkins Creek, Fish Creek East, Fish Creek West, Tonawanda Creek, Johnson Creek, Mud Creek, Jeddo Creek, Golden Hill Creek, and Keg Creek in Niagara County, New York.

2. The creeks were also sampled on 13 March 2006, 12 October 2006, 1 December 2006, 26 March 2007, and 17 April 2007 during hydrometeorological events.

3. Sampling consisted of grab water sampling collection and preservation as well as staff gauge readings to estimate point discharge.

4. Discharge rating curves were developed for Four Mile Creek, Twelvemile Creek East, Bergholtz Creek, Bull Creek, Cayuga Creek, Gill Creek, Hopkins Creek, Fish Creek East, Fish Creek West, Johnson Creek, Mud Creek, Jeddo Creek, Golden Hill Creek, and Keg Creek using stream velocity surveys completed on 13 dates. Rating curves had been previously developed for Twelvemile Creek West, Eighteenmile Creek, and Tonawanda Creek.

5. Comparing areal (g/ha/d) loss of phosphorus from the watershed to downstream systems, Berkholtz and Jeddo Creeks have significantly higher losses than other Niagara County watersheds by at least a factor of two. We have no data on the area of Tonawanda Creek, but the daily loss of phosphorus is comparable to both Berkholtz and Jeddo Creeks. Compared to other watersheds in western and central New York, these losses represent some of the highest losses per unit area of watershed we have observed.

6. Considering the non-weighted areal loss of phosphorus, Eighteenmile Creek had the greatest overall loss of phosphorus (221.8 kg/P/day) of any watershed evaluated. Bergholtz Creek had the highest concentrations of TP, TSS and TKN during both nonevent and event stream conditions. Keg Creek had statistically significantly higher mean nonevent nitrate concentrations than all the other watersheds in Niagara County monitored during this two-year study.

7. As a priority, we recommend the following group of watersheds for identification of point and/or non-point sources of pollution using a process such as Stressed Stream Analysis: Eighteenmile, Jeddo, Bergholz, Tonawanda, and Keg Creeks.

Introduction

Located in the northwest corner of New York State, Niagara County is bordered by Lake Ontario to the North, Tonawanda Creek to the South, Orleans County to the East, and the Niagara River to the West. Water resources play a vital role in the economic viability of this region especially in terms of recreation, tourism, and industry. According to the 1990 census, over 70% of the county's 220,756 residents live in urban areas on the county's 523-square mile land area. A large percentage of land use is in agriculture, including fruit trees, row crops, and vineyards. The close proximity to Lakes Erie and Ontario has an impact on climate patterns (including rainfall and lake effect snow), moderating the temperature extremes of the region which allows for the production of a diverse variety of crops.

Freshwater resources have historically played an instrumental role in community development and economic sustainability. The water resources in Niagara County play an important role in the economy, have aesthetic value, and provide diverse opportunities for those who enjoy the resource directly. A major thrust of the County's tourism industry is predicated on the availability of high quality water resources and angling opportunities in nearshore Lake Ontario and its tributaries. Needless to say, agriculture also has a major economic impact in Niagara County; loss of important resources, such as soil and nutrients, from a watershed is of concern to the landowner and the Soil and Water Conservation District. Remediation and protection of these resources depend largely on the identification of both the cause and effect of elements likely to reduce their economic and social value (Makarewicz 2000).

It follows that water quality is an issue of concern within the Niagara County area of Lake Ontario. For example, the International Joint Commission has identified Eighteenmile Creek and Olcott Harbor as an Area of Concern (AOC) due to high levels of conventional pollutants, heavy metals, and organic pollutants in the water, sediments and biota. The creek has been intensively studied in the past to determine the extent of organic chemicals and trace metals in the creek. Several reports and a Remedial Action Plan have been prepared detailing the industrial contamination in the Area of Concern.

Eighteenmile Creek is polluted by past industrial and municipal discharges, the disposal of waste, and the use of pesticides. Fishing is impaired by PCBs and dioxins found in the flesh of various game fish. The health of the benthos is impaired by PCBs and metals in the creek sediments. Bird and animal health is likely impaired by PCBs, dioxins, DDT and its metabolites, and dieldrin found in fish flesh. However, the preponderance of evidence suggests that the plankton community of Eighteenmile Creek was not impacted by contaminants (Makarewicz and Lewis 2002). Contaminated sediments in Eighteenmile Creek, inflow from the past discharge of contaminants into the NYS Barge Canal, and as yet to be determined source of PCBs between Olcott Street and North Transit Road, are sources of pollutants (Makarewicz 2000). Other sources have been identified as potential sources because the contaminants causing impairments are known to exist, but the link between the source and the impairment has not been clearly established. Nevertheless, because of these concerns, Eighteenmile Creek has been designated as an Area of Concern for which a Remedial Action Plan (RAP) has been developed.

Other work on water quality of Niagara County creeks is evident. Starting in August 2003, the Niagara County Soil & Water Conservation District (NCSWCD) monitored Eighteenmile Creek for two annual cycles. The purpose of the monitoring program was to collect data needed to accurately characterize the water quality in the creek and to quantify the concentration and loading of nutrients and suspended sediments transported from Eighteenmile Creek to Lake Ontario. A conclusion was that Eighteenmile Creek value was delivering high amounts of phosphorus to Lake Ontario. In fact, phosphorus levels measured were eclipsed only by watersheds that had a heavy loss of phosphorus from agricultural muckland and a watershed that receives discharge from a municipal sewage treatment plant. Eighteenmile Creek lost an annual average of 33 metric tones of total phosphorus during the two-year monitoring period. That rate translates to 90 kg of phosphorus lost per day or 3.83 g/ha/day on an areal basis. In a similar fashion, Twelvemile Creek was evaluated in 2000 (Makarewicz and Lewis 2000).

In recognition of the need to acquire a uniform, organized approach to addressing surface

water degradation and given the diverse nature of non-point sources of pollution within the County, the Soil and Water Conservation District formed a committee known as the Niagara County Water Quality Coordinating Committee (WQCC). Since little was known about the environmental status of other major creeks in Niagara County, the WQCC recommended a study to evaluate nutrient and soil loss from 17 watersheds and their creeks. The purpose of the monitoring program was to collect water quality data to quantify the concentration and loading of nutrients and suspended sediments transported from 17 Niagara County Creeks to Lake Ontario and to evaluate the health of the creek and its impact on Lake Ontario. In addition, the data serve as a database to make informed water quality management decisions including the development of a watershed management plan, and as a benchmark of discharge and nutrient data to measure the success of future remediation efforts and to suggest a priority listing of water quality goals.

Methods

In February 2006 the Niagara County Soil & Water Conservation District (NCSWCD), in conjunction with the Department of Environmental Science and Biology at the College at Brockport, began a survey of 17 streams located in Niagara County, New York (Four Mile Creek, Twelvemile Creek East, Twelvemile Creek West, Eighteenmile Creek, Bergholtz Creek, Bull Creek, Cayuga Creek, Gill Creek, Hopkins Creek, Fish Creek East, Fish Creek West, Tonawanda Creek, Johnson Creek, Mud Creek, Jeddo Creek, Golden Hill Creek, and Keg Creek). From February 2006 thru December 2007 NCSWCD personnel visited monthly the stream sampling sites (Tables 1 and 2, Figure 1). The sites were also visited during hydrometeorological events on five dates (13 March 2006, 12 October 2006, 1 December 2006, 26 March 2007, and 17 April 2007). During visits to the sites, staff gauge readings were recorded and a grab water sample was taken for laboratory analysis. On at least 13 dates, stream velocity was measured for all streams, except Twelvemile Creek West, Eighteenmile Creek, and Tonawanda Creek, where rating curves had already been developed for later discharge calculations (Makarewicz and Lewis 2000.)

Water samples were subsampled and filtered immediately after sampling for dissolved nutrient analysis of nitrate + nitrite and sodium using 0.45-µm MCI Magma Nylon 66 membrane filters and were frozen or put on ice and held at 4° C until analysis. The filtration unit and other processing apparatus were cleaned routinely with phosphate-free RBS. Monthly nonevent and event samples were transported to SUNY Brockport for water chemistry analysis for total phosphorus (TP), total Kjeldahl nitrogen (TKN), nitrate + nitrite, sodium and total suspended solids (TSS) (see detailed analytical methods below).

Water Chemistry

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

Sodium: Sodium was determined by atomic absorption spectrophotometry (Perkin-Elmer AAnalyst 100) (APHA 1999).

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 EPA Method 351.2 with the substitution of copper for mercury as the catalyst as per APHA Method 4500-N_{org} B (EPA 1979, APHA 1999).

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

Stream Velocity, Cross-sectional Area, Discharge, and Loading

In general, velocity, cross-sectional area, discharge and rating curves for each stream were developed following Rantz (1982). For Four Mile Creek, Twelvemile Creek East, Bergholtz Creek, Bull Creek, Cayuga Creek, Gill Creek, Hopkins Creek, Fish Creek East, Fish Creek West, Johnson Creek, Mud Creek, Jeddo Creek, Golden Hill Creek, and Keg Creek, stream velocity and water depth were measured at equally spaced increments perpendicularly across the streams. Stream velocity was measured by NCSWCD personnel utilizing a 622 or 625 Gurley flow meter, depending upon the water depth. Water depth was measured and cross-referenced using manual staff gauges. A cross-section of the sampling sites was manually surveyed. The survey data and velocity readings were used to calculate a discharge for each increment of the stream. The discharge of each stream increment was summed to provide discharge at each site for that particular date and time. Discharge was estimated a minimum of 13 times for each site. Discharge and staff gauge readings were used to develop a rating curve for the stream sampling sites. The rating curves were used to calculate discharge on each sampling date from staff gauge readings. Instantaneous discharge (in cubic feet per second) was expanded into daily discharge (in cubic meters per day) by assuming constant discharge over the course of the day. Losses from the watershed as daily loadings were calculated by multiplying the daily discharge of each sampling date by the corresponding water chemistry.

Discharge rating curves were previously developed for Twelvemile Creek West and Eighteenmile Creek (Makarewicz and Lewis 2003, Makarewicz *et al*. 2006). Staff gauge readings were taken on all sampling dates, and the rating curves were utilized to estimate discharge for this study. At Tonawanda Creek daily discharge was taken directly from the USGS gauging station 04218000 Tonawanda Creek at Rapids (Lat 43°05'35", Long 78°38'11").

External Quality Control

The Water Chemistry Laboratory at SUNY Brockport is State and Nationally certified through the National Environmental Laboratory Accreditation Conference (NELAC – EPA Lab Code # 01449) and New York State Department of Health's Environmental Laboratory Approval Program (ELAP - # 11439). This program includes biannual proficiency audits, annual inspections, and good laboratory practices documentation of all samples, reagents and equipment. Table 3 is a summary of the SUNY Brockport Water Chemistry Laboratory's last proficiency audit.

Results

Stream Water Chemistry Concentrations

Total phosphorus (Figs. 2-4)

Mean nonevent total phosphorus concentrations ranged from 50.2 µg P/L in Hopkins Creek to 210.3 µg P/L in Bergholtz Creek. The mean nonevent TP concentration in Bergholtz Creek was significantly higher ($p=0.00$) than in all other streams monitored in Niagara County, except Eighteenmile Creek. In addition to Bergholtz Creek, seven other streams had a mean nonevent TP concentration exceeding 100 µg P/L. Those creeks in descending order were Eighteenmile Creek (158.4 µg P/L), Jeddo Creek (138.6 µg P/L), Bull Creek (134.9 µg P/L), Mud Creek (110.2 µg P/L) and Twelvemile Creek East (101.1 µg P/L). Bergholtz Creek also had the highest TP concentration during events at 822.8 µg P/L which was 32% increase over the next highest tributary which was Twelvemile Creek East at 624.3 µg P/L.

Nitrate (Figs. 5-7)

Keg Creek, Eighteenmile Creek, and Jeddo Creek had the three highest mean nitrate concentrations during all stream conditions measured (nonevents, events plus nonevents, and events). The mean nonevent nitrate concentration for Keg Creek was 2.46 mg N/L which was statistically significantly higher than for all the other watersheds in Niagara County monitored during this two-year study ($p < 0.05$). Gill Creek, Mud Creek and Fish Creek West had the lowest nitrate concentrations (<0.32 mg N/L) during both events and nonevents.

Total suspended solids (Figs 8-10)

Mean nonevent total suspended solids concentrations were high in both Bergholtz Creek and Gill Creek (25.5 and 25.2 mg/L, respectively) when compared to the rest of the tributaries (mean = 9.8 mg/L) monitored in Niagara County. Curiously under event conditions, the TSS of Gill Creek did not increase all that much (44.4 mg/L) while Bergholtz Creek increased more than 10-fold to 255.8 mg/L. In addition to Bergholtz Creek, Twelvemile Creek East had a mean TSS concentration of over 200 mg/L (228.1 mg/L) under event conditions, while the TSS concentration of eight other tributaries (Four Mile Creek, Jeddo Creek, Twelvemile Creek West, Mud Creek, Cayuga Creek, Bull Creek, Eighteenmile Creek and Fish Creek West) exceeded 100 mg/L .

Total Kjeldahl nitrogen (Figs. 11 -13)
Six Niagara County creeks and branches of creeks (Bergholtz Creek, Twelvemile Creek West, Bull Creek, Twelvemile Creek East, Fish Creek East, and Golden Hill Creek) had a mean total Kjeldahl nitrogen concentration of over 1000 µg N/L for all samples taken under both event and nonevent conditions. Bergholtz Creek had the highest mean TKN concentrations during both event (2,216 µg N/L) and nonevent (1,048 µg N/L) conditions. All tributaries monitored had a mean event TKN concentration of over 1,000 µg N/L, except Gill Creek. The creek that had the lowest overall TKN mean concentration was Keg Creek at 718 µg N/L.

Sodium (Figs. 14-16)
Mean sodium concentrations ranged from 29.61 mg/L in Jeddo Creek to 64.43 mg/L in Cayuga Creek for all samples taken. Eight other streams (Four Mile Creek, Bull Creek, Bergholtz Creek, Gill Creek, Twelvemile Creek West, Fish Creek West, Mud Creek, and Twelvemile Creek East) had overall mean sodium concentrations over 50 mg/L. Gill Creek had the highest sodium concentration during event conditions at 55.85 mg/L.

Losses from Streams or Loading (Table 4)

While the mean water quality chemistry concentrations were the most reliable measurement that was made during this study to prioritize the creeks of Niagara County, loading and discharge of the streams is of importance. The mass loss (kg/day) of these constituents from the watersheds should be considered when evaluating the impact of each stream on its downstream ecosystem. Caution must be used, however, when using the loading estimates derived using the methodology employed for this comparison study as the temporal resolution was one month. While the loading estimate for each sampling date is certainly valid, the error of extrapolating that reading increases with the time-frame of that extrapolation. In other words, the instantaneous snapshot loading that was measured on each sampling date could be expanded to a daily, weekly, monthly or even an annual value by multiplying the instantaneous measurement by that time frame; however, each expansion increases the error inherent in that estimate. We have chosen to use a daily loading value for this analysis and will use that estimate only for comparative purposes and prioritization within this intra-county study.

Total phosphorus (Figs. 17-19)
Eighteenmile Creek had the highest loss of TP at 62.2 kg/d during nonevent and 955.6 kg/d during event stream conditions. Bergholtz Creek came in a distant second in event TP loading at 770.8 kg/d while the TP nonevent loading ranked in the middle of the scale at 5.1 kg/d. Using all the event and nonevent samples taken, Gill Creek had the lowest mean daily loading at 4.9 kg/d followed by Hopkins Creek (12.2 kg/d), Fish Creek West (18.2 kg/d), Keg Creek (20.7 kg/d), and Bull Creek (26.6 kg/d).

Nitrate (Figs. 20-22)
Tonawanda Creek and Eighteenmile Creek had the highest losses of nitrate from their

watersheds. Tonawanda Creek lost 598 kg/d and 2764.7 kg/d during nonevent and events, respectively. While Eighteenmile Creek lost 509.7 kg/d during nonevents and 1628.0 kg/d during event conditions, Gill Creek, Fish Creek West, and Hopkins Creek lost the least amount of nitrate from their watersheds during the study.

Total suspended solids (Figs. 23-25)
Tonawanda Creek, Eighteenmile Creek, and Bergholtz Creek (especially during events) ranked the highest in TSS loss from their watersheds. Tonawanda Creek lost over 11 metric tons per day during nonevent conditions and over 253 MT/d of TSS during events. Eighteenmile Creek lost over 257 metric tons/d and over 6 metric tons/d of TSS during events and nonevents, respectively. Gill Creek had the lowest loss of TSS during events at 0.4 metric tons/d while during nonevents Fish Creek West (0.06 MT/d) and Hopkins Creek (0.07 MT/d) lost the least amount of solids.

Total Kjeldahl nitrogen (Figs. 26-28)
The top five ranking watersheds in terms of TKN loss (kg/d) during both event and nonevent conditions were Tonawanda Creek (1215.5), Eighteenmile Creek (828.2), Bergholtz Creek (402.7), Twelvemile Creek East (304.3) and Golden Hill Creek (290.2). Nonevent losses of TKN were high for Tonawanda Creek, and Eighteenmile Creek when compared to the other Niagara County tributaries monitored (Tonawanda Creek = 516.2 kg/d, Eighteenmile Creek = 369.7 kg/d vs. the next highest Golden Hill Creek = 78. 3kg/d). Gill Creek had the lowest loading of TKN at 31.1 kg/d.

Sodium (Figs. 29-31)
Mean daily nonevent sodium losses ranged from 349.7 kg/d in Keg Creek to 22904.3 kg/d in Tonawanda Creek. Eighteenmile Creek also had the second highest loss of sodium at 17,572.9 kg/d during nonevents and 62,771.7 kg/d for events.

Discussion

Seventeen major creeks within Niagara county were monitored for baseline and storm event sediment and nutrient loads over a two-year period to identify problems, to compare watersheds within Niagara County, to provide scientific data to update the Priority Waterbodies List, and to prioritize local projects for further study. Some conclusions can be reached. Considerable variability existed in the concentrations and losses of nutrients from the 17 watersheds (see Figures). This is expected and is due to differences in land use and point and nonpoint sources within each watershed. For example, Eighteenmile Creek had the highest losses of TP at 62.2 kg/d during nonevent and 955.6 kg/d during event stream conditions. Not considering the area of Eighteenmile Creek, this watershed had the greatest overall loss of phosphorus (221.8 kg/P/day) of any watershed evaluated (Table 5). Bergholtz Creek had the highest

concentrations of TP, TSS and TKN during both nonevent and event stream conditions. Keg Creek had statistically significantly higher mean nonevent nitrate concentration than all the other watersheds in Niagara County monitored during this two-year study.

Comparing areal (g/ha/d) loss of phosphorus from the watershed to downstream systems, Berkholtz and Jeddo Creeks have significantly higher losses than other Niagara County watersheds by at least a factor of two (Table 5). We have no data on the area of Tonawanda Creek, but the daily loss of phosphorus is comparable to both Berkholtz and Jeddo Creeks. Compared to other watersheds in western and central New York (Table 6), these losses represent some of the highest losses per unit area of watershed we have observed. Other creeks have phosphorus losses that are comparable to land use associated with agriculture (Table 6).

Recommendations

Determination of sources and magnitude of soil and nutrient losses from a watershed is prerequisite to remedial action and essential to making cost-effective land management decisions as it reduces the likelihood of costly miscalculations based on the assumption of soil and nutrient sources and modeling rather than their actual identification. The goal of this study was not to evaluate the causes of the variability in loss of nutrients from the various watersheds. However, they clearly exist and are likely amenable to mitigation through management programs such as Whole Farm Planning in agricultural watersheds. As a priority, we recommend the following group of watersheds for identification of point and/or non-point sources of pollution using a process such as Stressed Stream Analysis (Makarewicz 1993): Eighteenmile, Jeddo, Bergholz, Tonawanda, and Keg Creeks.

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Table 1. Geographic Coordinates of Niagara County Water Quality Monitoring Stations D/M/S – NAD83/WGS84

Creek	Location Description	Latitude	Longitude
Eighteenmile Creek	@ Ide Rd., North Side	43° 17’ 11’’ N	78° 42’ 54’’ W
Hopkins Creek	@ Lake Rd., North Side	43° 19’ 42’’ N	78° 44’ 37’’ W
Twelvemile Creek East	@ Youngstown-Wilson Rd., South Side	43° 18’ 26’’ N	78° 49’ 53’’ W
Twelvemile Creek West	@ Youngstown-Wilson Rd., North Side	43° 17’ 20’’ N	78° 52’ 17’’ W
Four Mile Creek	@ Rt. 18, South Side	43° 16’ 06’’ N	79° 00’ 14’’ W
Fish Creek West	@ Rt. 104, West Side	43° 09’ 30’’ N	79° 02’ 19’’ W
Gill Creek	@ Buffalo Ave., North Side	43° 04’ 58’’ N	79° 01’ 32’’ W
Cayuga Creek	@ Access Rd. off of Tuscarora Rd., North Side	43° 05’ 50’’ N	78° 57’ 58’’ W
Bergholtz Creek	@ Williams Rd., East Side	43° 05’ 32’’ N	78° 56’ 27’’ W
Bull Creek	@ Townline Rd., West Side	43° 03’ 56’’ N	78° 49’ 22’’ W
Mud Creek	@ Transit Rd., East Side	43° 05’ 24’’ N	78° 41’ 48’’ W
Tonawanda Creek	@ Rapids Rd., West Side	43° 05’ 37’’ N	78° 38’ 11’’ W
Jeddo Creek	@ County Line Rd., East Side	43° 14’ 41’’ N	78° 27’ 43’’ W
Johnson Creek	@ County Line Rd., West Side	43° 17’ 28’’ N	78° 27’ 57’’ W
Golden Hill Creek	Access road north of Carmen Rd., East Side	43° 21’ 56’’ N	78° 29’ 45’’ W
Fish Creek East	@ Lower Lake Rd., North Side	43° 22’ 03’’ N	78° 32’ 01’’ W
Keg Creek	@ Lake Rd., South Side	43° 20’ 46’’ N	78° 39’ 12’’ W

Table 2. The watershed areas of Niagara County streams as determined by the Niagara County Soil and Water Conservation District.

Creek	Watershed Area (acres)
Eighteenmile Creek	55,385
Hopkins Creek	10,754
Twelvemile Creek East	24,928
Twelvemile Creek West	23,093
Four Mile Creek	11,449
Fish Creek West	3,286
Gill Creek	9,853
Cayuga Creek	10,899
Berkholtz Creek	7,748
Bull Creek	14,408
Mud Creek	26,518
Tonawanda Creek	Undetermined
Jeddo Creek	8,678
Johnson Creek	25,825
Golden Hill Creek	14,759
Fish Creek East	7,028
Keg Creek	9,502

Table 3. Results of the semi-annual New York State Environmental Laboratory Assurance Program (ELAP # 11439, SUNY Brockport) Non-Potable Water Chemistry Proficiency Test.

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

Proficiency Test Report

Lab 11439 SUNY BROCKPORT
WATER LAB LENNON HALL
BROCKPORT, NY 14420
USA

EPA Lab Id NY01449

Shipment: 305 Non Potable Water Chemistry
Shipment Date: 16-Jul-2007

Analyte	Sample ID	Result	Mean/Target	Warning Limits	Method	Score
Approval Category : **Non Potable Water**						
Sample: **Residue**						
Solids, Total Suspended 215 passed out of 221 reported results.	0502	64.9	66.6	57.0-71.3	SM18-20 2540D (97)	Satisfactory
Sample: **Organic Nutrients**						
Kjeldahl Nitrogen, Total 83 passed out of 91 reported results.	0504	5.00	6.71	5.23-8.09	EPA 351.2 Rev. 2.0	Satisfactory
Phosphorus, Total 104 passed out of 114 reported results.	0504	8.12	8.63	7.65-9.68	SM18-20 4500-PF	Satisfactory
Sample: **Inorganic Nutrients**						
Nitrate (as N) 118 passed out of 119 reported results.	0507	29.98	28.8	24.5-32.7	SM18-20 4500-NO3 F (00)	Satisfactory
Orthophosphate (as P) 93 passed out of 103 reported results.	0507	4.54	4.50	3.98-5.05	SM18-20 4500-PF	Satisfactory
Sample: **Minerals II**						
Sodium, Total 80 passed out of 84 reported results.	0537	82.06	79.3	71.3-87.0	SM 18-20 3111B (99)	Satisfactory
Sample: **Nitrite**						
Nitrite as N 107 passed out of 111 reported results .	0541	3.36	3.27		SM 18-20 4500-NO2 B	Satisfactory

Table 4. Average discharge and loading parameters for Niagara County stream sites from February 2006 thru December 2007 with associated Standard Error. Numbers in parenthesis are the minimum and maximum. Average equals the mean of all events and nonevents.

		Discharge (m^3/day)	Total Phosphorus (kg/day)	Nitrate + Nitrite (kg/day)
Four Mile Creek	Nonevent	26,496 ± 11,786 (245 - 274,517)	2.3 ± 1.4 (0.0 - 32.4)	13.7 ± 7.8 (0.0 - 181.2)
	Event	584,231 ± 243,717 (132,788 - 1,269,952)	341.6 ± 175.2 (16.8 - 823.2)	272.0 ± 100.4 (41.2 - 584.2)
	Average	126,091 ± 57,916 (245 - 1,269,952)	62.9 ± 37.9 (0.0 - 823.2)	59.8 ± 25.9 (0.0 - 584.2)
Twelvemile Creek East	Nonevent	83,981 ± 55,904 (0 - 1,304,804)	11.8 ± 9.2 (0.0 - 213.3)	66.3 ± 46.7 (0.0 - 1,083.0)
	Event	589,078 ± 175,499 (174,110 - 1,050,349)	452.0 ± 205.3 (84.3 - 1,047.5)	361.3 ± 84.8 (144.5 - 577.7)
	Average	174,177 ± 65,518 (0 - 1,304,804)	90.4 ± 47.2 (0.0 - 1,047.5)	119.0 ± 46.1 (0.0 - 1,083.0)
Twelvemile Creek West	Nonevent	47,114 ± 29,495 (0 - 671,238)	6.6 ± 4.8 (0.0 - 108.1)	33.6 ± 22.8 (0.0 - 523.6)
	Event	540,251 ± 122,614 (253,749 - 866,936)	302.9 ± 116.8 (84.8 - 624.5)	330.4 ± 66.5 (124.0 - 519.4)
	Average	135,174 ± 47,970 (0 - 866,936)	59.5 ± 29.2 (0.0 - 624.5)	86.6 ± 30.7 (0.0 - 523.6)
Eighteen Mile Creek	Nonevent	376,545 ± 54,105 (133,061 - 1,214,468)	62.2 ± 13.4 (7.0 - 302.6)	509.7 ± 73.9 (155.7 - 1,627.4)
	Event	1,872,581 ± 335,439 (650,591 - 2,628,021)	955.6 ± 341.8 (49.3 - 2,097.9)	1,628.0 ± 224.9 (865.3 - 2,260.1)
	Average	643,695 ± 130,748 (133,061 - 2,628,021)	221.8 ± 86.9 (7.0 - 2,097.9)	709.4 ± 108.6 (155.7 - 2,260.1)
Bergholtz Creek	Nonevent	21,984 ± 4,503 (2,256 - 77,125)	5.1 ± 1.4 (0.4 - 23.3)	17.9 ± 4.4 (0.0 - 72.2)
	Event	968,169 ± 146,999 (640,635 - 1,494,519)	770.8 ± 110.5 (429.2 - 1,024.5)	570.6 ± 44.3 (412.7 - 672.5)
	Average	190,945 ± 73,817 (2,256 - 1,494,519)	141.8 ± 59.2 (0.4 - 1,024.5)	116.6 ± 41.5 (0.0 - 672.5)
Bull Creek	Nonevent	31,180 ± 10,542 (4,781 - 230,469)	5.0 ± 1.9 (0.1 - 37.3)	14.2 ± 6.7 (0.1 - 154.4)
	Event	313,024 ± 54,063 (191,678 - 440,863)	126.2 ± 20.3 (71.4 - 196.6)	112.0 ± 36.6 (20.8 - 242.5)
	Average	81,509 ± 24,151 (4,781 - 440,863)	26.6 ± 9.7 (0.1 - 196.6)	31.6 ± 10.8 (0.1 - 242.5)
Cayuga Creek	Nonevent	21,678 ± 5,525 (3,871 - 122,346)	2.0 ± 0.8 (0.1 - 15.9)	15.3 ± 5.2 (0.4 - 115.0)
	Event	396,019 ± 125,603 (226,804 - 892,273)	151.2 ± 61.3 (57.7 - 392.8)	202.6 ± 36.0 (101.0 - 312.3)
	Average	88,524 ± 34,628 (3,871 - 892,273)	28.6 ± 14.9 (0.1 - 392.8)	48.7 ± 15.6 (0.4 - 312.3)
Gill Creek	Nonevent	14,517 ± 1,419 (4,494 - 31,679)	1.5 ± 0.4 (0.2 - 10.6)	3.9 ± 0.9 (0.0 - 15.3)
	Event	120,759 ± 48,658 (43,865 - 304,008)	20.3 ± 12.6 (4.0 - 69.9)	27.5 ± 10.8 (13.6 - 69.9)
	Average	33,489 ± 11,194 (4,494 - 304,008)	4.9 ± 2.5 (0.2 - 69.9)	8.1 ± 2.6 (0.0 - 69.9)
Hopkins Creek	Nonevent	14,114 ± 6,191 (0 - 131,677)	1.2 ± 0.7 (0.0 - 14.9)	10.8 ± 4.6 (0.0 - 100.1)
	Event	205,398 ± 64,391 (66,182 - 373,817)	62.9 ± 29.3 (5.1 - 153.6)	99.3 ± 27.4 (39.1 - 190.6)
	Average	48,272 ± 18,279 (0 - 373,817)	12.2 ± 6.6 (0.0 - 153.6)	26.6 ± 8.8 (0.0 - 190.6)
Fish Creek East	Nonevent	15,579 ± 10,920 (0 - 249,318)	2.4 ± 1.9 (0.0 - 44.4)	17.4 ± 12.1 (0.0 - 276.7)
	Event	298,691 ± 221,916 (31,267 - 1,183,059)	180.3 ± 154.4 (5.3 - 797.1)	176.6 ± 104.6 (18.8 - 579.7)
	Average	66,135 ± 42,639 (0 - 1,183,059)	34.2 ± 28.4 (0.0 - 797.1)	45.8 ± 22.9 (0.0 - 579.7)
Fish Creek West	Nonevent	6,524 ± 1,757 (698 - 37,199)	0.4 ± 0.1 (0.0 - 2.7)	1.8 ± 0.6 (0.0 - 13.8)
	Event	237,284 ± 118,204 (42,330 - 687,573)	99.9 ± 66.9 (7.2 - 362.9)	57.8 ± 22.8 (7.2 - 137.5)
	Average	47,731 ± 25,710 (698 - 687,573)	18.2 ± 13.1 (0.0 - 362.9)	11.8 ± 5.6 (0.0 - 137.5)
Tonawanda Creek	Nonevent	695,333 ± 144,157 (48,932 - 2,691,233)	42.6 ± 9.9 (3.7 - 161.9)	598.3 ± 138.6 (1.7 - 2,529.8)
	Event	4,213,003 ± 484,484 (2,544,439 - 5,504,795)	597.2 ± 112.1 (266.3 - 941.3)	2,764.7 ± 648.2 (610.7 - 4,238.7)
	Average	1,323,489 ± 295,539 (48,932 - 5,504,795)	141.7 ± 45.5 (3.7 - 941.3)	985.1 ± 222.4 (1.7 - 4,238.7)
Johnson Creek	Nonevent	79,044 ± 23,788 (22,334 - 557,940)	6.6 ± 2.2 (0.1 - 49.1)	50.2 ± 18.1 (6.3 - 429.6)
	Event	902,601 ± 218,372 (366,355 - 1,481,048)	245.7 ± 76.0 (39.8 - 461.6)	349.5 ± 47.3 (203.0 - 459.1)
	Average	226,108 ± 72,973 (22,334 - 1,481,048)	49.3 ± 21.6 (0.1 - 461.6)	103.6 ± 27.6 (6.3 - 459.1)
Mud Creek	Nonevent	60,768 ± 21,659 (4,772 - 410,016)	7.6 ± 2.8 (0.2 - 56.1)	15.9 ± 6.9 (0.0 - 154.5)
	Event	744,821 ± 141,831 (372,324 - 1,061,336)	218.2 ± 37.6 (94.6 - 306.1)	172.5 ± 43.3 (14.9 - 268.4)
	Average	182,920 ± 58,209 (4,772 - 1,061,336)	45.2 ± 16.8 (0.2 - 306.1)	43.8 ± 14.6 (0.0 - 268.4)
Jeddo Creek	Nonevent	74,607 ± 14,491 (17,056 - 371,879)	8.8 ± 1.3 (3.3 - 28.3)	91.3 ± 22.8 (31.5 - 554.1)
	Event	642,631 ± 187,913 (335,666 - 1,365,710)	438.6 ± 245.3 (96.7 - 1,398.9)	536.4 ± 105.9 (271.9 - 874.1)
	Average	176,040 ± 53,175 (17,056 - 1,365,710)	85.6 ± 51.0 (3.3 - 1,398.9)	170.8 ± 41.5 (31.5 - 874.1)
Golden Hill Creek	Nonevent	62,697 ± 38,842 (0 - 895,479)	6.3 ± 4.5 (0.0 - 104.7)	48.5 ± 31.5 (0.0 - 725.3)
	Event	685,998 ± 270,754 (327,636 - 1,762,418)	303.9 ± 189.0 (79.9 - 1,053.7)	414.1 ± 157.0 (143.6 - 987.0)
	Average	174,000 ± 71,132 (0 - 1,762,418)	59.5 ± 37.9 (0.0 - 1,053.7)	113.8 ± 45.2 (0.0 - 987.0)
Keg Creek	Nonevent	11,343 ± 5,038 (943 - 115,473)	1.0 ± 0.6 (0.0 - 13.6)	19.9 ± 6.7 (0.4 - 151.3)
	Event	302,935 ± 193,144 (92,863 - 1,075,294)	111.2 ± 90.6 (12.6 - 473.3)	209.5 ± 101.3 (88.9 - 612.9)
	Average	63,413 ± 38,286 (943 - 1,075,294)	20.7 ± 16.8 (0.0 - 473.3)	53.8 ± 22.3 (0.4 - 612.9)
All Streams	Nonevent	96,677 ± 13,337 (0 - 2,691,233)	10.2 ± 1.4 (0.0 - 302.6)	89.9 ± 13.2 (0.0 - 2,529.8)
	Event	801,028 ± 112,809 (31,267 - 5,504,795)	316.4 ± 42.3 (4.0 - 2,097.9)	487.3 ± 83.2 (7.2 - 4,238.7)
	Average	222,454 ± 25,982 (0 - 5,504,795)	64.9 ± 9.3 (0.0 - 2,097.9)	160.9 ± 19.6 (0.0 - 4,238.7)

Table 4 (cont.). Average discharge and loading parameters for Niagara County stream sites from February 2006 thru December 2007 with associated Standard Error. Numbers in parenthesis are the minimum and maximum.

		Total Suspended Solids (kg/day)	Total Kjeldahl Nitrogen (kg/day)	Dissolved Sodium (kg/day)
Four Mile Creek	Nonevent	328.8 ± 244.7 (0.1 - 5,682.5)	23.0 ± 12.5 (0.1 - 290.7)	1,761.6 ± 667.6 (14.1 - 14,856.9)
	Event	146,402.2 ± 76,858.6 (4,382.0 - 375,905.9)	1,050.1 ± 534.5 (10.0 - 2,774.8)	15,619.9 ± 3,640.0 (7,171.9 - 25,919.7)
	Average	26,413.3 ± 16,499.6 (0.1 - 375,905.9)	206.4 ± 115.7 (0.1 - 2,774.8)	4,236.3 ± 1,300.8 (14.1 - 25,919.7)
Twelvemile Creek East	Nonevent	2,712.5 ± 2,605.4 (0.0 - 60,021.0)	77.6 ± 52.1 (0.0 - 1,214.8)	2,723.7 ± 1,351.2 (0.0 - 31,732.8)
	Event	167,638.5 ± 72,638.6 (16,592.7 - 360,518.8)	1,347.2 ± 545.1 (127.7 - 2,962.8)	11,282.6 ± 1,736.0 (6,005.1 - 14,841.4)
	Average	32,163.6 ± 17,085.2 (0.0 - 360,518.8)	304.3 ± 135.8 (0.0 - 2,962.8)	4,252.1 ± 1,303.7 (0.0 - 31,732.8)
Twelvemile Creek West	Nonevent	514.0 ± 385.9 (0.0 - 8,591.8)	46.9 ± 30.6 (0.0 - 700.1)	1,466.2 ± 663.5 (0.0 - 15,351.2)
	Event	94,519.7 ± 41,767.6 (16,794.5 - 229,738.1)	1,038.0 ± 336.2 (300.3 - 1,918.5)	11,966.9 ± 469.6 (11,192.1 - 13,559.6)
	Average	17,300.7 ± 9,708.8 (0.0 - 229,738.1)	223.9 ± 94.6 (0.0 - 1,918.5)	3,341.4 ± 948.5 (0.0 - 15,351.2)
Eighteen Mile Creek	Nonevent	6,240.6 ± 2,251.8 (462.0 - 46,175.7)	369.7 ± 91.8 (36.4 - 2,024.5)	17,572.9 ± 3,487.5 (4794.2 - 85,680.7)
	Event	257,352.5 ± 115,303.8 (12,035.9 - 683,285.4)	2,937.2 ± 955.1 (514.0 - 5,957.7)	62,771.7 ± 10,099.7 (40,284.6 - 89,063.6)
	Average	51,082.0 ± 26,413.7 (462.0 - 683,285.4)	828.2 ± 256.1 (36.4 - 5,957.7)	25,644.1 ± 4,683.8 (4,794.2 - 89,063.6)
Bergholtz Creek	Nonevent	653.0 ± 234.0 (6.8 - 4,775.8)	27.5 ± 7.1 (0.9 - 119.7)	1,236.8 ± 200.3 (166.6 - 4,119.1)
	Event	241,138.3 ± 56,919.6 (59,592.8 - 381,102.3)	2,128.5 ± 337.0 (1,452.7 - 3,323.8)	19,488.5 ± 4,431.3 (7,622.0 - 29,795.9)
	Average	43,596.8 ± 19,998.5 (6.8 - 381,102.3)	402.7 ± 164.4 (0.9 - 3,323.8)	4,496.0 ± 1,535.0 (166.6 - 29,795.9)
Bull Creek	Nonevent	484.8 ± 134.6 (14.8 - 2,350.8)	33.3 ± 12.7 (1.9 - 277.3)	1,634.1 ± 542.6 (132.3 - 13,150.5)
	Event	37,802.7 ± 15,377.2 (11,291.5 - 97,430.8)	560.1 ± 102.9 (385.3 - 902.0)	6,264.2 ± 1,477.0 (3,037.5 - 10,766.0)
	Average	7,148.7 ± 3,719.3 (14.8 - 97,430.8)	127.4 ± 43.5 (1.9 - 902.0)	2,460.9 ± 609.3 (132.3 - 13,150.5)
Cayuga Creek	Nonevent	303.0 ± 100.0 (4.1 - 1,835.2)	19.2 ± 6.0 (0.9 - 132.5)	1,396.9 ± 368.7 (117.6 - 8,939.8)
	Event	48,734.5 ± 14,894.3 (17,666.8 - 95,473.2)	602.0 ± 212.0 (224.3 - 1,413.4)	9,488.5 ± 1,873.6 (4,616.9 - 15,903.0)
	Average	8,951.5 ± 4,314.9 (4.1 - 95,473.2)	123.2 ± 55.3 (0.9 - 1,413.4)	2,841.8 ± 734.5 (117.6 - 15,903.0)
Gill Creek	Nonevent	426.2 ± 131.3 (10.8 - 3,152.1)	11.3 ± 1.5 (3.1 - 37.0)	833.9 ± 205.4 (268.9 - 5,059.6)
	Event	8,392.1 ± 6,251.4 (886.1 - 33,296.2)	122.6 ± 56.9 (32.3 - 344.4)	4,853.9 ± 719.0 (2,926.3 - 7,375.2)
	Average	1,848.7 ± 1,179.0 (10.8 - 33,296.2)	31.1 ± 12.4 (3.1 - 344.4)	1,551.8 ± 360.1 (268.9 - 7,375.2)
Hopkins Creek	Nonevent	73.2 ± 45.4 (0.0 - 1,027.1)	13.4 ± 6.5 (0.0 - 142.1)	435.3 ± 197.1 (0.0 - 4,458.6)
	Event	13,826.4 ± 7,314.8 (1,060.2 - 37,381.7)	323.0 ± 126.9 (75.3 - 702.8)	4,149.4 ± 816.5 (2,163.5 - 6,141.8)
	Average	2,529.1 ± 1,563.5 (0.0 - 37,381.7)	68.6 ± 31.2 (0.0 - 702.8)	1,098.6 ± 344.3 (0.0 - 6,141.8)
Fish Creek East	Nonevent	170.8 ± 141.8 (0.0 - 3,241.1)	19.8 ± 14.5 (0.0 - 328.9)	360.2 ± 208.1 (0.0 - 4,714.6)
	Event	73,127.9 ± 68,696.6 (453.4 - 347,819.4)	683.4 ± 556.8 (33.4 - 2,905.6)	2,547.8 ± 1,064.9 (672.9 - 6,317.5)
	Average	13,198.8 ± 12,400.7 (0.0 - 347,819.4)	138.3 ± 103.6 (0.0 - 2,905.6)	750.8 ± 291.5 (0.0 - 6,317.5)
Fish Creek West	Nonevent	64.7 ± 21.2 (1.5 - 0,453.8)	4.1 ± 1.3 (0.2 - 29.7)	403.2 ± 128.3 (23.9 - 3,042.2)
	Event	40,489.9 ± 28,767.8 (1,265.5 - 154,016.3)	381.8 ± 227.7 (41.2 - 1,268.6)	3,826.3 ± 967.5 (1213.2 - 5,794.3)
	Average	7,283.5 ± 5,547.3 (1.5 - 154,016.3)	71.6 ± 46.3 (0.2 - 1,268.6)	1,014.5 ± 315.3 (23.9 - 5,794.3)
Tonawanda Creek	Nonevent	11,559.2 ± 2,843.8 (574.9 - 59,006.5)	516.2 ± 129.6 (26.2 - 2,430.2)	22,904.3 ± 4,747.8 (2713.7 - 100,436.8)
	Event	253,794.5 ± 45,150.0 (143,271.5 - 370,472.7)	4,432.1 ± 832.5 (2,087.5 - 6,365.0)	87,854.4 ± 12,501.6 (45,112.9 - 121,193.6)
	Average	54,815.5 ± 19,445.4 (574.9 - 370,472.7)	1,215.5 ± 336.0 (26.2 - 6,365.0)	34,502.5 ± 6,491.6 (2,713.7 - 121,193.6)
Johnson Creek	Nonevent	851.9 ± 231.5 (54.5 - 5,412.0)	62.2 ± 19.9 (8.4 - 445.8)	2,190.0 ± 513.1 (527.6 - 12,230.1)
	Event	58,198.6 ± 23,025.7 (13,657.8 - 137,737.5)	1,118.8 ± 243.8 (475.7 - 1,888.3)	13,508.1 ± 2,102.0 (8,571.0 - 19,029.1)
	Average	11,092.4 ± 5,650.5 (54.5 - 137,737.5)	250.9 ± 88.9 (8.4 - 1,888.3)	4,211.1 ± 994.5 (527.6 - 19,029.1)
Mud Creek	Nonevent	661.6 ± 242.2 (6.0 - 4,838.2)	58.5 ± 20.3 (0.9 - 379.7)	2,310.0 ± 893.3 (371.9 - 21,077.3)
	Event	87,314.1 ± 27,658.7 (19,100.2 - 155,948.7)	826.6 ± 210.0 (287.6 - 1,395.3)	16,112.2 ± 4,494.1 (5,059.9 - 24,516.9)
	Average	16,135.3 ± 7,814.7 (6.0 - 155,948.7)	195.6 ± 68.2 (0.9 - 1,395.3)	4,774.7 ± 1,450.3 (371.9 - 24,516.9)
Jeddo Creek	Nonevent	701.7 ± 167.6 (39.2 - 4,016.3)	60.7 ± 18.6 (12.5 - 451.8)	2,321.3 ± 466.5 (581.4 - 11,267.9)
	Event	132,056.0 ± 91,738.2 (16,548.4 - 497,118.3)	1,201.4 ± 624.4 (409.8 - 3,677.9)	8,508.5 ± 884.1 (6,099.1 - 11,417.2)
	Average	24,157.8 ± 17,787.6 (39.2 - 497,118.3)	264.4 ± 132.7 (12.5 - 3,677.9)	3,426.1 ± 611.8 (581.4 - 11,417.2)
Golden Hill Creek	Nonevent	515.5 ± 382.7 (0.0 - 8,775.7)	78.3 ± 53.4 (0.0 - 1,231.3)	1,496.3 ± 839.4 (0.0 - 19,351.3)
	Event	106,812.3 ± 83,552.6 (15,666.6 - 440,604.4)	1,264.9 ± 685.7 (110.6 - 3,879.1)	9,587.5 ± 1,623.7 (6,307.0 - 14,698.6)
	Average	19,497.1 ± 15,689.7 (0.0 - 440,604.4)	290.2 ± 148.3 (0.0 - 3879.1)	2,941.2 ± 947.1 (0.0 - 19,351.3)
Keg Creek	Nonevent	239.0 ± 165.0 (0.5 - 3,406.5)	9.3 ± 4.8 (0.3 - 106.6)	349.7 ± 129.8 (21.3 - 3,030.0)
	Event	47,247.9 ± 41,743.9 (2,457.0 - 213,983.4)	507.8 ± 368.0 (29.5 - 1,971.0)	3,750.8 ± 1,393.0 (1,824.4 - 9,269.0)
	Average	8,633.5 ± 7,623.8 (0.5 - 213,983.4)	98.3 ± 70.3 (0.3 - 1,971.0)	957.0 ± 354.2 (21.3 - 9,269.0)
All Streams	Nonevent	1,558.8 ± 0,299.6 (0.0 - 60,021.0)	84.2 ± 12.6 (0.0 - 2,430.2)	3,611.6 ± 480.4 (0.0 - 100,436.8)
	Event	106,755.8 ± 15,220.0 (453.4 - 683,285.4)	1,207.4 ± 155.3 (10.0 - 6,365.0)	17,151.8 ± 2,605.9 (672.9 - 121,193.6)
	Average	20,344.0 ± 3,285.3 (0.0 - 683,285.4)	284.7 ± 35.5 (0.0 - 6,365.0)	6,029.5 ± 653.2 (0.0 - 121,193.6)

Table 5. Average phosphorus loss from various Niagara County watersheds.

Creek	Watershed Area (acres)	Watershed Area (ha)	Average Load kg P/day	Average Load g P/day/ha
Eighteenmile Creek	55,385	22,431	221.8	9.9
Hopkins Creek	10,754	4,355	12.2	2.8
Twelvemile Creek East	24,928	10,096	90.4	9.0
Twelvemile Creek West	23,093	9,353	59.5	6.4
Four Mile Creek	11,449	4,637	62.9	13.6
Fish Creek West	3,286	1,331	18.2	13.7
Gill Creek	9,853	3,990	4.9	1.2
Cayuga Creek	10,899	4,414	28.6	6.5
Berkholtz Creek	7,748	3,138	141.8	45.2
Bull Creek	14,408	5,835	26.6	4.6
Mud Creek	26,518	10,740	45.2	4.2
Tonawanda Creek	Undetermined	No data	141.7	
Jeddo Creek	8,678	3,515	85.6	24.4
Johnson Creek	25,825	10,459	49.3	4.7
Golden Hill Creek	14,759	5,977	59.5	10.0
Fish Creek East	7,028	2,846	34.2	12.0
Keg Creek	9,502	3,848	20.7	5.4

Table 6. Comparison of phosphorus loading in subbasins of the Irondequoit Bay watershed, other Monroe County creeks, tributaries of Sodus and Port Bays, and Lake Neatahwanta tributaries. Irondequoit basin data are from 1980-81. Adapted from Makarewicz *et al.* (2006)

Subbasin or Creek	Land Use	Total Phosphorus Loading (g P/ha/d) Annual
Sucker Brook	Agriculture/Urban	7.66
Irondequoit Creek at Browncroft Blvd. 1975-77 (pre-diversion)	Several Sewage Plants	5.60
1978-79 (post-diversion)		2.00
Larkin	Suburban	0.70
Buttonwood	Suburban	1.58
Lower Northrup	Sewage Plant	6.64
Upper Northrup	Urban	3.23
First	Forested	0.11
Clark	Forested	0.22
Sodus East	Agriculture	8.57
Wolcott	Agriculture	5.01
Bobolink	Forested	0.02
Sheldon	Muckland	27.41
Summerville	Suburban	5.47
		1997-98 1998-99
Oak Orchard		3.48 2.86
Johnson		1.81 1.17
Sandy		0.98 0.77
		1998-99 1999-00
		1998-2002
Twelvemile Creek East	Agriculture	0.30
		1999-2002
Twelvemile Creek West	Agriculture	0.67
		2003-2005
Eighteenmile Creek	Urban/Agriculture	3.83

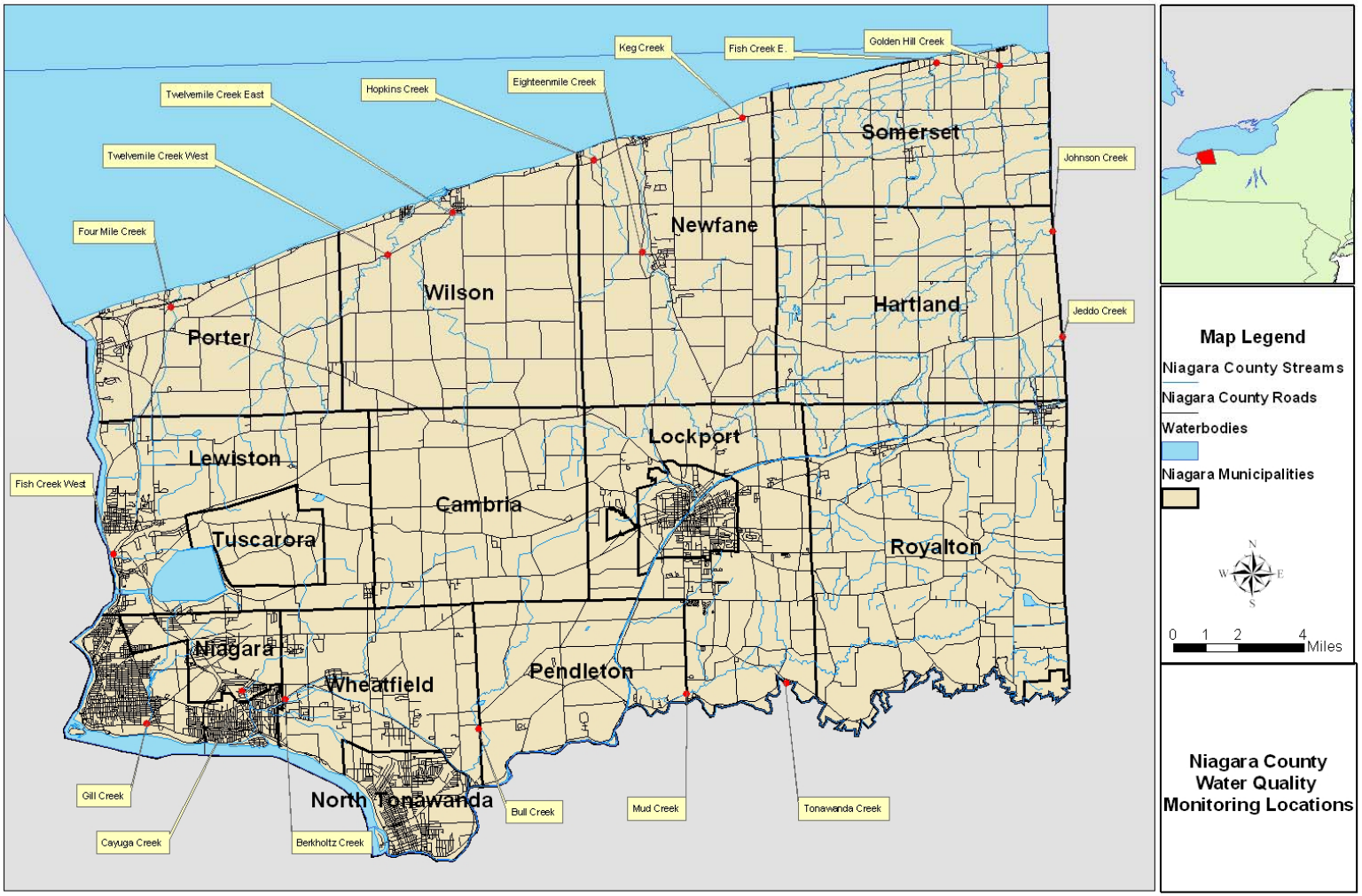


Figure1. Map of Niagara County stream sampling sites.

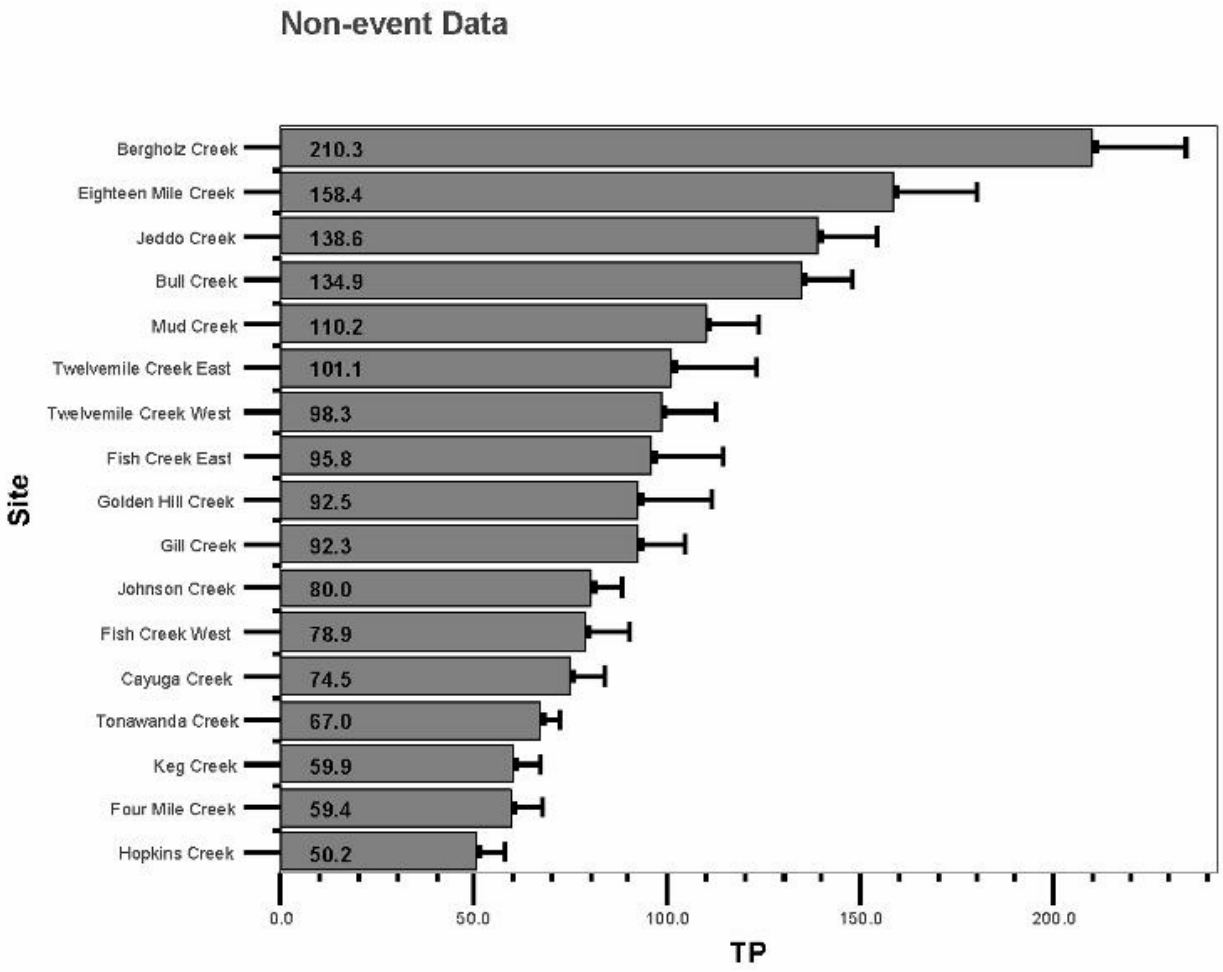


Figure 2. Mean nonevent total phosphorus concentrations (µg P/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

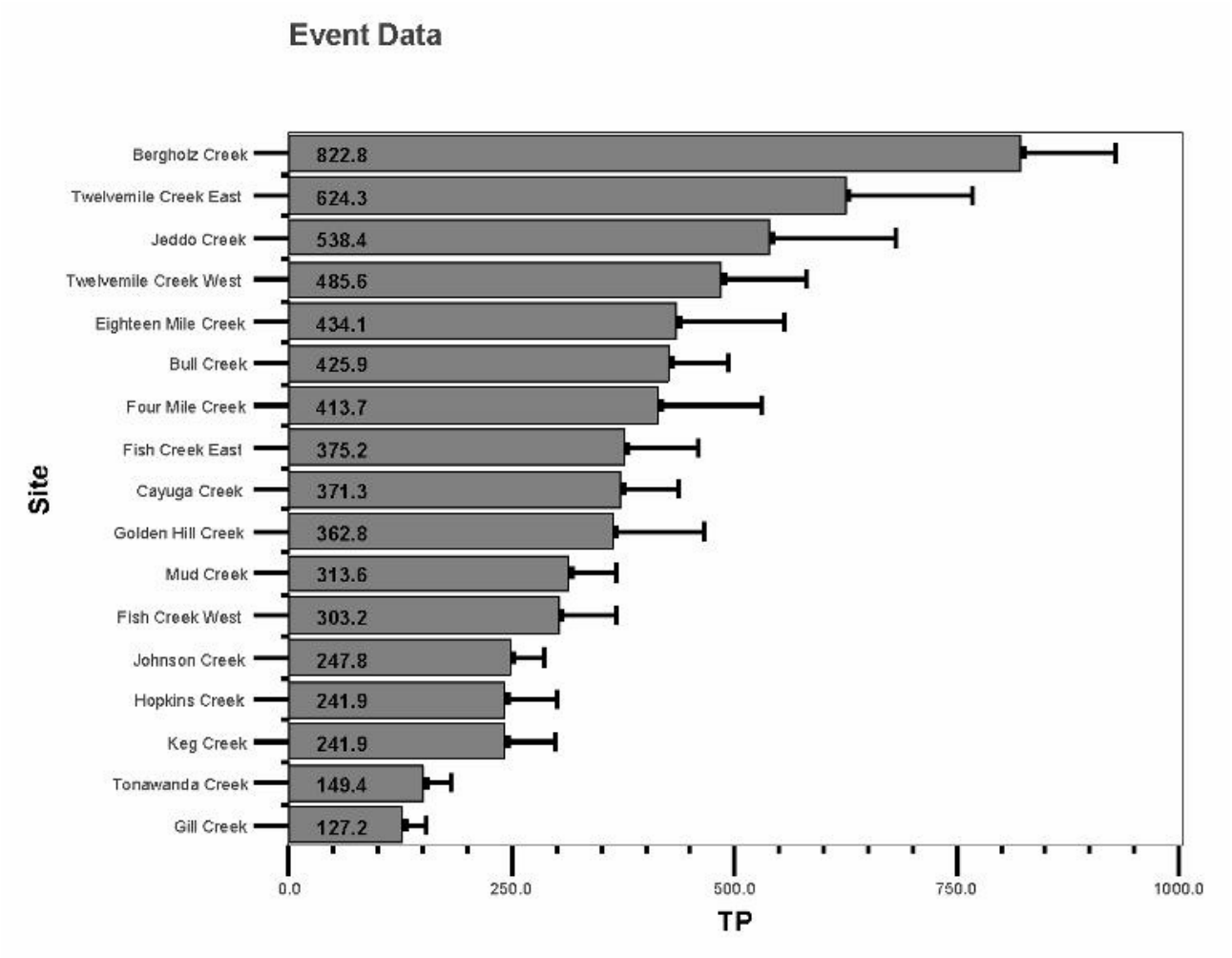


Figure 3. Mean event total phosphorus concentrations (µg P/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

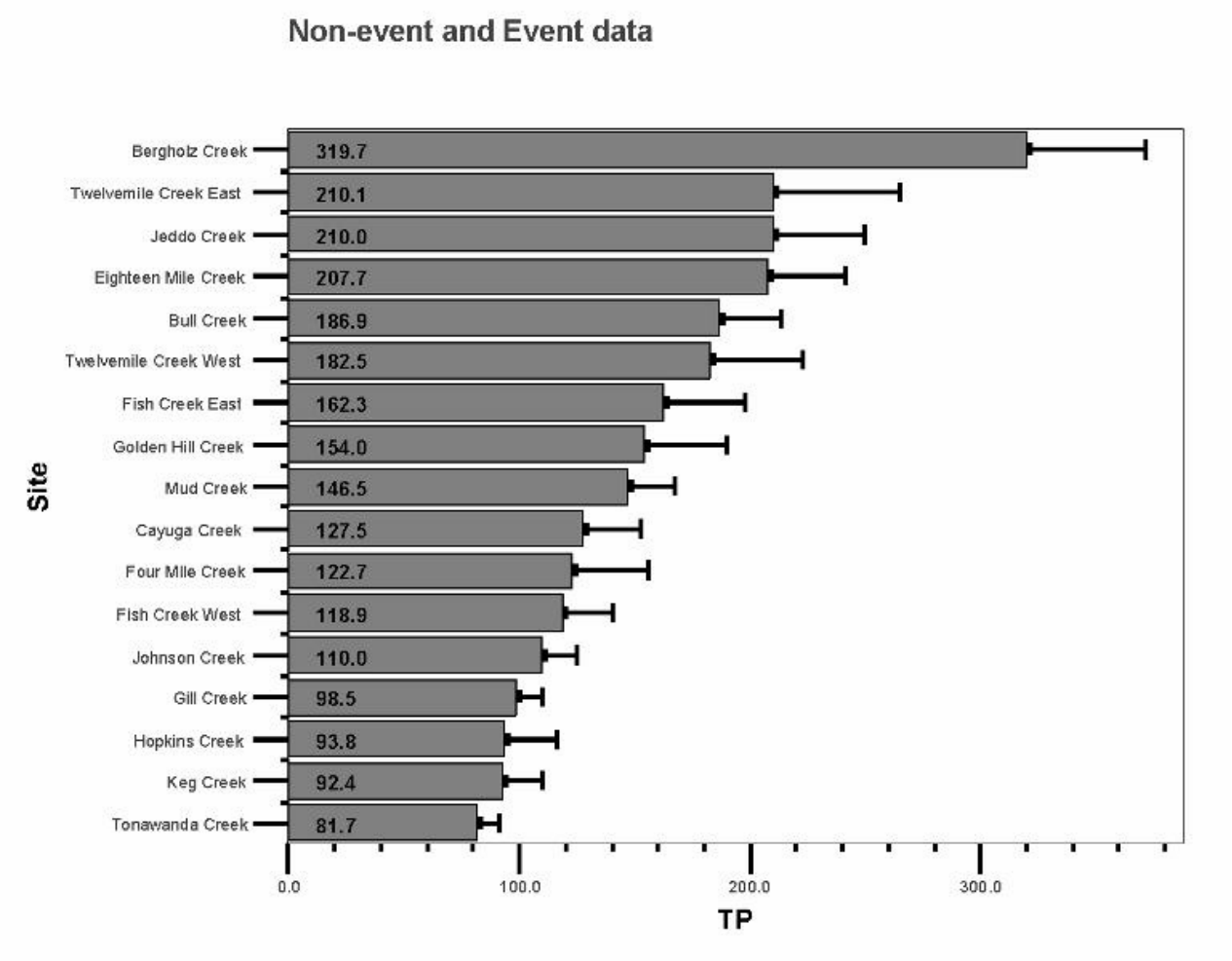


Figure 4. Mean nonevent plus event total phosphorus concentrations (µg P/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

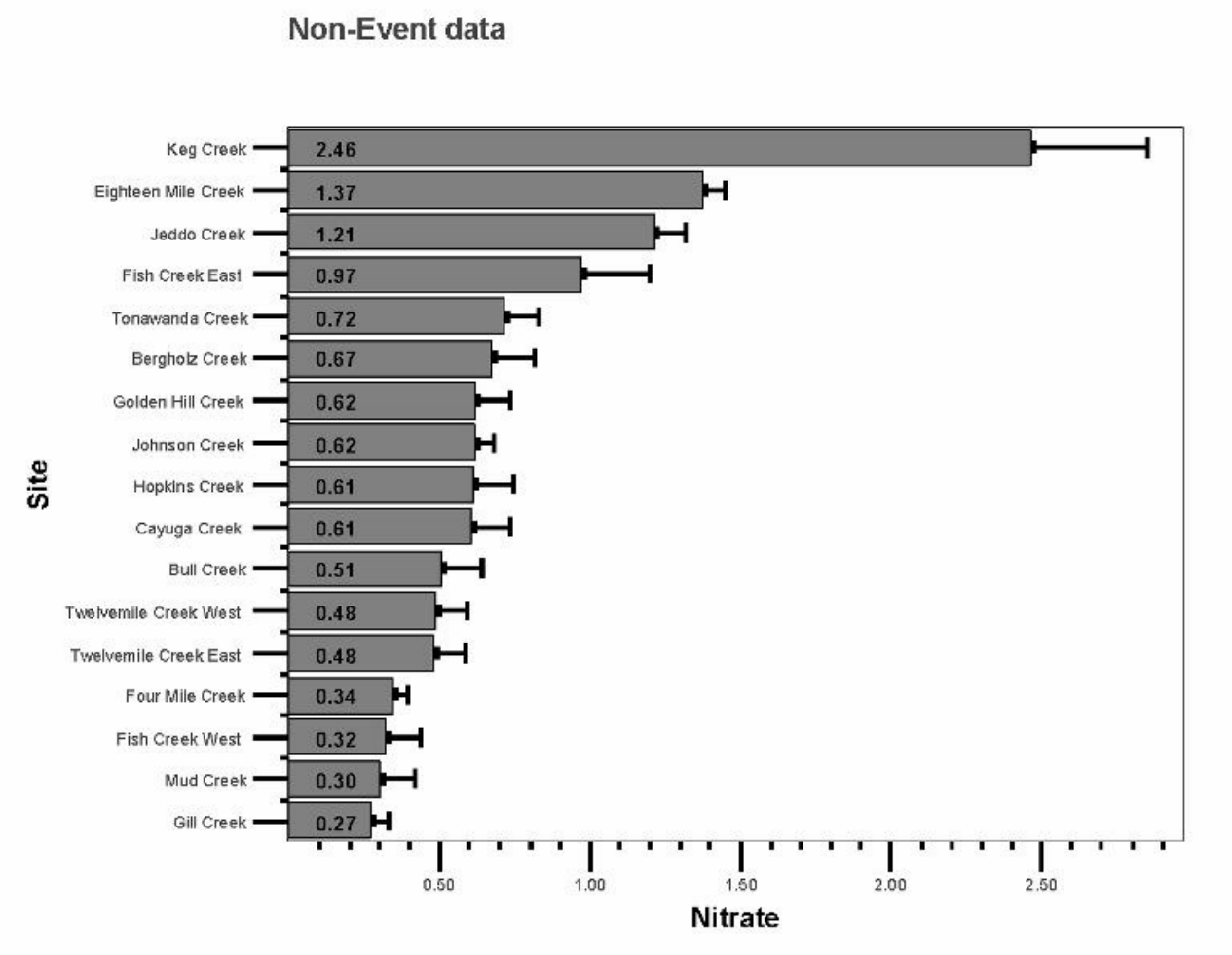


Figure 5. Mean nonevent nitrate concentrations (mg N/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

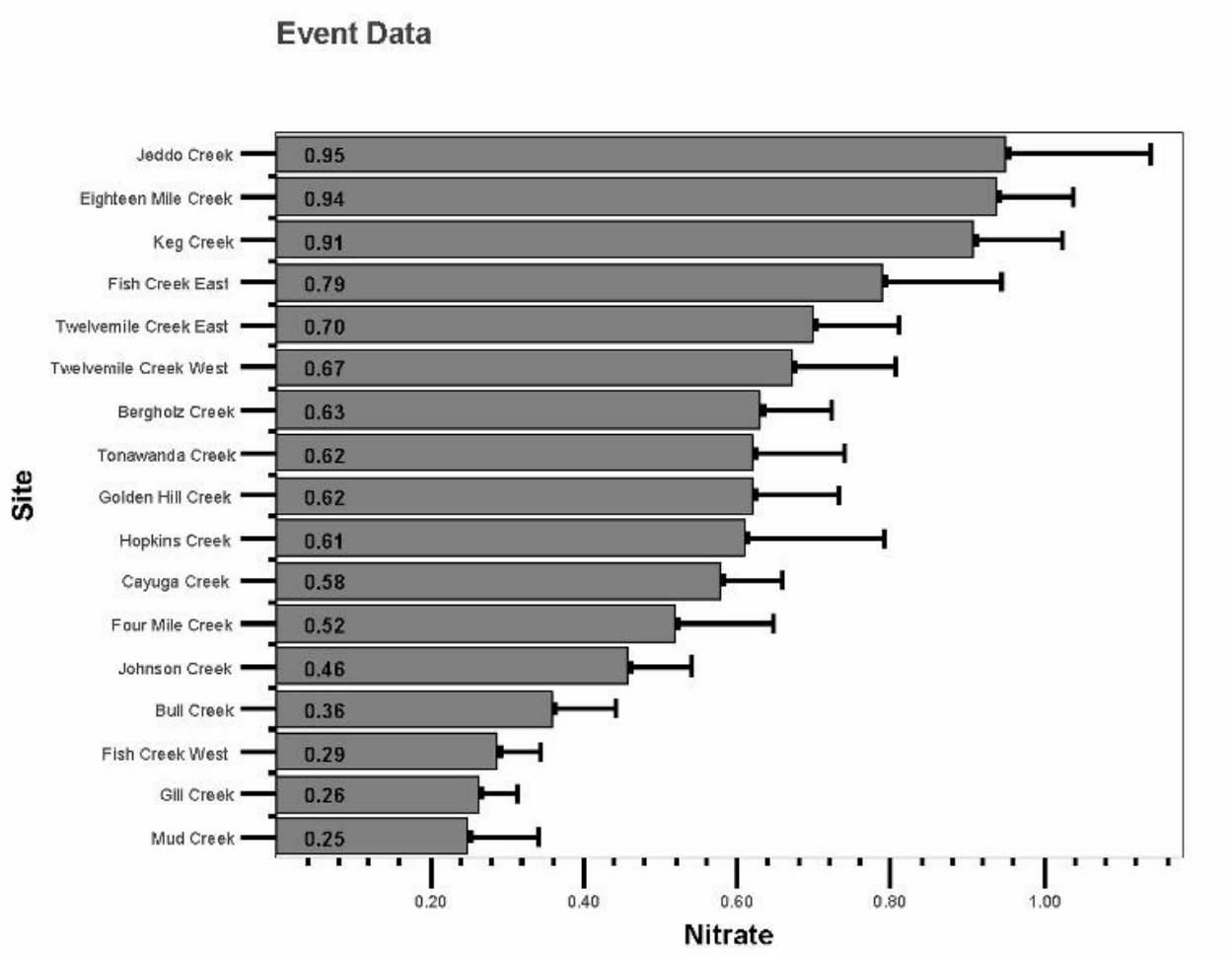


Figure 6. Mean event nitrate concentrations (mg N/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

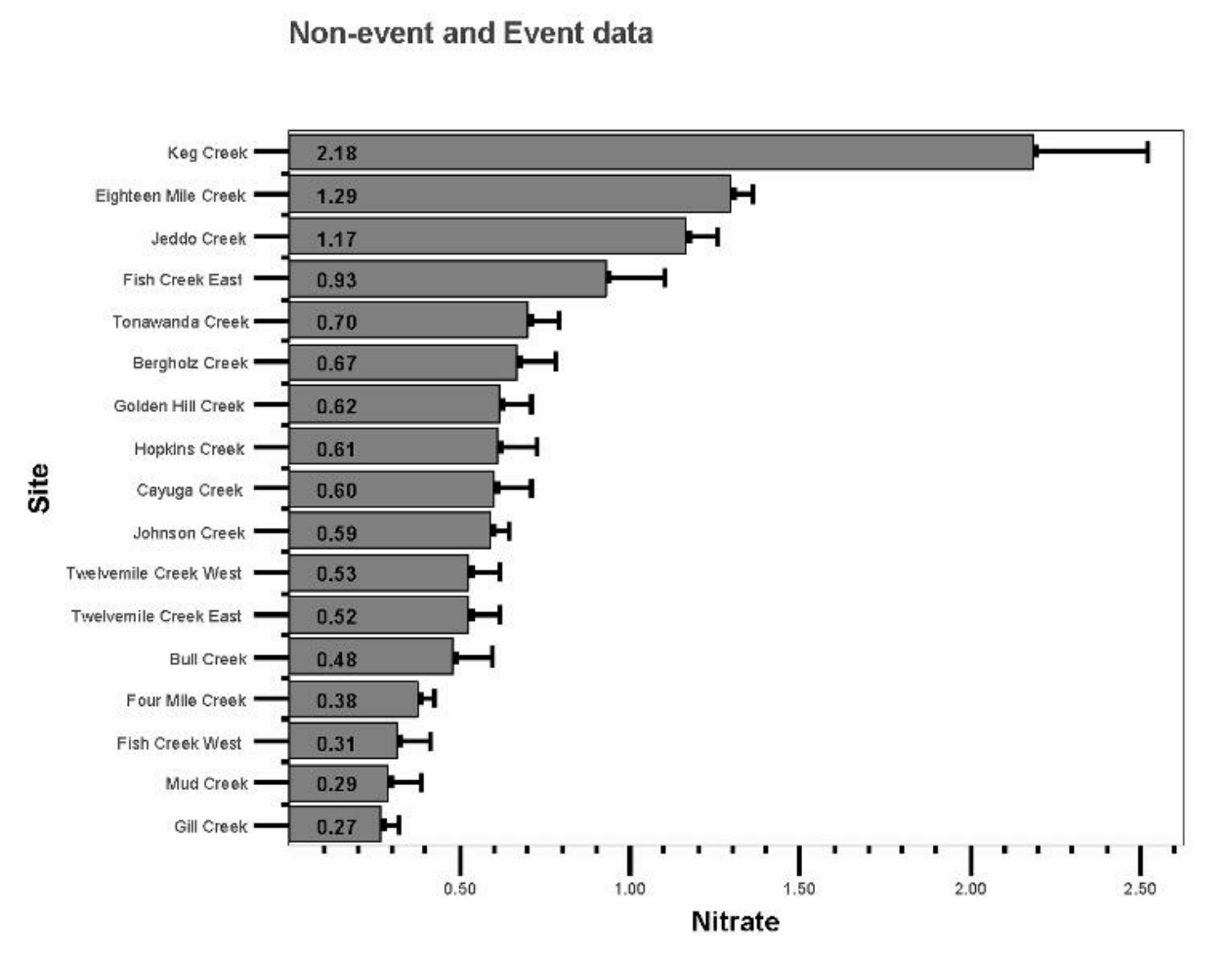


Figure 7. Mean nonevent plus event nitrate concentrations (mg N/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

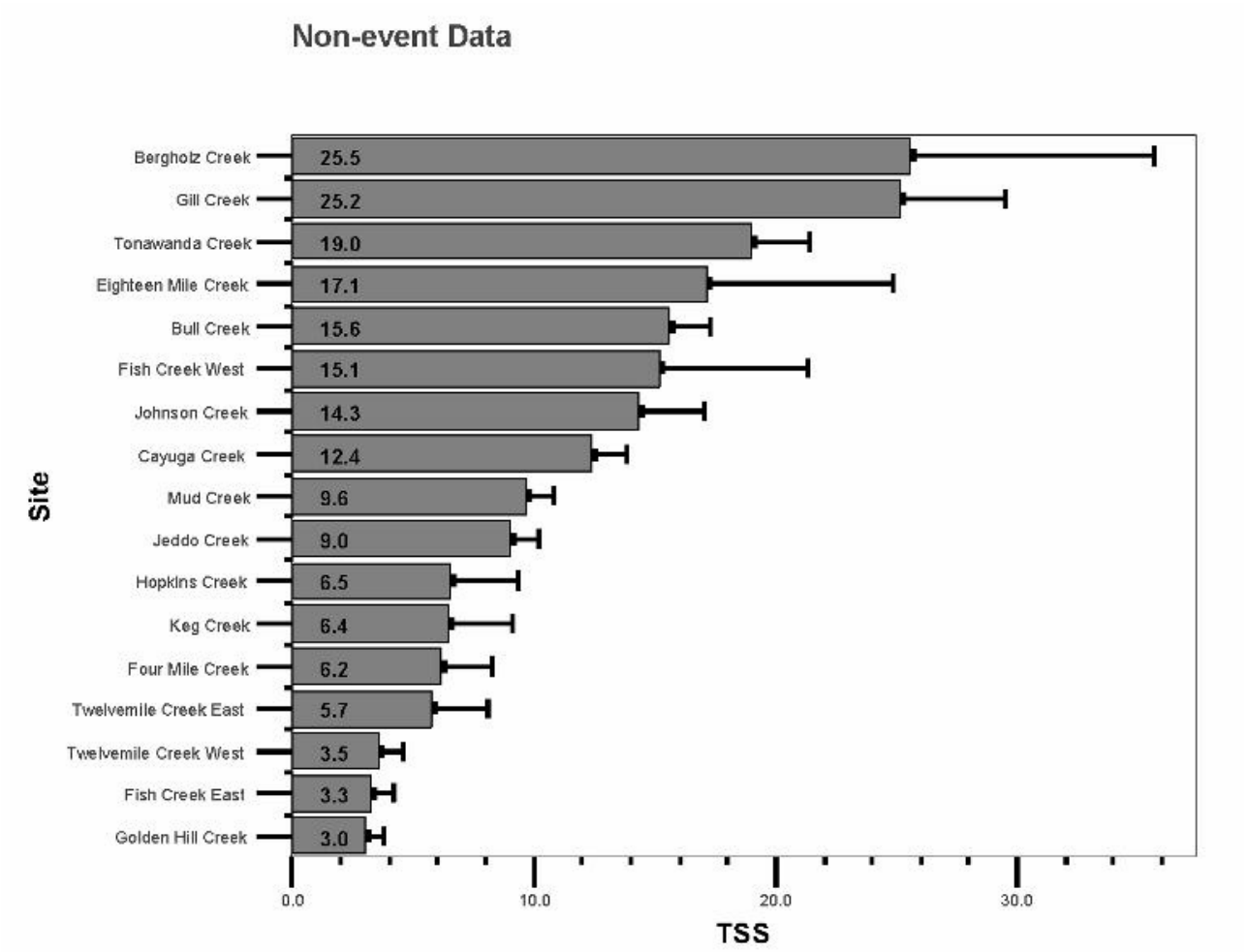


Figure 8. Mean nonevent total suspended solids concentrations (mg/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

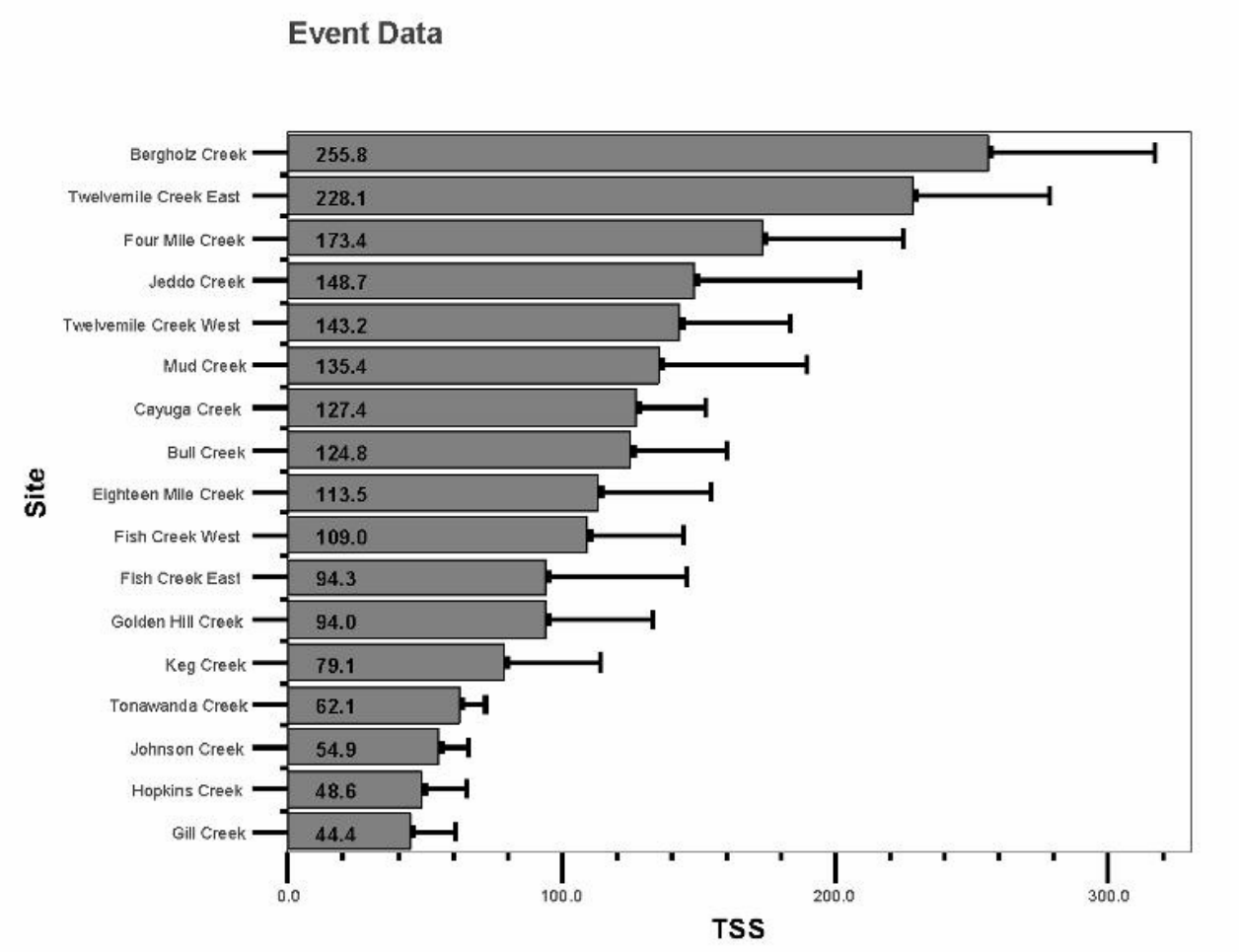


Figure 9. Mean event total suspended solids concentrations (mg/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

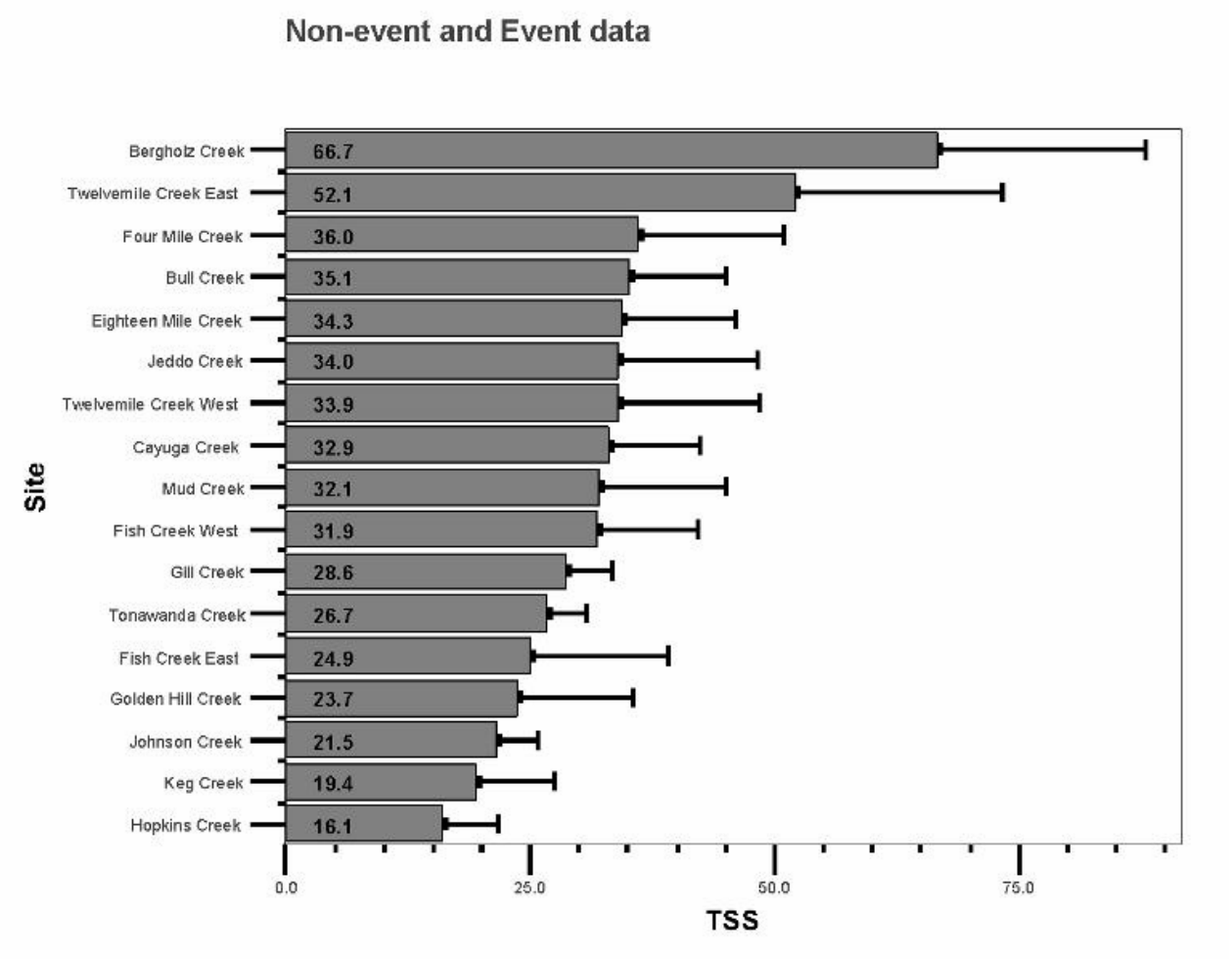


Figure 10. Mean nonevent plus event total suspended solids concentrations (mg/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

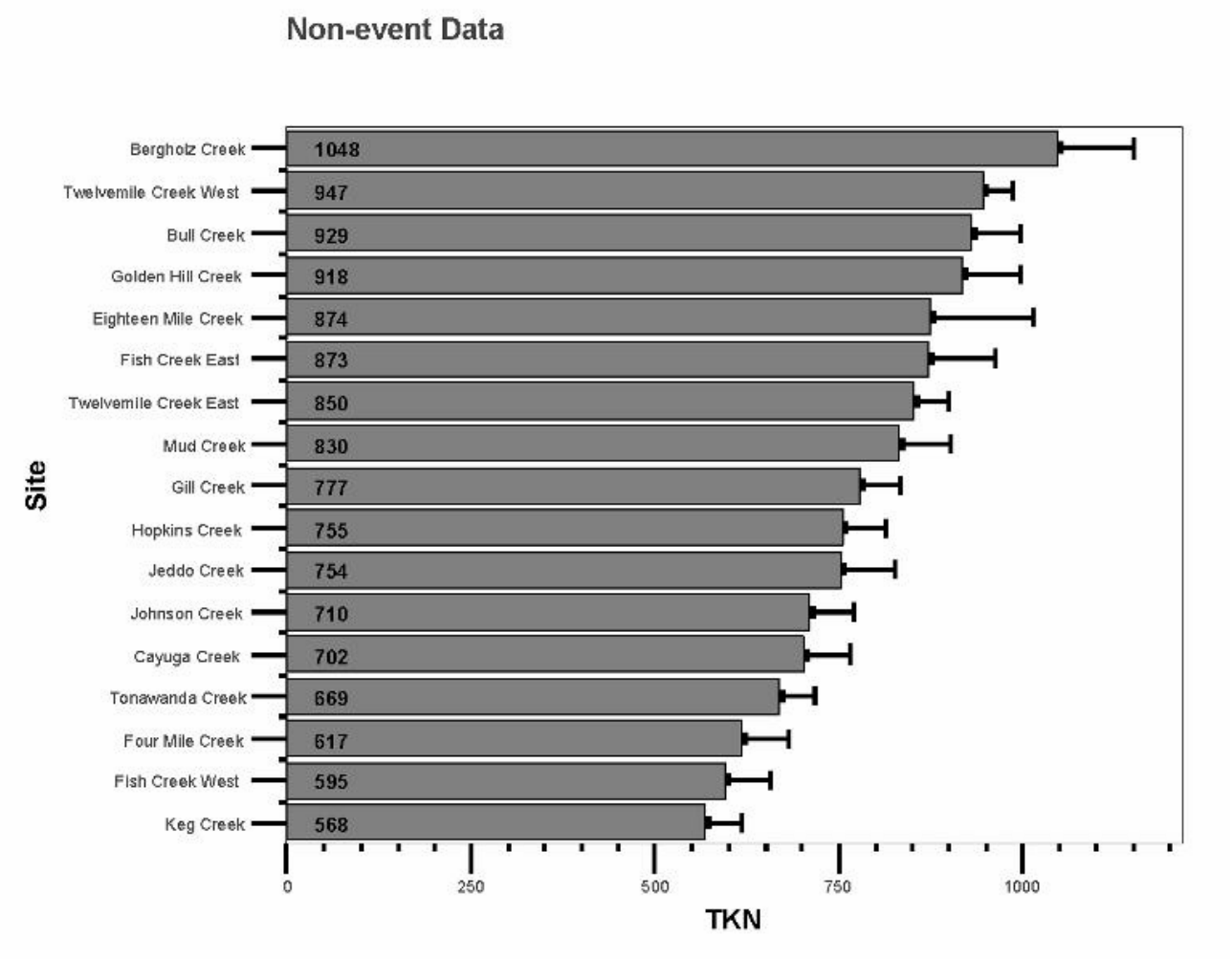


Figure 11. Mean nonevent total Kjeldahl nitrogen concentrations (µg N/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

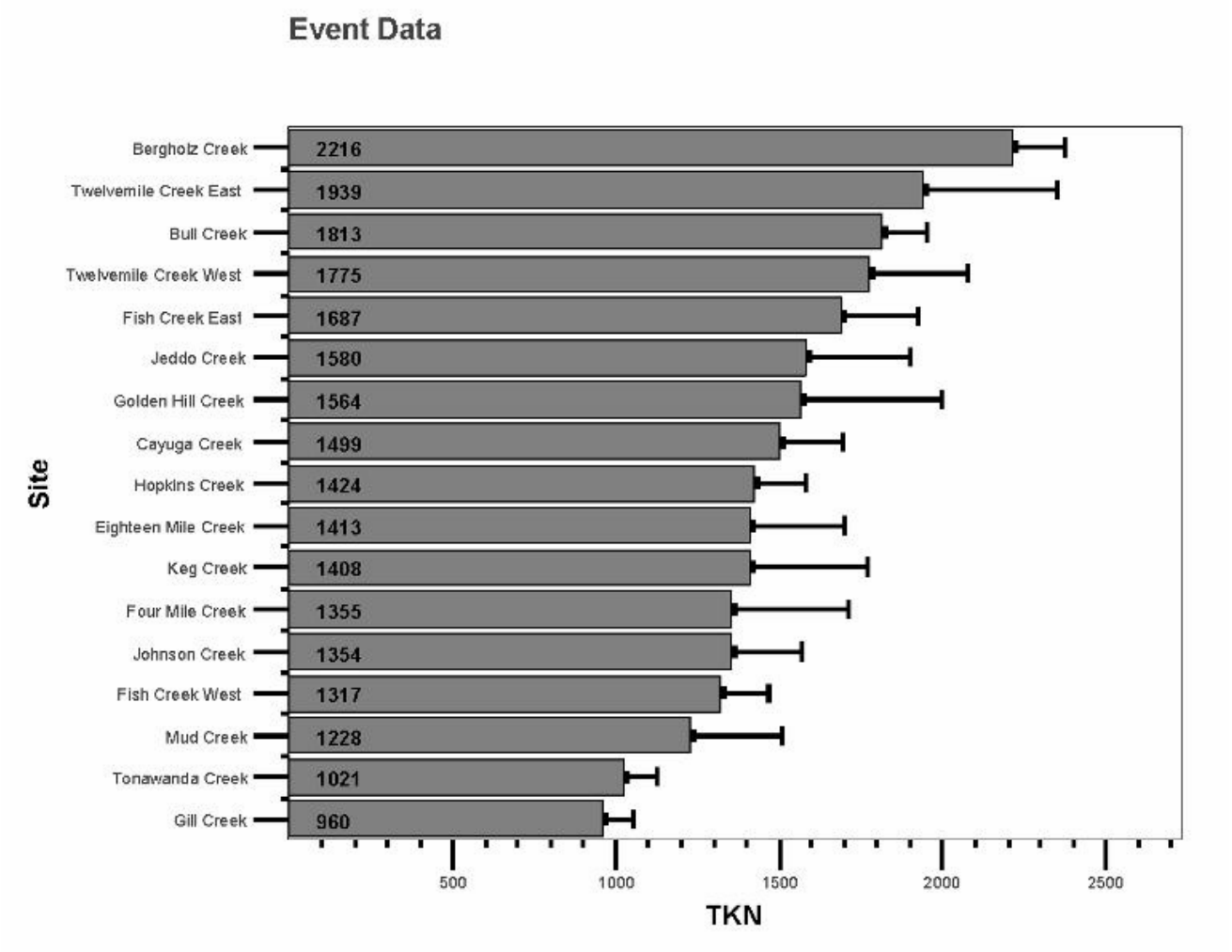


Figure 12. Mean event total Kjeldahl nitrogen concentrations (µg N/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

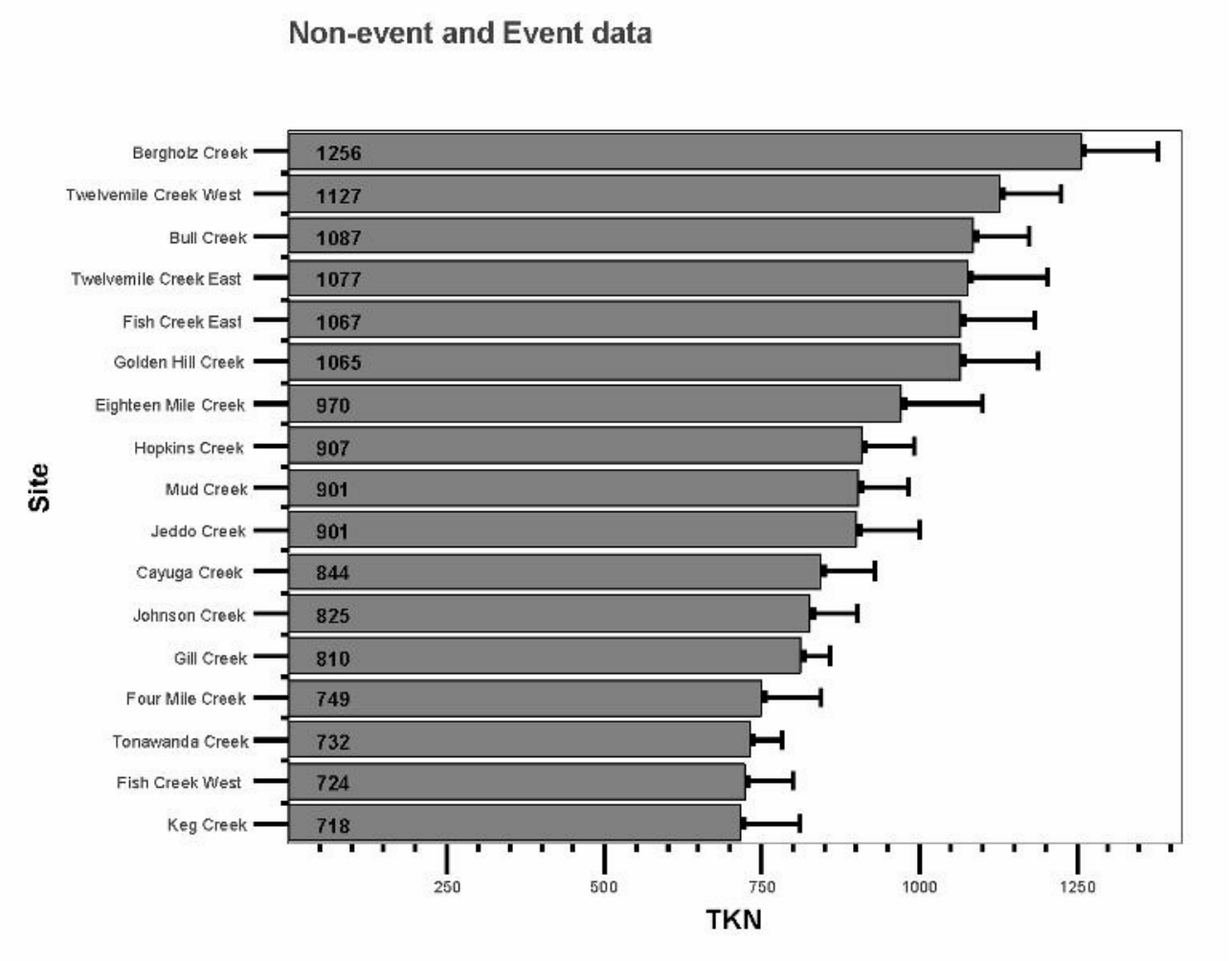


Figure 13. Mean nonevent plus event total Kjeldahl nitrogen concentrations (µg N/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

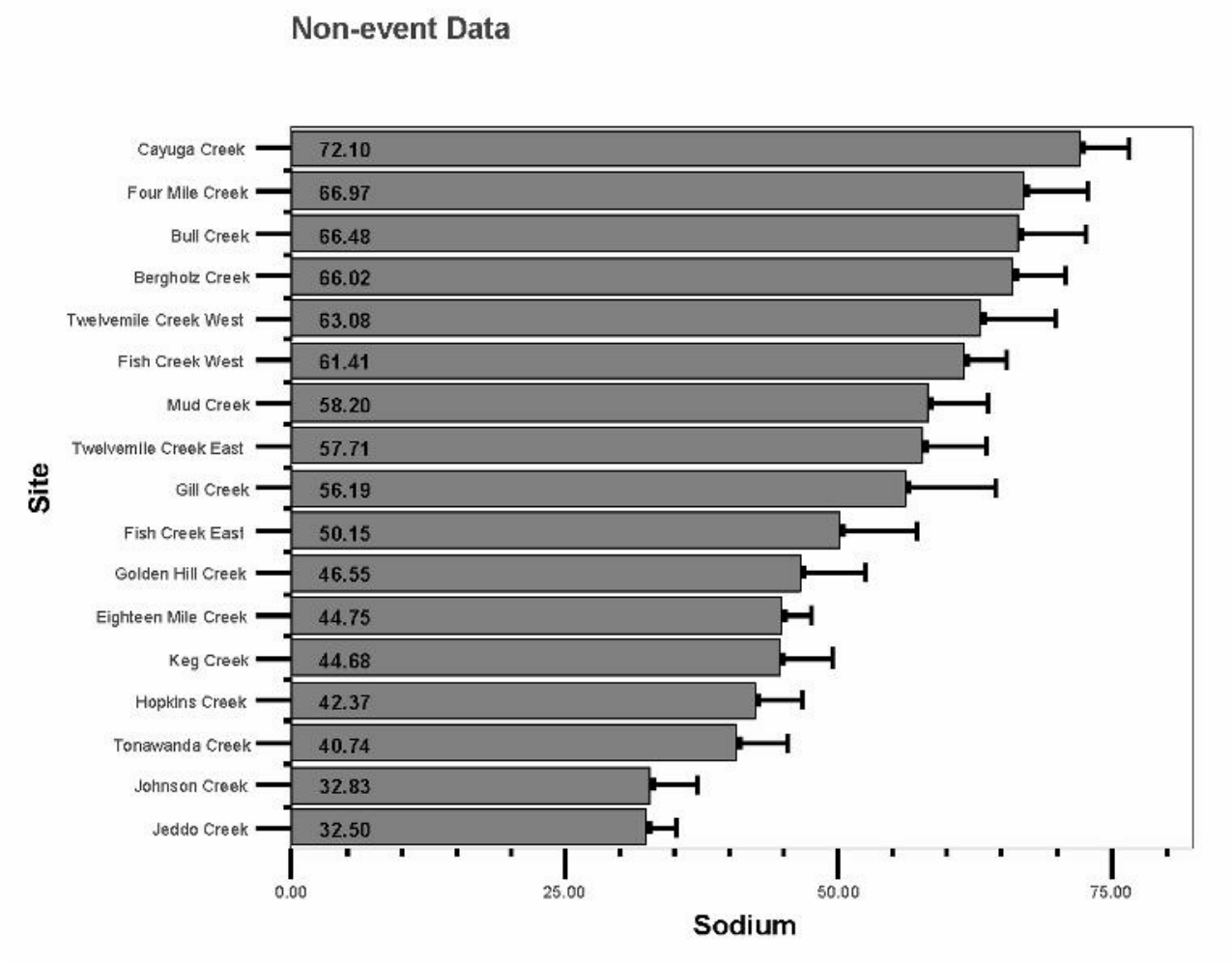


Figure 14. Mean nonevent sodium concentrations (mg/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

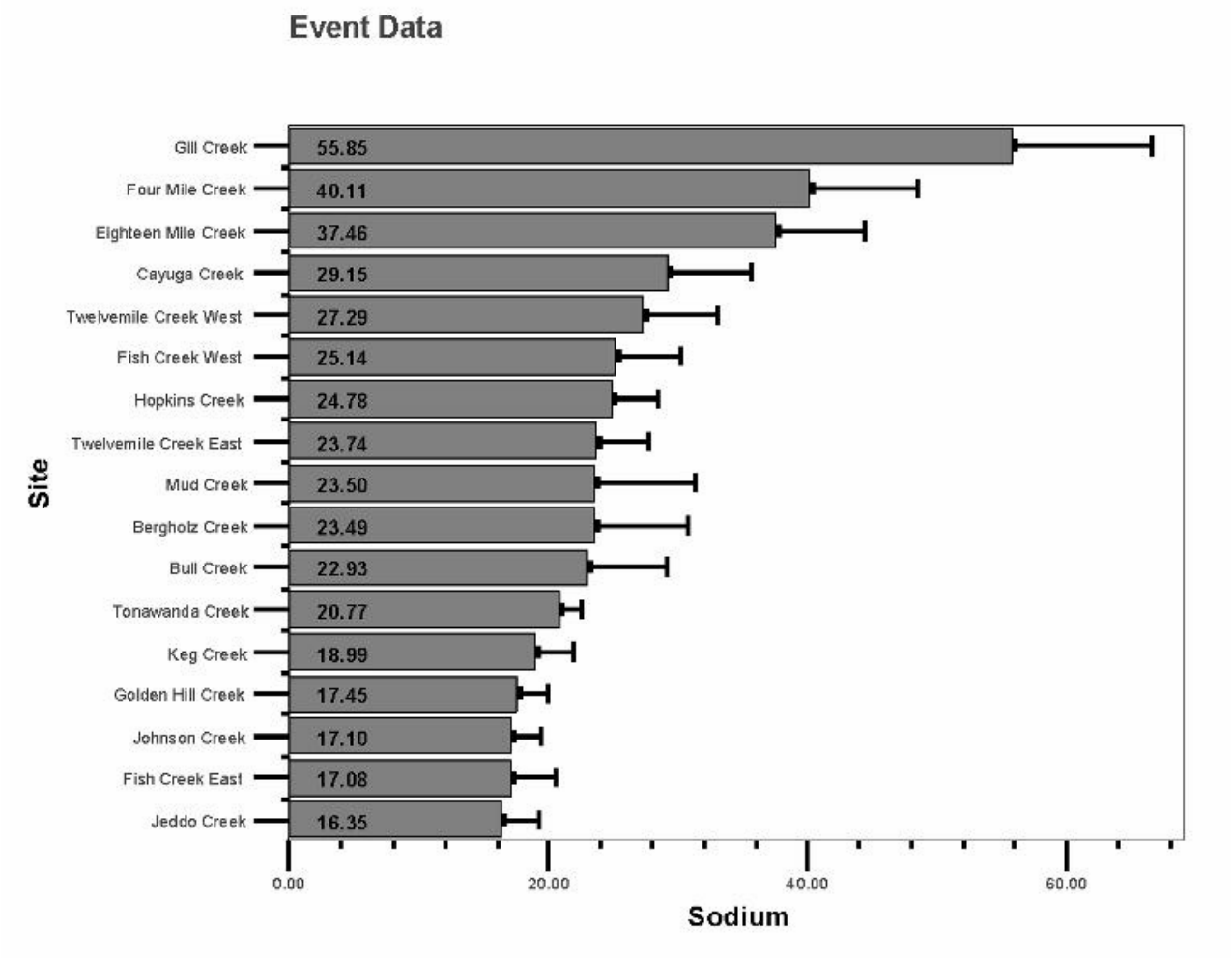


Figure 15. Mean event sodium concentrations (mg/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

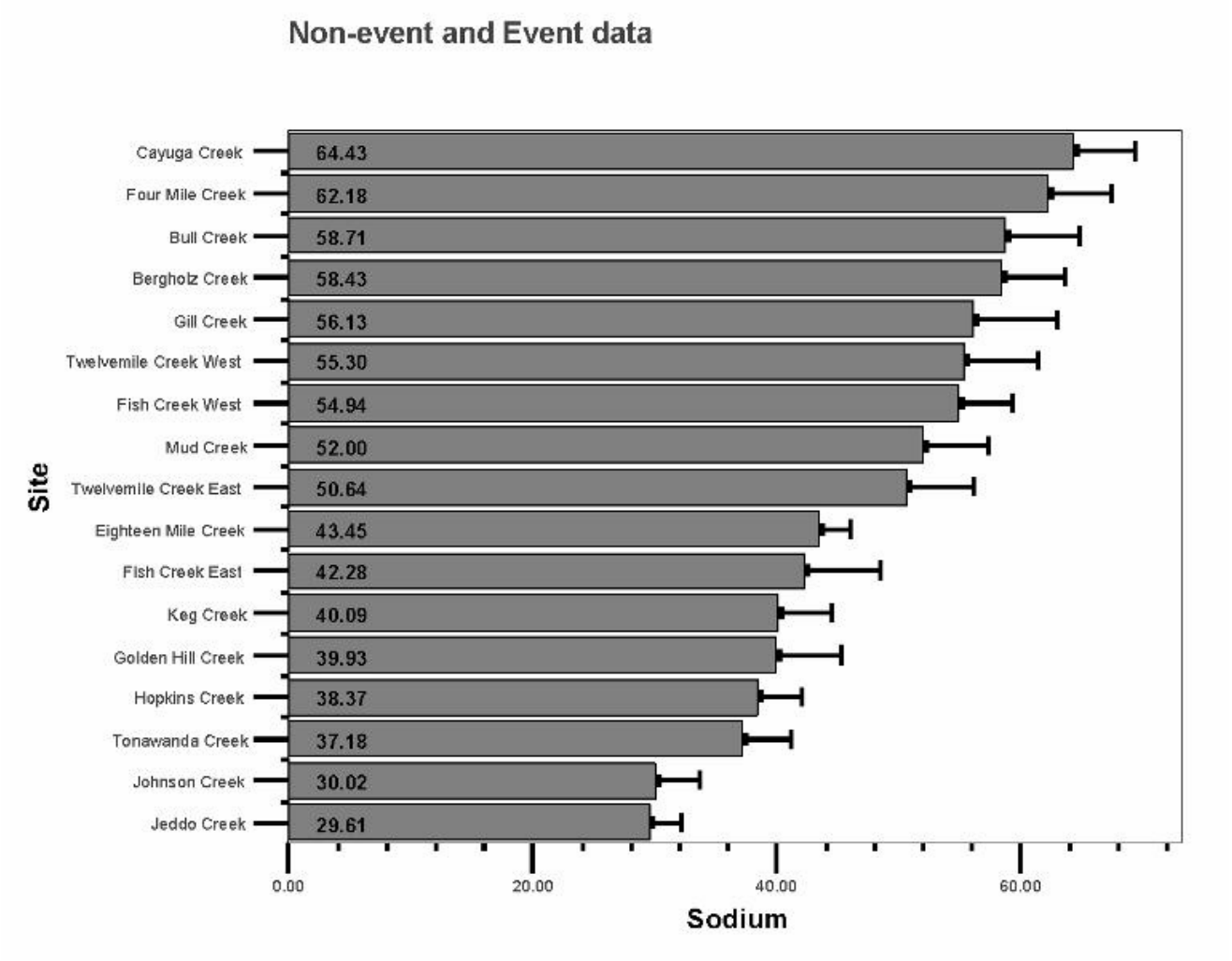
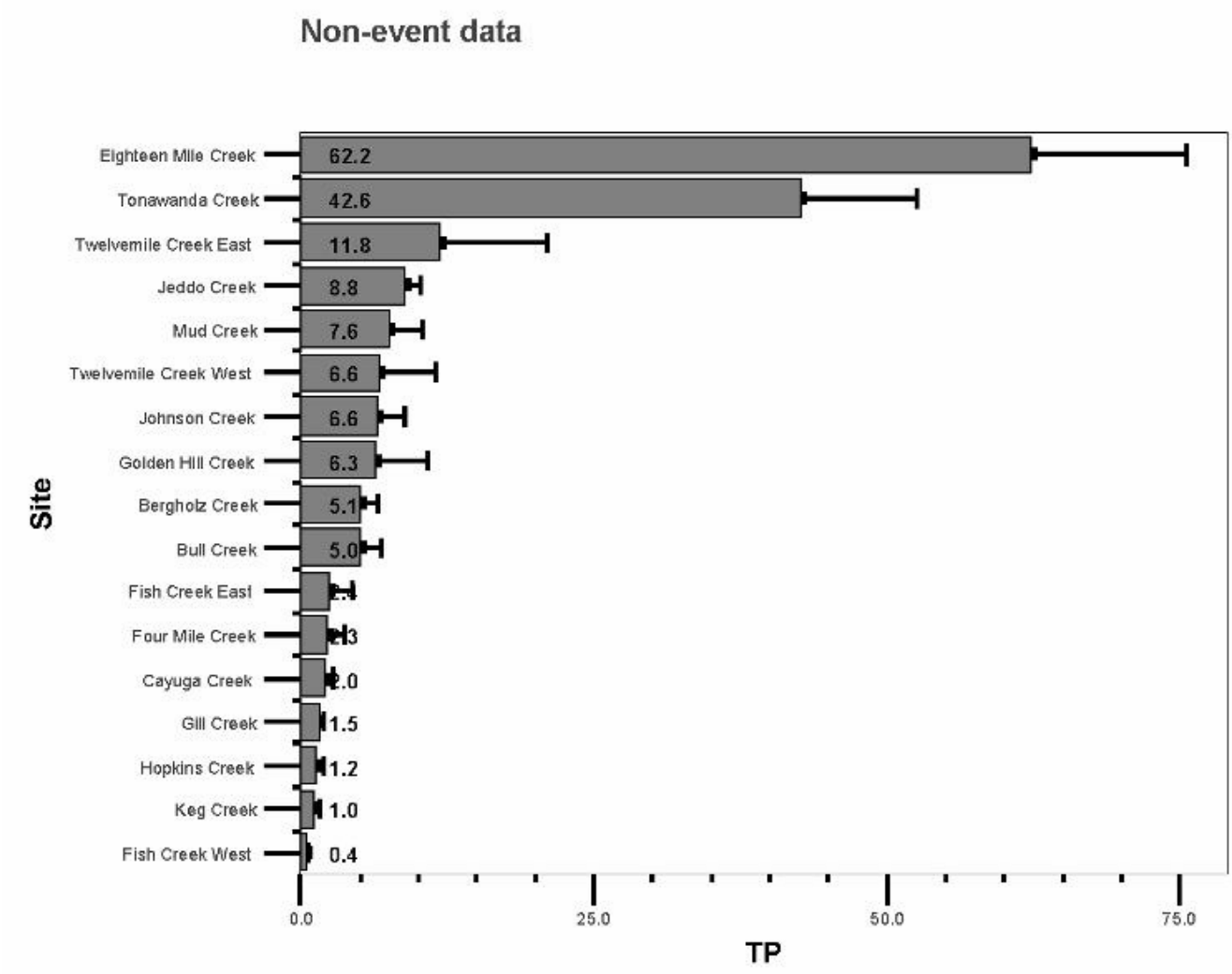


Figure 16. Mean nonevent plus event sodium concentrations (mg/L) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.



Fiigure 17. Mean daily nonevent total phosphorus losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

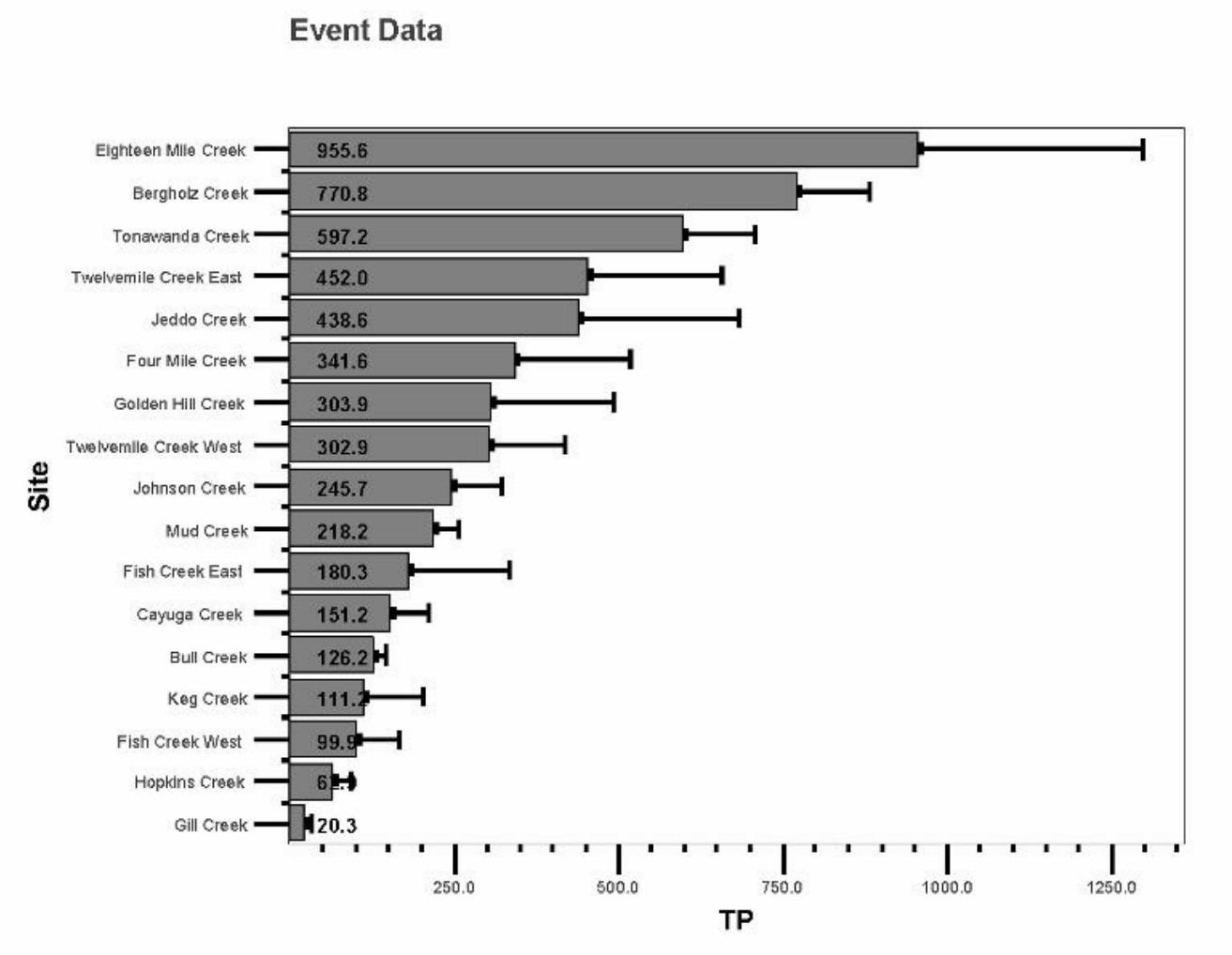


Figure 18. Mean daily event total phosphorus losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

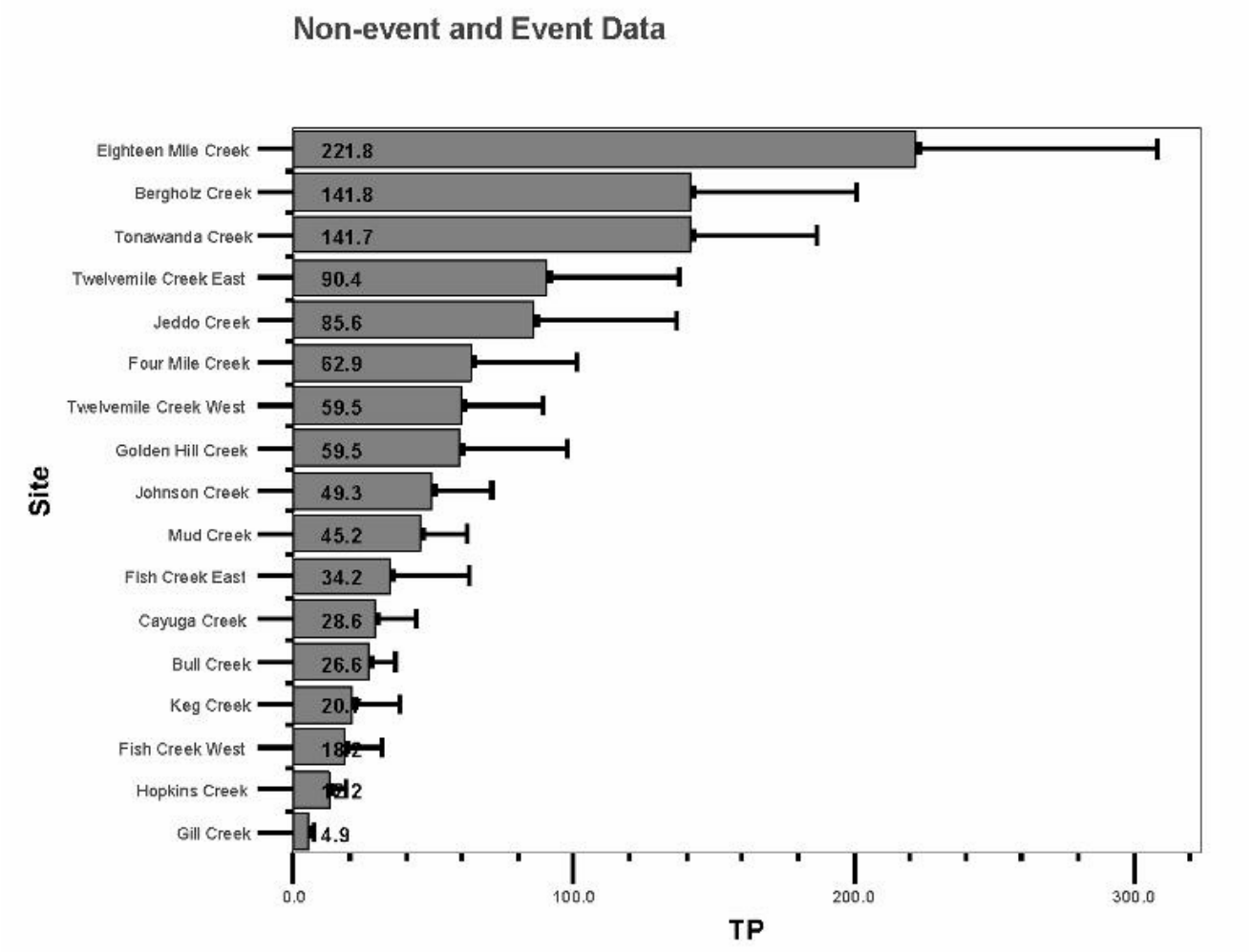


Figure 19. Mean daily nonevent plus event total phosphorus losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

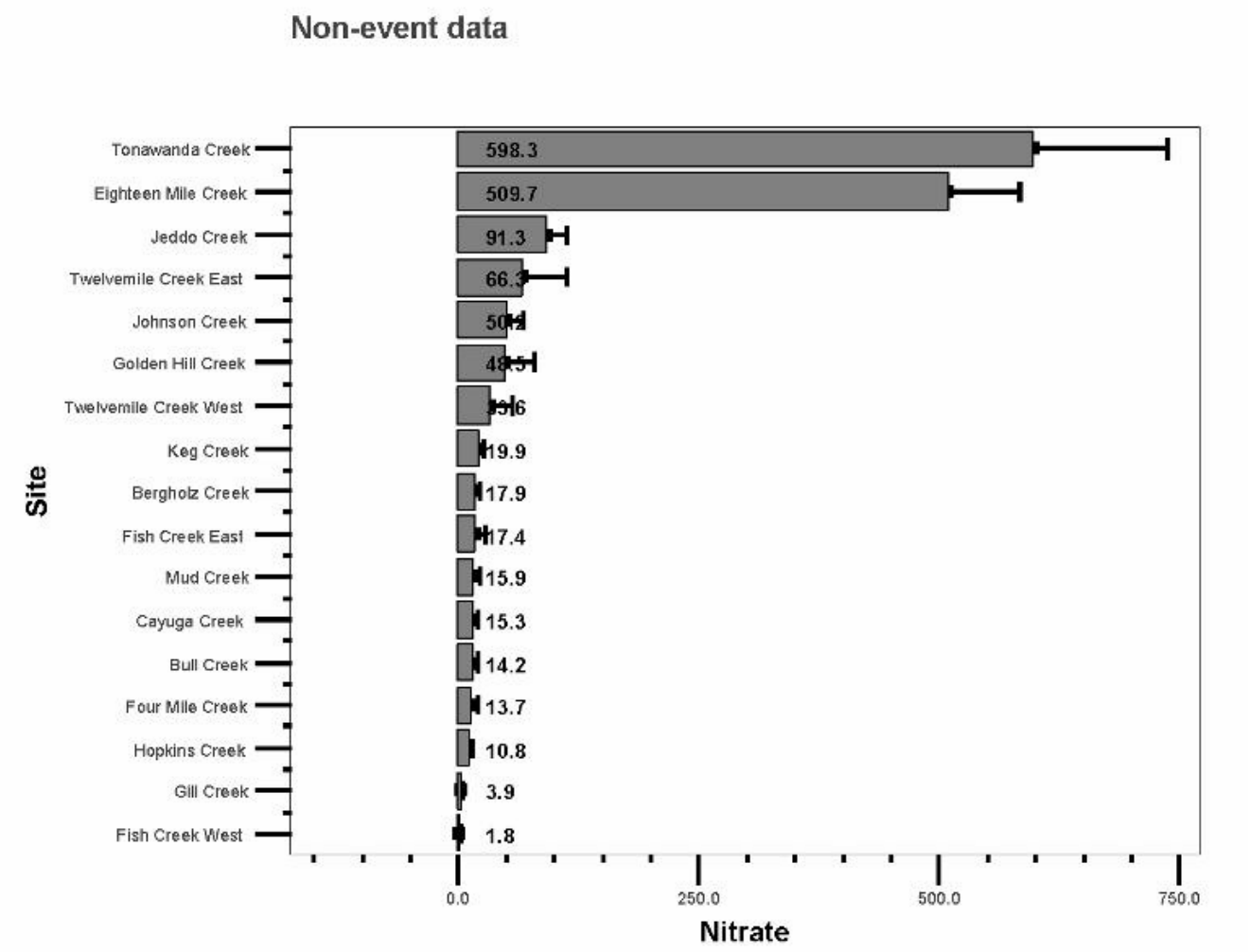


Figure 20. Mean daily nonevent nitrate losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

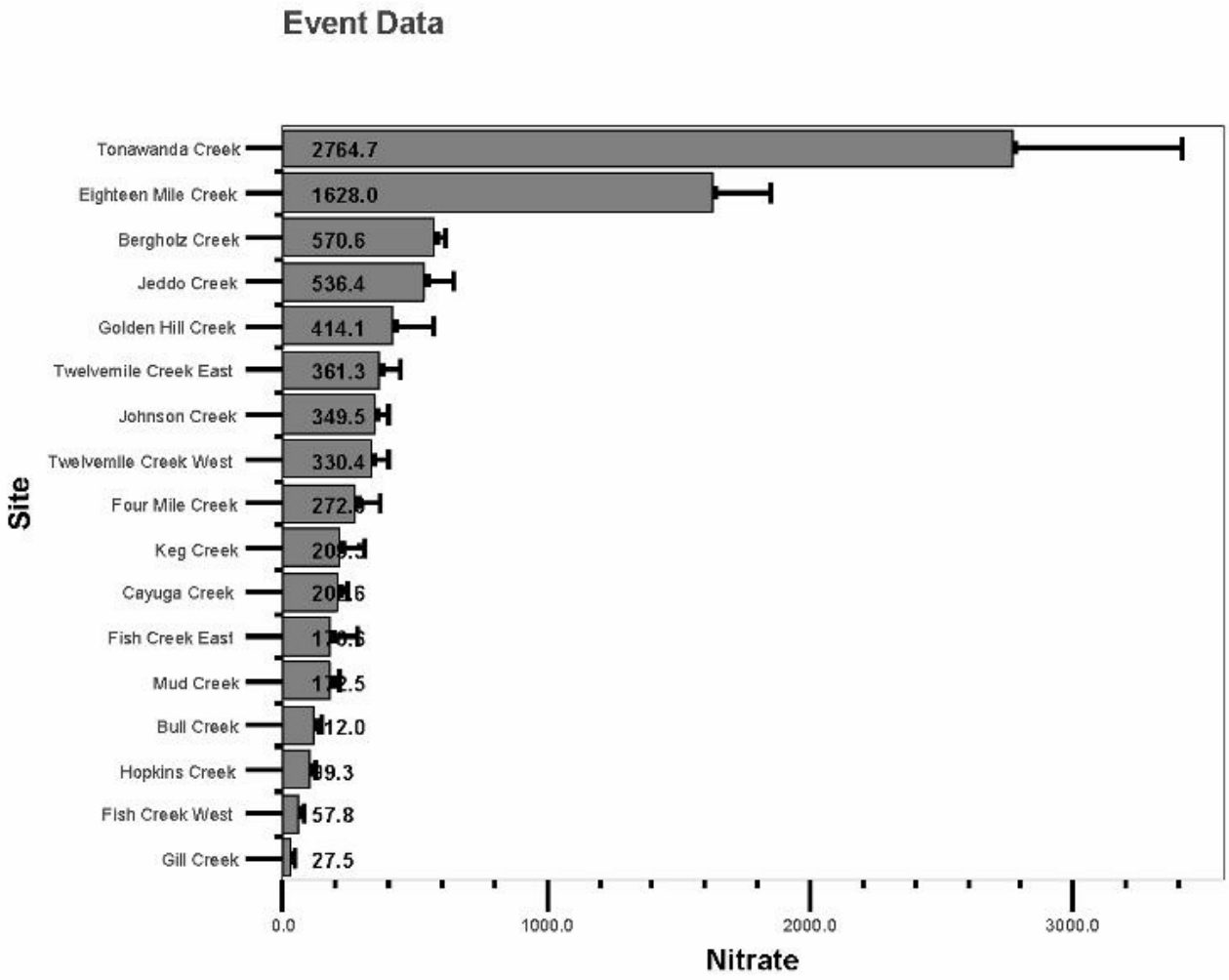


Figure 21. Mean daily event nitrate losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

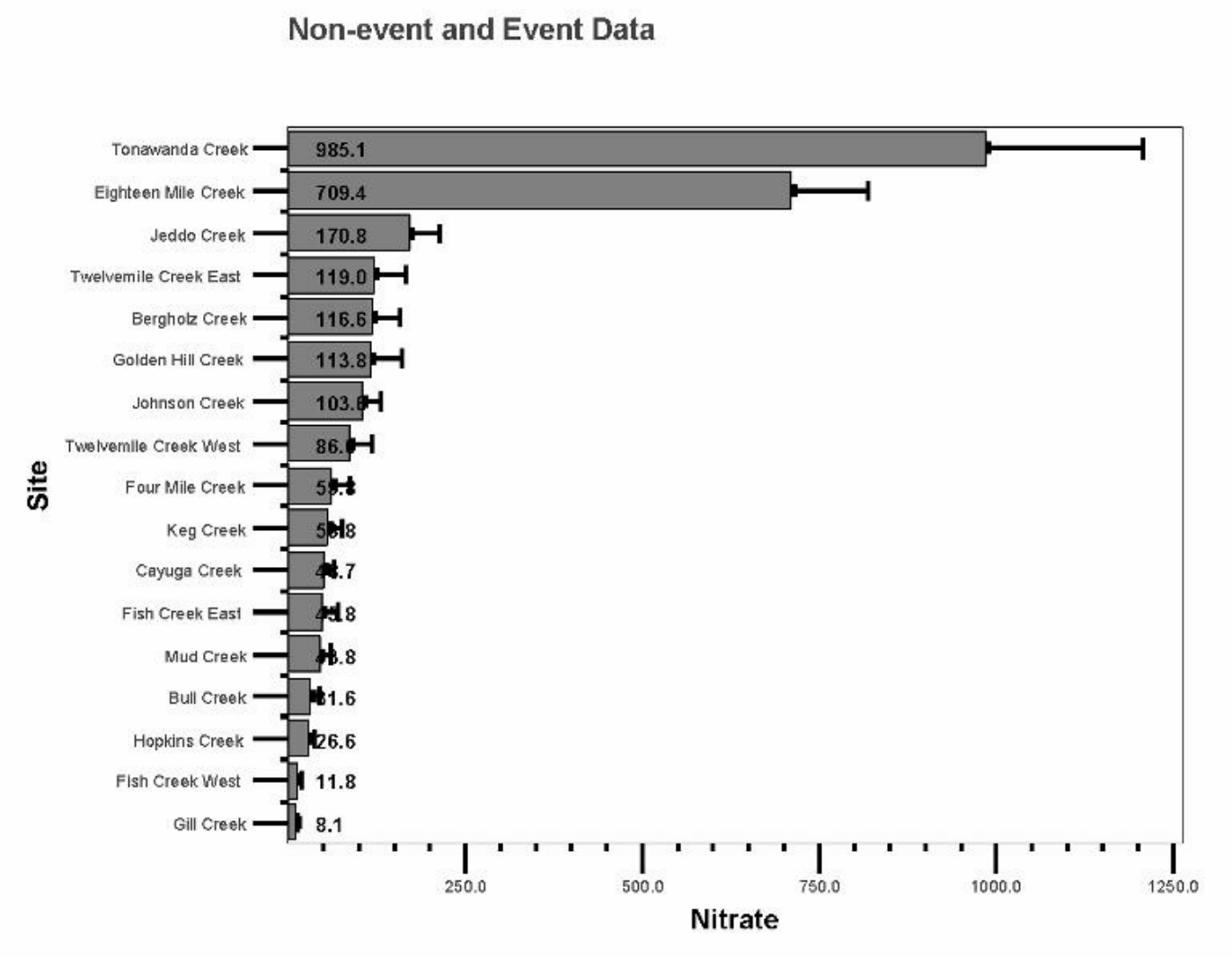


Figure 22. Mean daily nonevent plus event nitrate losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

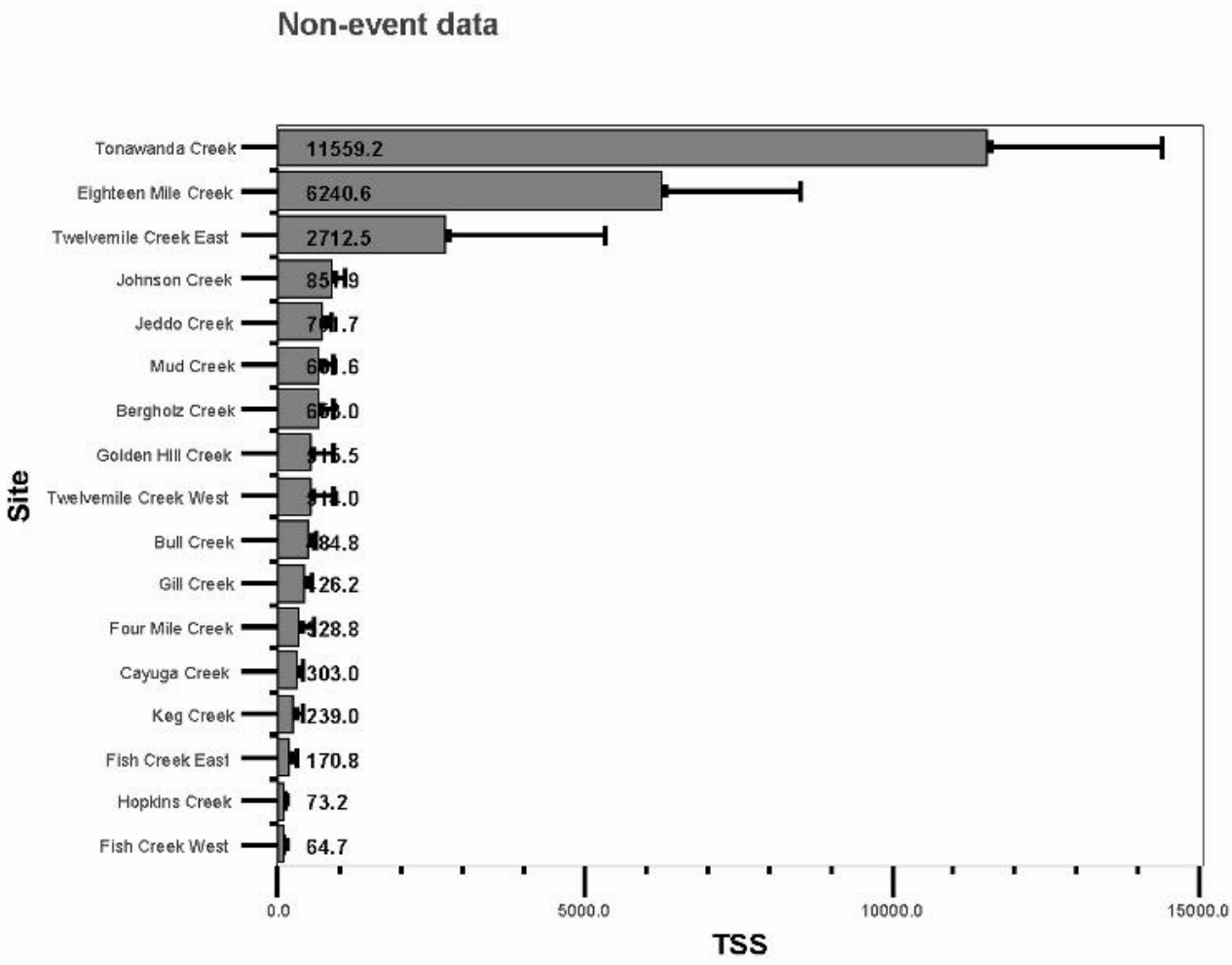


Figure 23. Mean daily nonevent total suspended solids losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

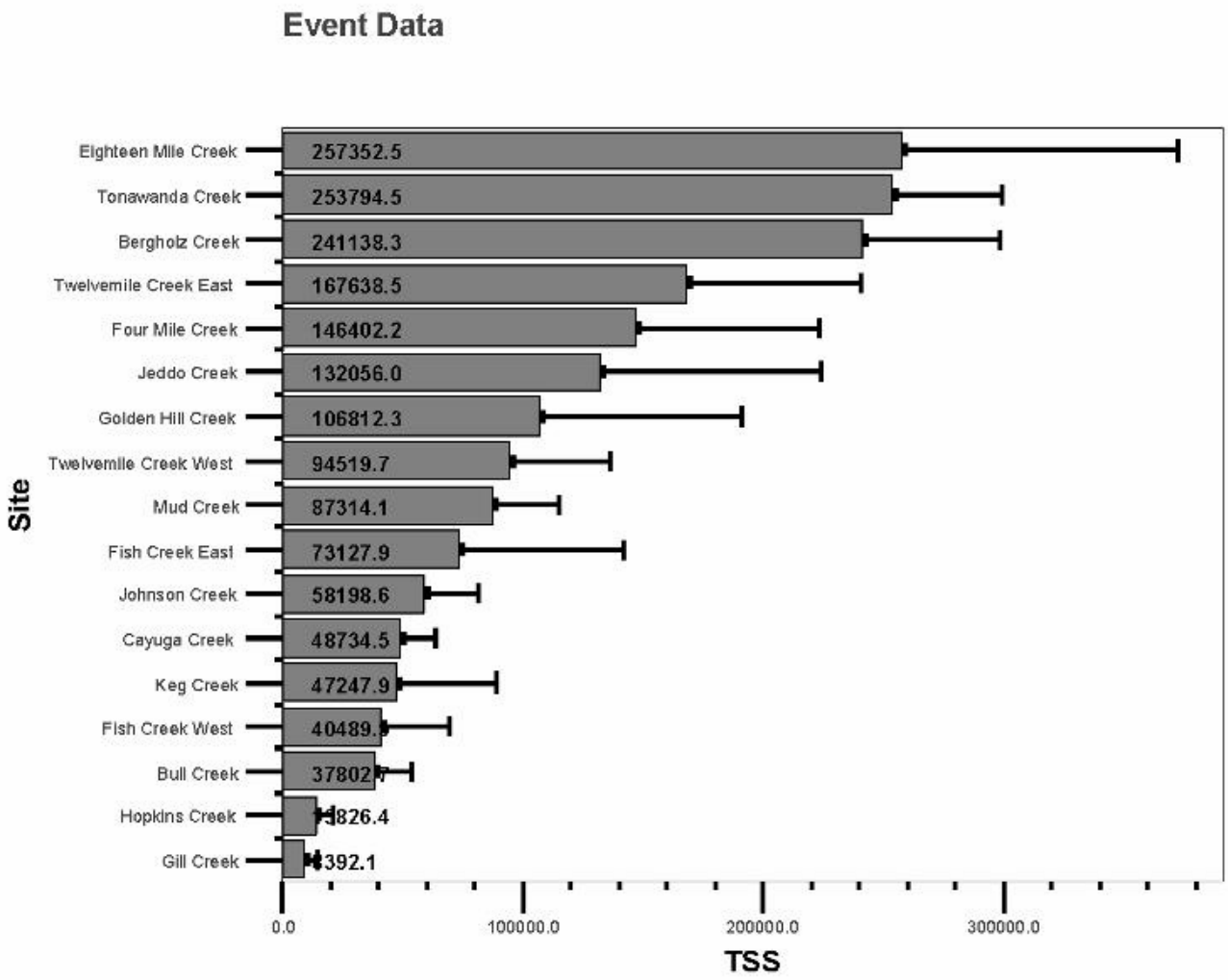


Figure 24. Mean daily event total suspended solids losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

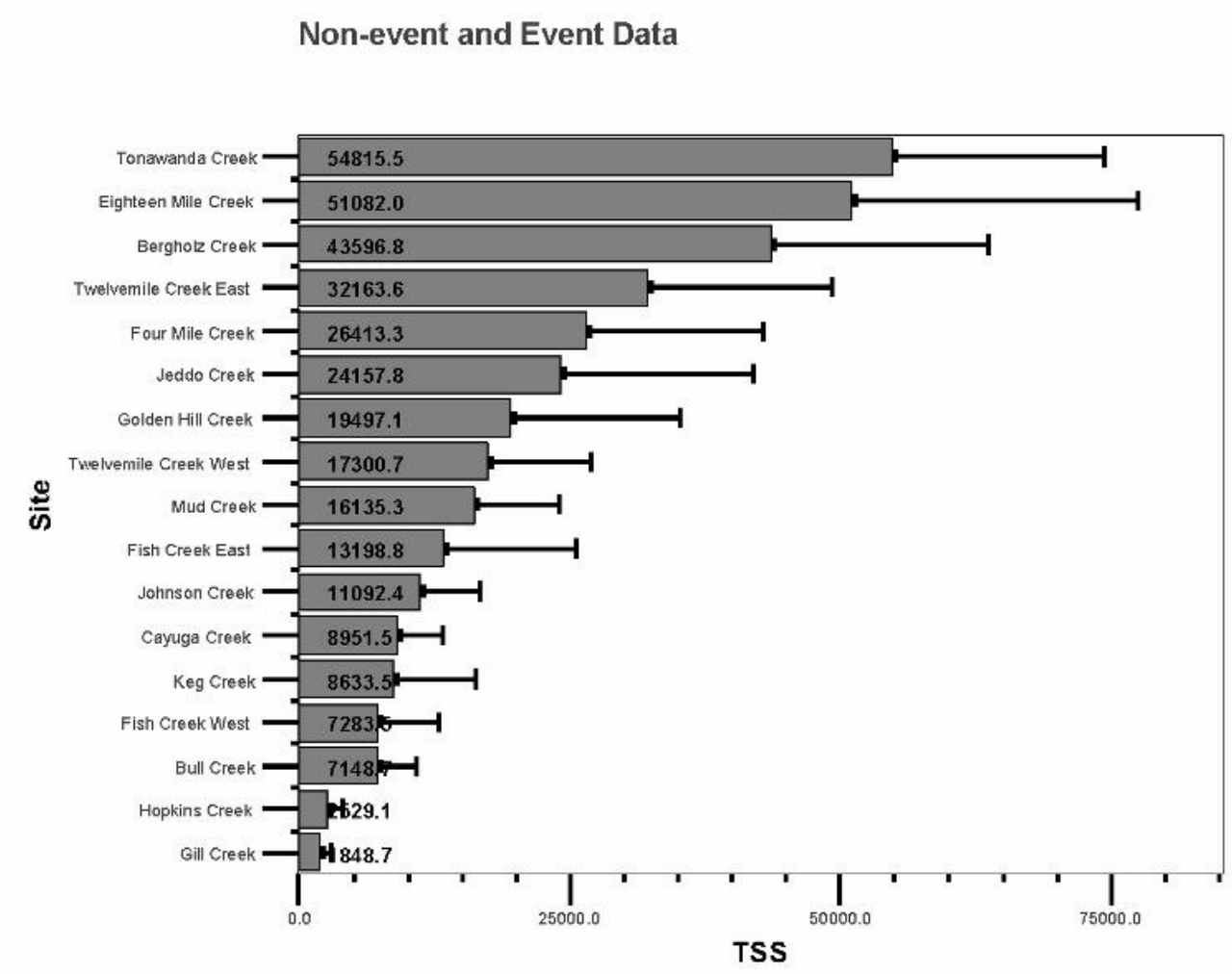


Figure 25. Mean daily nonevent plus event total suspended solids losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

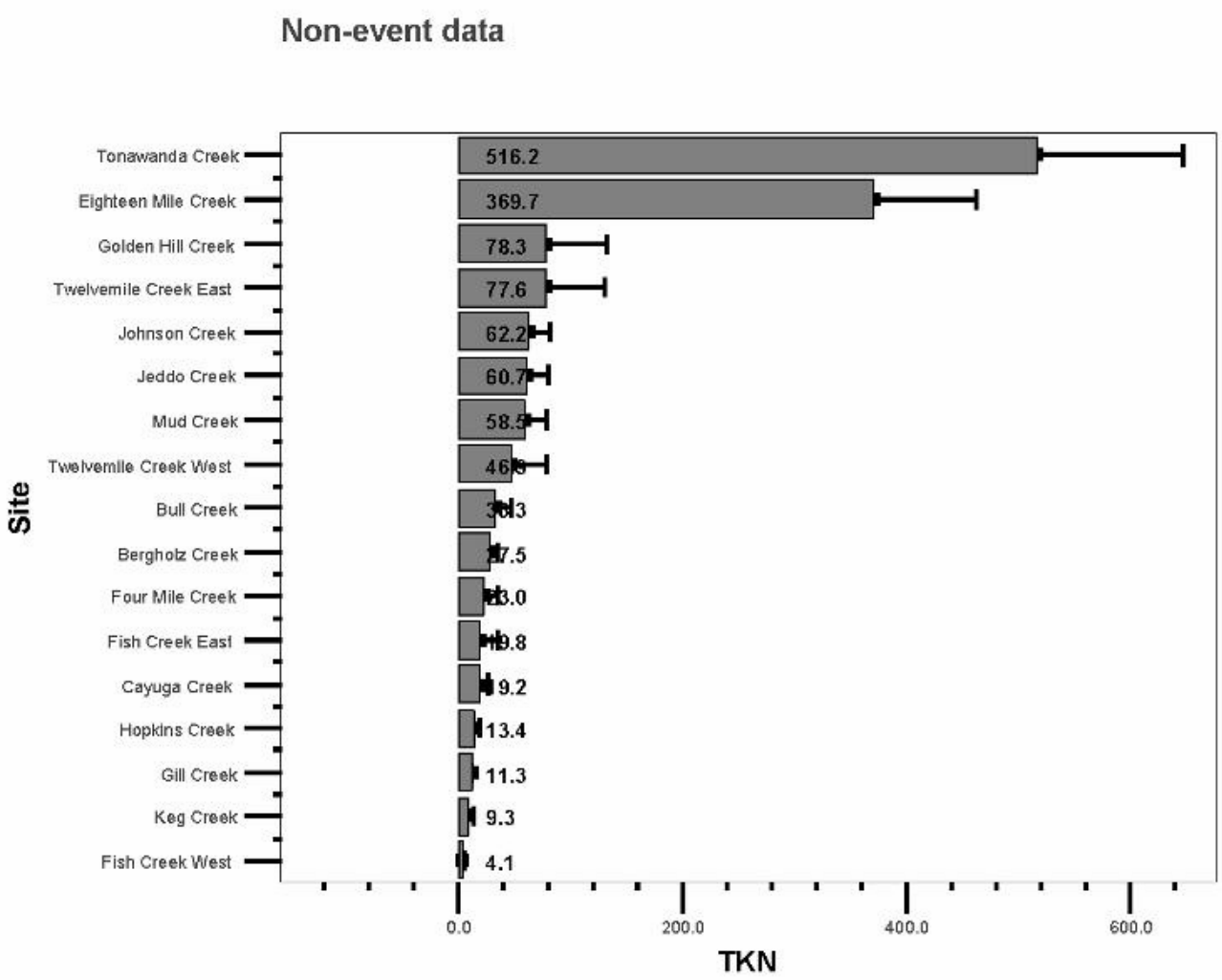


Figure 26. Mean daily nonevent total Kjeldahl nitrogen losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

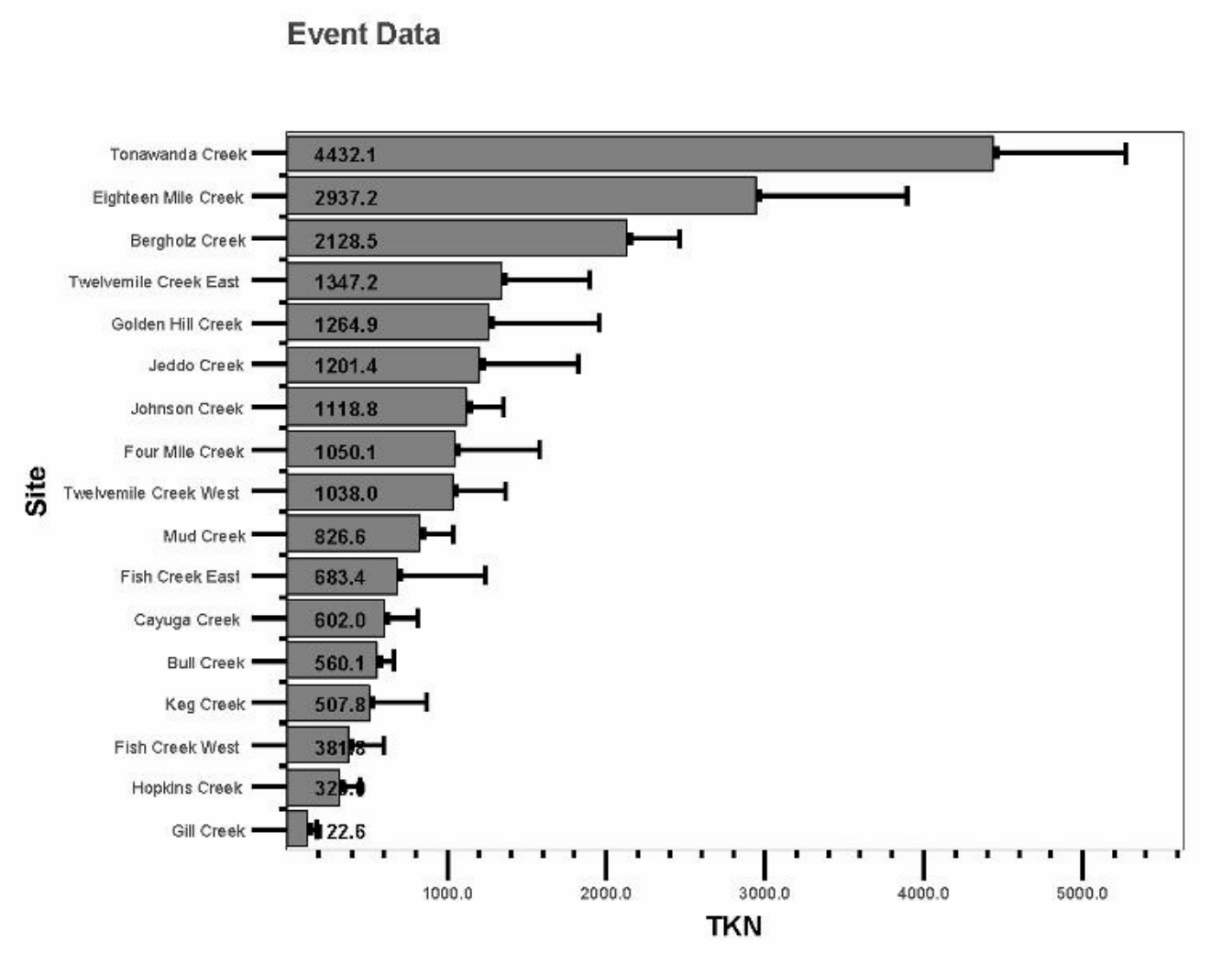


Figure 27. Mean daily event total Kjeldahl nitrogen losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

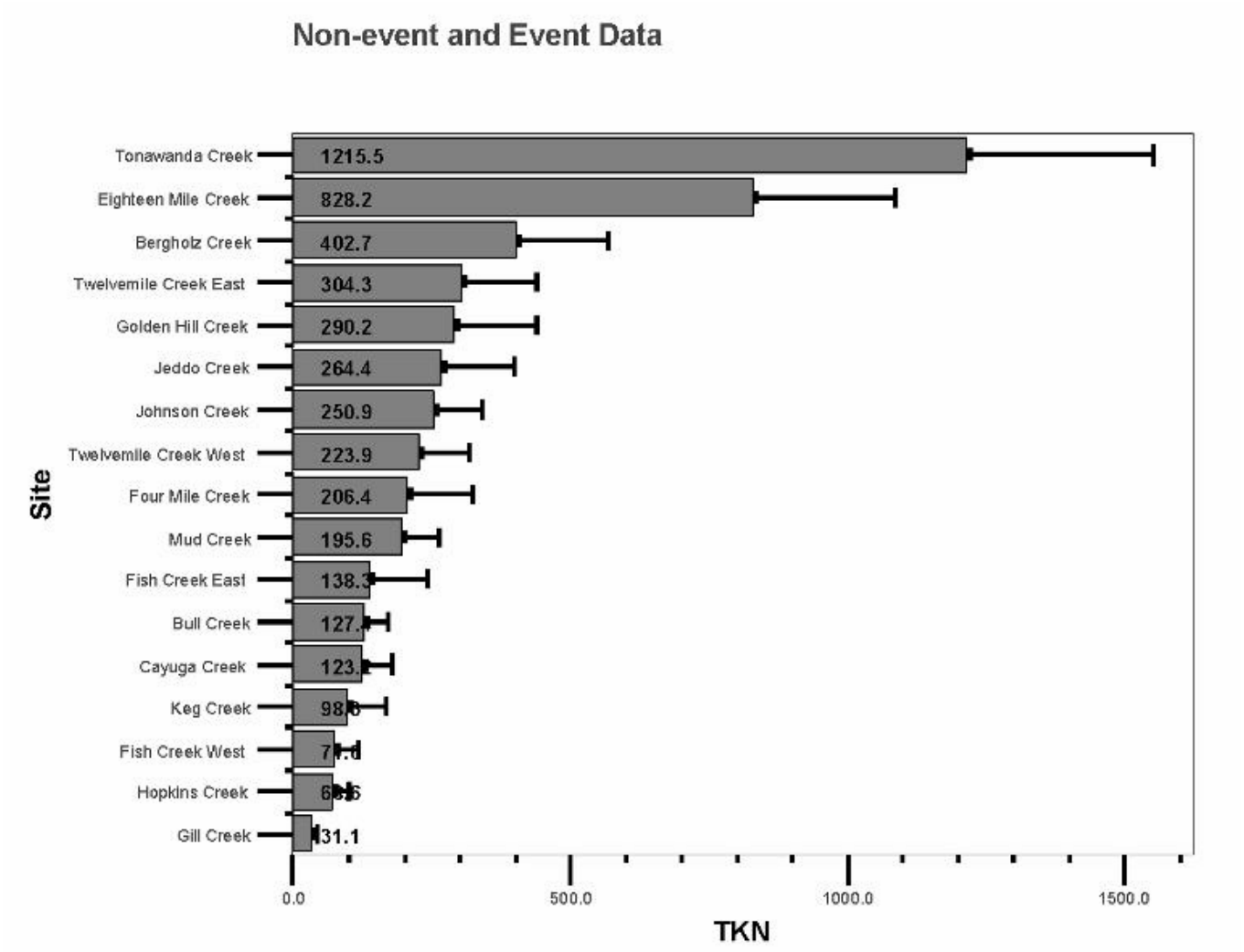


Figure 28. Mean daily nonevent plus event total Kjeldahl nitrogen losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

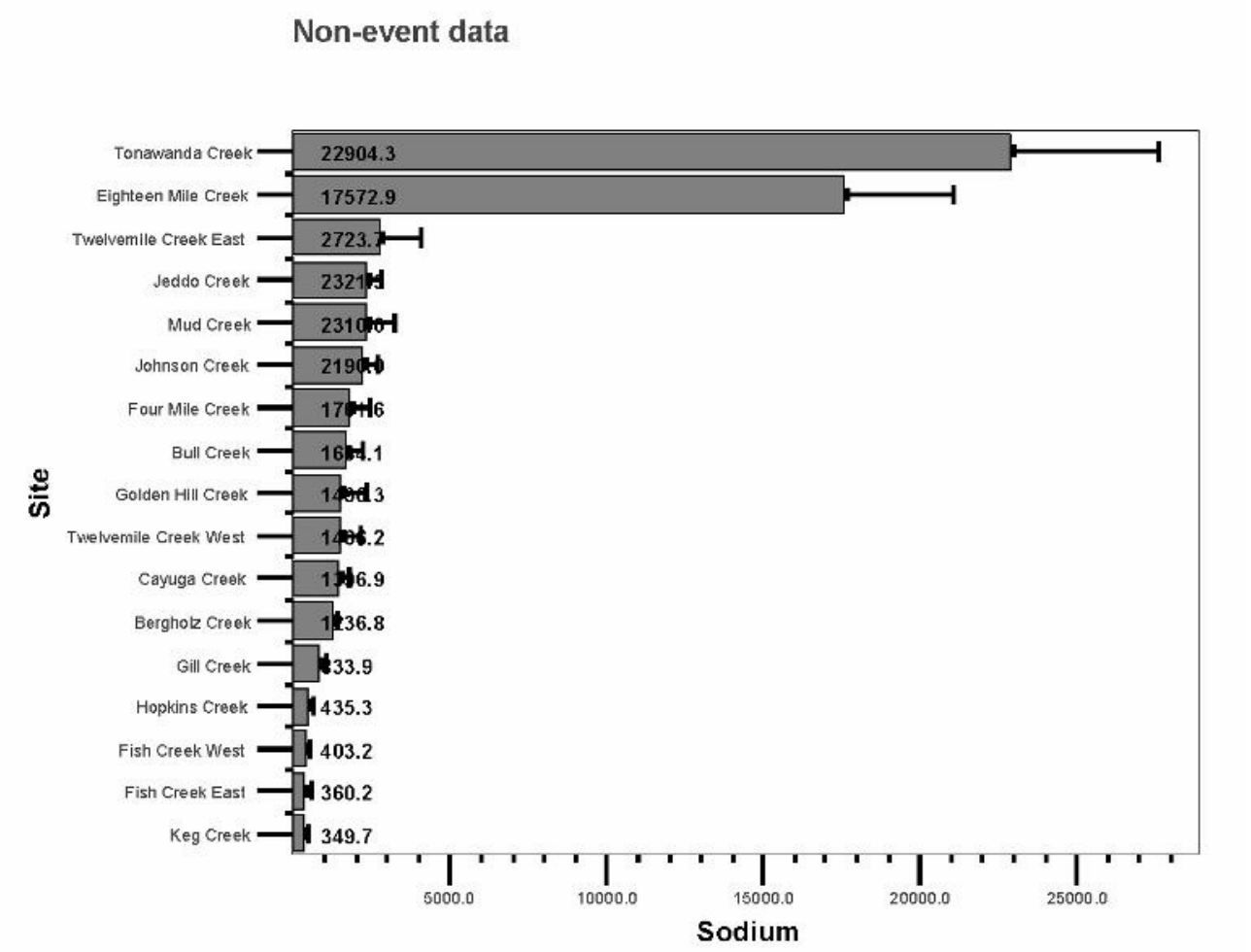


Figure 29. Mean daily nonevent sodium losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

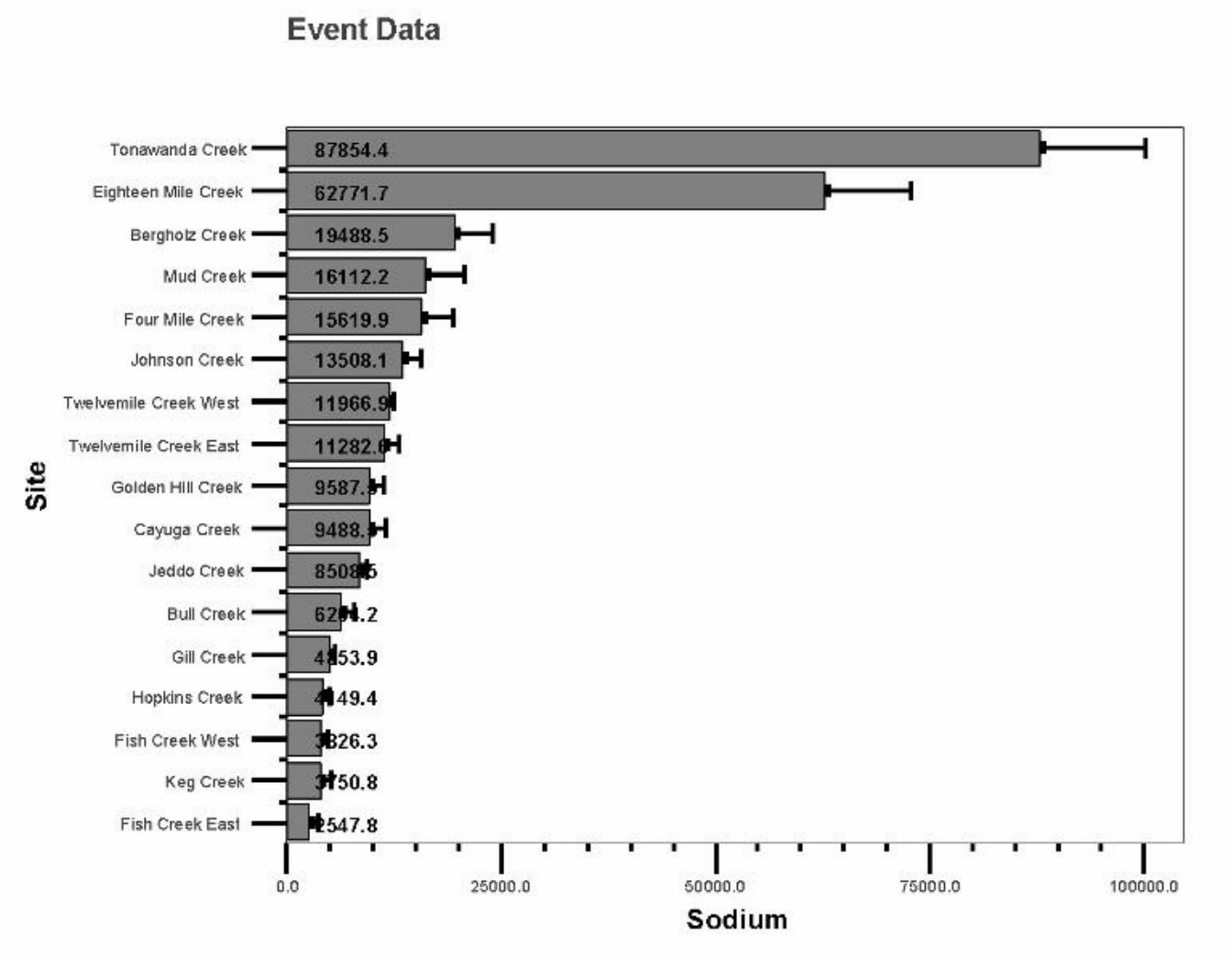


Figure 30. Mean daily event sodium losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.

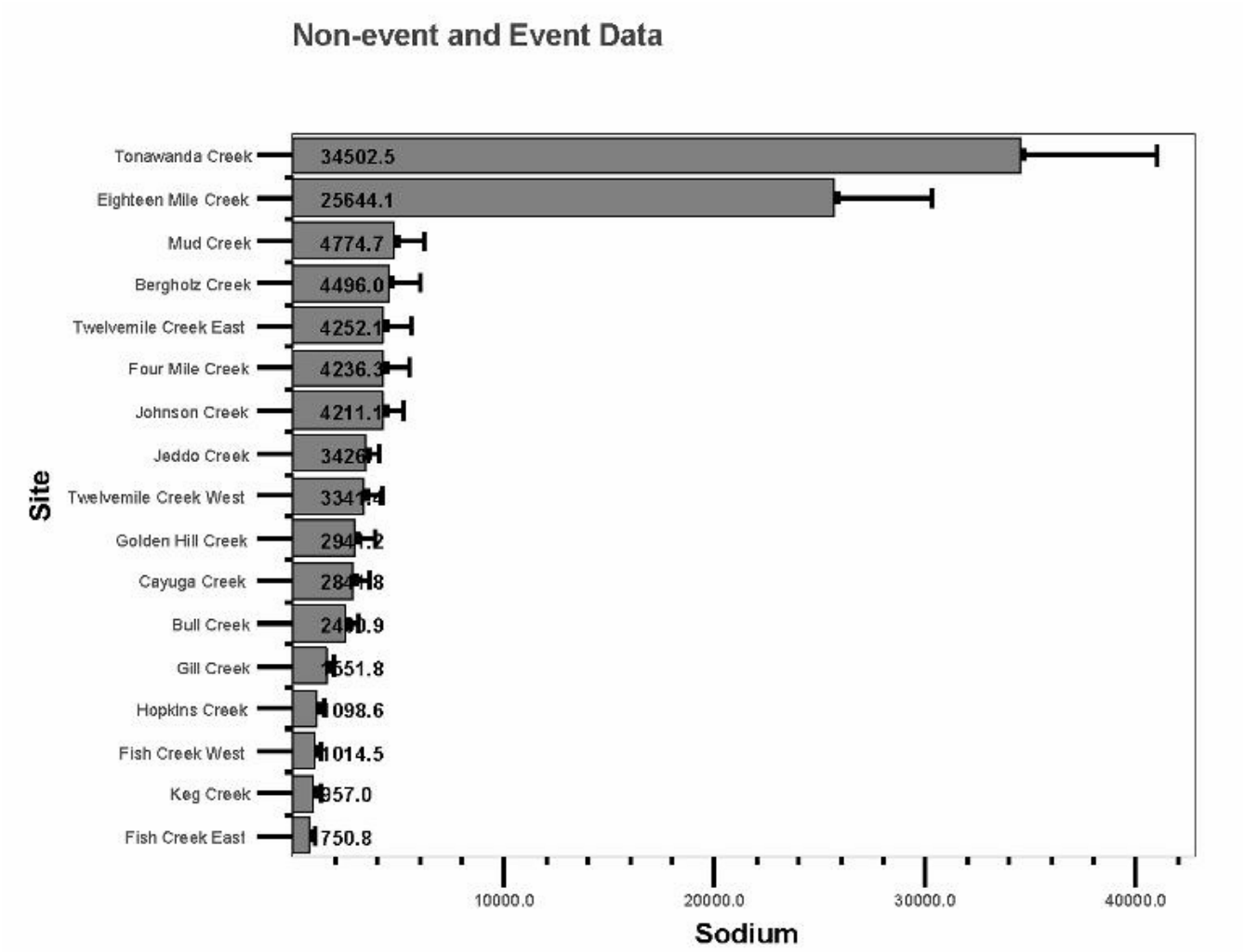


Figure 31. Mean daily nonevent plus event sodium losses (kg/day) for the seventeen Niagara County tributaries monitored from February 2006 to December 2007.